

AB052. A standardized quantification of the visual contrast response function

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Background: All neurons of the visual system exhibit response to differences in luminance. This neural response to visual contrast, also known as the contrast response function (CRF), follows a characteristic sigmoid shape that can be fitted with the Naka-Rushton equation. Four parameters define the CRF, and they are often used in different visual research disciplines, since they describe selective variations of neural responses. As novel technologies have grown, the capacity to record thousands of neurons simultaneously brings new challenges: processing and robustly analyzing larger amounts of data to maximize the outcomes of our experimental measurements. Nevertheless, current guidelines to fit neural activity based on the Naka-Rushton equation have been poorly discussed in depth. In this study, we explore several methods of boundary-setting and least-square curve-fitting for the CRF in order to avoid the pitfalls of blind curve-fitting. Furthermore, we intend to provide recommendations for experimenters to better prepare a solid quantification of CRF parameters that also minimize the time of the data acquisition. For this purpose, we have created a simplified theoretical model of spike-response dynamics, in which the firing rate of neurons is generated by a Poisson process. The spike trains generated by the theoretical model depending on visual contrast intensities were then fitted with the Naka-Rushton equation. This allowed us to identify combinations of parameters that were more important to adjust before performing experiments, to optimize the precision and efficiency of curve fitting (e.g., boundaries of CRF parameters, number of trials, number of contrast tested, metric of contrast used and the effect of including multi-unit spikes into a single CRF, among others). Several goodness-of-fit methods were also examined in order to achieve ideal fits. With this approach, it is possible to anticipate the minimal requirements to gather and analyze data in a more efficient way in order to build stronger functional models.

Methods: Spike-trains were randomly generated following a Poisson distribution in order to draw both an underlying theoretical curve and an empirical one. Random noise was added to the fit to simulate empirical conditions. The correlation function was recreated on the simulated data and re-fit using the Naka-Rushton equation. The two curves were compared: the idea being to determine the most advantageous boundaries and conditions for the curve-fit to be optimal. Statistical analysis was performed on the data to determine those conditions for experiments. Experiments were then conducted to acquire data from mice and cats to verify the model.

Results: Results were obtained successfully and a model was proposed to assess the goodness of the fit of the contrast response function. Various parameters and their influence of the model were tested. Other similar models were proposed and their performance was assessed and compared to the previous ones. The fit was optimized to give semi-strict guidelines for scientists to follow in order to maximize their efficiency while obtaining the contrast tuning of a neuron.

Conclusions: The aim of the study was to assess the optimal testing parameters of the neuronal response to visual gratings with various luminance, also called the CRF. As technology gets more powerful and potent, one must make choices when experimenting. With a strong model, robust boundaries, and strong experimental conditioning, the best fit to a function can lead to more efficient analysis and stronger cognitive models.

Keywords: Contrast response function analysis neuron

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