Hue perception is mediated by pathways in which S cone signals are combined with M vs L at the first synapse in the retina

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S cones contribute to all four hue percepts assayed psychophysically. However, textbook 'red-green' opponent cells have no S cone input. To account for this discrepancy, a two-stage model has been proposed in which color signals are recombined in the cortex. However, an alternative is that the most frequently recorded parvocellular L vs M cells are not responsible for hue perception. Instead, hue percepts could rely on a small subset of ganglion cells in which S signals are combined with opposing L and M inputs via horizontal cells providing the substrate for S-cone input to both red/green and blue/yellow hue at the first synapse. We tested this hypothesis by taking advantage of the fact that S-cone inputs to blue-cone bipolar cells can be blocked by intravitreal injections of L-AP4 in animals or mutations to the gene encoding mGluR6 in humans. We, thus, studied S-cone signals introduced to the visual pathways via horizontal cells in isolation in rodents and monkeys and in a human subject with mGluR6 mutations. S cone signals were examined using S-cone isolating stimuli at the bipolar level using the light-adapted, long-flash ERG and at higher levels using ultrahigh field strength fMRI and psychophysics. Robust S-cone signals were detected at all levels of the visual pathway from bipolar cells to perception under conditions that block S-cone input to blue-cone bipolar cells but leave S-cone pathways via horizontal cells intact. We conclude that S-cones have access to the L/M pathway via horizontal cell connections such that signals from all three cone types are combined in the retina, at the first synapse. S-cones input to either L or M cones, which, in turn, output to either ON or OFF bipolar cells, producing four combinations corresponding to circuits for red, green, blue and yellow.

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