**Exploring stimulation and plasticity in tailored neuronal cultures monitored on high-density multielectrode arrays**

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The modern world is increasingly dependent upon artificial intelligence. However, current deep-learning machines and neural network algorithms have important limitations, namely ineffective learning rules, long training, and high-power consumption. The latter is particularly important since a human brain with more than 86 billion neurons can process external information in a power-efficient way. Thus, a substantial interest has grown to develop computing devices in which biological neurons are the main actors.

In the present project, we aim to gain a better understanding of the information processing of biological human neuronal networks by using small *in-vitro* neuronal cultures. To accomplish this objective, we utilize cortical neuronal networks derived from human induced pluripotent stem cells, as well as rat primary cultures, comprising neurons and glial cells. These cultures are cultivated on a high-density multielectrode array (HD-MEA) chip, which allows high-resolution recordings of the neuronal activity. Moreover, the HD-MEA chip is combined with a modular polydimethylsiloxane (PDMS) cast for better control of neuronal network formation. To investigate information processing of neuronal networks we use precise bidirectional microelectrode stimulation, which is applied to stimulate specific cells within the network.

We show that with the inclusion of a modular design, we approach brain-like dynamics in the neuronal cultures. Moreover, we show that we can induce plasticity in these cultures. Analysis of parameters governing neuronal circuit responses to patterned stimuli paves the way toward trainable circuits with desired processing capabilities. The acquired data also provides detailed information about the complex network dynamics of large populations of human neurons, facilitating advancements in neuroinformatics, cognitive neuroscience, and various related fields.