Literature Review for Maria Geffen Lab

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The purpose of this document is to detail possible computational projects related to auditory coding.

1 Biophysical Mechanism for Gain Control

Many of Maria Geffen's papers involve using a linear-non-linear model (LN model) to fit firing rate data as a function of a convolution of the neural receptive field with the input signal (see for example [3]). This type of model fitting is of interest because gain control of firing rates appears to be a hallmark of many neural coding problems.

In particular, gain control depends on the degree of spatiotemporal contrast of the input stimulus. In [5], the authors find that if the standard deviation in stimulus spatiotemporal contrast, the neurons have a relatively high gain, and when the standard deviation of the input stimulus is high, the neurons have a relatively low gain.

The biophyical mechanism for this gain control is unknown, although several hypotheses exist. The authors of [5] cite two papers. The first paper uses a modified LN model. The start with a classic LN model, where the receptive field is convolved with the local stimulus contrast in time, then this scalar is input into a rectifying nonlinearity to estimate the firing rate of the population. The modification before and after the rectifying nonlinearty: a simple ciruit is added before the rectification, which include a conductance g. This conductance depends on a pool of additional neurons where the aggregate behavior affects the conductance g depending on an additional parameter k. Aspects of these choices are for mathematical convenience with no physiological basis. However, the authors are successful at producing a shunting inhibition [2].

The second paper suggests that given synaptic balance, the rate of inhibitory and excitatory inputs contributes to gain control [1]. They demonstrate using an integrate and fire model the type of divisive change in firing rate as a function of input current that are observed in experiments.

Naively, the second paper may be a better candidate for modeling, as the biophysical basis is more realistic. In addition, balanced networks are an active area of mathematical research with a wealth of resources available to analyze such networks. Combined with [4], there are enough raw materials to begin building a model to describe gain control.

2 Mean Field Description of the Auditory Cortex

References

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[3] Ryan G Natan, Isaac M Carruthers, Laetitia Mwilambwe-Tshilobo, and Maria N Geffen. Gain control in the auditory cortex evoked by changing temporal correlation of sounds. *Cerebral Cortex*, 27(3):2385–2402, 2016.

[4] Ryan G Natan, Winnie Rao, and Maria Neimark Geffen. Cortical interneurons ensure maintenance of frequency tuning following adaptation. *bioRxiv*, page 172338, 2017.

[5] Neil C Rabinowitz, Ben DB Willmore, Jan WH Schnupp, and Andrew J King. Contrast gain control in auditory cortex. *Neuron*, 70(6):1178–1191, 2011.