Towards tracking homeostasis on high-density multielectrode arrays

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With a new generation multielectrode array - the APS (Active Pixel Sensor) MEA [1, 2] - it is now possible to simultaneously record from 4096 channels with a near-cellular resolution (64 by 64 grid of 21-micrometer electrodes spaced 42 micrometers apart). In vitro preparations cultured on such arrays can be recorded from for days; moreover, such neuronal cultures are easy to manipulate by pharmacological intervention. Those recent advances in electrophysiological techniques open up an exciting opportunity to investigate homeostasis in large populations of neurons.

What is needed to complement this rich dataset is analysis techniques able to shed some light on the mechanism of the underlying processes. Here we examine Maximum Entropy modelling - a statistical modelling method that has been shown to characterize spiking patterns in a compact manner [3, 4] and has been suggested to give a measure of higher-order correlations [5]. We aim to assess the utility of this approach for monitoring homeostatic plasticity changes.

What transpires from our analysis, the Ising model fit quality differs both between subgroups within a recording - and, importantly, between recordings for a given subgroup. Therefore the parameters of the model are unsuitable for homeostasis tracking or even comparing recordings. However, as suggested already in a study of in vivo recordings [5], the quality of a model fit can be treated as a measure of higher order interactions. From this viewpoint, the Ising model provides a measure of complexity of collective behaviour. As can be seen in our homeostatic pilot, this might be a useful tool, seeing that mean firing rates and correlations do not appear to change significantly across recovery from CNQX, but the log likelihood ratio increases.

References