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# Supplementary Materials for

## The elementary representation of spatial and color vision in the human retina

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**Supplementary Materials**

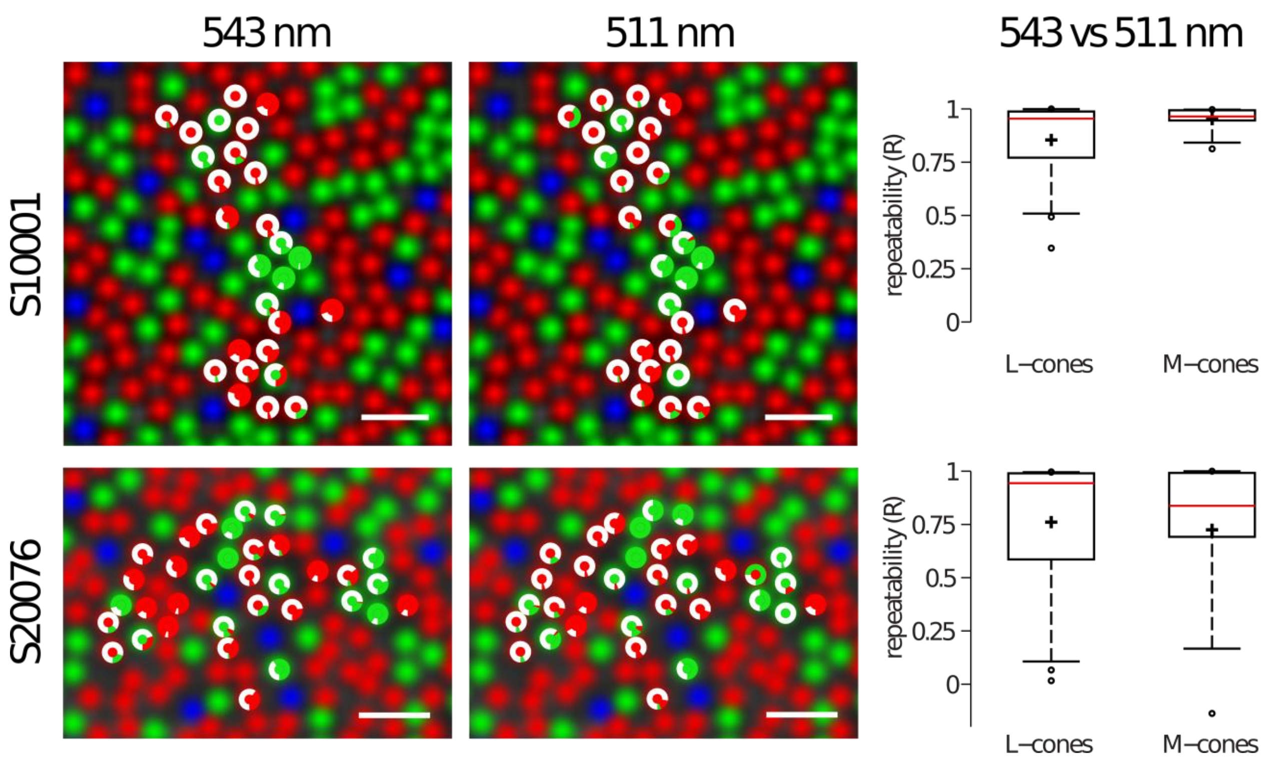


**fig S1. Wavelength invariance of color signals.** Subsets of cones in both subjects were re-targeted using a 511 nm stimulating light to test whether the color percepts were invariant to wavelength. The responses to a 511 nm stimulus were highly correlated with the responses obtained from the same cones with a 543 nm light. In some cases, cells were retested with 511 nm many months after the 543 nm conditions. The top row represents data collected from S10001 using a 543 nm (left column) versus a 511 nm stimulation light (middle column). The bottom row is data from S20076. For both subjects, the stimulation wavelength did not alter color responses substantially. The box and whisker plots in the right column represent the distribution of correlation coefficients across L- and M-cones. Plus marks indicate the mean; the red line denotes the median; box edges are 25th and 75th percentiles; whiskers 9th and 91st percentile. From this analysis we concluded that the stimulus wavelength did not substantially influence the behavior of our subjects.

