AB001. How to optimize the visual contrast response of cortical neurons

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Background: In the visual system, one of the most explored neural behaviors is the response of cells to changes in visual contrast. This neural response to visual contrast, also known as the contrast response function (CRF), can be fitted with the Naka-Rushton equation (NRE). Assessing the CRF of many neurons at the same time is critical to establishing functional visual properties. However, maximizing the performance of neurons to fit the NRE, while minimizing their time acquisitions is a challenge. We present a method to accurately obtain reliable NRE fits from experimental data, that ensure a reasonable time of record acquisition.

Methods: We simulated CRF of cortical neurons with a toy model based on the response of Poisson spike trains to varied levels of contrasts. We first tested whether mean values or the whole set of contrast responses fit better the NRE. Then, we analyzed what were the boundaries to optimize the fit of the NRE, and after we explore the consequences of fitting the NRE with single- or multi-units. With these outcomes, we varied experimental parameters such as the number of trials, number of input contrasts and length of time acquisition to calculate the errors of fitting CRFs. Those data sets that maximize the CRF fit but minimize the time of recording were selected. The selected data set was then evaluated in visual cortical neurons of anesthetized cats from areas 17, 18 and 21a.

Results: First, we found that is always better to fit the NRE with mean values rather than the whole set of points. Then, we noticed that either removing or imposing loose boundaries to the CRF parameters lead to an increase in the performance of the NRE fit. Afterward, we found that single units (SU) or assume multi-unit formed of several SUs (>30) adjusted considerably better the NRE fit. Finally, the experiments showed that specific sets of patterns (number of trials, number of input contrasts and length of time acquisition) satisfied our two constraints: minimize the error of the NRE fit while maximizing the acquisition time of recording. The most characteristic pattern was the one with 6 points, 15 repetitions and 1 second of duration. However, cortical areas varied in the representation of the patterns.

Conclusions: Theoretical simulations of many different sets of patterns and their following experimental validation suggest strongly that a particular set of patterns can satisfy the imposed constraints. With this approach, we provided a tool that allows an optimal design of stimuli to assess the CRF of large neuronal populations and guarantees the finest fit for each unit analyzed.

Keywords: Contrast response function (CRF); Naka-Rushton function; optimization neural responses

doi: 10.21037/aes.2019.AB001

Cite this abstract as: Demers M, Cortes N, Ady V, Casanova C. How to optimize the visual contrast response of cortical neurons. Ann Eye Sci 2019;4:AB001.