
Dynamical Principles: Neuronal Motor Microcircuits
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A central goal of Neuroscience is to understand the laws and mechanisms by which complex coherent activity of the nervous system can emerge from the cooperative activities of many relatively simple dynamical elements i.e., neurons and synapses. Because the arrangement of neurons and synapses in different microcircuits (MCs) vary, any general principles common to all of them will require a general theoretical framework. Dynamical System Theory (DST) is such a framework. DST gives a geometrical view of a behavior's structural elements, such as attractors, basins, and separatrices and also addresses the question of what activity is common across the spectrum of neural systems. By using small invertebrate MCs, which are central pattern generators (CPGs), virtually all synaptic connections and cellular properties can be determined. With these preparations, principles may be found which can help determine the dynamical properties of vertebrate MCs where present techniques do not allow the detailed mapping of cell to cell circuitry. To measure the dynamical properties of the MCs, particularly in relation to the competing demands of robustness and flexibility, we will change the intrinsic properties of constituent neurons, synapses and MC architecture using electronic neurons, synapses, an improved dynamic clamp technique and hybrid circuits. We will work with CPGs of lobster, crab and Clione as well as with model MCs. The proposed research provides the opportunity of obtaining fundamental dynamical principles which govern the operation of neural circuits in a wide range of nervous systems. The formulation of the dynamical principles that govern the activity of small neural circuits is important not only for the understanding of robustness, sensitivity, flexibility, and synchronization mechanisms but, even more importantly, gives us the ability to build artificial systems based on such general principles without a detailed knowledge of the biological circuits. Such artificial systems would be extremely important clinically in the design of prosthetic devices.

Publications

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