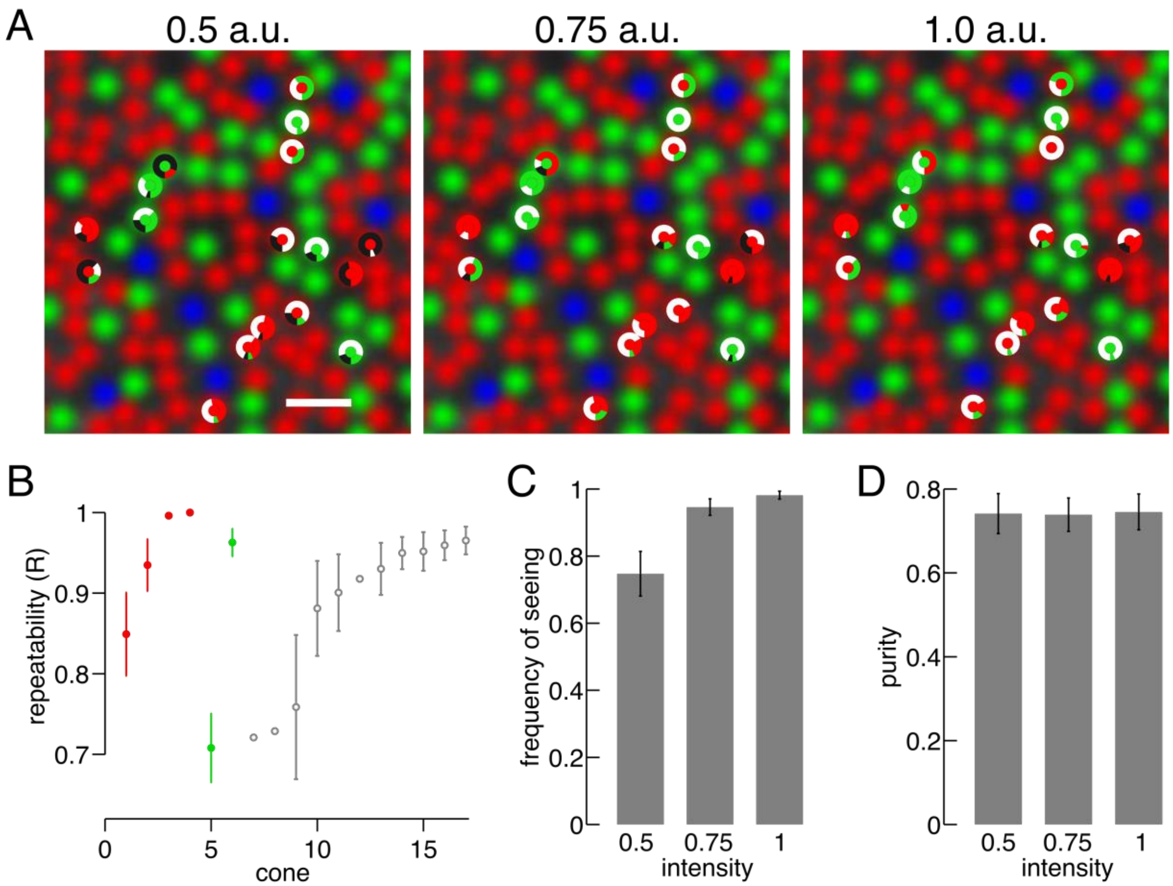


**fig S2. Intensity invariance of color signals.** To assess whether fluctuations in contrast influenced color-naming behavior, we modulated the intensity of our stimulus. Three cones were selected during each session and each cone was targeted 20 times with three intensities (0.5, 0.75 and 1 a.u.). Trials within each session were randomly interleaved. One cone was an S-cone and eliminated from subsequent analysis. (**A**) Response histograms for 17 L- and M-cones that were targeted in one subject (S20076). Not seen trials (black) were included here for comparison across intensities. (**B**) Repeatability (R) was computed between each condition. Circles represent the average repeatability across the three conditions for each cone, except in cases where frequency of seeing was too low in the 0.5 a.u. condition. In that case, only 0.75 and 1 a.u. were compared. The color of the circles corresponds to the dominant color category elicited by each cone. Flashes that were not seen were excluded from repeatability analysis. The mean correlation coefficient across all cones was 0.87. Error bars are SEM. (**C**) Frequency of seeing decreased with decreasing intensity. (**D**) Response purity did not change as a function of intensity.

