THE EFFECT OF LIGHTING ON EMOTIONAL STATES AND BEHAVIORAL INTENTIONS IN URBAN TRANSITIONAL SPACES

By

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TRANSITIONAL SPACES

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Abstract: Extending precedent studies on ambient lighting and its effects on people's perceptions, this study explored the influence of lighting on the users' emotional states in the urban transitional space at nighttime. The investigation of stimulus factors and their effects on individuals' emotional state (arousal/pleasure) and behavioral intentions (avoidance/approach) as positive engagements can provide the key to what makes urban transitional spaces a final destination in the public realm. The main question was the extent to which light intensity and the color temperature of lighting influence people's emotional states and behavioral responses in these urban transitional spaces.

The current study employed technology as a mechanism to represent and manipulate existing environmental lighting conditions. A 2 (warm lighting vs. cool lighting) × 2 (dim lighting vs. bright lighting) factorial experiment was conducted. All digital perspectives were initiated into four different lighting conditions: (a) bright lighting with warm color, (b) dim lighting with warm color, (c) bright lighting with cool color, and (d) dim lighting with cool color. A Rico Theta S camera and Cupix software were used to capture and develop the environment's spherical tour, and Adobe Photoshop was employed to manipulate the lighting condition of each scenario.

Participants were randomly assigned to one of the four lighting conditions and navigated through the specific spherical image (360°). At the end of the experiment, participants were asked to rate their feelings and intentions by completing a 5-point Likert scale questionnaire. This method allows designers to compensate for other factors in the surroundings and minimize external influences that might impact the users' emotional states or decision-making. It was predicted that both light intensity and the color temperature of light would influence individuals' perceptions and psychological responses. Results showed, there is a positive relationship between the CCT of light and the participants' rating of the levels of pleasure and arousal as well as how individuals' approach or avoid an urban transitional space because of their lighting conditions. The current study contributes to a better understanding of lighting characteristics on peoples' willingness to approach and avoid urban transitional spaces.

KEYWORDS: Urban transitional space, Lighting condition, Spherical image, Emotional states, Behavioral intentions.

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CHAPTER I

INTRODUCTION

Consideration of the ways that public space can draw attention and influence people's lived experiences in their everyday routines has been missing from modern urban design and architecture (Kaplan et al., 2007). Public spaces are the most common shared places where people can meet, communicate, experience an "in between" destination, and engage with public life. However, going from indoors to outdoors, considered an ordinary experience of perceptual preference, involves a clear change in territorial conditions and social involvement. This description is close to that of Carr et al. (1992), who expands the definition of types of public places, including community gardens and commercial spaces; how people experience the environment continues to shape the design and management of public realms (Carr et al., 1992). Public life and such spaces have also influenced individuals' experiences as well as design strategies in both interior and urban design (Attiwill, 2011). Therefore, it is critical for designers to evaluate people's experiences and feelings as they enter transitional spaces. Because urban transitional spaces act as an extender of people's previous activity and can provide visual and physical interactions with indoor and outdoor environment at the same time.

In general, designers do not consider how transitional spaces can attract people's attention. According to Can and Heath (2016), *transitional space* is defined as the interface between the interior and exterior, such as front "open" spaces including sidewalk cafes or a building's interior space extended directly to the street (Kray et al., 2013, September). This interpretation of transitions could create ambivalence for designers when they are trying to classifying places as interiors or exteriors.

Transitional spaces are the juxtaposition of the interior and exterior, allowing for contact and interaction with people and the surrounding environment and giving people both physical and visual access (Tibbalds, 1992). There are many definitions and interpretations of transitional spaces (Can & Heath, 2016; Gehl, 1989; Harle & Ribevald, 1993; Kray et al., 2013, September; Laiprakobsup, 2007; Ruckle, 2011; Taleghani et al., 2015; Tibbalds, 1992). In this study, transitional space is defined as the intermediate areas that act as an in-between space marked as a destination (Sharma, 2017), particularly for individuals to rest for a while, wait for a friend, or pause for a second to look around and intermediate with the characteristics of the place.

