Time-Spatial Organization of the Human EEG Segmental Structure

Ph.D. Dissertation

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Scalp EEG (and MEG) is believed to provide a crude measure of the very large-scale fields of synaptic action and is remarkably correlated with behavior and cognition. Cognitive functions like perception, memory, language, or consciousness are based on the extraordinary integrity of the brain that organized into parallel processing streams with complementary properties thereby providing conditions to generate a multisensory scene, to form a Gestalt.

It is well known that EEG (and MEG) signal is extremely nonstationary. It was assumed that the EEG signal is "glued" from several *segments* of random stationary processes with different probabilistic characteristics. In this case, it is possible to consider *one segment* as the *single event* in EEG-phenomenology – discrete **operation**. Within the duration of one segment, the system that generates the oscillations is in the steady stationary state. The transition from one segment to another reflects the changes of the generator system state or changes in the activity of the two or more systems. In the frame of EEG nonstationarity it was shown that brain activity might be characterized by a finite number of discrete stable states.

The understanding of the nonstationary structure of EEG signal is of intrinsic scientific importance because without understanding the character of the processes under consideration, the use of many methods gives often false results. For example, invariants, such as the mean spectrum, average ERP and ERD/ERS, coherency, fractal dimensions, Lyapunov exponents and others have a sense only for stationary dynamics. Further, the nonstationarity of the EEG process usually does not allow constructing a global dynamical model for the whole observable. In this connection it should be noted that there is little sense in using the methods indicated above for purposes of understanding the character of the processes studied and their identification.

Thus, regardless of how powerful or statistically significant the different estimations of averaged event-related EEG phenomena may be, there might be difficulties in the meaningful interpretation of these if they are not matched to their piecewise stationary structure.

In the dissertation project a new promising area of the study of EEG dynamics during cognitive processing which based on the reduction of the signal to the individual segments sequences or elemental *operations* is proposed. It has been suggested that the operational elements of behavioral and mental activity are originated in the periods of short-term stable states of the whole brain and its individual subsystems. This stability originated from the short-term picture of spatial mutual stability of EEG segments (operations) along the brain cortex **(operational synchrony)**.