Poster: 25

The cellular basis of receptive field plasticity in visual cortex, an integrative experimental and theoretical approach

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Harel Z. Shouval
Department of Neurobiology and Anatomy, The University of Texas Medical School at Houston
Department of Biomedical Engineering, The University of Texas, Austin

Mark F. Bear
Howard Hughes Medical Institute
The Picower Institute for Learning and Memory, Department of Brain and Cognitive Sciences
Massachusetts Institute of Technology

Synaptic plasticity is a likely basis for information storage by the Neocortex. Understanding cortical plasticity requires coordinated investigation of both underlying cellular mechanisms and their systems-level consequences in the same model system. However, establishing connections between the cellular and system levels of description is non-trivial. The objective of the current project is to generate a theoretical description of experience-dependent plasticity in the rodent visual system. The advantages of rodents are, first, that knowledge of the molecular mechanisms of synaptic plasticity is relatively mature and continues to be advanced with genetic and pharmacological experiments, and second, rodents show robust receptive field plasticity in visual cortex (VC) that can be easily and inexpensively monitored with chronic recording methods. In this project we will use realistic assumptions about the activity of inputs to rat visual cortex. In the first nine months of the project we have been able to model experimental results about RF plasticity in rodents, under various deprivation conditions using rate-based plasticity models. In order to account for some of the new data we made the additional assumption that suturing an eyelid blurs the visual image but does not completely eliminate it. In addition we modeled synaptic plasticity induced by multi spike protocols in visual cortex, using a biophysical model of synaptic plasticity. Our original simplified model could not account for multi spike induction protocol. We show that the addition of realistic assumptions about stochastic synaptic dynamic, and about the dynamics of back propagating action potentials significantly improves the predictions of the model. We demonstrate that a stochastic implementation produces significantly different results from a deterministic implementation. Results of the stochastic implementation match better experimental results, and are more robust. Moreover, we show how to calculate key statistics of the stochastic synaptic dynamics, and how to use these statistics to calculate the effect of synaptic dynamics on synaptic plasticity.

Project (or PI) Website

http://nba.uth.tmc.edu/homepage/shouval/index.htm

Publications

1. Y. Cai, J.P Gavornik, B.S Blais, L.N Cooper and H.Z. Shouval The effect of Stochastic Synaptic and Dendritic Dynamics on Synaptic Plasticity in Visual Cortex and Hippocampus. In preparation (2006).