Effects of Light Adaptation on Stimulus Encoding in Mouse Retinal Ganglion Cells

Retinal ganglion cells are the output cells of the retina and the first neuronal layer to encode visual stimuli with spikes. The cells are divided into two groups: ON type cells, which respond to increases in brightness, and OFF type cells, which respond to decreases in brightness. If the average light level of visual stimulation changes, the response characteristics of retinal ganglion cells also change. To investigate these adaptations, we stimulated isolated mouse retinas by projecting flickering light onto them and alternated between a dim and a bright flicker. We recorded the spikes of retinal ganglion cells with a multi-electrode array and then analysed the data to extract the stimulus-response relationship. For this, we analysed the average spike-eliciting stimulus of a cell ("spike-triggered average") and how the cell’s spike rate depended on stimulus strength. For both ON and OFF retinal ganglion cells, we found similar changes in response delay, while other temporal filtering properties and the cells’ sensitivity to stimulation changes in opposite directions. We found that, initially after the change in mean light intensity, the response of retinal ganglion cells to identical relative stimulus intensities changes dramatically. These change in the response behavior persisted when we employed a different stimulus that only changed the mean intensity in sub-regions of the stimulus field. Despite the fact that the temporal contrast was the same over the whole stimulus field, we found that those sub-regions where we increased the mean intensity contributed more to spike generation than the other sub-regions.

These finding supply a phenomenological overview for the light adaptation of the response characteristics of ganglion cells. Additionally, a thorough investigation of the adaptive differences between ON and OFF cells has been absent from the scientific literature up to this point. The differences between ON and OFF cells that we found show how the division of early visual information processing into ON and OFF retinal ganglion cells might increase the encoding efficiency over changing light levels.