A new view of receptive field structure of midget ganglion cells

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The receptive field centers of midget ganglion cells of the parvocellular pathway are assumed to derive from a single cone. The input to the surround is controversial; cone-specific or mixed-cone surround models have been suggested. In a new approach we measure spatial frequency (SF) tuning curves to luminance, red-green chromatic, or L- and M-cone isolating gratings. Predictions for the tuning curves for this grating set are different for the two models. Which model can predict responses for all four conditions? Both fail dramatically. With L- or M-cone isolating gratings, for most cells the slope of the SF tuning curve is too shallow to be predicted by a single Gaussian mechanism. An inverse cosine transform of the SF curves gives spatial structure for M- and L-cone receptive fields. For both (irrespective of center type) there was a sharp central peak (giving responses to high SFs) set in broad, shallow flanks (to give the shallow slope). We could describe the data satisfactorily with a dual opponent-mechanism model, a local, opponent receptive field added to a much wider opponent mechanism. However, some other cells showed more complex behavior, but with spatial phase properties again consistent with a dual opponent mechanism.
These results indicate receptive field structures for midget ganglion cells are more complex than expected from pure or mixed cone surround models. We suggest the small-scale opponent field is derived from outer retinal connectivity, in some cells at least with mixed surrounds. The broader opponent mechanism might arise from amacrine cell networks in inner retina. It is possible that the broad-field opponent mechanism serves to amplify in the PC pathway the |M-L| opponent signal, which is known to be weak in natural scenes. Lastly, the extensive spatial summation observed with psychophysical detection of red-green perturbations may have in part a retinal substrate.

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