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Colored LED Lighting as a Primary Interior Spatial Condition

Human Preference and Affectual Response

Judy THEODORSON¹,
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***Abstract.** This research explores the human response to colored lighting with light emitting diodes (LEDs) in a space with the intent of understanding preference and affectual response. The research was conducted through photographic appraisal of a single interior space illuminated with monochromatic and mixed colored lighting³. Results indicate that the stimuli of monochromatic lighting (red, blue, green) confers distinct subjective impressions to a spatial setting and, for a number of subjects, prompts memories. When mixed color lighting is introduced, there are preferences for warm colors and consensus that red lighting is energizing. Future studies will replicate this study with in-situ, immersive experiences.*

Keywords. Colored Lighting, LED, Lighting, Interiors

Introduction

For centuries, colored light has been a tool of architects and designers to shape notable experiences in the built environment. With the emergence of inexpensive light emitting diodes (LEDs), there is substantial opportunity for designers to create intentional, expressive, and individualized ambiances in both interior and exterior environments. This research explores the human response to colored lighting as the primary physical stimulus in an interior space. The intent is to understand preferences and appraisal of colored light in order to make informed design decisions.

There is substantial research around color perception that extends beyond aesthetics. Nakashian (1964) theorized that longer color wavelengths such as red and orange are experienced as arousing and warm, while shorter wavelengths such as blue and green are relaxing and cool. Adams and Osgood (1973) published a seminal study of the affective meanings of color that used a semantic differential tool. Findings include the following: red has emotional salience; the blue-green spectrum is more highly evaluated than red-yellow; blue and green are good; red is potent and active; and blue is familiar. This study was cross-cultural and identified differences related to geographic location, climate, religion, and factors related to culture. A literature review by Elliot and Maier (2014) on the psychological aspects of color determined that color has impact on affect, cognition, and behavior. While they found trends, such as that red is powerful, they caution around generalization.

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3. This research was originally planned as an immersive experience but was interrupted by COVID-19 restrictions

Architectural phenomenology theory recognizes that senses and memory are triggered by environmental conditions, especially light and color. Controllable LED colored lighting is a relatively new technology but is being quickly adopted as a design element that can be used to stimulate senses, trigger memory, and support personal expression. While research is nascent, there is indication that colored lighting as a spatial experience confers a measurable emotional response (Lee, 2019).

This research specifically investigates the following: What is the affectual and preferential response to colored light as the primary spatial condition?

Method

This is a within-subject experiment whereby subjects are presented a series of photographs of colored lighting scenarios and asked to assess each through survey tools and open-ended questions. An experimental space was established with controllable LED colored lighting, both ambient and accent. The space was photographed under various monochromatic and mixed color lighting scenarios.

The subjects (n=41) were recruited through a university design and construction program and screened for color-blindness. Demographics include: 85% female; 25% report having substantial color theory background while 70% report having some background. The subjects' reported favorite colors: pink (21%), green (21%), blue (19%), purple (7%), yellow (7%), red (4%), and no favorite (14%).

Subjects were first presented the monochromatic scenes, in the order of blue, red, green and cool white, and asked to assess each on a semantic differential scale with nine word-pairs (antonyms) selected to appraise atmospheric and spatial conditions (fig. 1). The word pairs are sorted into three dimensions: evaluation, potency, and activity. The subjects were given the opportunity to discuss if they had a positive or a negative association with each scene. Finally, they asked to rank each scenario according to preference.

Next, the subjects were presented four sets of mixed color scenarios: each set comprised monochromatic ambient lighting with three variations of accent light (red, green, blue, yellow). Subjects were asked to rank their preference of each set (fig.2) and to assess on a Likert scale if each scenario was energizing or relaxing (fig.3).

Results

Monochromatic Scenarios

The addition of ambient colored light to a simple interior space transforms the space into an unfamiliar atmospheric condition with distinctive spatial and visual qualities. In the narrative responses, a substantial number of subjects reported that the colored light triggered memory and emotion, perhaps as they sought to make sense of what might be perceived as an alien space.

Of the four colors, the red lighting scenario consistently generated the most consistent and intense responses. On the semantic differential scale, the red space is evaluated as somewhat negative - *unpleasant, bad* - and as highly potent and active, garnering the strongest responses to the following terms: *powerful, warm, confined, tense, flashy, and unfamiliar*. In the narrative discussion, subjects reported mostly negative and ominous associations with red light though there several positive responses:

“It reminds me of almost any movies depiction of hell and while I’m not religious it still makes me uncomfortable”

“Negative because it reminds me of a warning light“

“Positive. Warm, like a hug. Lots of energy, exciting.”

