Why does neural activity in ASD have low complexity: from a perspective of a small-world network model

Koki Ichinose[1], Jihoon Park[1], Yuji Kawai[1], Junichi Suzuki[1], Hiroki Mori[2], Minoru Asada[1]
[1] Department of Adaptive Machine Systems, Osaka University, Osaka, Japan
[2] Department of Computer Science, University of Cergy-Pontoise, Cergy-Pontoise, France
E-mail: koki.ichinose@ams.eng.osaka-u.ac.jp

Autistic spectrum disorder (ASD) is a neurobiological developmental disorder, and many studies have shown abnormality of connectivity structures or neural activites in the brain of ASD. The most typical example of the abnormality is local over-connectivity characterized by increased short range connectivity [1]. Furthermore, it was reported that neural activity in ASD measured by electroencephalography (EEG) have low complexity (multiscale entropy: MSE) [2] and enhanced high frequency oscillation [3]. However, mechanism of the abnormal connectivity and neural activity is not well understood. We aim to comprehend the relation between connectivity and neural activity in the brain of ASD from a perspective of a small-world network model. Our network model consisted of 100 neuron groups, and each neuron group has 1000 spiking neurons. The connectivity of the neuron groups was determined according to the Watts and Strogatz method. The degree of local over-connectivity was modified by the rewiring probability. In our model, the regular and small-world networks denote ASD and typical brains, respectively. We analyzed the complexity and frequency spectrum of the neural activities. Figure 1 shows the relation between graph-theoretical properties (clustering coefficient and degree centrality) and complexity. The regular network has local over-connectivity (high clustering coefficient and high degree centrality) corresponding to the connectivity of ASD. These local over-connected neuron groups of the regular network exhibited higher frequency oscillation and lower complexity than those of other networks.

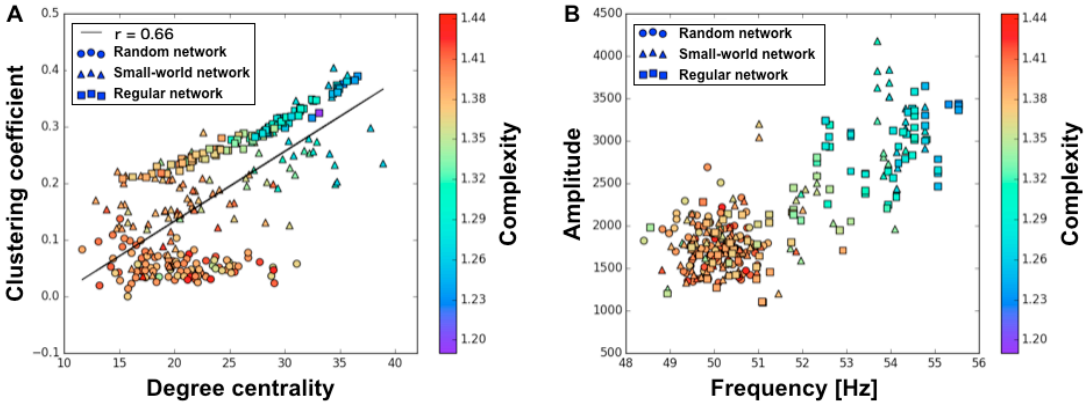

Figure 1. Each dot corresponds to each neuron group in the network and its color indicates the complexity (MSE) of the activity in the neuron group. Panel A shows the graph-theoretical properties of neuron groups. Clustering coefficient indicates how many closed triangle connections each neuron group has. Degree centrality is the sum of the connection strengths into each neuron group. Panel B shows the frequency components of the activities in the neuron groups. The x-axis indicates the peak frequency of neural activity and the y-axis indicates the amplitude of the peak frequency.

Conclusion

Our results show that ASD brain model which has local over-connectivity (high clustering coefficient and high degree centrality) enhances high frequency oscillation and decreases complexity in neural activity. This implies that local over-connectivity induces the abnormality of neural activity in ASD.

References

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