An excitation / inhibition ratio impacts on organization of neural connectivity and information transfer

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Unusual behaviors in autism spectrum disorder have been supposed due to the elevation of an excitation / inhibition (E/I) ratio of neurons [1]. It has been hypothesized that this E/I imbalance causes atypical neural connectivity in autistic brains [2]. However, how the E/I balance affects neural connectivity remains unclear. The purpose of this study is to understand relationship among the E/I ratio, the connectivity, and information transfer based on the Izhikevich's spiking neural network model [3]. Our model consists of two neuron groups, each of which has 1000 excitatory or inhibitory neurons. An excitatory neuron has 100 connections to others in the same group and three connections to neurons in the other group. An inhibitory neuron is connected to 100 excitatory neurons in the same group. Inter and intra connections are updated according to the spike-timing-dependent plasticity rule [4]. We conducted experiments with different E/I ratios, and evaluated inter connectivity and transfer entropy. Fig.1 shows the averaged weights of interconnections and the transfer entropy. Here, we defined group1 as a neuron group with a higher value of weights to the other group than the other, for each trial. We tested the model with each E/I ratio 10 times. Our results show that when the E/I ratio was close to 8.2:1.8, asymmetric connections were organized between groups (Fig.1 A and B). We also found that the transfer entropy from group1 to 2 was higher than the opposite transfer entropy (Fig.1 C and D) which was among zero (Fig.1 D).

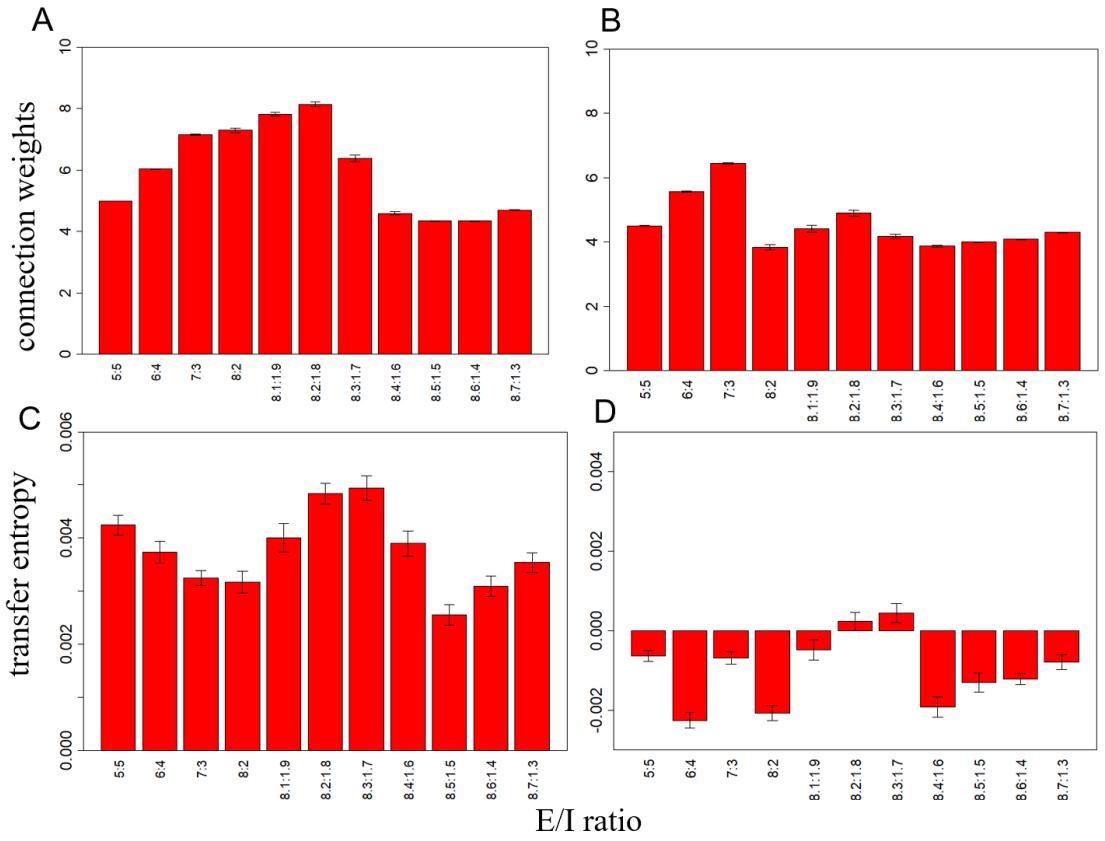

Figure 1. Panel A and B show connection weight from group1 to 2 and from group2 to 1, respectively. Panel C and D show the transfer entropy from group1 to 2 and from group2 to 1, respectively.

Conclusion

Our simulation demonstrated that the typical E/I ratio (around 8:2) caused asymmetric intergroup connections and the higher transfer entropy. We suppose that this bias for the asymmetric connectivity and directionality of information transfer might be a basis of functional organization of a brain. This may imply atypical connectivity in autistic brains might originate from the E/I imbalance, which leads to atypical information processing.

References

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