Multi-Electrode recording for classification of retinal ganglion cells for bionic vision

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Introduction

Recent work in the Tuebingen Experimental Retinal Prosthetics group has shown that different ganglion cell types can be characterized by their electrical input filters using Spike Triggered Averaging (STA). ON and OFF cells are ganglion cell types whose electrical and visual input filters are correlated [sekhar]. We plan to go one step further and test this method on additional ganglion cell types by using a more diverse visual stimulation set by which we can detect orientation selective and color sensitive pathways.

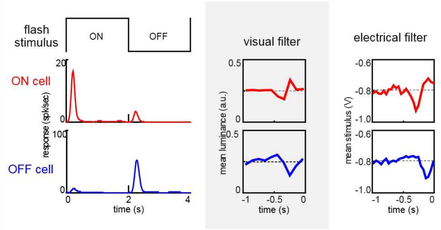

Fig 1: Visual and electrical input filters correlate. Visual and electrical input filters of example ON and OFF cells. It is shown there could be some similarity between visual and electrical input filters. Furthermore, the input filters of neurons could vary depending on the cell type.

Methods

In this study we used the data recorded from seven dark adapted retinas of six adult wild type mice. A 60 channel microelectrode array in contact with the ganglion cell side of the retina was used to record the spiking neural activity of RGCs. The visual stimulation set was adapted from Baden et al. (Nature 2016), including moving bars, contrast and temporal frequency chirps, blue-green color flashes, and spatiotemporal white noise. In order to extract electrical input filters, a sequence of filtered and interpolated Gaussian white noise voltage steps was used. Similar to Baden et al. we used sparse principle component analysis (sPCA) to extract response features to the visual stimuli.
After projecting data into a lower-dimensional space, we assigned each neuron to one of the 75 clusters reported by Baden et al. This assignment is done by finding the highest correlation between our neuron's response and the clustered data provided by Baden et al.

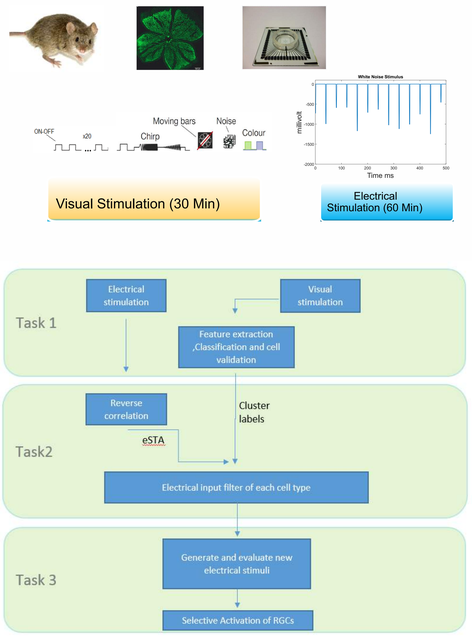

Fig 2: Project workflow. Our proposed method uses both visual and electrical stimulations to find the electrical input filters of different RGCs types. The extracted input filters could be used in designing new electrical stimuli for selective activation of RGC types.

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Results

From one retina, we recorded visual responses from 155 RGCs. These responses mapped onto about half of the previously described clusters. Despite convolving our spike trains with a filter to create pseudo-calcium traces for correlation with the previous dataset, many of our responses were significantly more transient than previously reported. ON and OFF cells had different electrical input filters as we have previously reported.

