# Small-world networks enhance the inter-brain synchronization

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Many hyperscanning studies have shown that activities of the two brains often synchronize during social interaction (e.g, [1]). This synchronization occurs in various frequency bands and brain regions [1]. Further, Dumas et al. [2] constructed a two-brain model in which Kuramoto oscillators, as brain regions, are connected according to an anatomically realistic human connectome. They showed that the model with the realistic brain structure exhibits stronger inter-brain synchronization than the network with a randomly shuffled structure. However, it remains unclear what properties in the brain anatomical structure contribute to the inter-brain synchronization. Furthermore, since Kuramoto oscillators tend to converge to a specific frequency, the model cannot explain the synchronous activities in different frequency bands which were observed in the hyperscanning studies. In the current study, we propose a two-brain model based on small-world networks proposed by Watts and Strogatz method (WS method) [3] to systematically investigate the relationship between the small-world structure and the degree of inter-brain synchronization. WS method can control the clustering coefficient and shortest path length without changing the number of connections by rewiring probability p (p=0.0: regular network, p=0.1: small-world network, and p=1.0: random network). We hypothesize that the small-world network, which has high clustering coefficient and low shortest path length, is responsible for the inter-brain synchronization owing to its efficient information transmission. The model consists of two networks, each of which network consists of 100 neuron groups composed by 1000 spiking neurons (800 excitatory and 200 inhibitory neurons). The neuron groups in a network are connected according to WS method. Some groups in the two networks are directly connected as inter-brain connectivity, which is in the same manner as the previous model [2]. We evaluated the inter-brain synchronization between neuron groups using Phase Locking Value (PLV). Fig.1 shows PLVs in each combination of networks with different rewiring probabilities in the gamma band (31-48Hz). The mean PLV of the combination of small-world networks was higher than those of the other combinations.

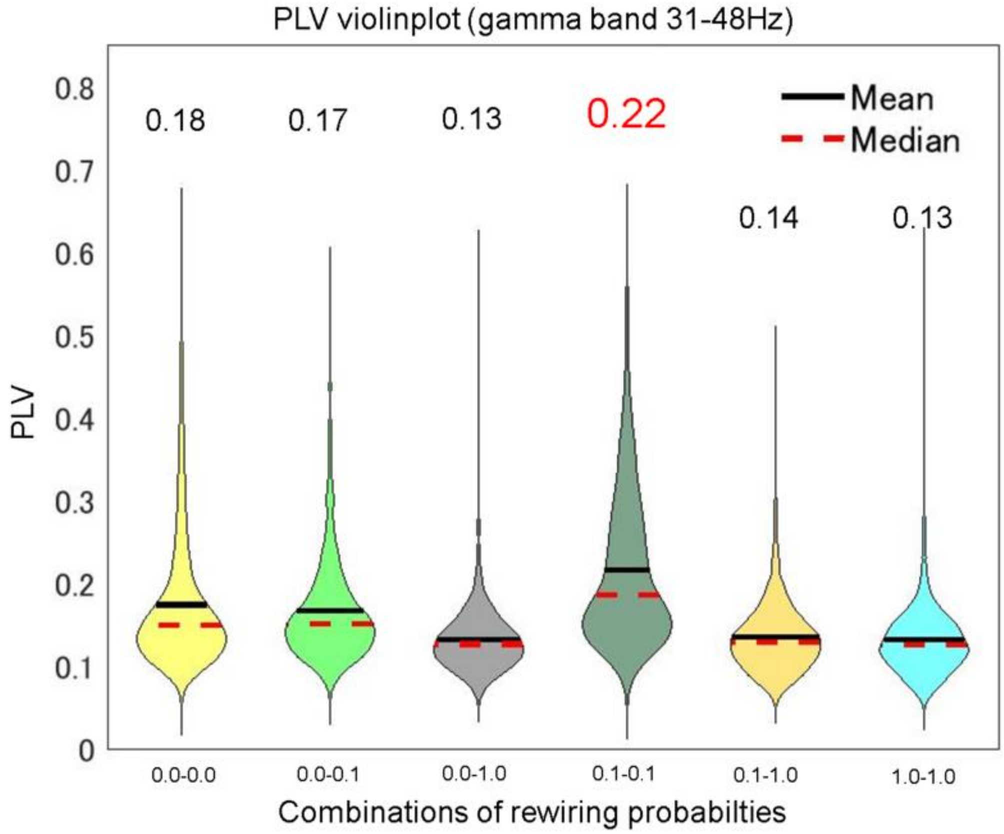


**Fig. 1.** PLVs between the networks in gamma band (31-48Hz), where a higher value indicates stronger synchronization. X-axis indicates the combinations of values of rewiring probability p (p=0.0: regular network, p=0.1: small-world network, and p=1.0: random network). Black lines and red broken lines indicate the mean and the median of the PLVs, respectively.

**Disucussion**

The result implies that the small-world structure in the brains may be a key factor of the inter-brain synchronization. As a future direction, we plan to impose an interaction task on the current model instead of the direct connections to aim to understand the relationship between the social interaction and structure properties of the brains.

**References**


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**Acknowledgments**

This work was supported by JST CREST Grant Number JPMJCR17A4, and a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).