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Bin-width selected for Brain-Machine Interfaces optimizes rate decoding

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Introduction

The wide interest in spike-train variability stems mainly from its limiting effect on the accuracy of neural coding and thus the reliability of behavioral responses [1,2]. Consequently, most investigations have focused on determining spike-train variability under identical conditions. However, during natural and novel conditions, spike-train variability reflects also the variability of the underlying rate. Under the assumption of rate-coding, it is this variability that can reflect the changes in the encoded signals and thus is of major interest for neural decoding in general and Brain Machine Interfaces (BMI) in particular.

During planning and execution of reaching movements, the firing rate of cortical motor neurons encodes multiple motor, sensory, and cognitive variables [3-5]. In this context, rate variability is considered the signal, while only the inherent variability of the spike trains, beyond rate variability, is considered the noise (i.e., 'neural noise'). These two components can be estimated from the recorded neural activity under the assumption that the spike trains are realizations of doubly stochastic Poisson processes – the simplest point processes that can encode stochastic signals [6]. Analyzing spike-trains recorded during BMI experiments, we have demonstrated that the fraction of the variance that is attributed to rate-variability is higher when the monkeys operate the BMI [6].

Here we focus on investigating the signal-to-noise ratio (SNR) in the neural activity, i.e., the ratio between rate-variability and noise-variability – the two components of spike-train variability – and how it varies with the bin-width (BW). Theoretical analysis indicates that the SNR should increase with the BW; increasing linearly for short BWs before saturating for long BWs. Since increasing BW has an adverse effect on the update rate, we suggest that the ratio SNR/BW captures the trade-off between SNR and update rate. Furthermore, this ratio is related to the capacity of the neural channel under different assumptions.

Analysis of neural spike-trains recorded during BMI experiments from different cortical areas indicates that the SNR indeed increases with the BW as expected, except for very short BWs. At very short BWs the SNR increases faster than expected, possibility due to dead-time effects or other deviations from the theoretical assumption. Thus the SNR/BW curves exhibit a broad peak, and it is possible to define an optimal BW that maximizes the SNR/BW. Interestingly, for the mean SNR/BW, the optimal BW is around 100 msec – the BW that was selected by trial and error for decoding the neural activity in the BMI. Within the context of the theoretical analysis this can be interpreted as optimizing the trade-off between the SNR and update rate, or alternatively as maximizing the capacity of the neural channel.

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References

1. Warzech AK, Egelhaaf M: **Variability in Spike trains During Constant and Dynamic Stimulation.** *Science* 1999, **283:**1927-1030.
2. Shadlen MN, Newsome WT: **The variable discharge of cortical neurons: implications for connectivity, computation, and information coding.** *J Neurosci* 1998, **18:**3870-3898.
3. Georgopoulos AP: **Neural aspects of cognitive motor control.** *Curr Opin Neurobiol* 2000, **10:**238-241.
4. Johnson MTV, Mason CR, Ebner TJ: **Central processes for the multiparametric control of arm movements in primates.** *Curr Opin Neurobiol* 2001, **11:**684-688.
5. Scott SH: **The role of primary motor cortex in goal directed movements: insights from neurophysiological studies on non-human primates.** *Curr Opin Neurobiol* 2003, **13:**671-677.
6. Zacksenhouse M, Lebedev MA, Carmena JM, O'Doherty JE, Henriquez CS, Nicolelis MAL: **Cortical modulations increase during early sessions with Brain-Machine Interface.** *PLoS-ONE* 2007, **2(7):**e619.