Adaptation and learning in ex-vivo developing networks

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Adaptation and learning are basic and general phenomena. My assumptions are that (1) these phenomena are "beyond anatomy" in the sense that they are realized in a wide range of neural systems that are different from each other at the cellular and tissue organization levels. (2) To be manifested at the behavioral level, the mechanisms underlying adaptation and learning need be considered from the neuronal population point of view; for, as much as we know, no behavior is dependent on the activity of a single neuron, let alone single spike or single synapse. With these two assumptions in mind, we are attempting an experimental approach to uncover the principles underlying adaptation and learning in population terms. The properties of the experimental model in use, a large random network of cortical neurons, will be presented. As a prototype of network adaptation I will show how selective adaptation to input is realized by these "structureless" networks, where interactions between different activation paths, as well as the balance between excitatory/inhibitory sub-networks, play a key role. I will proceed by commenting about two general types of learning environments, one in which a rewarding entity is required and the other in which learning follows the classic drive-reduction principle (Freud, 1985; Hull, 1943; Guthrie, 1946). Based on recent results from dopamine application experiments I will suggest that the two types of learning environments are related to each other. I will show how closed-loop designs may provide the conditions to embed functionality onto the networks, following the drive-reduction principle. I will close the presentation by listing the required technological developments that will enable experimentally addressing key aspects network neurophysiology, and their impacts on future brain-machine interfacing.