Effect of Diverse Recoding of Granule Cells on Optokinetic Response in a Cerebellar Ring Network

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We consider a cerebellar ring network for the optokinetic response (OKR), and investigate the effect of diverse recoding of granule (GR) cells on OKR by varying the connection probability p_c from Golgi to GR cells. For an optimal value of p_c^* (= 0.06), individual GR cells exhibit diverse spiking patterns which are in-phase, anti-phase, or complex out-of-phase with their population-averaged firing activity. Then, these diversely-recoded signals via parallel-fibers (PFs) from GR cells are effectively depressed by the error teaching signals via climbing fibers (CFs) from the inferior olive which are also in-phase ones. Synaptic weights at in-phase PF–Purkinje cell (PC) synapses of active GR cells are strongly depressed via strong long-term depression (LTD), while those at anti- and out-of-phase PF–PC synapses are weakly depressed through weak LTD. This kind of "effective" depression at PF-PC synapses causes a big modulation in firing of PCs, which then exert effective inhibitory coordination on vestibular nucleus (VN) (which evokes OKR). For the firing of VN neuron, the learning gain degree L_g, corresponding to the modulation gain ratio (i.e., normalized modulation divided by that at the 1st cycle), increases with increasing learning cycle, and it saturates at about the 300th cycle. By varying p_c, we find that a plot of L_g versus p_c forms a bell-shaped curve with a peak at p_c^* (where the diversity degree D in firing of GR cells is also maximum). The more diverse in recoding of GR cells, the more effective in motor learning for the eye-movement.

Keywords: OKR, Cerebellar ring network, Granule cells, Diverse recoding, Motor learning

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