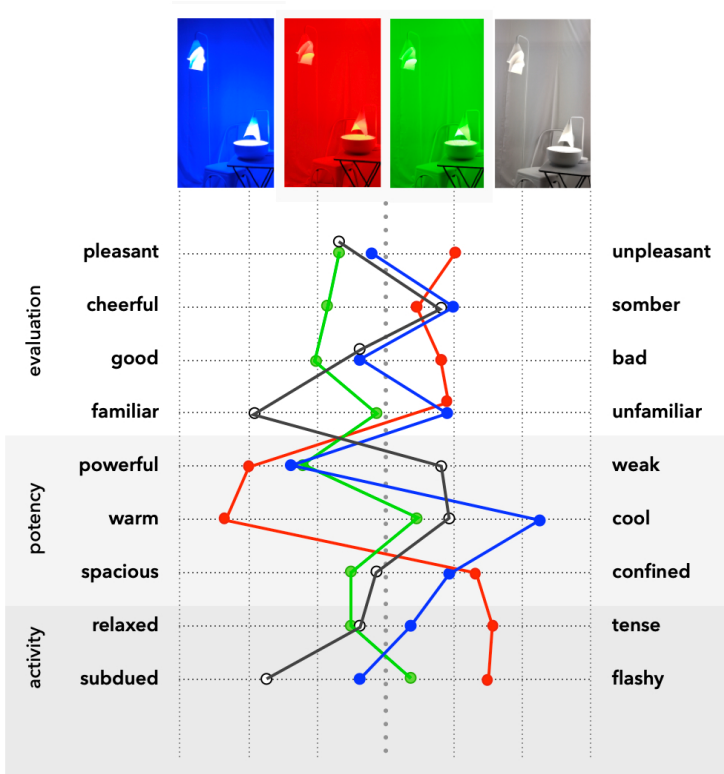


Figure 1. Monochromatic lighting scenarios and semantic differential results

Green light is the most positively evaluated scenario, with the highest ratings on *pleasant*, *cheerful*, *good*. This corresponds to Adams and Osgood’s findings. Additionally, it is seen as the most *spacious* and *relaxed*. In general, the comments leaned toward positive and several noted an association with the natural world:

“I feel more toward positive about green. It is a very strong color in this image but I feel like it could be very soft as well. This color is definitely energizing to me and would make me feel cheerful. It also makes me feel like I am in a jungle.”

“Green is positive. Very natural and familiar. Makes me think of environmental surroundings. Not tense.”

Blue light is strong in potency dimension, appraised as *powerful* and *cool*. It is also seen as *somber* and *unfamiliar*. While color theory suggests blue is a calming color, this was not borne out by the semantic differential. The subjects’ comments are laced with melancholy, references to water, and trepidation although a few found blue calming.

“The blue color displays feelings of sadness, loss, and desire. These feeling [sic] are coming from the light, if the blue was lighter (cyan), the feeling could change in favor for the light.”

“Positive, it’s calming. Feels like floating, like an ocean”

“I am terrified of sharks and drowning and being surrounded in blue makes me panic.”

Mixed Color Scenarios

The intent of mixed color scenarios (ambient and accent) is to explore the potential to create atmospheric conditions that are perceived as energizing or relaxing and also, to gain insight into spatial color combination preferences. The mixed color scenarios offer more dimension and focus to the photographic depictions. When two colors of light are introduced to the space, there is a mixing of the color wavelengths resulting in a shift of colors, primarily affecting the minor color. For example, blue accent light shifts to a purple/pink hue when mixed with red ambient light (fig.2).

Warm accent colors correlate to a stronger preference of the overall spatial condition. In the spaces with colored ambient light, the most preferred accent color is yellow. In the white space, yellow was not an option and red was the preferred accent color. The least preferred scenarios have shorter wavelength colors - green or blue - as the accent color.

Subjects were asked to rate each scenario as *energized* or *relaxed* (fig.3). The strongest predictor of *energized* is the use of red light. The three red ambient light scenes are the rated the highest of the entire group; when red light is the accent color, it rated highest in the set. Spaces with blue light trend slightly toward relaxed; white ambient with blue accent is the rated the most relaxed.

Discussion

The human response to colored light as a spatial circumstance is complex and idiosyncratic. There are clear trends in this study: red is potent, warm, active, and signals threat; green is generally positively evaluated and references the natural world; blue is cool and unfamiliar. However, there are number of divergent responses, for instance green is seen as equally familiar and unfamiliar, and some find red comforting rather than threatening. Given the pool of subjects has exposure to color theory, it should be considered that this knowledge influenced responses. In the case of the blue space, the semantic differential results do not indicate that blue is calming, however three subjects used the word calm in their comments. Were they influenced by color theory that suggests blue is a calming color?

