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Studying the precision of temporal neural code: some limitations of spike train distances

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Since the introduction of a family of cost-based distances between spike trains by Victor and Purpura [1,2], spike train distances are widely used to study the precision of the temporal coding of neurons (see [3] for a review). Subsequently, other distances that act on convoluted spike trains have been proposed [4,5]. All of these distances involve the choice of a parameter determining the time scale at which the spike trains are compared. In general, the extent of the stimulus-specific clustering manifest in the distances between spike trains of a neuron firing in response to a set of trials of different stimuli is used to quantify the mutual information between the stimuli and the spike trains in dependence of the respective parameter. The time scale for which the maximum mutual information is obtained serves as an indicator about the precision of the temporal coding.

Here we discuss limitations of the use of spike train distances as well as principal shortcomings of the mutual information maximization procedure for the study of neural coding. The implementation of this whole procedure relies on some initial implicit assumptions about the actual neural code: the single neuron is assumed as the coding unit, the stimuli are conjectured to be the ones encoded by this neuron and the existence of an optimum temporal precision is taken for granted. However, since the calculation of the spike train distances and the maximization of mutual information are always possible and will always provide an optimal time scale even if these assumptions are incompatible with the actual code, naïve applications can lead to wrong conclusions.

To demonstrate the dangers of such implicit assumptions, we simulate examples in which the relation between stimuli and spike trains is known and study the performance of the techniques recovering the actual coding when the assumptions above are not justifiable. In particular, we consider the non-existence of a unique time scale simulating spike trains with bimodal or non-stationary firing rates. For this case we also compare the use of the time scale parametric distances with a scale adaptive distance [6]. Furthermore we show that misinterpretations can be caused by concluding a precision for a temporal code from neurons which in fact participate in a population coding. We also show that false conclusions can be drawn due to an incorrect identification of the stimulus relevant for the neural code.

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References
1. Victor JD, Purpura KP: **Nature and precision of temporal coding in visual cortex: A metric-space analysis.** *J Neurophysiol* 1996, **76:**1310-1326.
2. Victor JD, Purpura KP: **Metric-space analysis of spike trains: theory, algorithms and applications.** *Network* 1997, **8:**127-164.

3. Victor JD: **Spike train metrics.** *Curr Opin Neurobiol* 2005, **15:**585-592.
4. Schreiber S, Fellous JM, Whitmer D, Tiesinga P, Sejnowski TJ: **A new correlation-based measure of spike timing reliability.** *Neurocomputing* 2003, **52:**925-931.
5. van Rossum MCW: **A novel spike distance.** *Neural Computation* 2001, **13:**751-763.
6. Kreuz T, Haas JS, Morelli A, Abarbanel HDI, Politi A: **Measuring spike train synchrony.** *J Neurosci Methods* 2007, **165:**151-161.