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Poster presentation

How is stimulus processing of the lateral geniculate nucleus derived from its input(s)?

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LGN neurons can respond with extreme precision to a variety of temporally varying stimuli [1]. This precision requires non-linear processing of the stimulus and therefore cannot be described by standard linear (or linear-non-linear, LN) models. Rather, in previous work, we have found that precision arises through the interplay of an excitatory receptive field and a similarly tuned – but delayed – suppressive receptive field, allowing for fine time scales in the LGN response to arise in the brief window where excitation exceeds the suppression [2]. However, it is not clear whether such non-linear interaction arises in the retina, at the retinogeniculate synapse itself or involves other secondary LGN inputs.

To investigate this, we applied a newly developed a Generalized Non-Linear Modeling (GNLM) framework to data involving the simultaneous recording of LGN neurons and their predominant retinal ganglion cell (RGC) input. This framework uses efficient maximum-likelihood optimization [3], adapted to include nested non-linear terms [2,4]. Using this novel approach, we simultaneously optimize the shape of postsynaptic currents resulting from RGC stimulation along with other non-linear excitatory and inhibitory elements tuned to the visual stimulus, based on the observed RGC and LGN spike trains alone. We also can directly characterize the non-linear elements in the RGC.

We found that while there were subtle non-linear elements in the RGC response, they were amplified in that of the LGN. Consistent with previous reports [5], summation with a threshold explains a large part of the increased sparseness of LGN responses relative to those of the input RGC. However, an additional opposite-sign suppressive term was also present, possibly contributing to the push-pull nature of the LGN response observed in intracellular recordings [6]. In many cases, we also detected additional non-linear excitatory inputs, possibly resulting from other RGC inputs. Interestingly, such additional terms were much more sensitive to contrast than the dominant input, possible resulting in the well-known contrast gain control effects, though present both at the level of the retina and LGN.

Thus, the GNLM modeling methods reveal how non-linear computation performed is performed the RG synapse, and allows for more general characterization of non-linear computation throughout the visual pathway.

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