Some Regularities of the Human EEG Spectral Patterns Dynamics During Cognitive Activity

Ph.D. Dissertation

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Brain oscillatory systems have been proposed to act as possible communication networks with functional relations to integrative functions. It is assumed that brain oscillations are of fundamental importance for mediating and distributing "higher-level" processes in the human brain. Also it was shown, that oscillations which are synchronous across distributed cortical regions, may represent a crucial mechanism by which the brain binds together or integrates spatially distributed activity.

However, conventional methods assess the mean characteristics of the EEG (or MEG) power spectra averaged out over extended periods of time and/or broad frequency bands in order to obtain statistically reliable characteristics. In that case, averaging procedures resulting in "static" picture might not only mask the signal dynamic aspects, but also give rise to ambiguous data interpretation.

It is well known that EEG (and MEG) signal is extremely nonstationary. In the frame of EEG nonstationarity it was shown that brain activity might be characterized by a finite number of discrete stable states, which may be described by individual short-term **spectral patterns**. It has been shown that the EEG signal consists of a limited number of typical segments, which are stationary and usually do not exceed 1-2 sec. These results suggest that the quasi-stationary segments (spectral patterns) reflect the particular operational acts of nervous activity which continue to occur *even without* external stimulation. From this viewpoint, it is justified to perform the single short-term spectral estimations of the individual EEG (and MEG) segments for their subsequent **adaptive classification**.

The parameters of the relative presence of the individual EEG segments of each spectral type and the peculiarities of its alternation in the analyzed EEG fragment permit studying of the EEG "grammar" – its *frame structure* specific for particular functional state or activity. In that case, after classification of individual EEG segments the whole EEG fragment would be characterized by so called classification profile or "portrait" of brain activity – the histogram of the relative presence of each spectral pattern's type.

In the dissertation project the short-term structure of EEG spectral transformations during different brain functional states (closed/opened eyes and memory task) was studied. It was shown that about 50% of spectral pattern types occur not more than 2-3 times per 149 analysis epochs in a one-minute EEG. The spectral pattern identified in a given epoch has only a limited predictive value on the spectral patterns identified in the subsequent epochs. The findings of this study suggest that the multi-variability of neuronal nets is discrete in time, and limited by the dynamics of the short quasi-stable brain states.