Exploring visual and affective qualities of equivalent colors under architectural-scale, full-field exposure conditions

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I. EXTENDED ABSTRACT

I.I. Background

Color used in architectural settings impacts our perception of form, space, and ambiance (Laganier and van der Pol 2011). The increased availability of light-emitting diodes (LEDs) eases the implementation of luminous color into the built environment. This is evident in urban light and color festivals (Besenecker 2015), as well as architectural projects (Bahamón and Alvarez 2010, CoopHimmelblau 2012).

LED lighting technology introduces the necessity and opportunity to mix and match luminous colors in various ways. Using color matching models (chromaticity), nearly-identical-appearing colors (so-called metamers) can be created that have different spectral compositions depending upon the specific technologies used to create them (Fairchild 2013, Boyce 2003). We set out to explore how individuals may respond to metameric colors in a spatial environment that are produced using different technologies.

Current research in visual perception demonstrates that, when viewed with the full field-of-view, the hue, saturation and brightness of these colors do not necessarily match (Besenecker and Bullough 2016, Gerlach 2003, Horiguchi et al. 2013). In addition, health related sciences suggest that different spectra can have distinct physiological, neurological and psychological effects, this is especially true for spectral compositions with varying melanopsin stimulation (Lockley et al. 2006, Lucas et al. 2014, Vandewalle et al. 2010). We used mixed research methods to conduct architectural-scale studies to explore possible differences in visual, affective and physiological qualities for nearly equivalent stimuli, matched very closely for chromaticity and light level (Besenecker and Krueger 2015).

I.2. Methodology / Procedure

Two different color series were tested, amber and cyan. For each, there were seven different ways to produce near-metameric color conditions: 1) color filtered tungsten, 2) distinct narrowband LED, 3) RGB source LED, 4) 7-color source LED, 5) video projector, 6) colored paint illuminated by white tungsten, and 7) colored paint illuminated by white LED. The conditions illuminated semicircular 'tubicles' (14' height x 9' diameter) that were located in a 50' x 60' x 32' black box studio space (see Figure 1). A qualitative study was performed first (Study 1), with 17 participants who were free to comment on the conditions close-up (immersed) and from afar in comparison to a reference. Based on the responses we received, we conducted a quantitative follow-up study (Study 2) with 12 participants that used a fixed viewing location. All subjects also participated in sessions where heart rate and blood pressure were measured. About half of each of the participant groups had professional experience working with light and/or color.

I.3. Outcome / Discussion

Results from both Study 1 and 2 suggested that there were reliable differences between the seven near metameric conditions for the perceived visual perceptions of brightness and saturation as well as the affective qualities of emotional and spatial qualities. Furthermore, we were interested in the possible relationships between visual, affective and physiological measures. We assessed whether there were statistically significant correlations between the dependent variables of visual (brightness, saturation), affective (emotional, spatial quality) and physiological (heart rate, blood pressure) measures in Study 1 and 2. Figure 1 depicts these significant correlations ($p<0.05$).

In addition, as we noticed that variations between individuals' responses were substantial, we have started to more closely examine the influences of factors such as, age, sex/gender, and color experience. Future work will continue to examine these relationships and extend this work by assessing consistency with using different colors and spatial set-ups.

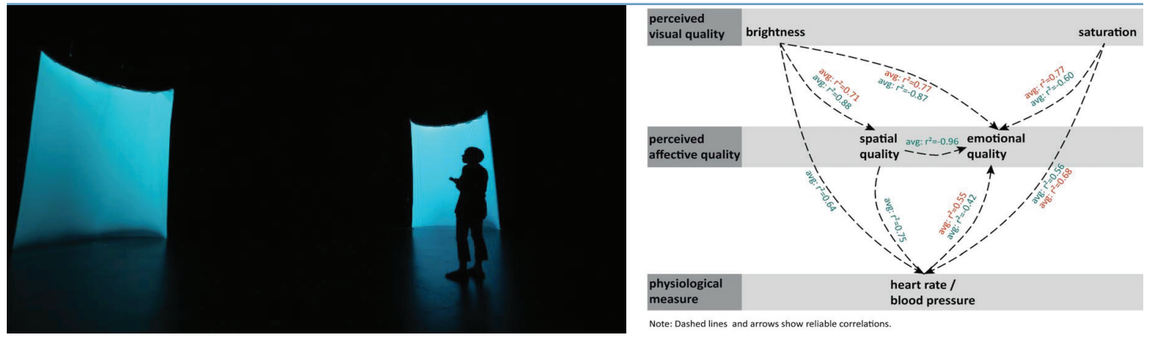

Figure 1. Left: Experimental set-up for Study 1 (cyan session) showing reference condition 1 (left) and test condition 4 (right).
Right: Diagram illustrating statistically significant correlations between visual and affective qualities as suggested by the results from Studies 1-2. Amber or cyan values correspond to the comparison of seven nearly-metameric conditions, amber or cyan respectively.

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5. AUTHOR BIOS

Ute Besenecker is a PhD candidate in Architectural Sciences at the School of Architecture (SoA) and the Center for Cognition, Communication and Culture (CCC) of Rensselaer Polytechnic Institute (RPI). In addition to working on her dissertation (The impact of spectrum on the experience of equivalent coloR in architecture), she currently assists her advisor, Prof. Krueger, with research and teaching assignments at SoA.

Prior to her doctoral work, she received a master's degree in lighting from RPI's Lighting Research Center (LRC) with a research focus on light spectrum and scene brightness perception (advisors: Prof. Figueiro and Dr. Bullough). During her time at the LRC she also worked as research assistant in the outdoor lighting program.

Mrs. Besenecker has presented her research at national and international lighting conferences and her articles have been published in peer reviewed journals. She also holds graduate architectural degrees from the University of Hanover in Germany as well as Columbia University in New York City. Prior to starting her studies at RPI, she worked at several architectural and lighting design firms in Europe and New York City, amongst them Rafael Vinoly

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