The OptoMEA Platform: a New Tool Combining Local Chemical Stimulation with Distributed Multi-Electrode Array Recordings

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We present a novel OptoMEA platform that combines multisite electrical recording with local chemical stimulation. Applying UV light pulses through an array of optical fibres aligned to transparent indium-tin oxide electrodes of an MEA biochip leads to local compound uncaging (e.g. glutamate), thereby stimulating only the tissue/cells around the electrode vicinity. Experimental results obtained using the OptoMEA platform demonstrate its capability to uncage chemical compounds and to locally stimulate neuronal networks, thus providing a significant improvement in spatial control of chemical stimulation. It is expected that this methodology will be useful in facilitating studies of neuronal network systems, and may also find applications in drug screening.

Micro-Electrode Array (MEA) biochips have been exploited as devices providing distributed information about learning, memory and information processing in tissue slices and cultured neuronal networks. MEA biochips represent a growing technology for the study of the functional activity of neuronal networks providing the possibility to gain information about the spatio-temporal dynamics of the network and to allow recordings of electrical activity over periods of time not compatible with conventional electrodes at several sites in parallel. The presence of large stimulus artefacts and the poorly controlled spread of electrical stimuli in the culture medium limit the applicability of MEA biochips for neuronal stimulation. Although the problem of artefacts has been recently solved using blanking circuits, the problem of electrical signals spreading is inherent to the use of electrical stimulations in a conductive volume. Moreover, due to natural interconnection of neurons in complex networks, electrical stimuli applied to a region of the network may activate neurons of that region and also fibres of passage coming from neurons of other regions. To overcome these limitations, an optical method for local neuronal stimulation has been developed, via the local optical activation of caged compounds.

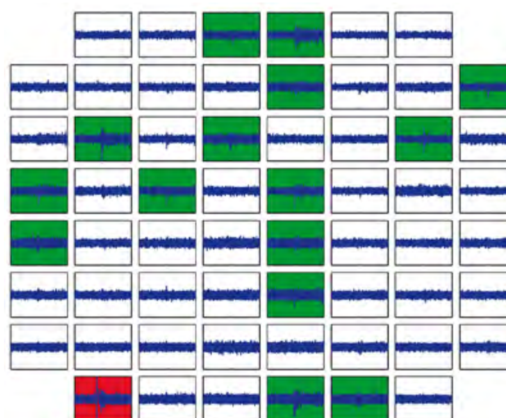

Fig. 1. Activity recorded from the entire network. The red box highlights the local stimulation site. Electrodes showing biological response to the local chemical stimulation are highlighted by green boxes.

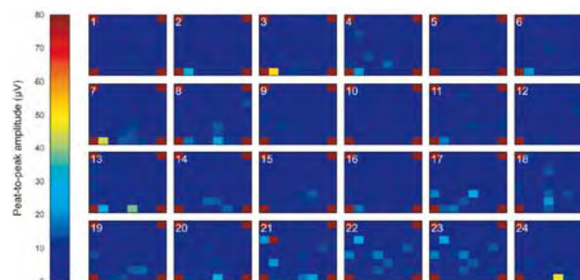

Fig. 2. Graphical representation of the spreading of the electrical activity in the network after the optical pulse. Every frame, acquired with a sample rate of 1kHz, represents a measure of the activity at every site. The colour map represents a colour representation of the peak-to-peak amplitude at every recorded site.

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