Spatial extent of inputs to primate ganglion cells in natural viewing conditions

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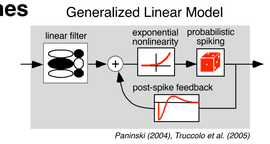
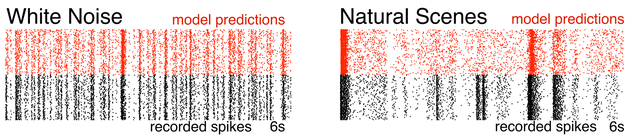
Background

Modeling responses to natural scenes

Responses of primate retinal ganglion cells (RGCs) to natural scenes are poorly predicted by commonly used psuedo-linear models such as generalized linear models[1].



Paninski (2004), Truccolo et al. (2005)



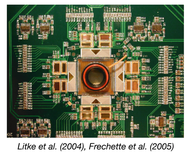
Extra-classical receptive field effects

Previous studies have shown that under certain conditions, RGCs in various species can recieve peripheral input from outside their classical receptive fields[2-6].

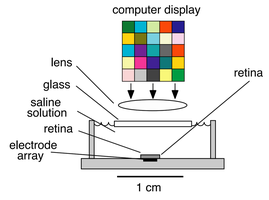
How do peripheral stimuli influence responses of primate RGCs in natural viewing conditions?

Methods

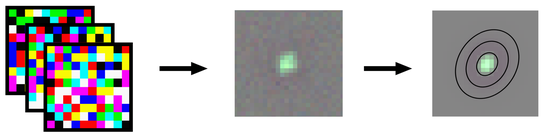
Large-scale multielectrode recordings were performed in peripheral macaque retina *ex vivo*.



Litke et al. (2004), Frechette et al. (2005)

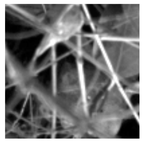


ON and OFF parasol cells were identified, and their receptive fields were measured by reverse correlation with a white noise stimulus and fit with a Gaussian envelope with standard deviation σ, shown on right with contours of 2σ, 4σ, and 6σ.

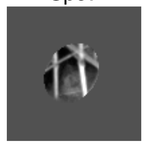


Natural scenes, consisting of images from the van Hateren database[7] with fixational eye movements simulated by Brownian motion[8], were presented in the three conditions.

Full Field



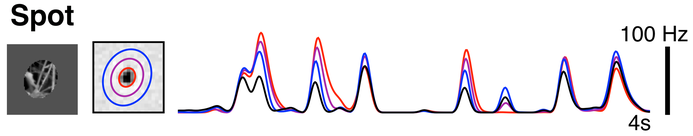
Spot



Gap

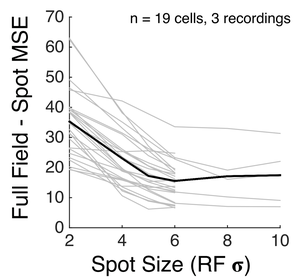
What effect does peripheral stimulation have on RGC responses under natural viewing conditions?

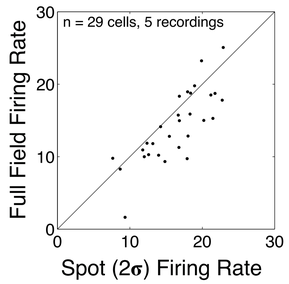
Spot



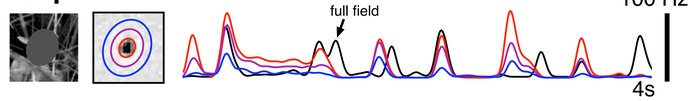
The response to the spot stimulus (above) had a time course **similar to the response to the full field** stimulus.

Consistent with previous findings, the periphery had a **mostly suppressive effect**.



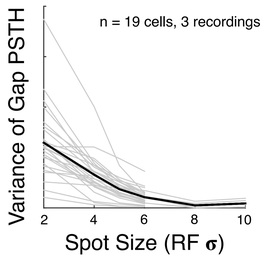


Gap



The response to the gap stimulus (above) had a time course **different than the response to the full field** stimulus.

In addition, the response to the gap stimulus did not disappear until greater than 6σ, **well outside the classical receptive field**.



Peripheral stimulation far outside the classical RF had a significant effect during natural viewing conditions.

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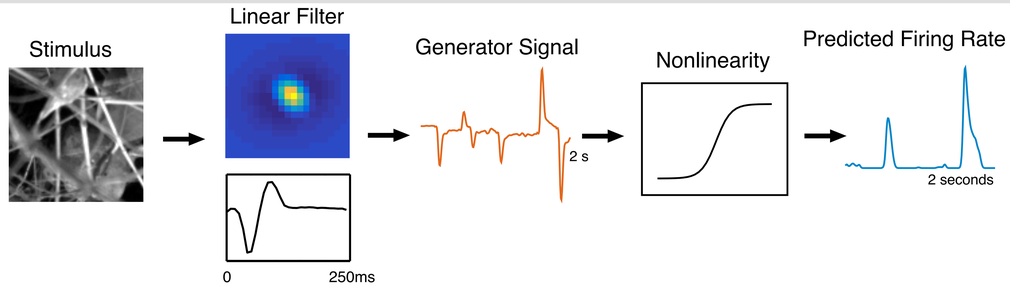
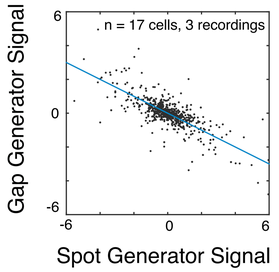
Can we understand these responses with linear-nonlinear models?

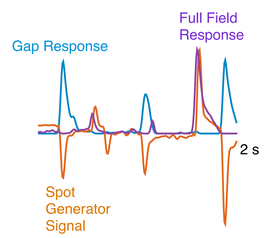


The observed effects can be explained by the fact that spatial correlations in natural scenes introduce anticorrelation in the gap and spot generator signals.

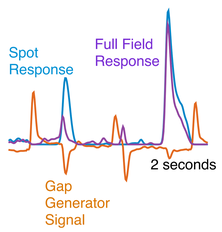


Since the spot generator signal tends to be stronger, gap response events tend to not be present during full field stimulation, while spot events tend to be reduced.

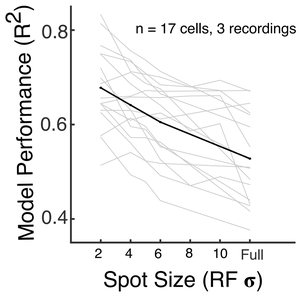
Gap Response vs Spot Generator Signal

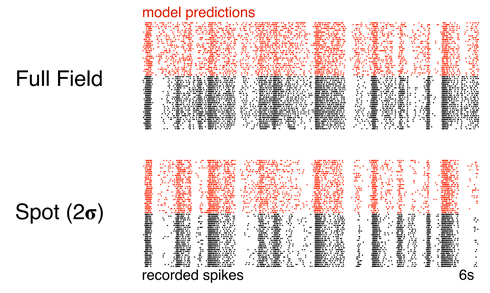


Spot Response vs Gap Generator Signal



Surprisingly, this **model was more accurate for small spot sizes**. The model captured responses to stimuli restricted to the receptive field center more accurately than responses to stimuli in the surround and periphery.





While the observations can be qualitatively explained by linear summation of the spot and gap generator signals, a full linear-nonlinear model did not accurately capture responses outside the RF center.

Future work will focus on developing models that more effectively incorporate the surround and peripheral input.

Acknowledgements

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