Sophie Sackstein

Independent Small Group Discussion Write-up

1. What was the motivation for this study? (e.g. big picture questions motivating experiments, prior work motivating experiments, etc)

Two powerful inhibitory networks in the visual thalamus converge on relay cells and influence every spike that travels downstream. Local interneurons provide feedforward inhibition to relay cells and each other. The thalamic reticular nucleus receives input from relay cells and inhibits them in return. To understand this researchers record from inhibitory cells directly and monitor the inhibition they generate in relay cels during vision. Exploring the integration of On and Off pathways in the LGN. Relay cells have receptive fields made of concentric On and Off subregions with a push-pull layout of excitation and inhibition; e.g. where bright stimuli excite, dark inhibit. Retina supplies the push (excitation). We propose that the pull (inhibition to stimuli of the reverse sign) comes from local interneurons with receptive fields like those of their postsynaptic partners, but with the opposite preference for stimulus polarity. It is difficult, however, to map connectivity between and On and OFF cells because these cannot be anatomically distinguished in most mammals.

The article describes two hypotheses- the searchlight hypothesis and the thermostat hypothesis.The searchlight hypothesis assumes that neurons in the TRN are able to exert a focal influence on the LGN, whereas the thermostat hypothesis a global effect.

The thermostat hypothesis was the longstanding ideal- since analysis and experimental methods hadn't proven otherwise. But this article explores the alternative hypothesis- proposing that despite previously beliefs cells of the PGN are, in fact, highly selective for individual features.

2. List the key methodological details (species, preparation, recording/ anatomical techniques, data analysis methods)

White noise stimuli were used for the experiment. Standard methods of reverse correlation and the resulting spike-triggered averages (STAs) Used statistical methods used in fMRI to localize task-related changes, resulting mapping were called “footprints”. Eyes were prepared with atropine sulfate and contact lenses, then craniotomy allowed researchers to view the thalamus. The multi-electrode array mapped to the retinotopic positions in the thalamus and were arranged in a arranged in either a concentric or linear configuration. To identify cells, they recorded LGn and PGN and located the electrode tracks and used electrolytic lesions in Nissl-stained sections of the PGN. Using reverse correlation the spatio–temporal receptive field was computed with the STA of the stimulus. By subsiding temporal dimension, they found a clear spatial map of significant pixels, referred to as “footprint” of a receptive field through out the article.

3. For each figure, describe the important points including how the authors interpret the findings and what the findings may actually show.

Figure 1

1a) Figure 1a describes the pathways of the PGN and LGN. The LGN receives information directly from the ascending retinal ganglion cells via the optic tract and from the reticular activating system. Neurons of the LGN send their axons through the optic radiation, a direct pathway to the primary visual cortex. In addition, the LGN receives many strong feedback connections from the primary visual cortex. The axons that leave the LGN go to V1 visual cortex. Both the magnocellular layers 1–2 and the parvocellular layers 3–6 send their axons to layer 4 in V1. Axons from layer 6 of visual cortex send information back to the LGN.

1b) The layers of the LGN are marked with gray and the PGN is marked with blue; red lines

indicate retinotopic position. The dashed box is a multi-electrode's representation of a single retinotopic location.

1c) This shows a nissl-stained coronal section, aforementioned in the methods section, the arrow indicates a recording site.

1d) The PGN is the blue recoding and the relay cell in the LGN is shown in black. The red highlighting has shown at an expanded time scale, displayed below the figure.

1e) This shows the thermostat hypothesis. This hypothesis posits that uniformly thalamic activity is regulated through negative feedback (inhibition shown in the diagram).

1f) The Searchlight hypothesis posits a role in focal attentional modulation through positive feedback, this is shown by the rebound excitation. Rebound excitation is when following hyperpolarizing inputs, many neurons respond with an increase in firing rate.

Figure 2

All these show the spatio-temporal receptive fields estimated by reverse correlation of spikes to Gaussian white noise in two-dimensional spatial maps.

2a) Figure 2a shows the on and off excitation of a monocular cell in the LGN. This inhibitory feedback is topographically organized like it is the auditory and somatosensory parts of the LGN. The LGN is more closely representative of the retina than the PGN is.

