Spatial integration in mouse retinal ganglion cells

Studying the convergence of neural signals can help us understand information processing in sensory circuits. In the retina, ganglion cells pool excitatory input in their dendritic trees from bipolar cell terminals. The bipolar cells form the spatial subunits of a ganglion cell’s receptive field center. It has long been suggested that subunit integration can be either linear or nonlinear, and different types of nonlinearities have been identified in a single-cell manner. However, a method that allows the measurement of such nonlinearities in population recordings is still missing. Here, under a classical open-loop design, we use a checkerboard-like light stimulus to infer the spatial integration properties of populations of ganglion cells. We do so by performing multielectrode array recordings of the mouse retina in vitro. By relating the stimulus to the ganglion cell responses, we develop ways to quantify nonlinearities in spatial integration. We mainly use the iso-response framework: we search for stimulus patterns that elicit the same response in ganglion cells. Additional to linear cells, we find ganglion cells with a variety of nonlinear integration profiles in the mouse retina. We show that ON and OFF ganglion cells have different spatial integration properties: while both populations show linear and nonlinear integration, the relative proportion of cells with linear integration is larger in the OFF population. Although we find threshold-quadratic nonlinearities for the majority of nonlinear ON cells, there are examples of threshold-linear nonlinearities for one class of ON direction selective cells. Using the stimulation and analysis protocol we have developed, one can now determine how different functional types of ganglion cells integrate subunit signals over space.