Connectivity Profiles: How information flow, across and within hemispheres, differs in various brain states

Abstract

In general, the brain can be considered as a complex system. Such perspective lends itself to study of consciousness in terms of the levels of integration and differentiation within the brain. However, it is unclear what mechanisms give rise to such profound changes in neural activity. Here, we ask a simple question, namely how information flows across and within hemispheres and could such changes be altered by the homotopic connectivity of the brain? Functional connectomes derived from functional magnetic resonance imaging are an intuitive summary of various brain states. We build an Ising spinglass computational model as a parsimonious and compressed version of the data by deriving synthetic structural connectome (J) given the functional connectomes of participants during resting-state fMRI (58 participants). We further test the brain susceptibility to the edge perturbations. Finally, we derived the connectivity exceptions to the Markov-Kennedy rule for the (J). We show that the structural connectivity of (J) is highly correlated to the empirical structural connectivity (Pearson's R ~ 0.7) with the main differences in the homotopic connectivity which are magnified in the synthetic connectome. Then, we derive the connectivity exceptions to the euclidean distance Markov-Kennedy rule, shown to be fundamental to the optimal functioning of the brain, showing the largest overlap with homotopic connectivity (84% overlap). Lastly, we show that the homotopic connectivity perturbations have the biggest impact on the brain's susceptibility. Homotopic connectivity profile seems to be important for optimal brain functioning. It is also pronounced in the parsimonious model description of its underlying structural connectivity and shows alterations to the brain's susceptibility. These connections, in turn, are exceptions to the Markov-Kennedy rule known for the importance in brain's information processing and might be an important factor in altering brains organisation and hierarchy in altered states of consciousness.