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Estimation of Endogenous Brain Noise from Brain Response to Flickering Visual Stimulation Magnetoencephalography Visual Perception Speed

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Abstract : Intrinsic brain noise was estimated via magneto-encephalograms (MEG) recorded during perception of flickering visual stimuli with frequencies of 6.67 and 8.57 Hz. First, we measured the mean phase difference between the flicker signal and steady-state event-related field (SSERF) in the occipital area where the brain response at the flicker frequencies and their harmonics appeared in the power spectrum. Then, we calculated the probability distribution of the phase fluctuations in the regions of frequency locking and computed its kurtosis. Since kurtosis is a measure of the distribution's sharpness, we suppose that inverse kurtosis is related to intrinsic brain noise. In our experiments, the kurtosis value varied among subjects from $K = 3$ to $K = 5$ for 6.67 Hz and from 2.6 to 4 for 8.57 Hz. The majority of subjects demonstrated leptokurtic kurtosis ($K < 3$), i.e., the distribution tails approached zero more slowly than Gaussian. In addition, we found a strong correlation between kurtosis and brain complexity measured as the correlation dimension, so that the MEGs of subjects with higher kurtosis exhibited lower complexity. The obtained results are discussed in the framework of nonlinear dynamics and complex network theories. Specifically, in a network of coupled oscillators, phase synchronization is mainly determined by two antagonistic factors, noise, and the coupling strength. While noise worsens phase synchronization, the coupling improves it. If we assume that each neuron and each synapse contribute to brain noise, the larger neuronal network should have stronger noise, and therefore phase synchronization should be worse, that results in smaller kurtosis. The described method for brain noise estimation can be useful for diagnostics of some brain pathologies associated with abnormal brain noise.

Keywords : brain, flickering, magnetoencephalography, MEG, visual perception, perception time
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