ELSC-ICNC Seminar: Mark Shein-Idelson

June 7, 2012

On the topic of: "Modular topology introduces gating in neuronal networks through excitation-inhibition balance"

ELSC & ICNC cordially invite you
to the lecture given by:

Mark Shein-Idelson
Department of Physical electronics, School of Electrical Engineering - Tel Aviv University

On the topic of:

"Modular topology introduces gating in neuronal networks through excitation-inhibition balance"

The lecture will be held on Thursday, June 7, 2012
at 17:00, at ELSC-ICNC: Silverman Bldg., 3rd Wing, 6th Floor, Edmond J. Safra Campus

Light refreshments at 16:45

Abstract:

One of the basic tasks of a functional neuronal network is to reliably transmit information from input to output. Even in simple feed-forward networks, this is a highly non-trivial operation. All the more so when the transmission takes place in a recurrent network where multiple pathways are embedded within the same network of connected neurons. One way to restrict the propagation of activity to specific pathways is by utilizing a gating mechanism between connected neurons and sub-populations. A basic question in this context is what part does the network topology play in controlling activity propagation and routing and whether the topological properties of the network may be utilized to allow such an activity gating?

Such questions are hard to study in-vivo due to the limited accessibility to complete circuits and limited capacity for manipulation. The connectivity maps of circuits are highly untraceable in the three dimensional architecture. In addition, the circuits are not prone to design, preventing the possibility of systematic studies. To overcome these limitations we utilized in-vitro cell patterning techniques which offer a large set of tools for controlling neuronal network architecture. We used soft lithography of Poly-D-Lysine islands to induce the self-organization of cells into small (tens to hundreds of cells) isolated clusters and to connected clusters that are characterized by a modular topology. These networks were patterned on top of multi-electrode arrays allowing long-term non-invasive recording of their activity.
The activity of isolated clusters is characterized by network bursts (NBs), activating the whole cluster synchronously. The intra burst patterns is characterized by fast onset and a gradual decay with superimposed oscillations in the gamma range. When examining pairs of connected clusters, we found conditional activity propagation. NBs initiated in the "sending" cluster did not always propagate to the "receiving" cluster. The propagation was conditioned by the activity intensity in the sending cluster, where stronger NBs had a higher transmission probability. In cases where activity was transmitted, the propagation was characterized by long time delays between the activation of connected clusters. Furthermore, this propagation was asymmetric in the sense that one propagation direction was preferable to the opposite direction. This conditional activation was also observed in large networks of many connected clusters. It is manifested as events initiated at different network locations and which propagating to different distances. Interestingly, blocking network inhibition (by application of Bicuculline), replaced the conditional activation by network-wide synchronized events across all clusters.

Using patterned networks we were able, for the first time, to systematically study how network topology affects activity transmission. We found that modular topology gives rise to conditional activation, activation asymmetry and long delays. The delays result in temporal separation between intra and inter cluster activation which may be important for separating different functional processes in the network. The activation asymmetry may be important for controlling the directionality of propagation. Finally, the conditional activation highlights a possible mechanism for restricting activity propagation and controlling the degree of the network synchrony. While connected clusters have the potential to synchronize, they also exhibit segregated activity in which NBs are confined to one or a limited number of clusters. Most interestingly, such topology-related conditional activation may be gated by the balance between excitation and inhibition in the network.

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