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Neuronal reactive microcircuits: Calibration of cellular parameters modulated during activation as experimentally studied in the CNS of *Gryllus bimaculatus* DeGeer 1773

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Neuronal pattern generators and neural passive filters for a certain type of dynamic activity contain as essential components excitatory or inhibitory recurrently coupled neurons which form a microcircuit (Grillner et al. 2005). The recurrency is not active per se, requires activation by a neuromodulator to become a band-pass filter for a pattern of distinct frequency and also a generator of rhythmic neural activity.

The experimental work presented here uses two recurrently coupled giant lateral inhibitor neurons from the auditory pathway of the cricket Gryllus bimaculatus to measure the cellular parameters which contribute to activate the recurrency and to generate effects of ringing in the identified neurons (nick-named: omega neurons). The microcircuit, fitted with neuromodulation by identified neurosecretory cells, processes the conspecific sound signal of the cricket, an invariable rhythmic (=dynamic) pattern of vital importance to the survival of the species.

By intracellular recordings and current injection in both locust muscle cells and in the omega neuron of the cricket auditory pathway Rm was found to increase from 740 ohms.-cm^2 in controls to 1800 ohm-cm^2 under modulation. Calculation of the length constant lamda yielded 400 µm in controls versus 700 µm under modulation by octopamine. Push-pull activation of the two inputs to the recurrency by sound pulses at repetition frequencies 15 to 70 Hz showed the time constant in the modulated recurrency at a period of 33ms of sound pulse repetition at one input.

The ion channel modulated by octopamine was identified using patch clamp measurements in primary culture nerve cells of the cricket. A delayed rectifying potassium current lowered current flow by 40% in the presence of 10 µM of octopamine.

The activation of the inhibitory recurrent loop in the microcircuit consists of postinhibitory rebound depolarisation (PIRD). In the majority of the experiments made, PIRD was expressed only in the presence of octopamine.

The known dependency of PIRD from the strength of synaptic coupling (Eilts-Grimm, Wiese 1984) has led to the measurement of coupling factor b in this microcircuit (Schledermann 1997). According to this source, b amounts to 0.4 in controls while in the presence of octopamine b was found to increase to a maximum of 0.7.

A horizontal cut through the prothoracic ganglion of the cricket was prepared for examination by Scanning Electron Microscopy (SEM). The cut reveals, that a lacuna between auditory neuropiles right and left likely enshures balanced modulation of both neuropiles. A transport of octopamine via a lacuna along the big axon arc could not be confirmed.

An electric analogue circuit is suggested which combines spatial integration of many inputs to the dendrite, temporal integration, start of ringing in a recurrency, both inhibitory and excitatory, all by a shift in transmembrane resistance Rm.

Based on the assumption that recurrent excitatory microcircuits are building blocks of cortices in mammalian and human brains (Douglas, Markram, Martin, 2004) a hypothesis is presented which points at a shift in the threshold of activation of the respective recurrency which potentially accounts for establishing memory of sensory constellations.

Ref.:

Douglas, Markram, Martin (2004):In: The synaptic organization of the brain, Gordon M. Shepherd (ed.) Chapter 12, Oxford Univ. Press
Grillner, S. et al. (2005) Trends in Neurosciences **28,** 507-570