Observing slow EEG activity from same area as spikes in paediatric patients with focal epilepsy by using signal decomposition and dipole modelling

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Introduction

The background EEG in patients with focal epilepsy often shows abnormalities related to the disorder such as asymmetric and intermittent delta activity (<4 Hz) [1] [2]. We report our own observations in comparing events automatically detected using signal decomposition and dipole modelling with those found by an experienced electroencephalographer (EEGer) in which we have been able to demonstrate the presence of *focal* slow-wave activity arising from the same region as the epileptogenic focus.

Methods

An algorithm has been developed for the detection of activity originating from a dipolar field in multi-channel EEG recordings [3]. The EEG is divided into overlapping epochs, which are processed in two steps. The first is singular value decomposition (SVD) which gives the most dominant potential distribution with respect to energy. When the fraction of the energy in the epoch associated with this distribution is high, we can assume this has arisen from a single primary active source in the brain. In the second step, EEG dipole source analysis (assuming a single dipole and 3-layer spherical model of the head) is applied to that dominant potential distribution. This aims to find the focal neural sources represented by a dipole, which generate scalp potentials corresponding as closely as possible to the given potentials. This is accomplished by changing the dipole parameters until a minimum is found in the cost-function given by the relative residual energy (RRE). The smaller the RRE the better the dominant potentials obtained from the SVD represent a dipolar source. It was found that dipoles located on the inner-shell representing the brain-skull boundary are typically attributed to EEG artifacts [4]. The detection algorithm flags an EEG epoch when SVD indicates a dominant source, the RRE is low and the dipole is not located too close to the inner-shell. In addition the dipole parameters can provide valuable information on the location of the epileptogenic source.

The algorithm has been applied to eight EEGs of paediatric patients with focal epilepsy. The EEG duration ranged between 10 and 20 minutes and contained multiple epileptiform transients. The flagged epochs were highlighted and the EEGer was asked to mark the epileptiform events. The highlighting was done on purpose as this gave the EEGer the opportunity to carefully inspect each flagged epoch.

Results

The method flagged several epochs in the EEG coinciding with the epileptiform events marked by the EEGer. However, also flagged were focal epochs whose dipole positions were not marked by the EEGer (Figure 1). Although the wave shapes of these flagged epochs were considered definitively non-epileptiform by the EEGer, in 5 out of the 8 EEGs a large number of these flagged epochs came from the same brain region as the marked events (i.e., their associated dipole lay in the same region as the epileptiform activity) as illustrated in Figure 1. Close inspection of these 'non-epileptiform' events indicated that they were in the delta (1-4 Hz) and theta (4-8 Hz) range.

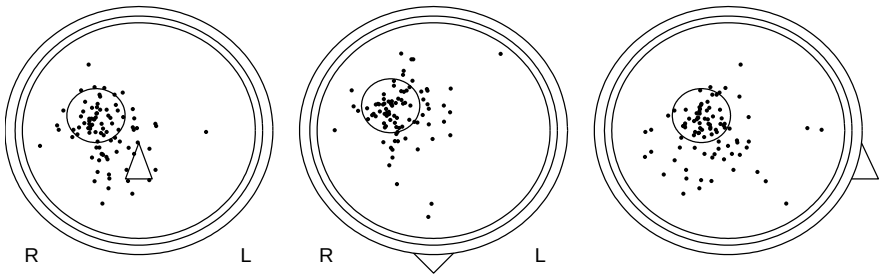

Figure 1: A frontal, top and side view of the head. The dots represent the dipole position of the flagged epoch not marked by the EEGer. The small circle denotes the spherical volume from where the epileptiform activity originates.

Conclusion

To our knowledge, this is the first study to demonstrate the presence of abnormal focal slow-wave arising in the same region as the epileptiform focus in paediatric patients with focal epilepsy.

References

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