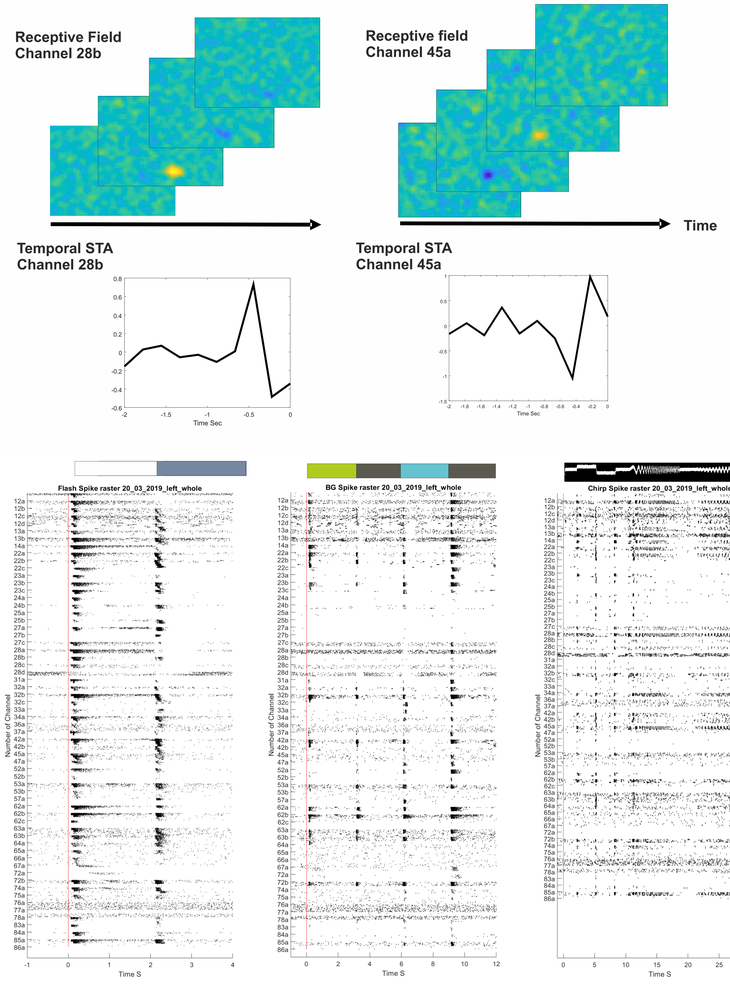

Fig 3: STA and spike raster of sample neurons. The spatial and temporal STA of two sample ON and OFF neurons are shown. In the spike raster plot, the activity of these two neurons(28b, 45a) in response to different visual stimuli is demonstrated.

References

[1] Baden, T. et al. "The functional diversity of retinal ganglion cells in the mouse." Nature 529.7586 (2016): 345.
[2] Sekhar, S., et al. "Correspondence between visual and electrical input filters of ON and OFF mouse retinal ganglion cells." Journal of Neural Engineering 14.4 (2017): 046017.

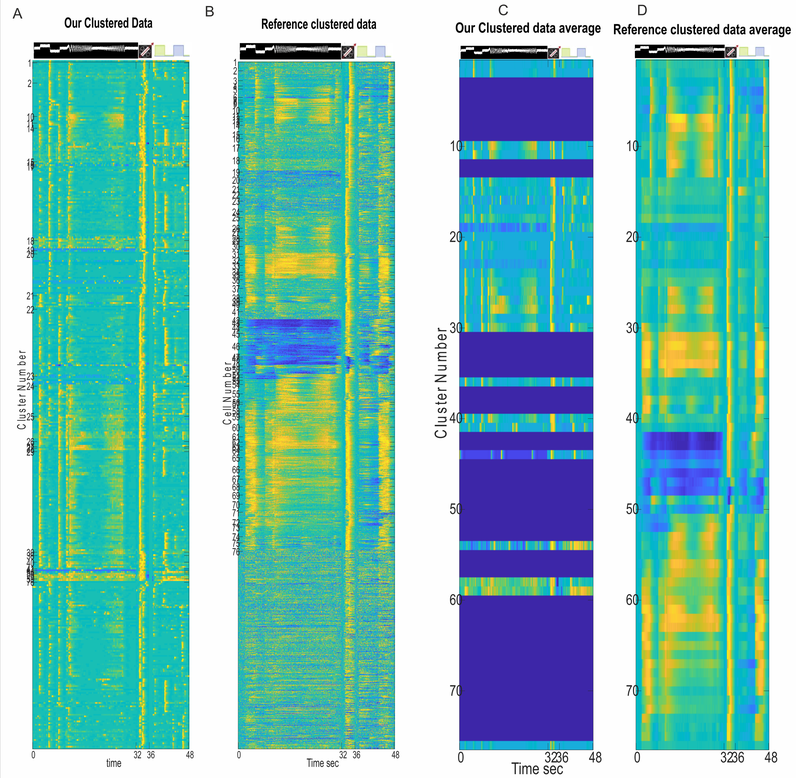

Fig 4: Comparing the results of our clustered data with reference data. The left two plots show the activity of single cells after clustering them. A) our data clustered into 76 clusters consisted of 410 neurons. B) shows the reference clustered data include 11000 neurons. The right two plots show average neural activity for each cluster. C) average of neural activity of 76 different clusters recorded from 410 cells. D) Average of clustered activity of reference data recorded from 11000 neurons. Dark blue area shows the clusters that are not found in our data set.

Conclusions

Adaptation of the Baden et al. methodology for spike trains instead of calcium recordings was partially successful. For better classification results, new cluster definitions should be derived from a large data set.

We hypothesized that different types of RGCs can be selectively activated using different electrical input filters.To test this hypothesis, our approach is to classify different types of RGCs using a rich set of visual stimuli and then try to detect the electrical input filter properties of each cell type. Electrical input filters do appear to vary with RGC type, but more precise cluster definitions are needed to refine this result.

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