

Task and behavior related formation of cell assemblies

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Identifying the principles of neuronal information processing is one of the most important and most controversially discussed issue in experimental and theoretical neuroscience. Part of the reason for ongoing disputes is the still debated role and existence of fine temporal coordination of spiking activity, as it was hypothesized for assemblies and synfire chains. To help resolving this issue, we present, first, a method called NeuroXidence that allows to draw a line of demarcation between the rate and the temporal codes, and second, experimental results that provide strong evidence for task, behavior and stimulus related formation of neuronal cell assemblies on a timescale of 3-5 ms. NeuroXidence is a non-parametric and computationally-efficient method that detects coordinated firing of two or more neurons and tests whether the observed level of coordinated firing is significantly different from that expected by chance. The method considers the full auto-structure of the data, including the changes in the rate responses and the history dependencies in the spiking activity. Also, the method accounts for trial-by-trial variability in the dataset, such as the variability of the rate responses and their latencies. NeuroXidence can be applied to short data windows lasting only tens of milliseconds, which enables the tracking of transient neuronal states correlated to information processing. It can identify changes of coordinated firing that co-occur with changes in firing rate. We demonstrate, on both toy-data and single-unit activity recorded in cat cortex, that NeuroXidence discriminates reliably between significant and spurious events that occur by chance. Using NeuroXidence for the analysis of three data sets (1. primary motor cortex in an awake monkey performing a delayed pointing task, 2. prefrontal cortex in an awake monkey performing a delayed matching to sample task, 3. responses to moving gratings from anesthetized cat area 17), with up to 42 simultaneously recorded single units revealed coordinated spiking activity that involved 2 to 8 neurons in individual patterns on a timescale of 3-5 ms. To identify behavior, task, and stimulus induced changes of the neuronal synchronization we performed bi- and multi-variate tests.

Our Results demonstrate, first, that cell assemblies exist and involve large groups of cells, and second, that the formation and synchronization of cell assemblies is task, behavior and stimulus dependent.

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References

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