ABSTRACT

HASLUP, JENNIFER REID CLONTS. Perception of Blackness and the Foundations of a Blackness Index. (Under the direction of Drs. Renzo Shamey and David Hinks.)

Many researchers have investigated various aspects of blackness, but a detailed examination of the perception of blackness has not been reported to date. This study aims to generate a thorough review of blackness from theoretical and perceptual perspectives. Since the quantification of blackness, due to relatively large signal to noise ratio, is specifically subject to errors and has not been sufficiently elucidated, this work also aims to examine the measurement of blackness and determine inter- and intra-instrument agreement. Finally, perceptual assessments are to be analyzed to propose a blackness index that sufficiently correlates with measured colorimetric values and visual perceptions.

Experimentally, this research covers three stages. In the first, twenty samples of uniform chroma and lightness with varying hues were ranked in order of perceived blackness. In the second stage, thirty samples were produced that varied in hue and chroma, but remained of approximately uniform lightness. Observers first categorized these samples as black or not black, and then rated them in relation to an "ideal" black, which was essentially a black velvet light trap. The third stage assessed the measurement of near-black objects and determined the repeatability and reproducibility of such measurements.

From the observation trials, it was determined that samples with hue angles between 200° and 270° are considered blacker than samples with hue angles in other regions of color space. Samples with hue angles above 315° or below 45° are considered less black than other samples. The effect of chroma is much less significant than that of hue angle, but samples with lower chromas are considered to be blacker than samples with higher chromas. The measurement of near-black objects is subject to more variation than that of lighter samples.

The Perception of Blackness and the Foundations of a Blackness Index

by
Jennifer Reid Clonts Haslup

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APPROVED BY:

Renzo Shamey Committee Chair	David Hinks Committee Co-Chair
Peter Bloomfield	Brent Smith

supported Neifeld's statement that spatial or temporal contrast is required to obtain a perfect black [9]. Dimmick argued that transitions from black to white pass through a neutral grey point [10]. Rich pointed out that black and white could not be truly opposite colors since adaptation to one over a long period would eventually result in seeing a neutral grey [11]. Based on results of a series of experiments Dimmick supported Rich's hypothesis that a neutral grey existed as an elementary color [12]. Deane Judd argued that black and white apply to surfaces and stated that they are characterized by being completely opaque and matte, differing only in lightness [13-14]. He then suggested that the appearance of blacks was based on the surface mode, and that this was in agreement with the works of Helmholtz [3], Troland [15], and Neifeld [8]. Heggelund proposed a model to describe the achromatic colors in which black and "luminous" were opponent colors [16-17]. W.D. Wright pointed out that the separation of television color signals into a luminance channel and a chrominance channel, and their subsequent combination, would result in the regeneration of the original signal [18]. Wright also indicated that blackness is a subjective perception and that cannot be measured on any simple photometric scale [19]. Quinn, Wooten, and Ludman revived the issue of achromatic colors in 1985 and determined that grey is a mixture of black and white, which should not be treated as a separate elemental color [20]. Several workers also examined blackness from a spatial and temporal induction viewpoint [21-25]. It was found that blackness was a function of the luminances of the reference and inducing stimuli, regardless of the chromatic content of either. It was also found that induced blackness was additive [26-27]. Caivano defined five "primary cesias": transparence, specular reflection, translucence, diffuse reflection, and absorption and eight scales of cesia: white–black, specular–black, translucent–black, transparent–black, specular–white, transparent–translucent, specular–transparent, and white–translucent [28]. Stockman, Plummer and Montag used flicker photometry to attempt to elucidate the achromatic visual pathways [29]. Their research indicated that seven mechanisms are involved in the perception of luminance. In 2009, Bimler, Paramei, and Izmailov found hue and saturation shifts in spatially induced blackness [30].

1.1. Efforts Aimed at Development of a Blackness Index

A few one-dimensional scales of blackness have been proposed for use in various industries. The Kenya Bureau of Standards, for example, recommends a method for specifying the blackness of pencil leads based on reflectance measurement of thirty lines drawn 1.5 mm apart on a white drawing paper with a reflectance of 79±2% [31]. This method gives values generally between 60 and 80 percent reflectance. At least one patent recommends rating blackness as a function of the lightness of a sample [32].

In the 1970's and 1980's, several blackness indices were suggested for use in the German printing industry [33-36]. As these were created for specific applications they mostly dealt with blackness in terms of lightness, although a few also incorporated chromaticity terms. These formulae included an assumption that bluish blacks appear deeper than brownish blacks of similar lightness values. Westland, et al reported work on the density of the ink as a metric for blackness [37].

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