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Poster presentation

Detection of task-related synchronous firing patterns

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Background

To test the importance of synchronous neuronal firing for information processing in the brain, one has to investigate if synchronous firing strength is correlated to the experimental subjects. This requires a tool that can compare the strength of the synchronous firing across different conditions, while at the same time it should correct for other features of neuronal firing such as spike rate modulation or the auto-structure of the spike trains that might co-occur with synchronous firing. Here we present the bi- and multivariate extension of previously developed method NeuroXidence [1,2], which allows for comparing the amount of synchronous firing between different conditions.

Methods

In order to eliminate the effect that spike rate changes may bring to the precise synchronous firing patterns, we define two time scales, τ_c and τ_r, to distinguish the joint-spike-event (JSE) with rate modulation. The assumed temporal extension of JSE is denoted by τ_c (~5 ms), while the lower bound of rate changes is denoted by τ_r, which is η times slower than τ_c ($\tau_r = \eta * \tau_c$, usually $\eta = 5$). Surrogate data is then generated by jittering each spike train by an amount smaller than τ_r, which only destroys the fine temporal cross-structure and keeps other features of the spike train. Hence, for each trial (m), each joint-spike pattern (k) and each condition (i), the change amount of JSE ($\Delta f^{m,k,i}$) is derived based on the difference between original and surrogate data sets. Thus, from all the trials, the change amount of JSE for each joint-spike pattern and each condition assembles the set $\Delta F^{k,i}$. To assess whether $\Delta F^{k,i}$is different across conditions, bi- and multivariate statistical test (Mann-whitney, Kruskawalis) are applied.

Results

Based on different simulated data sets, we demonstrate the bi- and multivariate NeuroXidence is a reliable and robust method for detecting modulations of synchronous firing across different conditions. To this end, we calibrated our method on various scenarios (such as fast rate change, rate co-variation, low rate and different forms of renewal processes), which have been discussed to induce false positives. Moreover, after applying our method to the simultaneous recordings from awake monkeys in a short-term memory task, we exhibit that the encoding and maintenance of information in the brain rely on the formation of neuronal assemblies characterized by precise and reliable synchronization of spiking activity on a millisecond time scale.

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