SENSITIZATION AND HABITUATION IN COMMAND NEURONS OF THE DEFENSIVE
REFLEX IN Helix lucorum*

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Identified neurons of the subesophageal complex of ganglia in Helix pomatia [3] can be divided into several groups depending on their role in the organization of the unconditioned defensive reflex of closing the aperture of the mantle cavity (the pneumostome). Changes in spike activity of command neurons, whose function is to trigger the motor programs of the efferent part of the reflex arc [1], were shown to be controlling factors for the function of the pneumostome.

In the present investigation sensitization and habituation were studied at the level of identified neurons with known functional roles, taking place parallel with sensitization and habituation of the behavioral response of the snail.

EXPERIMENTAL METHOD

Experiments were carried out on a semi-intact preparation of Helix lucorum (a species very similar to H. pomatia) [4], in which all connections were preserved between the CNS and the peripheral organs, and access was opened to giant identified neurons of the subesophageal complex of ganglia [2]. The foot of the mollusk was divided into symmetrical halves. For convenience of description of the point of application of the tactile stimulus, the receptive surface of the snail's body was divided into areas. Four left and four right zones were distinguished. Four zones also were distinguished on the surface of the mantle ridge [2].

For tactile stimulation standard Frey's hairs, calibrated by weight from 0.15 g (weak stimulation) to 1 g (strong stimulation) were used: the hairs were fixed to the plunger of an electromagnetic coil, controlled by pulses from a stimulator generating stimuli at an arbitrary frequency.

The amplitude of the reflex movement of closure of the pneumostome was recorded by means of a photosensitive cell. A series of tactile stimuli was applied in the experiments with a frequency of 0.1–0.05 Hz so that the pneumostome would open after each stimulation.

Intracellular activity was recorded by capillary microelectrodes and dc amplifier with high-ohmic input. Two independent electrodes were used for recording and passing the stimulating current into the cell. In most cases activity of two or more neurons was recorded simultaneously. The nervous system was continuously irrigated with Ringer's solution for cold-blooded animals.

To study habituation and sensitization 12 identified neurons were studied (94 derivations).

EXPERIMENTAL RESULTS

Before the results of the experiments to study habituation and sensitization are described, the reasons must be given for the choice of identified neurons and their functional role must be defined.

Among the identified neurons of the subesophageal complex of ganglia in H. lucorum several functional groups can be distinguished depending on their role in the organization of the unconditioned defensive reflex of pneumostome closure.

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First Group. Neurons LPa2, LPa3, LPa5, RPa2, and RPa3 (see the schematic map in [3]) possess certain common properties justifying their inclusion in one group: 1) no action potentials of pacemaker origin are present in their spontaneous activity; 2) most of the postsynaptic potentials recorded in these cells are synchronous (Fig. 1), i.e., their source is common interneurons, but no synaptic or electrical connections were found between the neurons themselves (Fig. 2a, b); 3) these neurons respond with a discharge of one to four action potentials after a latent period of 90-100 msec to tactile stimulation of any part of the body, if the stimulus evokes the defensive reflex of pneumostome closure; 4) each neuron has its own specific part of the receptive field, stimulation of which evokes a stronger response; 5) these nerve cells respond to adequate stimulation of four modalities (tactile, thermal, electrodermal, and photic); 6) intracellular activation of any of these neurons during passage of a depolarizing current leads to pneumostome closure with a latent period of 300-3000 msec, and if the frequency of the discharge is high, to contraction of the muscles of the mantle fold (Fig. 2a, b).

It would be logical to suggest that these nerve cells are motoneurons, but there is evidence to show that this is not so: first, the movement triggered by a discharge evoked in these cells is a coordinated contraction of many muscles of the mantle fold, including contraction of the annular muscle of the pneumostome; second, during perfusion of the CNS with Ringer's solution with an increased concentration of magnesium ions (or with the addition of cobalt ions), lowering the efficiency of central synaptic transmission, the effect of intracellular activation of neurons LPa2, LPa5, and RPa2 disappears and stimulation of cells LPa3 and RPa3 leads only to contraction of the annular muscle of the pneumostome (coordinated contraction of the muscles of the mantle ridge is ruled out); third, action potentials in these neurons precede reflex pneumostome closure, but they are not essential during the movement; fourth, the latent period of the effector response may reach 3000 msec; fifth, spontaneous activity of these neurons does not correlate with spontaneous movements of the muscles of the pneumostome.