Effect of EEG electrodes density (32 and 64 EEG channels) on the fMRI signal

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Introduction

Good scalp coverage is important to EEG/ERP analysis in order to improve source localisation and increase specificity in signal decomposition methods such as ICA (Bell & Sejnowski, 1995), which extract as many components as the number of electrodes. However, researchers have been cautious to increase the electrode density in the EEG-fMRI studies, because the presence of EEG electrodes and leads causes signal drop-out and geometric distortion in fMRI images (George et al., 2001). Therefore, the potential cost of increasing EEG electrode density in the MRI scanner needs to be assessed. The aim of the present study is to investigate the influences of the EEG electrode density on the BOLD fMRI signal by comparing the results obtained using two EEG caps: 32 and 64 electrodes systems. We employed the widely used 'fast' event-related paradigm and a well-documented cognitive task (the 'go-nogo' task).

Methods

Participants: 18 healthy, right handed (aged 20-44) participants.

Stimuli: A modified version of the 'go-nogo' paradigm was employed that required a right-hand button-press in response to the presentation of 'go' stimuli (probability 0.75) and withholding the response to 'nogo' stimuli (probability 0.25). Each condition used two letters in upper/lowercase (go: B /b, J /j; nogo: P/p, G/g).

Procedure: Before commencing each task run, the participant was fit with an elastic EEG cap (BrainCap-MR, BrainProducts) with either 32 or 64 plastic-coated Ag/AgCl electrodes. Between runs, the participant came out of the scanner, the EEG cap was removed and the participant's hair was washed and dried to remove residual EEG gel, after which the second EEG cap could be applied.

Following each treatment, participants were scanned using a 1.5 T Philips Intera system. Functional scanning was performed using a one-shot EPI sequence (TR/TE = 3000/50 ms; flip angle = 90^0; FOV = 230 mm; slice thickness = 4 mm; $64\times64\times32$ matrix).

Trials began with a fixation cross lasting for 450ms followed by a go-nogo condition (1400ms) then a blank screen (700ms). Stimuli were presented centrally in white against a black background. The selection of condition/letter/case on each trial was random with the constraint that the two letters within each condition were equiprobable, as were upper/lowercase presentations. During the scanning session, each participant completed two runs of the task, each run comprising 352 trials and lasting for 25 min: one with the 32-channel EEG electrode set-up and the other with the 64-channel electrode set-up, with their order counterbalanced across participants. To allow for a better estimation of the fMRI baseline, in addition to the task trials, each run contained 8 intervals when the screen was blank for 15 sec; these intervals were spread evenly throughout the course of the run (one in about 40 trials). The testing runs were preceded by a short practice block.

Data Analysis: Analyses were conducted using SPM2. A threshold of p <0.001 and a cluster threshold of 16 (corresponding to a corrected cluster-level significance level at p<0.05) were used for whole brain analyses. To maximise power, ROIs were created using MarsBar based on the clusters of activation identified within 32-ch or 64-ch runs in whole-brain analyses, and the average activity within clusters was compared for the two runs.

Results

There were six regions, in which whole brain testing identified greater activation for the 'nogo' relative to the 'go' condition both in the 32-electrode run and in the 64-electrode run: right dlPFC, right insula, right premotor cortex/SMA, inferior parietal lobule, ACC and inferior temporal cortex (see Fig. 1). Four regions showed reliably greater 'go' than 'nogo' activation in both runs: right cerebellum, left motor cortex, medial frontal cortex and the posterior cingulate (right in the 32-electrode run; bilateral in the 64-electrode run) (see Fig. 2). Whole-brain tests identified no clusters in which the two runs differed in the magnitude of either experimental contrast: 'nogo' > 'go' or 'go' > 'nogo' (i.e. no clusters showed a reliable run by condition interaction), even when the cluster extent threshold was relaxed to uncorrected (6 voxels).
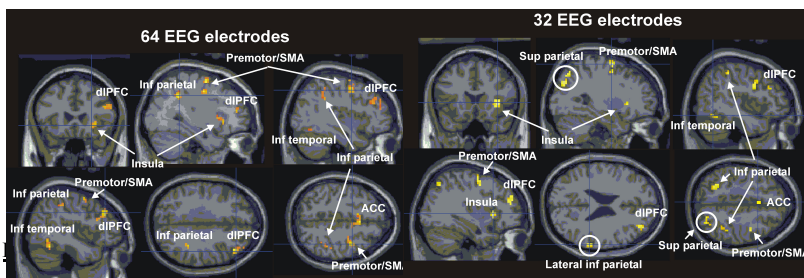

Fig 1: fMRI activations in the 'nogo' > 'go' contrast. Activations that are only reliable in one EEG electrode condition (32 or 64) are encircled.
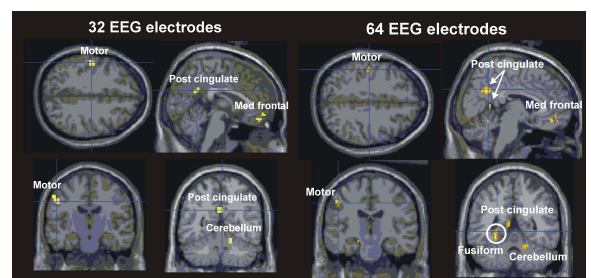

Fig 2: fMRI activations in the 'go' > 'nogo' contrast. Activations that are only reliable in one EEG electrode condition (32 or 64) are encircled.

The results show that the increase in the number of EEG electrodes is not associated with a significant cost to the detectability of task-related fMRI activations. This conclusion is based on a pattern of 'nogo' vs. 'go' differences which is highly consistent with the literature (Wager et al., 2005), as well as on the good overall correspondence between the task-related activations in the two runs, tested in conditions of optimal statistical power. These outcomes are in line with previous findings that the detrimental effects of EEG electrodes and gel on the BOLD fMRI signal are restricted to a relatively superficial depth and that the signal measured from the brain is largely unaffected.

References

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