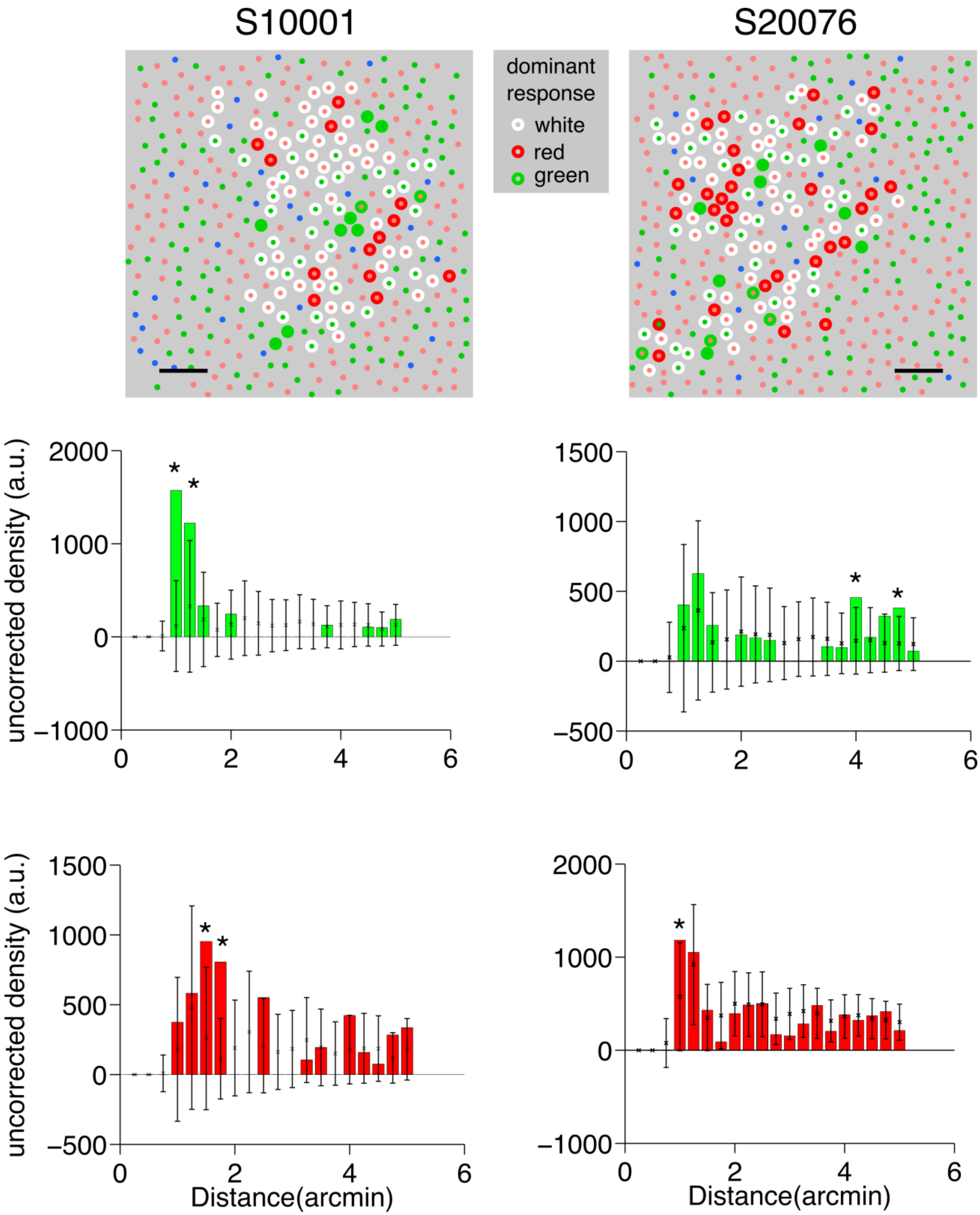


**fig. S3. Cones signaling color sensations are spatially clumped.** A modified version of the density recovery profile analysis described by Rodieck (*23*) was used to assess the degree of non-random clumping in our dataset. Cells were classified as red, green or white based on their dominant response. Low response purity cones were excluded. The top row displays the mosaics used in the analysis. Histograms display the results of this analysis on the green (middle row) and red (bottom row) signaling cones in our dataset. Left column contains results from S10001; right column from S20076. Error bars represent 2 standard deviations in either direction from the mean bootstrap simulation. An asterisk denotes a significant ($p<0.05$) departure of the data from random. Scale bar = 3 arcmin. The red and green sub-mosaics from S10001 and red sub-mosaic from S20076 indicate a tendency for cells with the same dominant response category to clump more than is expected due to chance.