While photography is an accepted method to appraise a spatial setting, there are limitations to photographing a colored light space. It is difficult to control color balance and exposure and to capture the actuality of the colored light circumstance. While the photographs show a spatial situation, the appraisal is likely weighted toward the color of light. D’Andrade and Egan (1974) point out that emotional associations to color are perhaps more related to saturation and brightness rather than the actual hue of the color. The researchers theorize that an immersion experience in a colored light space offers a fuller visual, spatial and sensory experience. Once COVID-19 restrictions have been lifted, there are plans to replicate the study in-situ; this could be a valuable comparative analysis.

Further research might explore the link between color light and the association to

non-conventional or alien spaces such as those noted by the subjects: hell, a jungle, under water, sci-fi films. While colored light is not appropriate for many traditional built environment activities, it offers the potential for expressive exploration, branding, and abstracted interiors. Moreover, this study offer insight into nocturnal urban spaces which are not bound by the constraints of the interior.

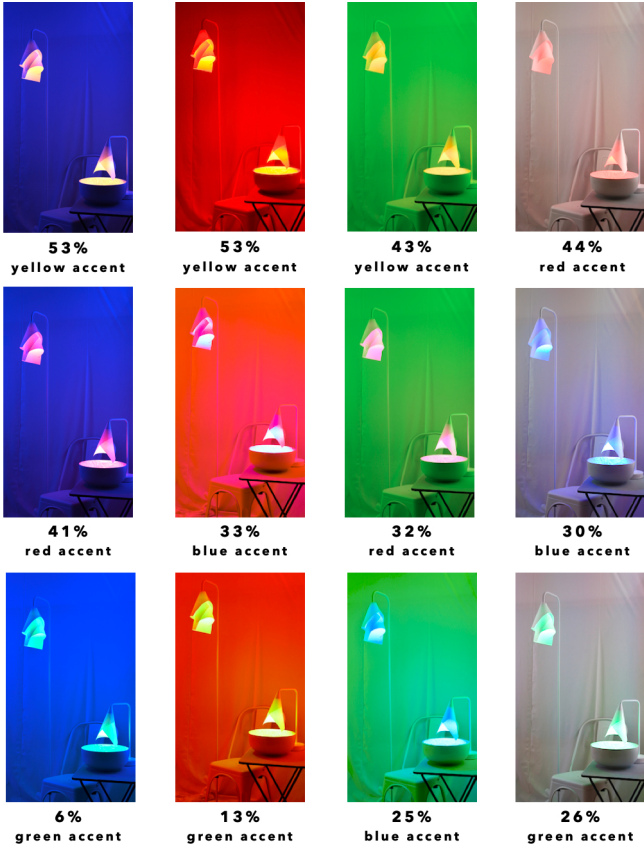


Figure 2. Preferences of mixed colored lighting scenarios

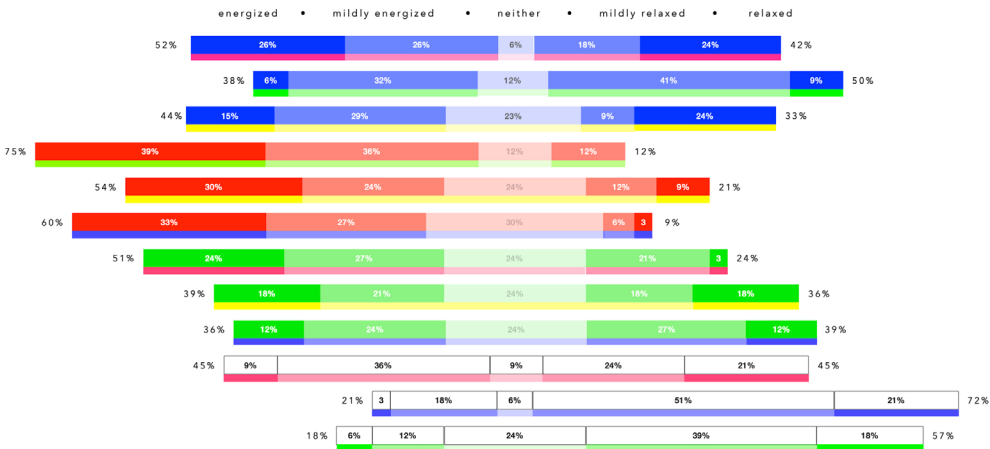


Figure 3. Evaluation of mixed color lighting scenarios as energized or relaxed

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