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FC1_4. Clustering of Interictal Events for Improved Source Imaging and fMRI Regressor Design in High-Density EEG–fMRI Investigations

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During presurgical planning in focal epilepsy, high-density EEG–fMRI of interictal activity can be used to locate epileptic foci in a multimodal context. The interevent variability in morphology and amplitude poses a problem for comprehensive identification of events and subsequent group analysis. Our objective is to develop a semiautomated method of identifying and clustering interictal events for improved electric source imaging (ESI) and fMRI regressor design.

A 128-channel EEG was recorded of a patient with left temporal lobe epilepsy in an electrically shielded room and during fMRI (1.5 T). The MR-gradient and cardiac pulse–related artifacts were removed. A representative interictal epileptic discharge (IED) from the shielded room recording was selected as the template and template matching using a set of indicative channels was performed to identify IEDs. The correlation and amplitude thresholds were relaxed to increase sensitivity. Intertrial correlations were calculated and used to cluster the IEDs based on mean within-cluster correlation, which provided specificity. Clusters were averaged and a cortically constrained current density reconstruction (CDR, sLORETA) was performed using a boundary element model at the time period around the first peak and from that an equivalent dipole was derived. ESI-based cluster selections were used to define the regressor for the fMRI analysis (FSL FEAT, Gaussian smoothing FWHM 6 mm, double gamma HRF with +1 s, +3 s, +5 s, +7 s delays).

In the shielded room recording 456 events were detected over 35 minutes and in the scanner recording 233 in 25 minutes. Concordant event clusters could be identified as well as a separate group of spikes that occur within the sharp wave of a preceding spike. Weakly correlated events, for example, artifact corrupted or overlaid with other activity, could be separated and rejected. The left temporal blood oxygenation level–dependent (BOLD) activation was concordant with ESI. Selecting ESI-positive concordant event clusters for fMRI regression notably reduced spurious activation regions and isolated an otherwise unclear second contralateral precentral activation spatially concordant with the equivalent source of the postspike wave complex.

Semiautomatic event discovery and clustering can increase the sensitivity and specificity of IED analysis. ESI-based design of the fMRI regressor can notably improve BOLD contrast. Noninvasive ESI/fMRI of epileptic events shows promise in improving presurgical evaluation of epilepsy.