Regardless of its psychological, physical, ecological, or aesthetic functions, public places are primarily used as arenas for social interactions. Public spaces, on the other hand, give opportunities for individuals to be introduced to new sights and learn about new places. (Carr et al., 1992; Ercan, 2007). Compared with public spaces, the interior arrangement of any specific area or structure would ideally be divided into a variety of attractive, comfortable, and welcoming spaces (Kruse, 2003). To accomplish the complex and dynamic relationships between public and private spaces, interior elements such as lighting, color, materials, or design components can provide a true liveliness.

However, it should be pointed out that the role of the interior designer is as a practitioner who "determines the relationship of people and spaces based on psychological and physical parameters, to improve the quality of place" as defined by the International Federation of Interior Architects and Designers (Attiwill, 2018, p. 61). People, on the other hand, determine how the space between indoors and outdoors is utilized according to their experiences, and as a transitional area, it constitutes a source of new destinations. For these reasons, designers must pay more attention to urban transitional spaces and user environments. In order to meet the critical view, they must do research and begin implementing evidence-based design.

The key to planning a great city is lively, enjoyable public spaces (Burden, 2014). However, though our cities were initially designed to be used in the daytime, our work and social lives increasingly take place after dark. Nighttime in public spaces can also induce people along sidewalks to watch the liveliness of interactions, presence, and activities, mostly for business or for those people who are at work or home during the daytime. Whereas May (2014) focused on the significance of interpersonal interactions among diverse cultures with regard to the economy at nighttime in public spaces, Jacobs (1961), Rudofsky (1964), and Venturi et al. (1977) described nighttime life in public spaces as an informal, incidental space that lacks unifying plans (Campo & Ryan, 2008; May, 2014; Shaw, 2015). The importance of nighttime design and lighting in public environments has been significantly developed in the urban design and illumination technology (Slater & Entwistle, 2018; Yuan, 2014). Lighting in a transitional space between the exteriors and interiors of buildings can create a nightscape that increases the chance of interactions in public settings (Grazian, 2009).

Studies have shown that lighting is an environmental stimulus that influences individuals' perceptions and can evoke a sense of pleasantness or arousal as well (Ciani, 2010; Russell, 2008; Summers & Hebert, 2001; Venegas Gil & I.C, 2018). The quality of light is a design feature that influences a place's character. Depending on the types of activities that take place in a particular environment, the quality of light will change (Illuminating Engineering Society of North America [IESNA], (2000). In transitional spaces, successful ambient lighting can contribute to creating unique and pleasant places that facilitate a positive experience at the juxtaposition of interior and exterior. Ambient lighting in a transitional space can define the character of that particular space in terms of activity. Lin and Yoon (2015) demonstrated that people in bright ambient lighting environments experienced higher levels of pleasantness and pleasure (Fleischer et al., 2001; Russell, 2008). In terms of the effects of lighting on emotional states and behavioral intentions, this study looked for the correlation of light intensity and color of light in urban transitional spaces functioning as the new public destinations, mostly at their entrances.

Moreover, willingness and motivation to remain in a place link to people's emotions because design features, including lighting, can induce more pleasure or arousal in response to the place. In terms of emotional states, individuals could be encouraged to start an activity or to interact with their surrounding environment, or feel happy and pleased by being at the place. However, Correlated Color Temperature (CCT), or the color of light, strongly relates to emotional states (Baron et al., 1992) and significantly affects people's feelings (Lin & Yoon, 2015). Precedent studies have suggested that designers should obtain a perception of lighting preferences prior to planning a transitional space (Fleischer et al., 2001; Lin & Yoon, 2015; Ryu & Jang, 2007).

General satisfaction and social activities are dependent on how users perceive comfort, safety, legibility, accessibility, aesthetics, and locations (Kaźmierczak, 2013; Lelévrier, 2013; Moulay et al., 2018; Moulay et al., 2017). These findings make most of urban designers to promote public spaces that are more physically and visually functional (Moulay et al., 2018). Urban transitional spaces can be depicted in cultural and social environments as new destinations

(Luz, 2006). Much research has suggested that many people behave based on certain ways for emotional reasons and link emotions and motivations to the experience of new places (Lin & Yoon, 2015; Moulay et al., 2017; Runyon & Stewart, 1987). Therefore, emotional responses frequently elicit various behaviors from visitors in urban transitional spaces.

