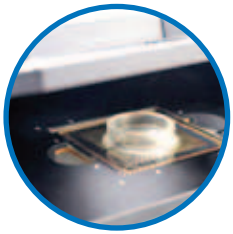
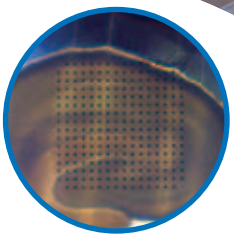
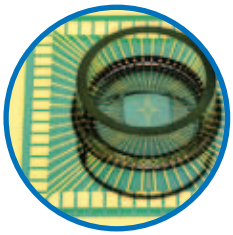




In vitro Microelectrode Array Recording Techniques

45th Annual SfN Meeting
Satellite Event

Monday, October 19, 2015
6:30 pm - 7:30 pm
McCormick Place Convention Center, Chicago, IL
Room: S403



Event is not sponsored by SfN.

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Program

Large Scale Exploration of Three Layered Cortical Circuits Using Multi-Electrode Arrays

Mark Shein-Idelson, PhD

Max Planck Institute for Brain Research, Frankfurt, Germany

Brief Wide-Field Photo Stimuli Evoke and Modulate Oscillatory Reverberating Activity in Cortical Networks

Michele Giugliano, PhD

Department of Biomedical Science, University of Antwerp, Belgium

Role of Synaptic Transmission and Intrinsic Neuronal Properties in Shaping Network Burst Dynamics in Hippocampal Neuronal Cultures Grown on Multi-electrode Arrays

Jyothsna Suresh, PhD candidate

Computational Neuroscience, van Drongelen lab, University of Chicago, USA

Large Scale Exploration of Three Layered Cortical Circuits Using Multi-Electrode Arrays

Mark Shein-Idelson, PhD
Max Planck Institute for Brain Research, Frankfurt, Germany

Circuits generally display emergent properties that result from a complex interplay between single-neuron and synaptic properties, local circuit connectivity and interactions with other brain areas. Observing such distributed activity patterns and testing their underlying causes necessitates new approaches in which circuit complexity is reduced whereas sampling resolution is maximized.

We address this with large-scale recordings from the three-layered cortex of turtles. As in mammalian hippocampus and piriform cortex, all pyramidal cell somata occupy a single layer (L2) close to (50-100µm) the ependymal surface. This structure is very well suited to dense electrical recordings with planar electrode arrays, enabling the simultaneous sampling of many hundreds of neurons.

Because of the tolerance to anoxia of the turtle brain, long-term and very stable measurements can be made from highly accessible, intact, eye-brain preparations. These allow accurate control over sensory input while combining extra-cellular and intra-cellular measurements with imaging and optogenetics.

We can thus carry out large-scale sampling and manipulation of cortical and extra-cortical dynamics. Using this approach we can for example map simultaneously the functional input and output fields of hundreds of single neurons and reveal biases in axonal projection field directionality across cortex.

Brief Wide-Field Photo Stimuli Evoke and Modulate Oscillatory Reverberating Activity in Cortical Networks

Michele Giugliano, PhD
Department of Biomedical Sciences, University of Antwerp, Belgium

Cell assemblies control by optogenetics is pivotal to advance neuroscience and neuroengineering. In in vivo applications, photostimulation often broadly addresses a population of cells simultaneously, leading to feed-forward and reverberating responses in recurrent microcircuits. The former arise from direct activation of targets downstream, and are straightforward to interpret. The latter are consequences of feedback connectivity and may reflect a variety of time-scales and complex dynamical properties.

In this talk, I will present an investigation of wide-field photostimulation in cortical networks in vitro, employing substrate-integrated microelectrode arrays and long-term cultures. The effect of brief pulses of light will be discussed, in a system where the expression of channelrhodopsin has been restricted to principal neurons. Robust reverberating responses, oscillating in a physiological (i.e. gamma) frequency range, were evoked by brief light stimuli and found to determine the oscillation frequency in a counter intuitive way. By pharmacology, mathematical modelling, and intracellular recordings, we conclude that oscillations emerge as in vivo from the excitatory-inhibitory interplay and that, unexpectedly, the light stimuli can transiently facilitate excitatory synaptic transmission. Of relevance for in vitro models of (dys)functional cortical microcircuitry and in vivo manipulations of cell assemblies, we give for the first time evidence of network-level consequences of the alteration of synaptic physiology by optogenetics.

