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Neural network model of the lateral accessory lobe and ventral protocerebrum of *Bombyx mori* to generate the flip-flop activity

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Experimental background

The lateral accessory lobe (LAL) and the ventral protocerebrum (VPC) are known to form a premotor center of brain in insects. The present report focuses on the neural network of the LAL-VPC of *Bombyx mori*, which is known, from the neuroethological experiments, to generate the pheromone oriented behavior composed of a sequential activity of surge, zigzag-turn and loop [1-3]. The physiological experiments partly elucidate the information pathway which is evoked by a pheromone stimulus given to antennal lobe (AL) and finally projected to LAL-VPC to generate a motor command to thoracic motor systems. The LAL-VPC regions have been characteristically considered to be similar to the electric flip-flop circuit by the records of response from the descending neurons (DN). Moreover, electrophysiological and immunohistochemical studies enable the morphological and physiological classification of each LAL-VPC neuron, and show possible anatomical connection among the neurons [4].

Methods

We propose a neural network model in which a connection between a pair of neurons is intermediated by a region, which is called a neuropile. This is based on the experimental finding that both LAL and VPC in each hemisphere consist of two compartments [4]. Therefore, our model assumes four regions (or an additional fifth region according to the new report), and each neuron possesses input branches from one or more regions and output branches to one or more regions. The temporal activity of each region is given by the weighted summation of inputs from the corresponding neurons, and it gives outputs to the corresponding neurons. In other words, a kind of mean field coupling through the neuropile region is assumed, and thus the connection from *i*-th neuron to *j*-th neuron is decomposed into two connections from *i*-th neuron to the region, and from the region to *j*-th neuron.

The goal of this study is to estimate the weights of the anatomically observed connections to elucidate the main pathway of information processing to generate the characteristic flip-flop activity in LAL-VPC, under the constraints that the stimulus-evoked activities of all regions and all LAL-VPC neurons are consistent with the physiologically observed response activities of all neurons. At the first step, the possible connection weight patterns are searched by the optimization of an evaluation function, which measures and evaluates the degree of the above consistency using a static model. Then, a neural network simulator is applied to verify whether the obtained connection is able to reproduce the temporal activity with alternating flip-flop patterns between both hemispheres. All of experimentally observed LAL-VPC neurons with a physiological classification are considered in our simulator, and the dynamics of each model neuron is given by a simple integrate-and-fire model.

Results

The search of the connection patterns with high evaluation scores are executed, and some characteristic patterns are obtained from the statistics of the highest groups. On the other hand, the simulator shows an alternating firing between both hemispheres when the post inhibitory rebound firing (PIR) is taken into the consideration. The details of the obtained connection patterns and the verification by the simulator will be reported at the conference.

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