This study looks at how light's color temperature could be welcoming enough to influence people's perceptions or emotional-psychological responses such as pleasure and arousal in urban transitional environments experiencing; physical urban environments provides sensory input for users including their perceptions of urban transitional spaces. Using computer simulations to mimic an existing built environment allowed the control of non-lighting context variables, such as weather, people, and traffic, so lighting conditions could be evaluated in the research study. Preventing the impacts of such environmental variables is a common reason to use virtual environments and computer stimuli as a representation of the real world (Portman et al., 2015; Scorpio et al., 2020). Since interior designers bring different scale sets and decide on the component set of places and objects, they can play a key role in defining how design elements in transitional spaces can increase people's perception of appealing transitional spaces.

In terms of the effects of lighting on emotional states and behavioral intentions, this study looked for the correlation of light intensity and color of light in urban transitional spaces functioning as the new public destinations, mostly at their entrances. Despite the general acknowledgement of the importance of lighting for interior environments (Rainha, 2005), no published study focusing specifically on transitional space lighting has been found. Furthermore, the focus of this study revolves around the need to increase people's engagement with and desire to remain in transitional spaces, which the study accomplishes by examining the lighting preferences and perceptions.

1.1. Research Purpose and Questions

The purpose of this study was to determine whether different lighting conditions affect individuals' emotional states and behavioral intentions in a transitional environment. Specifically, the influence of design cues examined the power of the pleasure, arousal, and dominance (PAD) model (Mehrabian & Russell, 1974) in explaining user attitudes toward their behavioral intentions (approach-avoidance) in a transitional space. The aim of this study was to compare the effects of lighting that varied in intensity (bright and dim) and the color temperature of light (warm and cool). Using four study groups, this study examined the effects of lighting preferences on pleasure and arousal as emotional states and on behavioral intentions such as approaching or avoiding. This research focused on the following research questions:

1. How does the light intensity affect people's perception of a transitional space?
2. How does the lighting's correlated color temperature (CCT; warm/cool) affect people's perception of a transitional space?
3. To what extent does individuals' perceptions of lighting condition influence behavioral intentions in an urban transitional space?

1.2. Hypotheses

To explore why individuals might want to enter urban transitional spaces as a public destination and remain there for a while, I decided to consider the impact of lighting conditions on their emotional states and behavioral responses. The following specific research hypotheses have allowed the study to reach its objective.

Recent studies have asserted that light and color are key elements of interior design that have significant effects on space perception, emotions, and behavioral responses (Baron et al., 1992; Gifford, 1988; Lee, 2019; Pae, 2009; Park & Farr, 2007; Yang, 2015). According to Wu and Wang (2015), based on consumers' emotional response, warm lighting with bright illuminance offers people more pleasure, joy, happiness, and relaxation than a cool lighting setting. In addition, Russell (2008) stated that a warm CCT of light tended to elicit a stronger impression of pleasantness, whereas Miwa and Hanyu (2006) suggested that people tended to have a higher rate of communication in dim lighting conditions. Consequently, the following hypotheses are expressed:

H_{01}: Lighting with a warm CCT does not have a relationship with feeling of pleasure (H_{01}: μ warm CCT = μ cool CCT).
H_{11}: Lighting with a warm CCT leads to a higher feeling of pleasure (H_{11}: μ warm CCT > μ cool CCT).

H_{02}: Lighting with a higher intensity does not have a relationship with feeling of arousal (H_{02}: μ bright LI = μ dim LI).
H_{12}: Bright lighting leads to higher feelings of pleasure (H_{12}: μ bright LI > μ dim LI).

H_{03}: Lighting with a cool CCT does not have a relationship with feeling of arousal (H_{03}: μ warm CCT = μ cool CCT).
H_{13}: Lighting with a cool CCT leads to a higher feeling of arousal (H_{13}: μ warm CCT > μ cool CCT).

H_{04}: Lighting with a lower intensity does not have a relationship with feeling of arousal (H_{04}: μ bright LI = μ dim LI).
H_{14}: Dim lighting leads to higher feelings of arousal (H_{14}: μ bright LI > μ dim LI).

