Spatial organization of large-scale concerted activity in primate retina

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All visual signals in the brain originate in the electrical activity of retinal ganglion cells (RGCs). Standard models implicitly assume that RGCs signal information independently of one another. However, several studies have demonstrated significant concerted activity in nearby pairs of RGCs which may fundamentally alter visual signals. Very little is known about the spatial structure of this concerted activity in large populations of RGCs, particularly in the primate retina.

We performed large-scale multi-electrode recordings of the electrical activity of several hundred ON and OFF parasol (magnocellular-projecting) RGCs in isolated peripheral macaque monkey retina. The regular mosaic organization of the recorded cells indicated that we recorded from nearly every cell of both types in a 4x8 degree region of the visual field. In the presence of steady, spatially uniform photopic illumination, pairs of RGCs fired synchronously (within 10 ms) several-fold more often than expected by chance, indicating significant network interactions. Synchrony declined with distance between cells, and was universal among nearby cells of the same type, indicating that it arises from local and highly stereotyped circuitry.

To probe the spatial structure and scale of network interactions, we measured the total number, contiguous spatial extent, and number of adjacencies in the collection of cells firing within each 10 ms time bin. To test whether concerted firing can be explained by known interactions between immediate neighbors in the mosaic, we used a maximum entropy approach borrowed from statistical mechanics to predict the above measurements based purely on measured pairwise correlations between neighboring cells. The predictions of this nearest-neighbor Ising model accurately reproduced the data, although systematic departures were evident in larger populations indicative of non-local interactions. In summary, the spatial structure of spontaneous activity in parasol cells of primate retina can be understood largely on the basis of single cell activity and neighbor interactions.

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