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Homeostasis in large networks of neurons through the Ising model - do higher order interactions matter?

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Homeostatic activity in large networks of neurons is a relatively scantly explored area of neuroscience, both on experimental and computational level [1]. With recent advance in recording techniques, the lack of experimental data is gradually ceasing to be the limitation. New multi-electrode arrays (MEA) allow for monitoring cultures of thousands of neurons over many days with high spatial resolution [2]. However, the interpretation of multi-neuron recordings is not straightforward and requires methods going beyond the simplest descriptive statistics.

Here we explore a novel approach to analyzing multi-unit neuronal activity recorded over a five day homeostatic experiment by employing the Ising model [3,4]. This statistical model explains the probability of multi-neuron spike patterns solely on the basis of firing rates and correlations, assuming an otherwise minimally structured distribution. Its application to a variety of recordings has helped re-evaluate the importance of neural interactions in shaping the global activity [3,4]. In addition, due to the models minimal structure, the quality of the fits can be treated as an indicator of higher-order interactions in the activity [4].

We compare the Ising model fits in the same preparation over several recordings: before, during and after CNQX application. We find that, in addition to the changes in

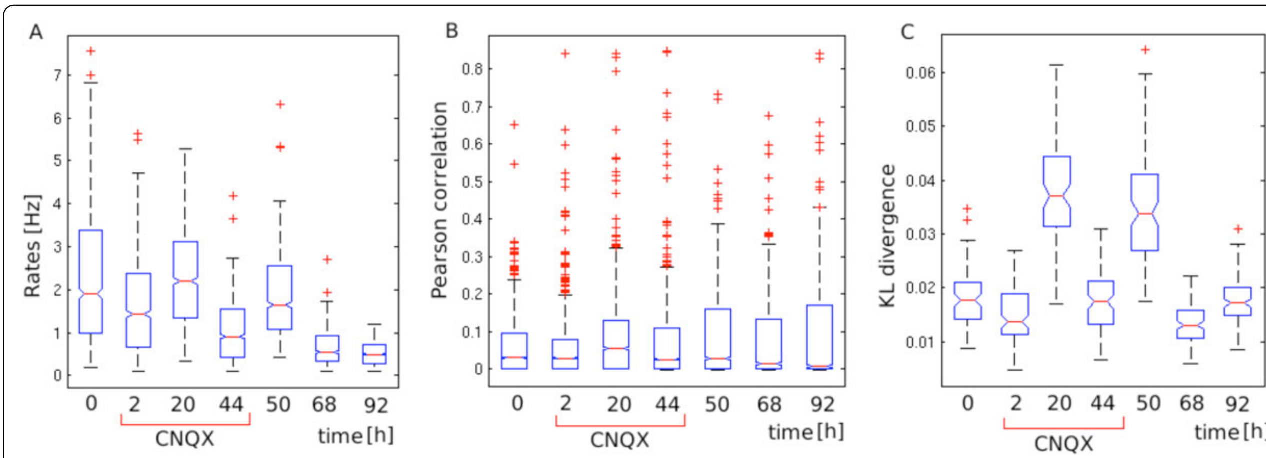

Figure 1 Boxplot comparisons of different measures across seven recordings from the experimental culture. **A** Firing rates; **B** Pearson correlation coefficient; **C** Kullback-Leibler divergence between the distributions of patterns predicted by the Ising model and the distributions of patterns observed in the data.

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firing rates and correlations, also the quality of the fits changes significantly across recordings (Figure 1). However, while firing rates and correlations to not appear to stabilize to a baseline level, the quality of the model fit does (Figure 1). Altogether this indicates that changes to first and second order statistics cannot explain the homeostatic changes in activity; and that higher order interactions might be a significant component of homeostatic compensation. Whether homeostatic maintenance of a complex higher-order dynamics is an effect of interplay of simple mechanisms or a global homeostatic set-point remains to be investigated.

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References

1. Turrigiano G: **Too Many Cooks? Intrinsic and Synaptic Homeostatic Mechanisms in Cortical Circuit Refinement.** *Annu Rev Neuroscience* 2011, **34**:89-103.
2. Berdondini L, Imfeld K, Maccione A, Tedesco M, Neukom S, Koudelka-Hep M, Martinoia S: **Active pixel sensor array for high spatio-temporal resolution electrophysiological recordings from single cell to large scale neuronal networks.** *Lab Chip* 2009, **9**:2644-2651.
3. Schneidman E, Bialek W: **Ising models for networks of real neurons.** *Nature* 2006, **440**:1007-1012.
4. Ohiorhenuan IE, Mechler F, Purpura KP, Schmid AM, Hu Q, Victor JD: **Sparse coding and high-order correlations in fine-scale cortical networks.** *Nature* 2010, , **466**: 617-621.

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