Supplementary Information for "Adult Neurogenesis in The Hippocampal Dentate Gyrus Affects Sparsely Synchronized Rhythms, Associated with Pattern Separation and Integration"

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Abstract This document provides the Supplementary Information (SI) for "Adult Neurogenesis in The Hippocampal Dentate Gyrus Affects Sparsely Synchronized Rhythms, Associated with Pattern Separation and Integration." In this SI, we briefly describe a spiking neural network for adult neurogenesis in the hippocampal dentate gyrus, developed in our prior work for the effect of adult-born immature granule cells on pattern separation (Kim and Lim, 2023).

1 Spiking Neural Network for Adult Neurogenesis in The Hippocampal Dentate Gyrus

Recently, we developed a spiking neural network for adult neurogenesis in the hippocampal dentate gyrus (DG) to study effect of adult neurogenesis on pattern separation (Kim and Lim, 2023). In our DG spiking neural network, the young adult-born immature granule cells (imGCs) and the mature GCs (mGCs) are incorporated along with more synaptic connections (Santhakumar et al., 2005; Morgan et al., 2007). Details on our DG spiking neural network are given in Sec. II in (Kim and Lim, 2023). Here, we make brief descriptions on them; for details refer to Sec. II in (Kim and Lim, 2023).

Figures 1(a) and 1(b) show the schematic representation and the box diagram for our spiking neural network for adult neurogenesis, respectively. Based on anatomical information (Myers and Scharfman, 2009, 2011; Myers et al., 2013; Scharfman and Myers, 2016; Chavlis et al., 2017), we construct the framework

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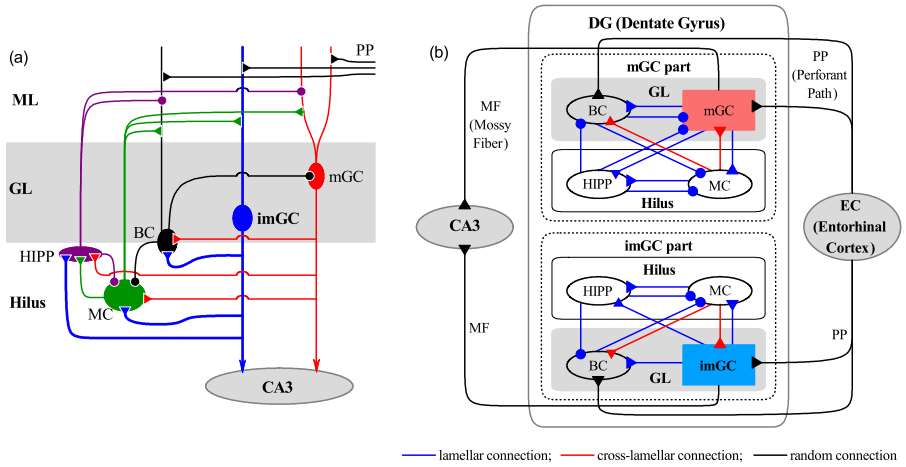

Fig. 1 Spiking neural network for adult neurogenesis. (a) Schematic representation of major cells and synaptic connections. Both mature GCs (mGCs) and adult-born immature GCs (imGCs) are incorporated in our spiking neural network; fraction of the imGCs is 10 %. We also consider the basket cell (BC), the mossy cell (MC), the hilar perforant path-associated cell (HIPP), perforant path (PP), granular layer (GL), and molecular layer (ML). (b) Box diagram for our spiking neural network with lamellar (blue), cross-lamellar (red), and random (black) connections.

(i.e., numbers of cells and connection probabilities) of our spiking neural network; for details refer to Sec. IIA in (Kim and Lim, 2023).

Details on single neuron models and synaptic currents in our spiking neural network are also given in Sec. IIB in (Kim and Lim, 2023). Here, we make brief descriptions on them; for details refer to Sec. IIB in (Kim and Lim, 2023).

As single neuron models, we consider leaky integrate-and-fire (LIF) spiking neuron models which have additional afterhyperpolarization (AHP) currents (Gerstner and Kistler, 2002; Kim and Lim, 2022a,b,c). Our spiking neural network consists of 5 populations of mGCs, imGCs, basket cells, mossy cells, and hilar perforant path-associated cells, as shown in Fig. 1. The state of a neuron in each population is characterized by its membrane potential. Time-evolution of the membrane potential is governed by 4 kinds of currents into the neuron such as leakage current, AHP current, external constant current,and synaptic current; refer to Eq. (1) in (Kim and Lim, 2023). As its membrane potential arrives at a threshold, firing a spike occurs, and then the AHP current follows.

The parameter values for the single neurons are the same as those in our previous DG networks (Kim and Lim, 2022a,b,c); refer to Table I in (Kim and Lim, 2022a). We note that the mGC and the imGC have different leakage reversal potential V_L; $V_L = -75$ mV and -72 mV for the mGC and the imGC, respectively. Hence, the imGCs exhibit higher excitability than the mGCs. For more details, refer to the $f - I$ (i.e., firing rate-current) curves of the mGC (red curve) and the imGC (blue curve) in Fig. 2 in (Kim and Lim, 2023).

Next, we consider the synaptic current. Detailed explanations on the synaptic current are also given in Sec. IIB in (Kim and Lim, 2023). There are 3 kinds of synaptic currents from a presynaptic source population to a postsynaptic neuron in

the target population; 2 kinds of excitatory AMPA and NMDA receptor-mediated synaptic currents and one type of inhibitory GABA receptor-mediated synaptic current. For each R (AMPA, NMDA, and GABA) receptor-mediated synaptic current, the synaptic conductance is given by a product of the synaptic strength per synapse, the average number of afferent synapses, and the fraction of open postsynaptic ion channels. The time course of fraction of open ion channels is provided by a sum of "double-exponential" functions over presynaptic spikes; for details, refer to Eq. (11) in (Kim and Lim, 2023). The synaptic parameters are given in Tables I-III in (Kim and Lim, 2023). These synaptic parameter values are also based on physiological information (Kneisler and Dingledine, 1995; Geiger et al., 1997; Bartos et al., 2001; Schmidt-Hieber et al., 2007; Larimer and Strowbridge, 2008; Schmidt-Hieber and Bischofberger, 2010; Krueppel et al., 2011; Chiang et al., 2012; Chavlis et al., 2017).

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