Analysis of the effect of magnetic fields on the amplitudes of the early and late cognitive potentials during fMRI

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Introduction

The utilization of a "hybrid magnetic resonance imaging- electroencephalography: MRI-EEG" instrument to analyze the cognitive potentials of the brain provides a high spatial resolution, in the range of millimeters (MRI), and a high temporal resolution, in the range of milliseconds (EEG). However, veridical recording of EEG components, typically in the range of millivolts, may be endangered in fMRI experiments. As an example, in their event related potential (ERP) study during MRI recordings, Mulert et al. (2004) reported attenuation in the earlier N100/P200 complex but not in the later P300 complex of ERP during active oddball paradigm. This observation casts doubt on the reliability of ERPs when recorded under MRI. This observation may be caused by a specific electrophysiological artifact that is called ballistocardiogram (BCG). BCG is a heart beat related artifact seen in MRI recordings resulting from micromovements of body and adjacent electrode wires cutting across lines of magnetic flux.

Purpose

The aim of the present study was to investigate the magnitude of the contaminating effect of the BCG during fMRI recording on specifically the earlier ERP component and to provide information on the reliability of MRI-EEG technique.

Materials and Methods

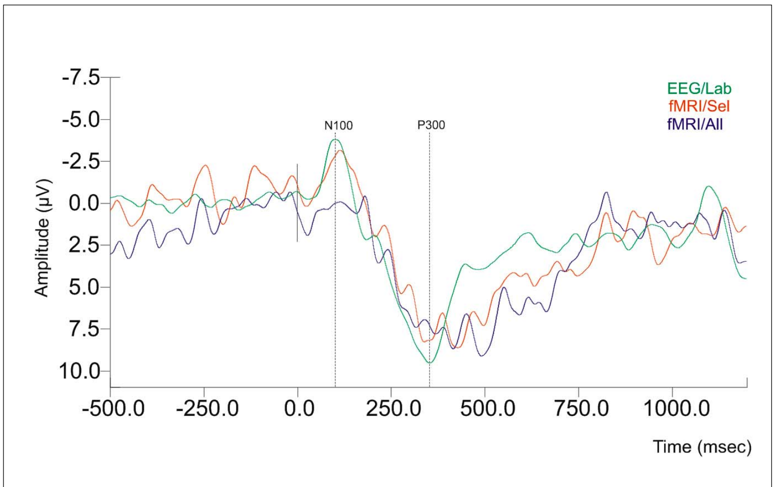
The study was conducted on 8 healthy subjects (age 25.3 ± 3.6). In line with the active oddball paradigm, the task was to mentally count the occurrence of auditory (10 ms r/f time, 50 msec duration) target stimuli (2000 Hz; p of occurrence: 20%; n = 48) that were embedded within a series of standard stimuli (1000 Hz; p of occurrence: 80%; n = 192). Recordings (filter limits in the EEG lab: DC- 100 Hz; under the scanner: DC-2000 Hz) were obtained from 64 channel EEG (reference: linked mastoids) using an EEG recording cap (QuikCap, USA). Total recording time was 1700 msec (prestimulus: 500 msec; poststimulus: 1200 msec) and sampling interval was 1 msec. Stimulus was presented using Stim (Neuroscan, Compumedics, USA) and Silent Scan audio system (SS-3100, Avotec, USA).

Data acquisition in the EEG lab was achieved using SynAmps 2 and Scan 4.3 software, that in the scanner was achieved using MagLink RT RC5 (Neuroscan, Compumedics, USA). Structural and functional MRI recordings were obtained using a 1.5 T scanner (Signa Excite, General Electric, USA) and a high resolution 8 channel array coil (InVivo, Intermagnetics, USA). EEG recordings were taken in a Faraday cage under standard EEG laboratory conditions (EEG/lab). Simultaneous EEG and fMRI recordings were taken inside the scanner. The order of the two conditions was counterbalanced. A standard software (Neuroscan Edit module) was used for fMRI artifact reduction. The effect of the BCG was removed using ECG noise reduction algorithm. Eye movements were corrected using singular value decomposition. In the fMRI/all condition, all of the ERP waveforms were analyzed. In the fMRI/selective (fMRI/sel) condition, an offline selection procedure was applied to obtain the ERP epochs between the EPI pulses.

Results

The figure displays the line graphs of the target-evoked ERPs that were obtained from the Cz recording site in the standard EEG laboratory (green) and during fMRI recording. Data for fMRI/sel is shown in red and those for fMRI/all are shown in blue. In this graph, the N100 for EEG/lab and fMRI/sel were comparable. However, no component seemed to exist in the latency range of N100 under the fMRI/all condition.

Contrary to this observation, repeated measures - one-way analysis of variance did not reveal a significant effect of the recording condition (EEG/lab, fMRI/sel, fMRI/all) on neither P300 nor on N100. The nonsignificant effect was obtained for all the studied recording sites. The Cz recordings show that, for EEG/lab, fMRI/sel and fMRI/all conditions, standard error of the latency values of N100 were 4.47, 9.55, 10.62 respectively; and those of P300 were 13.32, 20.97, 44.84, respectively.



Discussion

The present study eliminated the BCG through the utilization of relevant software and through a specific experimental design whereby only those ERPs that occurred between MR pulses were selected for further analysis. The present study showed that the early and late peaks were comparably obtained under all of the recording conditions. The attenuation in N100 that Mullert et al (2004) found was a result of inter-individual jitter in peak latencies. When averaged, jitter would cause attenuation in the latency of the peak and this would be most prominent in peaks (eg. N100) with low amplitudes.

These findings show that, provided that the effect of latency jitter is properly taken into account, ERPs can be recorded under magnetic fields and that the hybrid MRI-EEG technique can be used for a valid description of the temporospatial characteristics of ERP components.

Reference

Mulert C, Jager L, Schmitt R, et al. Integration of fMRI and simultaneous EEG: towards a comprehensive understanding of localization and time-course of brain activity in target detection. Neuroimage 2004;22:83-94.