Distances between EEG Spikes, BOLD Activation and Lesions for Different EEG Techniques

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Abstract

One of the common treatments in drug resistant Epilepsy is the surgical removal of the "offending" part of the brain and its success depends on the accurate localization of the focal region in the brain generating the seizures. The goal of EEG and MR Imaging is to help localization in pre-surgical evaluation, however the two techniques differ slightly and are not coincident with the lesion. So we quantified the distance between the EEG dipoles, the BOLD clusters and the lesions for different inverse problem approaches in order to develop analysis methods that diminish that discrepancy.

Introduction

EEG/fMRI has been used quite widely for the last years, to study Epilepsy, however the connection between EEG spikes and BOLD signal is not fully understood. Some work has already been done on the difference between the EEG and BOLD localizations[1], however there are lots of different inverse problem methods and algorithms used. In order to develop a better and more reliable method to analyze our data and try to diminish the discrepancy between the different techniques we studied the distances between the EEG dipoles calculated by three different methods, the BOLD clusters and lesion centers.

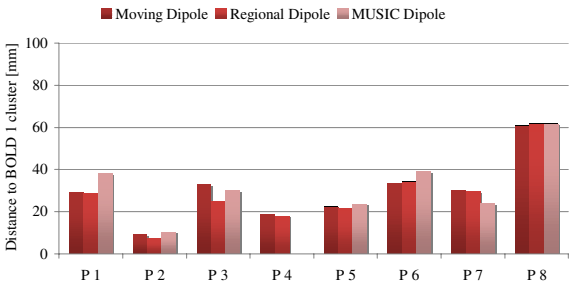
Methods

All patients were first submitted to a 60-min EEG recording outside the scanner, with a cap of 36 AgCl electrodes, using a sampling rate of 256 Hz and filters of 0.5–70 Hz. Later in the day, a session of functional MRI was performed while simultaneously recording the EEG (19 electrodes at standard 10–20 positions). The EEG/fMRI images were acquired on a 1.5T GE CVi/NVi scanner and consisted in the acquisition of blocks of 100 brain volumes each one made of 16 EPI images (in plane resolution 3.75 mm and slice thickness of 7 mm, no spacing; echo time 50 μs; flip angle of 90◦) obtained with a TR = 3 s, corresponding to periods of 5 min of continuous and simultaneous monitoring. 4 to 6 blocks were obtained per patient, providing 20 to 30 min of simultaneous monitoring. The simultaneous EEG was recorded through a set of fMRI compatible AgCl electrodes (MagLink, Neuroscan, El Paso, TX, U.S.A.). Our fMRI data was analysed with FSL, correcting for movement and slice acquisition time and smoothed with a Gaussian kernel of FWHM 8 mm, and using a local autocorrelation correction with z statistic images generated. The correction for the multiple comparison problem was done using a cluster threshold with p = 0.05. The EEG data was analysed with ASA 2.2 software(ANT, Enschede), applying three different methods: Moving Dipole, Regional Dipole and MUSIC Dipole.

Discussion

Below we show the distances in mm between the dipoles determined by the three different methods used and the centres of the closest BOLD cluster (Figure 1) and the centres of the second BOLD activation cluster (Figure 2), where it existed. In Figure 3 we show the difference in mm between the three different calculated dipoles and the two different BOLD clusters with respect to the lesion. Our data shows that by using different EEG processing methods our distances differ to some extent, with no technique giving a consistently better result. This poses a problem on the decision of what method to use and shows that we still need to better understand the mechanism of the two activations. Patient 8 showed a much greater discrepancy with the EEG than with the BOLD clusters, mainly because he had already undergone surgery. Obviously in these situations the BOLD activation is more reliable, because the EEG can be heavily affected by the change in conductivity of the scalp after surgery.

A lot more work still has to be done to develop a good methodology for combining EEG and fMRI analysis in order to obtain good and reliable co-registration maps of high resolution EEG with BOLD localizations.



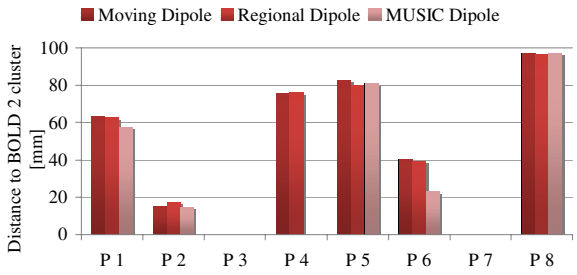


Figure 1: Distance in mm between the closest centre of the BOLD activation cluster and the dipoles determined by the EEG inverse solutions.

Figure 2: Distance in mm between the centre of the second BOLD activation cluster and the dipoles determined by the EEG inverse solutions.

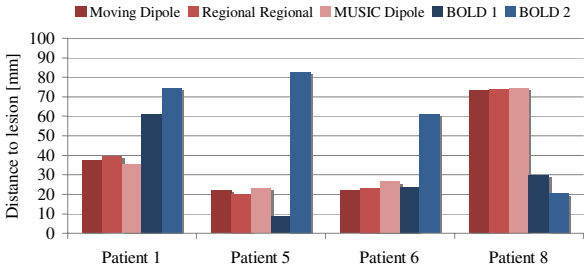


Figure 3: Distance of the epileptogenic source from the lesion for the different localization methods using EEG (red) and using BOLD (blue), in the cases where detectable.

References

1. Lemieux L, Krakow K, Fish DR. Neuroimage 2001;14:1097–104.