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Role of Synaptic Transmission and Intrinsic Neuronal Properties in Shaping Network Burst Dynamics in Hippocampal Neuronal Cultures Grown on Multi-electrode Arrays

Jyothsna Suresh, PhD candidate
Computational Neuroscience, van Drongelen lab, University of Chicago, USA

Mature dissociated hippocampal cultures exhibit stereotypical synchronous network-wide bursts, separated by order of magnitude longer inter-burst intervals. Using multi-electrode arrays (MEAs), we wanted to understand the specific contributions of intrinsic neuronal properties and synaptic interactions towards network bursting activity. We hypothesized that while slow intrinsic voltage dependent membrane currents, specifically depolarizing persistent sodium (Nap) currents, govern processes leading to burst onset during interburst intervals, much faster synaptic processes control spectro-temporal intraburst properties and network-wide burst propagation. To evaluate effects of Nap currents on burst onset, we used Nap channel-blocker, riluzole. To evaluate role of synaptic connectivity on network burst dynamics, we pharmacologically blocked combinations of inhibitory (GABAA) and excitatory (AMPA, NMDA) transmission using PTX, CNQX and CPP respectively. We systematically compared single-neuron and network activity recorded using patch-clamping and multi-electrode arrays under different combinations of synaptic transmission: GABAA+NMDA+AMPA, NMDA+AMPA, GABAA+AMPA, GABAA+NMDA, AMPA, NMDA, GABAA, all receptors blocked. We performed mixed-effects modeling to quantify the aforementioned linear and interactive contributions of synaptic receptors towards network responses measured in terms of intra-burst spike rate, burst activity index, burst duration, power in EEG frequencies and network propagation delays. We found that blocking Nap channels completely shut down bursting within the network, revealing their critical role in burst onset. Mixed-effects modeling revealed that synaptic connectivity is a requirement for the propagation leading to network-wide bursting and that, in addition to direct excitatory effects, nonlinear combined-effects of synaptic function are critical in shaping individual burst patterns.

In collaboration with: Jyothsna Suresh[1,2], Mihailo Radojicic[1], Lorenzo Pesce[1,3], Anita Bhansali[1], Andrew K. Tryba[1], Janice Wang[1], Jeremy Marks[1, 4], Wim van Drongelen[1, 2, 3, 4]

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Notes

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Speakers

Mark Shein-Idelson, PhD

Dr. Shein-Idelson completed his PhD in electrical enginering at Tel Aviv University, Israel, where he studied the information processing in modular neuronal networks.

Currently, he is a post-doc at Prof. Gilles Laurent's laboratory at the Max Planck Institute for Brain Research in Frankfurt, Germany.

In the lab, they are interested in the behavior, dynamics and emergent properties of neural systems (typically, networks of interacting neurons or neuron populations), especially as these properties relate to neural coding and sensory representation. The lab focuses principally on olfactory and visual areas, combining experiments, quantitative analysis and modeling techniques. As a model system, they mainly concentrate on reptiles.

Michele Giugliano, PhD

After earning his PhD at the Politecnico di Milano in Italy, Michele Giugliano spent his postdoc years at the University of Bern and at EPFL, Lausanne, Switzerland. Since 2008 he is an associate Professor at the Department of Biomedical Sciences at the University of Antwerp, Belgium,

Michele Giugliano's research activities are related to the field of Neuroengineering, where understanding, repairing, replacing, enhancing, or exploiting the electrical properties of mammalian neural systems are central ultimate goals.

His interests are particularly focused on the cellular mechanisms underlying the emergence of coordinated electrical activity in cortical microcircuits and large neuronal populations. He ultimately aims at bridging the missing links between synaptic and single-cell properties and the dynamical phenomena emerging at higher levels of organization.

Jyothsna Suresh

Jyothsna Suresh completed her masters degree in computer science engineering at The University of Texas, Arlington and worked as an engineer at Caterpillar Inc for 8 years. Currently, she is a PhD candidate in the computational neuroscience program at University of Chicago, studying mechanisms underlying epileptic networks in Prof. Wim van Drongelen's lab.

The primary research interest of the lab is to understand the pathological network behavior observed during the brain's epileptiform activity, by applying a variety of engineering techniques including digital signal processing, non-linear dynamics, modelling and advanced statistical analysis. The research approach in the lab is interdisciplinary including mathematical and computational modelling, animal models, study of tissue from patients with epilepsy ad well as analysis of clinical recordings.