H_{05}: Lighting intensity does not moderate the relationship between warm light and pleasure (H_{05}: μ bright LI. μ warm CCT = μ dim LI. μ warm CCT = μ bright LI. μ cool CCT = μ dim LI. μ cool CCT).
H_{15}: When the lighting intensity is low, the positive relationship between warm light and pleasure is strengthened (H_{15}: μ bright LI. μ warm CCT ≠ μ dim LI. μ warm CCT ≠ μ bright LI. μ cool CCT ≠ μ dim LI. μ cool CCT).

H_{06}: Lighting intensity does not moderate the relationship between cool lighting and arousal (H_{06}: μ bright LI. μ warm CCT = μ dim LI. μ warm CCT = μ bright LI. μ cool CCT = μ dim

LI. μ cool CCT).
H_{16}: When the lighting intensity is high, the positive relationship between cool lighting and arousal is strengthened (H_{16}: μ bright LI. μ warm CCT ≠ μ dim LI. μ warm CCT ≠ μ bright LI. μ cool CCT ≠ μ dim LI. μ cool CCT).

H_{07}: Pleasure does not have a relationship with arousal (H_{07}: $\rho = 0$).
H_{17}: Pleasure has a positive relationship with arousal (H_{17}: $\rho \neq 0$).

H_{08}: The feeling of pleasure does not have a relationship with willingness to approach an urban transitional space (H_{08}: $\rho = 0$).
H_{18}: The feeling of pleasure leads to a higher willingness to approach an urban transitional space (H_{18}: $\rho \neq 0$).

H_{09}: The feeling of arousal does not have a relationship with willingness to approach an urban transitional space (H_{09}: $\rho = 0$).
H_{19}: The feeling of arousal leads to a higher willingness to approach an urban transitional space (H_{19}: $\rho \neq 0$).

H_{010}: The feeling of pleasure does not have a relationship with willingness to avoid an urban transitional space (H_{010}: $\rho = 0$).
H_{110}: The feeling of pleasure leads to a lower willingness to avoid an urban transitional space (H_{110}: $\rho \neq 0$).

H_{011}: The feeling of arousal does not have a relationship with willingness to avoid an urban transitional space (H_{011}: $\rho = 0$).
H_{111}: The feeling of arousal leads to a lower willingness to avoid an urban transitional space (H_{111}: $\rho \neq 0$).

H_{012}: Approach does not have a relationship with avoidance (H_{012}: $\rho = 0$).
H_{112}: Approach has a negative relationship with avoidance (H_{112}: $\rho \neq 0$).

1.3. Definition of Terms

This study uses the following terminology to describe environmental stimuli and the behavioral responses they induce:

Ambient: “lighting throughout an area that produces general illumination” (DiLaura et al., 2011, p. 10.11)

Approach: Indicates a propensity to remain in a place or to move toward the desired stimulus in this study (Elliot, 1999); measurement of approach is discussed in Chapter 3.

Arousal: "A feeling state is varying a point along the dimension ranging from sleep to frantic excitement" (Mehrabian & Russell, 1974, p. 18); measurement of approach is discussed in Chapter 3.

Avoidance: Indicates a propensity to leave a place or move away from an undesired stimulus in this study (Elliot, 1999).

Behavioral intentions: "The degree to which a person has formulated conscious plans to perform or not perform some specified future behavior" (Warshaw & Davis, 1985, p. 214).

CIE[1]: Approximate colors can be assigned to specific areas on the CIE Chromaticity Diagram, which depicts all possible colors as specified by a pair of numerical co-ordinates. (Schanda, 2007).

Color of light: "A theoretical blackbody becomes yellowish-white (warm color) at 3000 K, white at 5000 K, bluish-white (cool color) at 8000 K, and deep blue at 60,000 K" (DiLaura et al., 2011, p. 6.18).

Color Rendering Index (CRI): "a metric developed in the 1960s to determine how true or natural a lamp produces color" (Rea & Freyssinier-Nova, 2008).

