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Contrast versus luminance in retina and visual cortex

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Abstract:

The traditional view is that visual cortex is concerned with contrast and discounts changes in background luminance as compared with retina. We studied responses of neurons in retina and primary visual cortex (V1) of mouse to stimuli including moving gratings and optic flows built from either dark or light dots or short line segments (Dyballa et al *PNAS* 2018). Stimuli subtending ~60° x 40° were presented for 1.25 sec separated by 0.75 sec mid-gray screens. We asked whether average luminance matters when comparing retinal with cortical responses.

Two interleaved stimulus sets were identical except for the background. In one, the flow stimuli background was the mid-gray of the inter-stimulus interval (equal background, *eqbg*), leading to a change of 9-10% in the space-average luminance. In the other, the space-average luminance of the entire stimulus field was adjusted to a constant (equal luminance, *eqlum*) within 0.5%; i.e., the background was slightly lightened when the dots in the flow were dark, and darkened when the dots were bright.

Most cortical cells appeared to respond similarly to the two stimulus sets, as if stimulus structure mattered but not the background change, while the responses of most retinal ganglion cells appeared to differ between the two conditions. Machine learning algorithms confirmed this quantitatively. A manifold embedding of neurons to the two stimulus sets was constructed using diffusion maps. In this manifold, the responses of the same cell to *eqlum* and *eqbg* stimuli were significantly closer to one another for V1 rather than for the retina. Geometrically, the median ratio of the distance between the responses of each cell to the two stimulus sets as compared to the distance to the closest cell on the manifold was 3.5 for V1 compared to 12.7 for retina. Topologically, the fraction of cells for which the responses of the same cell to the two stimulus sets were connected in the diffusion map datagraph was 53% for V1 but only 9% for retina; when retina and cortex were co-embedded in the manifold, these fractions were 44% and 6%.

While retina and cortex differ on average, it will be intriguing to determine whether particular classes of retinal cells behave more like V1 neurons, and vice versa.

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