STUDIES ON THE EFFECT OF ILLUMINANCE ON COLOR RENDERING

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The CIE is currently developing a new assessment procedure for color rendition by white light sources [1]. Color rendition can include different dimensions of color quality of light sources. This provides an opportunity to re-assess which dimensions are considered in the evaluation of color rendering. One very important aspect of the perception of object colors is the illuminance of the scene. Surely the intensity of the light source influences object colors in multiple ways, such as the Hunt effect [2], whereby objects with higher luminance appear more saturated, and the Bezold-Brucke effect [3], whereby objects' hues shift with changes in luminance. Despite the clear importance of illuminance on color rendering, as a practical matter this dimension have never been integrated into a color rendering metric. However, investigating how differences in illuminance affect perceived object colors can be useful in the development of a new metric. A new color rendering metric could seek to mitigate changes in object colors caused by the relatively low illuminance levels (compared to real daylight) that artificial illumination tends to provide. Conversely, these differences could be interpreted as a natural and important correlation within the visual system, which should be preserved.

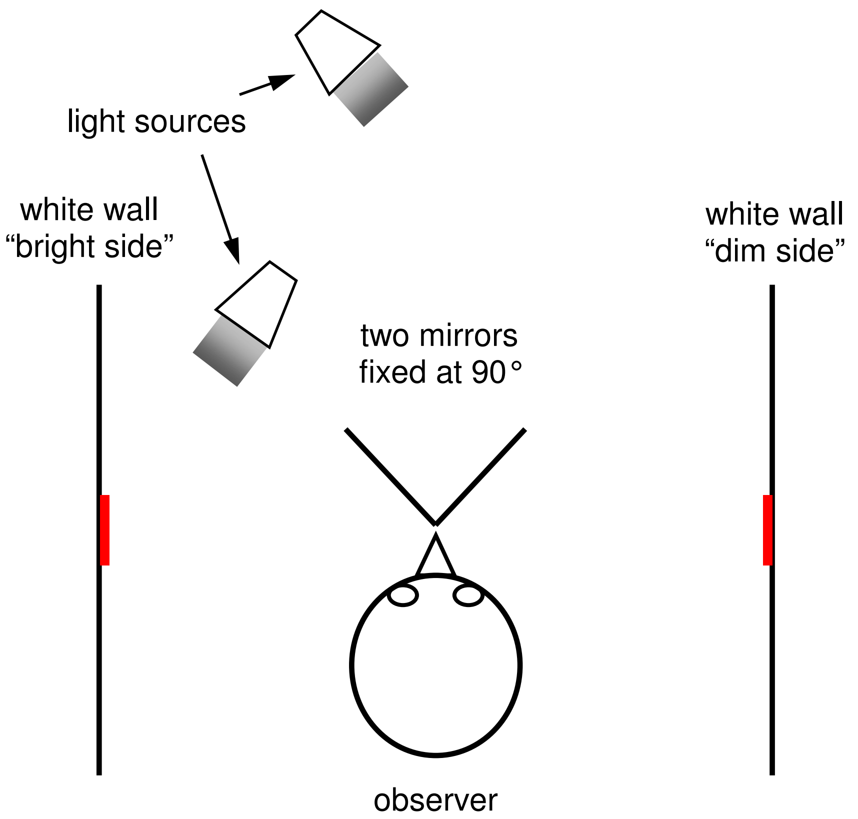

Figure 1. A simplified depiction of the haploscopic viewing arrangement. sources.

Methods

In these studies, observers were adapted to different illuminance levels in each eye, based on the knowledge that each eye would adapt to the illumination level independently [4]. To accomplish this, haploscopic viewing conditions were created with a mirror stereoscope. A simplified depiction of the viewing arrangement is shown in Figure 1. Additional optical elements not shown in the figure (e.g., mirrors, diffusers, baffles) were use to increase illumination uniformity on the walls and to shield observers from direct view of the light sources. The light sources were 3000 K quartz halogen lamps. The white wall on the "bright side" was illuminated with 2000 lx and the "dark side" was 200 lx.

Experimental stimuli were created with a nine-ink color inkjet printer. There were two main experiments: tests of the Bezold-Brucke hue shifts between illuminance conditions and tests of the Hunt effect saturation shifts between illuminance conditions. Observers adapted for at least five minutes prior to presentation of stimuli. In each experimental trial, a stimulus was presented on one of the two white walls. In an adjacent area of the visual field, a comparison chart showing 10-12 similar stimuli were presented on the other white wall. The observer's task was to choose the stimulus on the chart that matched the previously presented stimulus. Because of the different lightnesses of physically identical stimuli under the different illuminances, a preliminary experiment determined the perceived lightness differences. From this data, the stimuli for the two main experiments were physically adjusted so that they appeared to have identical lightnesses. In the Bezold-Brucke effect experiment, the comparison chart contained the stimulus color as well as those of neighboring hues. In the Hunt effect experiment, the comparison chart contained the stimulus color as well as those of higher and lower chromas. Due to the strength of the Bezold-Brucke effect and observers' difficulty matching saturation matches amongst different hues, the hue of the stimuli were adjusted, as was done with lightness, so that they appeared identical under the two different illuminances.

Results & Discussion

The findings of these experiments, as expected, were consistent with the Bezold-Brucke and Hunt effects. For certain stimulus colors, the magnitude of these effects was sizeable. Even when fully adapted, colored objects can appear markedly different under different illuminance levels in typical color rendering situations. When considering these findings in the context of color rendering assessment, interesting questions arise.

On one hand, one could suppose that daylight is humans' "real" reference source. Surely humans evolved with daylight; artificial lighting is a relatively new introduction. Daylight illuminance is far greater than typical artificial lighting. One could approach color rendering evaluation by rewarding lamps that make objects look most like they do under daylight and penalizing lamps that render objects differently. With this approach, lamps that increase objects' chromatic saturation to counteract the Hunt effect could be rewarded, as could lamps that introduce hue shifts that counteract the Bezold-Brucke hue shifts.

Inversely, the hue and saturation shifts that objects experience with decreased illuminance could be interpreted as normal and expected changes that are actually perceived as "natural." Just like Kruithof [5] found that the pleasantness of light source correlated color temperature was dependent on illuminance, it is possible that the pleasantness or naturalness of object colors depends on illuminance. In this case, color rendering assessment could embrace these effects.

References

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[5] Kruithof, A. A. "Tubular Luminescence Lamps for General Illumination," Philips Technical Review. 6 (3), 65–96 (1941).