

Understanding the Role of Brain Signal Complexity in Schizophrenia: a Resting-state Fmri Investigation

Yi-Ju Lee^{1*}, Su-Yun Huang², Shih-Jen Tsai^{3,4}, Albert C. Yang^{1,4,5}

¹Taiwan International Graduate Program in Interdisciplinary Neuroscience, National Yang-Ming University and Academia Sinica, Taipei City, Taiwan

²Institute of Statistical Science, Academia Sinica, Taipei City, Taiwan

³Department of Psychiatry, Taipei Veterans General Hospital, Taipei City, Taiwan

⁴Institute of Brain Sciences, National Yang-Ming University, Taipei City, Taiwan

⁵Division of Interdisciplinary Medicine and Biotechnology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Power law scaling is a well-defined physical concept in complexity science that has been used to evaluate the state of a dynamic system. Quantifying the complex brain signals across temporal scales, power law scaling represents the frequency domain of nonlinear characteristics. In this research, we firstly aim to investigate the power law scaling of resting-state fMRI signal in schizophrenic and healthy brain activities, and second, to examine the potential structural properties that may correlate to the altered brain complexity. Functional and structural brain imaging data of 200 schizophrenia patients (age mean = 43.56 ± 12.64 ; male = 49.5%) and 200 age and sex-matched, healthy Han Chinese (age mean = 43.56 ± 13.41 ; male = 49.5%) were retrieved from Taiwan Aging and Mental Illness (TAMI) cohort. Power law scaling was extracted by Pwelch function and grey matter and white matter volumes were calculated from T1 image. The clinical symptoms were scored with PANSS, and the dosage of antipsychotic medicine was controlled. Six brain regions were found showing the significant difference in power law scaling between schizophrenic and healthy participants. The identified brain regions were correlated with the regional structural network (hub at right superior frontal gyrus) and white matter volumes at right superior cerebellar peduncle and splenium of corpus callosum in schizophrenia. Besides, the power law scaling in identified regions were correlated with clinical symptom severity. The findings show that neuronal functional complexity is affected by brain morphometries, supporting the hypothesis of losing complexity in mental illness and the disconnectivity hypothesis in schizophrenia.

Keywords: power law scaling, complexity, 1/f signal, schizophrenia, resting-state fMRI

Email: jean890203@gmail.com