Empirical Mode Decomposition Products Complexity in EEG Studies: Influence of Functional State

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In studies on EEG complexity, held during last two decades, it was considered that EEG contains deterministic chaos and its corresponding parameters were calculated - correlation dimension of the reconstructed attractor, Lyapunov exponents, etc. Some researchers obtained spurious results in calculations and this led to disappointment and reports that EEG is not chaotic signal at all and these methods are not valid.

Recently there were some studies, in which the Empirical Mode Decomposition method (EMD) was applied to EEG by splitting latter into components known as Intrinsic Mode Functions (IMF). We have applied EMD to EEG as well and found that IMF#1, as a rule, contains noisy chaos, IMF#2 contains strictly pronounced deterministic chaos, modes from #3 to #5 may be chaotic or quasyperiodic ones (in different cases), and all the rest modes as well as the residual could be considered as quasiperiodic oscillations.

We studied differences in the nonlinear parameters correlation dimension (D_2) of the IMFs, extracted from EEG which was recorded in two different functional states - relaxed arousal with open or closed eyes. EEG registration (26 subjects) was performed using international 10-20 system, at 500 Hz sampling rate and 70 Hz low frequency filter.

In the most of channels, D_2 in "closed eyes" state was significantly less, then in "open eyes" state, just like in studies of many other authors. However for IMF#1 and IMF#2, which contain chaos, the difference in D_2 was not statistically significant. Statistical analysis showed significant difference only in IMF#3 and especially residual which is left after extracting of first three IMFs from the whole EEG.

The obtained results mean that difference in the EEG complexity in the functional states, we have studied, are mostly due to quasiperiodic components of EEG rather than chaotic ones.

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