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[1] CIE Color System (gsu.edu)

Correlated color temperature (CCT) of a light source: “the temperature of a blackbody can be used to describe the color appearance of a light source, said to be its Color Temperature. Blackbody temperatures are absolute temperatures, expressed in units of kelvin (k)” (DiLaura et al., 2011, p. 6.17)

Light intensity: “Luminous intensity specifies the light-emitting power of a point source in a particular direction and is defined as the density of luminous flux in space in that direction. In this study, the light intensity is perceived as either bright or dim” (DiLaura et al., 2011, p. 5.13).

Pleasure: The degree to which a person feels good, joyful, or happy (Robert & John, 1982).

Spherical photograph: “a spherical image is captured by at least one camera with a 180° or greater field of view lens for subsequent viewing” (McCall & Martin, 1999).

1.4. Summary

This chapter discussed the purpose of the current study: the importance of lighting as environmental stimuli that impact individuals’ emotional states and their behavioral responses to remain in a transitional space between exterior and interior at nighttime. In addition, the chapter discussed the hypotheses and questions of the research, as well as the definitions of key terms. The preceding section reviews the literature related to the hypotheses and the constructs.

CHAPTER II

LITERATURE REVIEW

2.1. Introduction

This chapter presents a review of previous studies to provide evidence for developing the research hypothesis. There are four main sections to this literature review, including existing literature on transitional space, previous studies on lighting temperature and intensity, and the precedent studies concerning developments of PAD theory and approach-avoidance theory. An analysis of behavioral responses and the effects of behavioral states and lighting preferences is presented in the final section.

2.2. Transitional Space

Beyond formally designated buildings or places, there is a need for spaces between them to create a reason for people to meet and socialize with one another. A particular challenge in design relates to places or spaces in between indoors and outdoors that might have been left unused or have shared certain characteristics and properties of both interiors and exteriors. Consideration of transitional spaces must not yield to certain typologies of functional realms that are neither indoors nor outdoors; Kray et al. (2013, September), and Jan Gehl (1989) claimed that most common transitional forms have been accepted as edges of places (Laiprakobsup, 2007, p. 4). There has been a tendency to investigate the notion of edges of designed spaces, which create the vast majority of public spaces in cities and need to be considered a platform for interior elements. As mentioned earlier, interior elements could add meaningful senses and characters. At the point of transitional space, there are three different phases of different characters, such as arrival (connecting space which offers an introduction), passage (movement between two spots), and transition (to adjust from one experience to another) (Kray et al., 2013, September). As Can and Heath (2016) claimed, these intermediate spaces form the interface between the interior and exterior, such as an extension of a building's interior space to the street or front open spaces such as sidewalk cafes. A transitional space can be similar to Augé's concept of an area that does not have a wholly defined identity because individuals entering it typically perceives it as in between two other places (Augé, 1995).

Clarifying the notion of transitional space can provide awareness of movements and actions through interior and exterior domains, which will enhance the holistic experience of an environment (Laiprakobsup, 2007). However, an urban transitional space is dissimilar to Augé's negative conception of "non-place" as an ambivalent space that incites no sense of belonging (Ruckle, 2011), undesignated spaces may result in unexpected situations that are unknown (Harle & Ribevald, 1993). Front yards as transitional spaces also connect private homes and public neighborhoods, depending on their design, character, and function (Carl, 2015). In the context of European interpretations of a good transitional space, Jacqueline Miller (1993) recollected a transitional space quite plainly as the threshold of the house, where one can sit on a chair to watch people (Harle & Ribevald, 1993). Courtyards also belong to the transitional space category, having social, cultural, environmental, and formal impacts (Taleghani et al., 2015).

Moreover, urban transitional spaces are often publicly owned, and everyone can access them (Carmona, 2010; Gehl, 1989; Laiprakobsup, 2007). Signage and wayfinding play a significant role in the characteristics of such spaces (Kray et al., 2013, September). Also, Bollerey (1993) introduced a good transitional space as small "public spaces which have permitted the daily custom of the alfresco lunch in the vicinity of New York offices" (as cited in (Harle & Ribevald, 1993, p. 1), a place one can pause for a moment and choose to distance from others. A significant aspect to consider in analyzing a transitional space includes the typical duration an individual remains in such areas (Kray et al., 2013, September). The imperative transition from one area to another involves a change in environmental and territorial conditions (Harle & Ribevald, 1993; Laiprakobsup, 2007; Ruckle, 2011).

