Enabling high-resolution bioelectrical imaging to improve large-scale monitoring of neural activity in health and disease conditions

Hayder Amin
Fondazione Istituto Italiano di Tecnologia, Italy

Notwithstanding the remarkable advances of the last decade in Biotechnology and Neuro-technologies, progresses in understanding brain disorders and in developing novel therapeutic strategies have remained stall. One of the today's challenges in neurodegenerative disease research is the lack of efficient predictive assays that can pinpoint the onset of disease mechanisms, and that can be used for drug development. In this respect, the confluence of new emerging in vitro high-density chip-based technologies represents a unique opportunity. High-density multielectrode arrays (HD-MEAs) enable recordings of neuronal spiking activity of neuronal networks, simultaneously from several thousands of densely integrated electrodes (4096 electrodes). The result is an unprecedented and a unique sensing capability that provides access to extracellular signals in large-scale neuronal networks cultured on-a-chip. Furthermore, HD-MEAs allow studying neuronal ensembles and their responses (with single-neuron detail) to chemicals and drugs as well as for assessing developmental impairments of neuronal spiking activity in genetic models of various diseases. On the other hand, new methodology such as high-content imaging (HCI) is providing multiple cellular measurements from a single experiment. Here, we present a novel approach based on the combination of these methodologies, i.e. HD-MEAs and HCI, aim at characterizing neuronal function and network-wide dynamics in neurodegenerative and neurodevelopmental disorders and translating these results into a human-based neural system. In particular, we demonstrate on-a-chip multimodal readouts; to reveal early activity-dependent effects induced by the excitotoxicity of Aβ oligomers in vitro hippocampal cultures of a neurodegenerative Alzheimer's disease (AD) model, to decipher critical developmental delay in an embryonic neuronal network of DiGeorge Syndrome, which is demonstrated by altered chloride cotransporters and aggravated electrophysiological developmental profile and to characterize electrical responses and spontaneous activity of human-iPS-derived neuronal networks.

Speaker Biography

Hayder Amin is a Senior Post-doctoral Researcher at the Fondazione Istituto Italiano di Tecnologia (IIT). He has received a Master's degree in Biomedical Engineering from Martin-Luther University and completed his PhD in Microtechnology for Neuroelectronic and Neuroscience from IIT in 2015. His research employs a diverse range of competencies, including, but not limited to, neuroscience, electrophysiology, neurodegeneration, neurodevelopment, data analysis, and cellular and molecular biology. He is using a combination of cutting-edge approaches such as confocal, calcium and high-content-imaging, and large-scale electrical platform (HD-MEAs) toward the development, implementation, and evaluation of bioassays for drug development, disease models, and fundamental neuroscience applications. His interdisciplinary competencies aim at addressing the functional changes of neuronal network-wide activity in neurodegenerative disease (Alzheimer's disease), neurodevelopment in genetic mouse models (DiGeorge Syndrome), and translated applications in human cell-based assays for drug development and cell therapy.

e:hayder.amin@iit.it

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