Understanding the Abnormal Brain Activity in Epilepsy as a Potential Predictor of the Onset of an Epileptic Seizure

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Equation Free Summary

The Brain Research Institute (BRI) uses various types of indirect measurements, including EEG and fMRI, to understand and assess brain activity and function. As well as the recovery of generic information about brain function, research also focuses on the utilization of such data and understanding to study the initiation, dynamics, spread and suppression of epileptic seizures. In order to assist with the future focussing of this aspect of their research, the BRI asked the MISG 2010 participants to examine how the available EEG and fMRI data and current knowledge about epilepsy should be analysed and interpreted to yield an enhanced understanding about brain activity occurring before, at commencement of, during and after a seizure. Though the deliberations of the study group were wide ranging in terms of the related matters considered and discussed, considerable progress was made with the following three aspects:

(i) The science behind brain activity investigations depends crucially on the quality of the analysis and interpretation of, as well as the recovery of information from, EEG and fMRI measurements. A number of specific methodologies were discussed and formalized, including
independent component analysis (ICA), principal component analysis (PCA), profile monitoring and change point analysis (hidden Markov modelling, time series analysis, discontinuity identification).

(ii) Even though EEG measurements accurately and very sensitively record the onset of an epileptic event or seizure, they are, from the perspective of understanding the internal initiation and localization, of limited utility. They only record neuronal activity in the cortical (surface layer) neurons of the brain, which is a direct reflection of the type of electrical activity they have been designed to record. Because fMRI records, through the monitoring of blood flow activity, the location of localized brain activity within the brain, the possibility of combining fMRI measurements with EEG, as a joint inversion activity, was discussed and examined in detail.

(iii) For the BRI, a major goal is to improve their understanding about “when” an epileptic seizure actually commences (relative to the EEG recording that it has commenced), “where” the source of this initiation is located in the brain, and “what” is the initiator. Because of the general agreement in the literature that, in one way or another, epileptic events and seizures represent abnormal synchronizations of localized and/or global brain activity, respectively, the modelling of synchronizations was examined in some detail.