Dipole Source Localization Of Post-Movement Beta Synchronization During Foot Movement

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Abstract: Dipole source localization of Post-Movement Beta Synchronization during foot movement resulted in a dominant dipole located underneath the vertex on the ipsilateral side. The localization was based on bandpower filtered single trial EEG data.

INTRODUCTION

Voluntary movement is accompanied by different changes in rhythmetic EEG activity within the alpha and lower beta bands. On the one side, the mu and central beta rhythms display a desynchronization prior and during voluntary movement. On the other side, after movement-offset the beta band displays a 'Post-Movement Beta Synchronization' (PMBS). This PMBS is short lasting and maximal within the first second after movement offset [1].

To study the origin of the PMBS, event-related EEG data was recorded at 32 closely spaced electrodes (2.5 cm) overlying the primary sensorimotor and premotor areas during a voluntary right and left foot movement task. The common average reference EEG data was bandpower filtered within the beta band (22-28 Hz) and triggered on movement-offset.

METHOD

Equivalent current dipoles can be used to reveal spatial and temporal source information. With non-linear optimization algorithms, like the Levenberg-Marquardt algorithm, it is possible to fit the dipoles to the measured scalp potential in least-squares sense. One difficulty with this method is that the number of dipoles responsible for the EEG must be set in advance. In our study different number of dipoles were used as an input for the optimization.

The volume conductor was modeled by three concentric spheres representating the brain, skull and scalp region. A Polhemus 3D digitizer was used to measure the electrodes sites. Radii and origin of the multi-sphere model were fitted to the measured electrode positions. Conductivity values of 0.33, 0.0042 and 0.33 S/m were assigned to, respectivily, the brain, skull and scalp compartment. All calculations were performed in the nasion-ear co-ordinate system.

Artefact-free single trial EEG data was used as an input for the non-linear dipole fit. Only rotating dipole solutions were allowed. A rotating dipole is a dipole which has a fixed position in time while the orientation and strength are allowed to vary in time. Averaged EEG data (ERP's) could not be used as input for the dipole fit since averaging over trials would cancel the not phase-locked beta components in the data. The dipole fit resulted in an ensemble of dipole solutions. Afterwards the positions and orientations of the single trial dipole solutions were averaged. Dipole solutions which deviated to much from the ensemble were not used for the calculation of the average.

RESULTS

From the potential distribution maps it could be seen that the PMBS was focussed to the central electrode C_z. A dipole solution close to this electrode was expected. In case one dipole was used for the optimization the position of the dipole was found on the ipsilateral side but too deep underneath the vertex. This might be due to the contribution of other active regions. The single dipole is fitted to the potential until it describes the activity from all contributing sources. In case these other sources are located superficial at some distance away from the vertex, the single dipole will be fitted deeper. Using two dipoles yielded unstable results, i.e. the solution of the optimization depended very much on the startpositions chosen for the dipoles. The best solution was obtained when three rotating dipoles were used as source model. The most dominant source was located underneath the vertex on the ipsilateral side. The other sources were positioned anterior and deeper in relation to the dominant source.

CONCLUSION

Spatiotemporal dipole modelling of EEG phenomena may give more insight in the neurophysiological generators responsible for the EEG recorded at the scalp. PMBS is still a new phenomena and the origin of this beta activity is unknown. Dipole localization is one way to isolate the active regions contributing to PMBS. Further investigation is needed.

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