Among other types of transitional space definitions, Kray et al. (2013, September) indicated a further explanation, common in many cities, of transitional space as arcades. In particular, the spaces that pedestrians used to protect themselves from frequent rain or hot temperatures were usually roofed and surrounded by walls but not separated from the exterior environment (Benjamin, 1999). Hence, it is possible to say that a transitional space as an experiential zone will provide the setting for collective activities (Harle & Ribevald, 1993). The significance of the transitional space will contribute new insight into the creation of the connection between both interior and exterior spaces as a whole entity. The psychological response to these intermediate spaces can be influenced by the lighting conditions, especially at nighttime (Grazian, 2009; Lekus, 2019). Therefore, the reason for choosing an intermediate space is that transitional spaces can leave an impression on individuals' perception of the environment, as they are intended to contribute to the quality of movement (Araji, 2004; Kray et al., 2013, September; Taleghani et al., 2015). And ambient lighting can help transitional spaces serve as both approaches and extensions of the building.

2.3. The CCT of Light and Light Intensity

Research suggests different lighting states affect social interaction (Gifford, 1988); Lee (2019) investigations demonstrated how the color temperature of light modifies various emotions, mood, memory, or behavioral responses.

According to DiLaura et al. (2011), CCT refers to the apparent color of a light source, which is typically expressed in terms of how light appears warm or cool. Lighting color temperature is always measured by CCT, describing the appearance of a light source with kelvin unit (k). According to Gordon (2015), when color temperatures are over 4000 k, they are called cool colors, and lower color temperatures, including 2700–3000 k, are called warm colors. Colors regarded as warm are orange-yellow, whereas colors regarded as cool are blue-white. A light that appears white usually indicates natural light with a color temperature range such as 3500–4000 k (Gordon, 2015).

The Illuminating Engineering Society (IESNA) and others note that the CCT of outdoor lighting has a dramatic impact on the way individuals perceive and interpret the visual aesthetic of the environment setting (DiLaura et al., 2011; Lee, 2019). Characteristics of the lighting can change an individual's impressions of an environment (Flynn & Spencer, 1977; Flynn et al., 1973; Hendrick et al., 1977; Yang, 2015). As claimed by Park and Farr (2007), based on their experiment related to the correlation of light's CCT and emotional states on behavioral intentions, warm light (3000 K) was more pleasurable, preferable, and generated a higher approach intention, whereas cool light (5000 K) was more arousing. Fleischer et al. (2001) also indicated that light with a cool CCT promoted higher arousal than warm lighting. Moreover, some research found that dimmer lighting induced more pleasure in terms of lighting intensity, whereas others reported more pleasant emotions with bright lighting. Also, dim lighting can induce little to no arousal, whereas bright lighting can elicit arousal and excitement (Gifford, 1988; Mehrabian & Russell, 1974; Steffy, 2002).

Pae (2009) described the correlation of an illumination level and reflectance as brightness. In addition, he defined *illuminance* as the amount of light falling on a surface and is measured in lux. In photometry, the lux (lx) is a unit of measurement for the perceived intensity of light impacting or passing through a surface (Pae, 2009). In terms of the influences of environmental light conditions, Baron et al. (1992), Rea and Freyssinier-Nova (2008) , and Baron et al. (1992) suggested that positive behavioral effects result from specific lighting conditions. Yet, relevant studies have not succeeded in finding the direct effects of light on mood and cognitive tasks (Baron et al., 1992; Pae, 2009; Park & Farr, 2007). Regardless of these disagreements, lighting can improve users' performance by meeting their physical and psychological demands (Pae, 2009). According to Mehrabian (1976), bright lighting in indoor environments is more arousing than dim lighting. Several studies applied Mehrabian’s theory, in which he stated that the level of arousal is influenced by lighting as the significant environmental stimulus (Areni & Kim, 1994; Biner et al., 1989; Gifford, 1988; Pae, 2009; Veitch, 1997; Veitch et al., 1991).

