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Conference Booklet

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Effect of Inhibitory Spike-Timing-Dependent Plasticity on Fast Sparsely Synchronized Brain Rhythms

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We consider the Watts-Strogatz small-world network (SWN) consisting of inhibitory fast spiking Izhikevich interneurons. This inhibitory neuronal population has adaptive dynamic synaptic strengths governed by the inhibitory spike-timing-dependent plasticity (iSTDP) [1-3]. In previous works without iSTDP, fast sparsely synchronized rhythms, associated with diverse cognitive functions, were found to appear in a range of large noise intensities for fixed strong synaptic inhibition strengths. Here, we investigate the effect of iSTDP on fast sparse synchronization (FSS) by varying the noise intensity D. We employ an asymmetric anti-Hebbian time window for the iSTDP update rule [1-3] (which is in contrast to the Hebbian time window for the excitatory STDP (eSTDP) [4, 5]) [see Fig. 1(a)]. Depending on values of D, population-averaged values of saturated synaptic inhibition strengths are potentiated [long-term potentiation (LTP)] or depressed [long-term depression (LTD)] [see Fig. 1(b)] in comparison with the initial mean value, and dispersions from the mean values of LTP/LTD are much increased when compared with the initial dispersion, independently of D. In most cases of LTD where the effect of mean LTD is dominant in comparison with the effect of dispersion, good synchronization (with higher spiking measure) is found to get better via LTD [compare Figs. 1(c1)-1(c3) and 1(d1)-1(d3)], while bad synchronization (with lower spiking measure) is found to get worse via LTP [compare Figs. 1(c4) and 1(d4)]. This kind of Matthew effect in inhibitory synaptic plasticity is in contrast to that in excitatory synaptic plasticity where good (bad) synchronization gets better (worse) via LTP (LTD). Emergences of LTD and LTP of synaptic inhibition strengths are intensively investigated via a microscopic method based on the distributions of time delays between the pre- and the post-synaptic spike times. Furthermore, we also investigate the effects of network architecture on FSS by changing the rewiring probability p of the SWN in the presence of iSTDP.

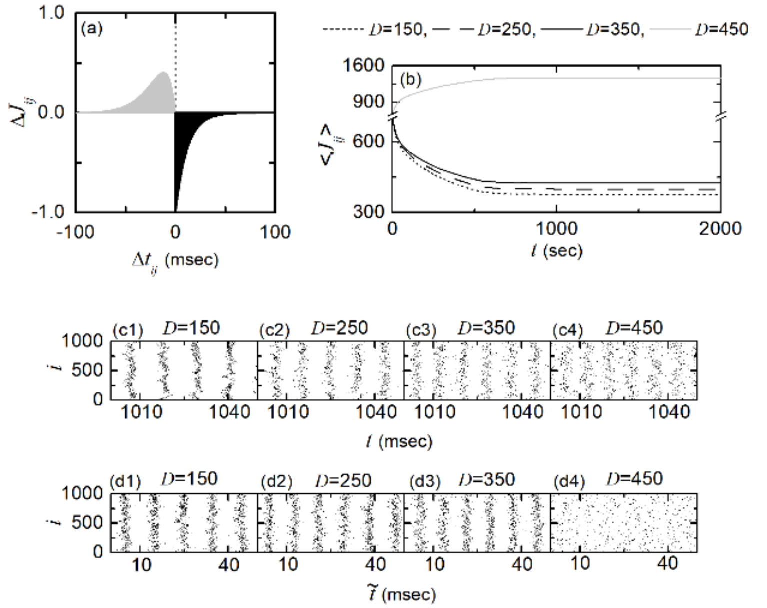

Figure 1: (a) Time window for the Anti-Hebbian iSTDP. Effects of iSTDP on FSS. (b) Time-evolutions of population-averaged synaptic strengths $\langle J_{ij} \rangle$ for various values of D. Raster plots of spikes (c1)-(c4) in the absence of iSTDP and (d1)-(d4) in the presence of iSTDP.

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