Higher-order correlations in large neuronal populations

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Spiking neurons are known to be quite sensitive for the higher-order correlation structure of their respective input populations [1]. But what is the role of these correlations in cortical information processing?

A prerequisite to answering this question is an appropriate framework to describe the correlation structure of neuronal populations, and an effective method to estimate it from sampled data. Previously suggested approaches suffer from the combinatorial explosion of the number of parameters, which typically grows exponentially with the number of recorded neurons. As a consequence, methods that go beyond pairwise correlations and aim for estimating genuine higher-order effects require vast samples, rendering them essentially inapplicable to populations of more than ~10 neurons.

Here, we discuss the compound Poisson process as an intuitive and flexible model for correlated populations of spiking neurons. Based on this generative model, we present novel estimation techniques to infer the correlation structure of a neural population from sampled spike trains [2-4]. Our techniques can provide conclusive evidence for higher-order correlations in rather large populations of ~50 neurons, based on sample sizes that are compatible with current physiological *in vivo* recording technology. Recent developments aim at coping with certain types of non-Poissonian processes, and with certain types of non-stationarities encountered in spike recordings from behaving animals [5].

This is ongoing joint work with Benjamin Staude and Imke Reimer (Bernstein Center Freiburg, Germany), Werner Ehm (IGPP Freiburg, Germany) and Sonja Grün (RIKEN BSI, Wako-shi, Japan).

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