

SATURATION AND COLOR CONSTANCY

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Color constancy is the phenomenon in which the colors of surfaces remain approximately constant despite considerable variations in the physical signals reaching the eyes from those surfaces. The analysis of color constancy is commonly restricted to changes in the intensity and chromaticity of the illuminant. We have been exploring aspects of color constancy which occur in the absence of shifts in the mean intensity or chromaticity of the stimulus, but depend instead on changes in the variance of the tristimulus values of the set of visible surfaces. (In natural settings, such effects may be due either to desaturation by haze, or to changes in the bandwidth of the illuminant.) The effects we consider are inconsistent with most previously published theories of color constancy.

Color constancy experiments are often done by studying color non-constancy, to learn how the color of a test spot depends on its surround. A test spot appears lighter against a dark surround than against a bright surround; this lightness contrast is thought to reflect the process of lightness constancy. A test spot appears greener against a red surround than against a green surround; this is thought to reflect chromatic constancy. We displayed test spots against complex, multi-colored surrounds whose component surfaces varied in saturation, but not in space-averaged lightness or chromaticity. We found¹ that a test spot appears more saturated against a low-saturation (greyish) surround than against a high-saturation (vivid) surround; by extension, this may be considered to reflect a process of saturation constancy, which acts to expand or compress the range of perceived colors in a scene.

A large class of color constancy theories, including Land's Retinex², predict that for any complex colored surround there is a homogeneous equivalent surround which has the same effect as the complex surround on the color appearance of a test spot. Our results

are strongly inconsistent with this principle. (For example, for any saturated multi-colored surround whose homogeneous equivalent surround is predicted to be grey, greens will appear greener and reds will appear redder against the "equivalent" surround than against the complex surround.) Other color algorithms, such as Maloney & Wandell's³, do consider the variance of the surround, but would still not account for these saturation effects, because the expansion and compression of the saturations of the surround colors should not systematically change the best-fit plane through them. It is possible that a color constancy theory involving normalization of the range of colors in a scene, in addition to normalization for shifts in lightness and chromaticity, may account for the saturation effects.

Another color phenomenon we have been studying in relation to the saturation constancy effects was described by Helmholtz⁴ in 1866 (and attributed to Meyer), but has received relatively little attention since. A grey square of paper against a green background appears tinged with red from simultaneous contrast, but it appears even more red when the whole scene is desaturated by viewing it through tissue paper. We simulated this stimulus on a computer display. When the induced redness was measured by matching to a comparison spot, the results were consistent with the tissue paper experiment: the strength of the induced color asymptotes at low levels of surround saturation, and in some cases falls at high levels. However, when the induced redness was measured by cancellation to neutral (neither red nor green), the induced redness rose monotonically over the entire range of surround saturations. This sharp divergence between the two different measures of induced color is consistent with an expansion of the scale of perceived saturations of colors (relative to the physical chromaticity) in a low saturation context.

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