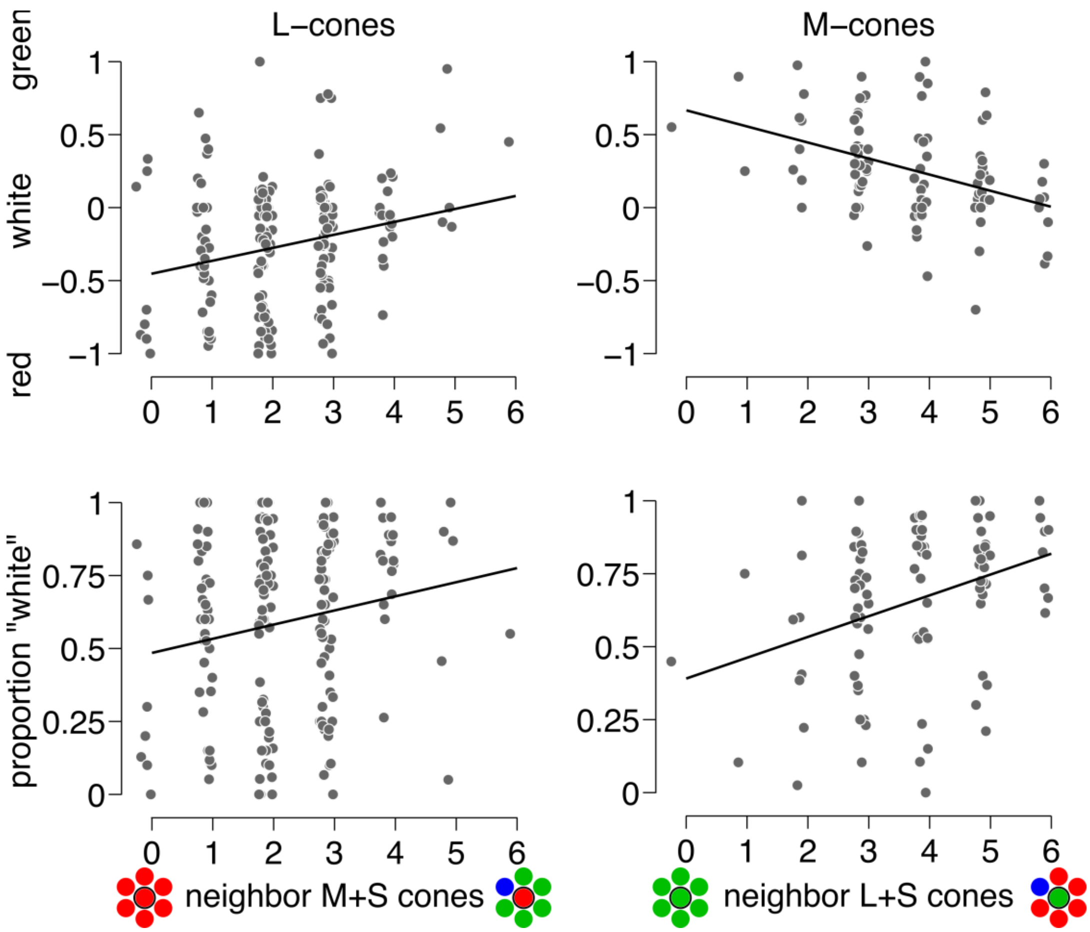


**fig S4. The influence of neighboring cones on color appearance.** (**A**) The red-green score for each L (left column) and M (right column) cone is plotted as a function of the number of nearest neighbors of the opposite type. Least squares regression lines are shown. L-cones: N=174, $R^2$ = 0.058, p = 0.001; M-cones: N=99, $R^2$ = 0.17, *p*=0.00002. (B) Same as (A), but the independent axis here represents the proportion of white responses elicited from each cone. L-cones: N=174, $R^2$=0.034, *p*=0.014; M-cones: N=99, $R^2$=0.122, *p*=0.0004. In all plots, the horizontal location of each point was jittered randomly for visualization. These regressions, while statistically significant, do not fully capture the variance in our data. However, these analyses do indicate that a cone situated in a spectrally opponent neighborhood is not more likely to signal chromatic percepts.