Scientific Report

Title: Focus Workshop: Spike-Frequency Adaptation in Neural Systems

Dates and duration: 26 and 27 of October, 2010
Coordinators: Jan Benda (Ludwig-Maximilians-Universität München) and Benjamin Lindner (MPI-PKS)

The Workshop brought together experts working on the various aspects of spike-frequency adaptation (SFA). Among the participants were internationally renown researchers, as, for example, Fabrizio Gabbiani, Simon Laughlin, David McAlpine, Alexander Neiman, and Klaus Obermayer. The program consisted of eight sessions each devoted to a specific topic of adaptation, including specific sensory modalities (auditory, visual, and electrosensory systems), effects of particular adaptation properties (sub- vs suprathreshold currents, stochastic adaptation, multiple adaptation time scales). Two lively poster sessions and one flash-talk session fostered the active involvement of younger researchers (PhD students and Postdocs) into the workshop program.

Computational advantages and drawbacks of SFA in the multi-staged mammalian auditory system were addressed by David McAlpine. Kai Hildebrandt and Martin Nawrot discussed similar issues in comparably simple invertebrate systems - the auditory system of the grasshopper and the insect olfactory pathway. These talks illustrated the complex demands on adaptation processes in sensory systems.

The talk by Maurice Chacron addressed experimentally the severe differences in the effect of sub- and suprathreshold adaptation currents on the information transfer of a neuron in the electrosensory line lobe of the weakly electric fish. Feedback and adaptation in the latter neurons were also the topic of John Lewis, who related their performance to behavioral aspects (two-point discrimination task). Alexander Neiman presented experimental and modeling results from the passive electrosensory system of the paddle fish and discussed the contributions of adaptation and epithelial oscillations on the spike statistics of receptor neurons.

Adaptation currents do not exist in isolation but may interact with each other yielding adaptation that can extend over many different time scales. This point was highlighted in the talks by Renaud Jolivet (discussing, in particular, adaptation induced by Na,K pump), Brian Lundstrom (introducing fractional differentiation as a mathematical description of adaptation with multiple time scales), and Richard Naud (presenting methods to extract adaptation models from data).

The theoretical analysis of neural systems is far from trivial, especially in a stochastic setting in which the various neural noise sources are taken into account. How to deal with these kinds of models analytically or with efficient numerical schemes was discussed in the talks by Giancarlo La Camera, Eilif Muller, William Nesse, Magnus Richardson and Tilo

Schwalger. In agreement with some of these theoretical results, Karin Fisch presented first experimental evidence for the stochasticity of an adaptation current due to the noise of the finite number of ion channels which mediate such a current.

Fascinatingly diverse were the topics related to adaptation in the visual system. Fabrizio Gabbiani gave insights on the working of looming sensitive neurons in locust, which is subject to SFA. Rafael Kurtz showed experimental results supporting a positive role of SFA in feature extraction from natural stimuli (optic flow for a moving blow fly). The importance of SFA for plasticity of orientation maps in the visual cortex was addressed by Klaus Obermayer. In the same system, Lars Schwabe discussed theoretically the impact of SFA on contextual effect in strongly connected networks.

In the beautiful final presentation of the workshop given by Simon Laughlin some of the undue simplifications regarding the role of adaptation were reviewed and a number of remaining questions were posed triggering a lively concluding discussion.

In summary, the workshop on Spike-Frequency Adaptation in Neural Systems provided a broad review of this modern and dynamic research topic in neuroscience. Experimentalists got a comprehensive overview to the exhaustic theoretical studies of SFA in single neurons, whereas theoreticians learned that the investigation of functional aspects of SFA in sensory systems is still in its infancy and is heavily in need of guiding theories. Thus, the workshop triggered some unexpected insights, potentially resulting in new exciting research projects and collaborations.

Jan Benda and Benjamin Lindner (organizers of the workshop)