

Poster presentation

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Bicoherence and synchrony characteristics of sleep, wakeful and seizure electroencephalograms

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Background

Electroencephalogram (EEG) morphology may not reveal the degree of phase coupling and thus information coding. Here we analyze instantaneous phase synchrony and the bicoherence index to quantify quadratic phase coupling of awake, sleep and seizure EEG.

Method

Ten minutes, 16 channel, bipolar EEG of generalized seizure ($n = 13$), normal eyes open ($n = 10$) eyes closed ($n = 10$), and sleep stages 2,3,4 and Rapid eye movement sleep (REM) ($n = 10$) were studied. Time-lagged instantaneous phases were determined using Hilbert transform across one-dimensional channel data. Synchronization index (SI) was defined using Shannon entropy measures [1]. Auto-bicoherence index (BI) was calculated using higher order spectral estimate [2].

Results

SI of normal eyes open, eye closed and seizure EEG was 0.122 ± 0.006 , 0.164 ± 0.034 and 0.352 ± 0.091 respectively. SI of Stage 2,3,4 and REM sleep was 0.114 ± 0.009 , 0.0143 ± 0.018 , 0.156 ± 0.014 and 0.105 ± 0.013 respectively. SI between the groups varied significantly ($p < 0.001$). BI of eyes open EEG was 0.031 ± 0.005 , which was comparable with the BI of seizures EEG (0.049 ± 0.046). BI between sleep stages did not vary significantly ($p = 0.212$). Seizure BI was significantly higher when compared with eyes closed BI ($p = 0.022$) and clubbed sleep BI ($p = 0.003$). There was no correlation between SI and BI ($r = 0.399$, $p = 0.081$).

Discussion

Degree of synchrony was found to be: seizure > normal eyes closed > Stage 4 > Stage 3 > eyes open > Stage 2 > REM. We found higher bicoherence in seizures and eyes open states suggesting increased quadratic phase coupling of neural networks. This was not seen in eyes closed states where phase decoupling occurs akin to what was seen in stage II/III sleep [3]. The synchrony of neural discharge (signal morphology) and the non-Gaussian component (frequency coupling) are probably heterogeneous.

References

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