2b) Figure 2a shows the on and off excitation of a binocular cell in the PGN. neurons in the PGN are mostly binocular and are thought to be selective for complex visual features

2c) Contrary to the LGN, receptive fields in the PGN varied widely in shape and complexity. About 26% of reticular cells in the data were strongly binocular. These spike-triggered averages show a sequence of contour plots that show the temporal evolution of the response. These show the contralateral and ipsilateral activation patterns of PGN binocular cells (with light and dark activation, like before)

2d) This shows the reverse-correlation analysis- also known as a bootstrap resampling by randomly shifting spike trains, a method commonly used in fMRI analysis. This shows STA and responding Z-score statistical analyses.

2e) Figure 2e shows the scores for two example stixels, the stiles were determined as significant on and off stixels using the false discovery rate test on all the q-values, at a significance level of 0.01.

2f) This shows a time-collapsed spatial map of all significant stixels, mentioned above, form the "footprint" - this will determine the size of the receptive field.

Figure 3

The sizes the receptive field in the LGN and the PGN are similar, indicating that functionality of picking a particular stimuli might not be as unilateral as previously believed and the STA show that there is communication between the LNG and the PGN.

3a) Spatial receptive fields and footprints of the LGN relay cells are ranked by their eccentricities in this figure. These receptive fields and corresponding footprints of cells in the LGN and PGN have different eccentricities.

3b) This shows the PGN receptive fields and footprints of the PGN at matching eccentricities. This shows the intensity and correspondence of inputs, but looking at the off-center cells it seems to not overlap that much, not as much with less intense stimuli.

Figure 4

4a) This shows scatter plots with footprint sizes as a function of eccentricity for the LGN and PGN, on and off, dominant, and polarities. The sizes of the receptive fields of PGN and similar to sizes of the LGN are similar across all eccentricity. The
anomaly was the pattern for increased relative increase in size of fields in the PGN in the far periphery.

4b) The anomaly described above was true for the footprint of the cell in the LGN and PGN. The square are LGN and circular PGN symbols mark the mean, the wide pale bars show the quartiles, and the lines indicate extreme values.

4c) Footprint sizes in PGN for ordinate as compared as LGN for abscissa across eccentricities. The line of unity slope is in gray. The dominant footprints had an increase in field size given the eccentricity.

4. What is your assessment of the overall findings? Did the experimental data support the authors' interpretation? Why or why not?

The TRN involves complex visual processing and these result in different predictions about the relative spatial scales of receptive fields in the PGN and LGN. Moreover, this article assessed the predictive power of the receptive field and the information each component subunit conveyed. How do the response properties of neurons in the PGN compare with those of the LGN and cortex? In cat, most cortical cells that receive input from relay cells inherit key properties of the receptive field such as segregated On and Off subregions. Further, like relay cells, these cortical neurons can be simulated by simple computational models. In essence, knowledge of the spatiotemporal receptive field not only describes preferences for visual features but provides a basis to predict responses to novel stimuli. Many investigators have reported that neurons in the cat's PGN are often binocular and have overlapping On and Off responses. This may motivate research to explore feature selectivity in the reticular nucleus quantitatively and re-examine the searchlight hypothesis. Further, we observed that the spatial structure of receptive fields constructed from either the cardinal spikes of bursts or from tonic action potentials were similar. Thus, they used a mixture of both types of spikes for further analysis. This observation recalls work in LGN that used white noise to compare receptive fields formed with tonic spikes vs. bursts; both maps had the same shapes, with subregions in the bursts-triggered averages slightly stronger . Stimuli with strong spatial and temporal correlations (gratings, naturalistic patterns), however, seem to evoke bursts far more effectively than noise. For weaker stimuli there was less overlap as shown in figure 3, there is still activity in the cels showing important areas may not be activated.

5. Describe new insights that you gained from the small group discussion of this paper.

I found that the receptive field size was shown to be important for selectivity those helping to prove the searchlight hypothesis. Most footprints of reticular neurons were only slightly larger than those of relay cells at similar eccentricities and there was no apparent difference between receptive fields in the PGN vs. the LGN for either on or off footprint sizes For dominant polarity, the LGN's region corresponded to the receptive field center whereas for the PGN it was defined by pixels with the same polarity as the pixel with the largest significance value.

6. List all of your questions and/or points in the paper that you did not understand.

I don't understand how retinal receptive field size and eccentricity relate to one another and how they can thus prove the searchlight hypothesis. What cell is being represented in figure 2, is it multiple monocular cells, or a singular cell in the PGN?