

# Structure-Function Relationship in Complex Brain Networks Expressed by Hierarchical Synchronization

Changsong Zhou<sup>1</sup>, Lucia Zemanová<sup>1</sup>, Gorka Zamora<sup>1</sup>, Claus C. Hilgetag<sup>2</sup>, Jürgen Kurths<sup>1</sup>

<sup>1</sup>Institute of Physics, University of Potsdam, PF 601553, 14415 Potsdam, Germany

[cszhou@agnld.uni-potsdam.de](mailto:cszhou@agnld.uni-potsdam.de)

<sup>2</sup>International University Bremen, Campus Ring 6, RII-116, D-28759 Bremen, Germany

February 28, 2007

The brain is one of the most complex systems in nature, with a structured complex connectivity. Recently, large-scale corticocortical connectivities, both structural and functional, have received a great deal of research attention, especially using the approach of complex network analysis. Understanding the relationship between structural and functional connectivity is of crucial importance in neuroscience. Here we try to illuminate this relationship by studying synchronization dynamics in a realistic anatomical network of cat cortical connectivity. We model the nodes (cortical areas) by a neural mass model (population model) or by a subnetwork of interacting excitable neurons (multilevel model). We show that if the dynamics is characterized by well-defined oscillations (neural mass model and subnetworks with strong couplings), the synchronization patterns are mainly determined by the node intensity (total input strengths of a node) and the detailed network topology is rather irrelevant. On the other hand, the multilevel model with weak couplings displays more irregular, biologically plausible dynamics, and the synchronization patterns reveal a hierarchical cluster organization in the network structure. The relationship between structural connectivity and functional connectivity at different levels of synchronization is explored. Thus, the study of synchronization in a multilevel complex network model of cortex can provide insights into the relationship between network topology and functional organization of complex brain networks.

## References:

Changsong Zhou, Lucia Zemanová, Gorka Zamora, Claus C. Hilgetag and Jürgen Kurths, “Hierarchical organization unveiled by functional connectivity in complex brain networks”, *Phys. Rev. Lett.* **97**, 238103 (2006).

Lucia Zemanová, Changsong Zhou and Jürgen Kurths, “Structural and functional clusters of complex brain networks”, *Physica D* **224**, 202 (2006).