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It is well known that retinal ganglion cell response properties vary with changes in ambient light [1]. For example, a cell that behaves as an ON cell at one luminance level might behave as an OFF cell at another [1,2]. However, the consequences of these changes for information processing in the retina are still largely unknown. Here, we investigated how retinal ganglion cell response type changes due to different ambient luminance levels are related to stimulus information carried by these cells.

We used multi electrode arrays to record spiking activity from a total of 86 ganglion cells of two isolated mouse retinas during visual stimulation. Our visual stimuli consisted of homogeneous contrast steps of positive and negative contrast at different ambient light levels, covering the scotopic (dark) to mesopic (bright) regimes.

To quantify information carried by the ganglion cell responses, we first applied temporal non-negative matrix factorization (temporal NMF) to decompose each retinal ganglion cell's spike trains into a set of trial-independent non-negative temporal firing patterns and trial-dependent non-negative activation coefficients that represent the strength of temporal firing profiles within a given trial. This factorization yielded a robust low-dimensional representation of the neural responses that captures efficiently a ganglion cell's temporal information [3]. We then decoded stimuli from this low-dimensional representation using multi class linear discriminant analysis (LDA) and used cross-validated decoding performance to estimate mutual information between stimuli and spike trains.

Confirming earlier studies [1], we found that a significant number of retinal ganglion cells changed their response type when the ambient light level changed from scotopic to mesopic. Our quantification of stimulus information showed that ganglion cells that kept their response type carried significantly more stimulus information than ganglion cells that changed their response type from scotopic to mesopic vision. Moreover, we found that ganglion cells that clearly behave as ON or OFF cells in at least one ambient light level carried significantly more information than cells without a clear type in any of the ambient light levels (Fig 1).

Our results suggest that ambient luminance dependent response type changes cannot be attributed to efficient coding at the single-cell level but do not exclude the possibility that these type changes aid population codes.

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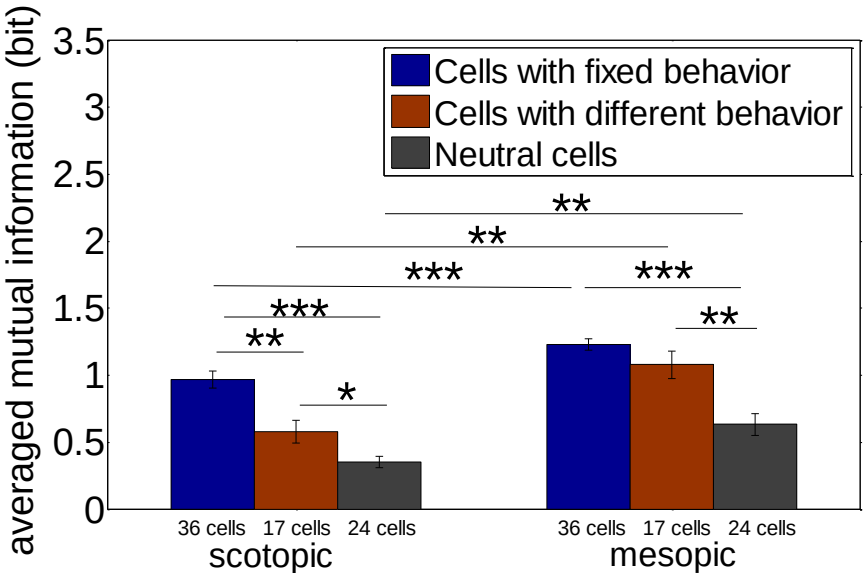

Figure 1. Information carried by retinal ganglion cells with different types. Comparison of stimulus information encoded by cells with fixed response type (either ON or OFF) with stimulus information encoded by cells that have an ambient luminance dependent or no clear type in scotopic and mesopic vision.