Microelectrode arrays

They are providing unprecedented access to the neurons.

These microelectrodes have active tip dimensions that are similar in size to neurons and because they penetrate the nervous system, they provide selective access to these cells (within a few microns). However, the very long-term viability of chronically implanted microelectrodes and the capability of recording the same spiking activity over long time periods still remain to be established and confirmed in human studies.

It will become essential to control the neural tissue damage induced by these intracortical microelectrodes in order to achieve the high clinical potentials accompanying this technology [1].

They offer an excellent approach to study the spatio-temporal patterns of spontaneous interictal and evoked seizure-like events and the mechanisms underlying seizure onset and propagation. Here we describe how to prepare human cortical slices from surgically resected tissue and to record with MEAs interictal and ictal-like events ex vivo [2].

Barriers

Many barriers to entry remain for this technology - including low-cost and effective hardware for combined optical stimulation and electrophysiologic recording. To address this, Laxpati et al, adapted the open-source NeuroRighter multichannel electrophysiology platform for use in awake and behaving rodents in both open and closed-loop stimulation experiments. Here, we present these cost-effective adaptations, including commercially available LED light sources; custom-made optical ferrules; 3D printed ferrule hardware and software to calibrate and standardize output intensity; and modifications to commercially available electrode arrays enabling stimulation proximally and distally to the recording target [3].

Macroelectrodes activated about 5.8 times more neurons than a single microelectrode, but displaced ~20 times more neural tissue. The sphere of influence of stimulating electrodes can be significantly increased by reducing their impedance. By ultrasonic electroplating (sonicoplating) the microelectrodes with platinum to increase their surface area and reduce their impedance by an order of magnitude, the radius of activation increased by 50 µm and more than twice the number of neurons were activated within this increased radius compared to unplated microelectrodes.

A new approach to DBS, one that uses multiple high-surface area microelectrodes, may be more therapeutically effective due to increased neuronal activation [4].

Scar tissue formation

The invasiveness of these implants often results in scar tissue formation, which can have detrimental effects on recorded signal quality and longevity. Traditional histological techniques can be employed to study the tissue reaction to implanted micro-electrode arrays, but these techniques require removal of the brain from the skull, often causing damage to the meninges and cortical surface. This is especially unfavorable when studying the tissue response to electrode arrays such as the micro-electrocorticography (micro-ECoG) device, which sits on the surface of the cerebral cortex. In order to

better understand the biological changes occurring around these types of devices, a cranial window implantation scheme has been developed, through which the tissue response can be studied in vivo over the entire implantation period. Rats were implanted with epidural micro-ECoG arrays, over which glass coverslips were placed and sealed to the skull, creating cranial windows. Vascular growth around the devices was monitored for one month after implantation. It was found that blood vessels grew through holes in the micro-ECoG substrate, spreading over the top of the device. Micro-hematomas were observed at varying time points after device implantation in every animal, and tissue growth between the micro-ECoG array and the window occurred in several cases. Use of the cranial window imaging technique with these devices enabled the observation of tissue changes that would normally go unnoticed with a standard device implantation scheme [5].

1)
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