According to (IESNA, 2000) light’s CCT and color rendering for outdoor lamping impact individuals’ sense of visual attraction and aesthetic. Therefore, it is essential for lighting conditions in an urban transitional space that "light CCTs extend outside the range of 2700 K to 4100 K," and lamps with CRIs ≥80 employed a better identifying and distinguishing colors where people meet outdoors (DiLaura et al., 2011, p. 3.26). Park and Farr (2007) found that the way people from different cultures and backgrounds perceive and feel about lighting conditions affected their emotional states as well as behavioral intentions of "approach-avoidance" in a retail environment. Furthermore, the result indicated that color temperature significantly affected the users' behavioral responses. The 5000 k (cooler, more bluish) lighting was found to be more enticing than the 3000 k (warmer, reddish) illumination (Park & Farr, 2007).

2.4. Correlation Between Emotional States and Behavioral Responses

Depending on the emotion, the behavioral response can be non-cognitively induced and can be more intense, attention-grabbing, and specific to a behavior (Clark & Isen, 1982). As Mehrabian and Russell (1974) claimed, based on the stimulus, organism, and response (S-O-R) paradigm, also known as the (M-R) model, environmental stimuli influence emotional states (internal states), which then induce behavioral responses (approach-avoidance). Some schools of thought introduced mood as a synonym of emotion, whereas some resected mood from emotion (Kim & Lennon, 2010).

On the other hand, Eroglu et al. (2003) recommended consideration of cognitive internal states in addition to emotional states. The processes by which information is acquired, processed, retained, and retrieved constitute cognitive states (Eroglu et al., 2003). For instance, Eroglu et al. (2003) expanded the S-O-R model to include cognitive attitude as part of an organism, to test the Mehrabian and Russell (1974) model in the context of online shopping environments (Kim &

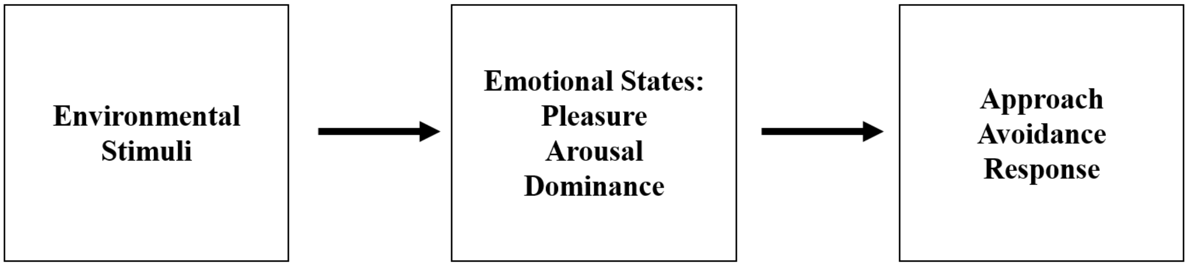
Lennon, 2010). In terms of describing the state of emotion, Gardner (1985) calls mood “a phenomenological property of individual’s subjectively perceived affective states” (Gardner, 1985, p. 282). Some studies explored the effects of lighting design on the customers’ emotional states and behavioral responses in retails, restaurants, and hotel room environments (Lee, 2019; Lin & Yoon, 2015; Park, 2001; Park & Farr, 2007; Yang, 2015). There is still no detailed explanation of how the lighting in urban transitional environments should be designed to be pleasant enough yet exciting for people to remain in such places.

2.5. Conceptual Model for the Study

Environmental experience cannot be exercised independently of context, its users, and their relationships. Studies in environmental psychology provided the theoretical base centered on “the direct impact of physical stimuli on human emotions” and “the effect of the physical stimuli on a variety of behaviors” (Mehrabian & Russell, 1974, p. 4). As previously mentioned, Mehrabian and Russell (1974) proposed the S-O-R paradigm, also called M-R model, which suggested that environmental stimulus (S) and behavioral response (R), as moderated by the individual emotional states (O), is equipped with an algorithm that generates behavioral responses depending on one’s emotional state, such as approach and avoidance. Mehrabian and Russell suggested three dimensions, “arousal, pleasure, and dominance,” as essential emotional reactions to an environment. *Arousal* represents a feeling of excitement and energized feelings, whereas *pleasure* represents the extent to which the individual is pleased and satisfied. *Dominance* is defined as the degree to which a person feels influential, in control, or free to act in an environment (Park, 2001; Park & Farr, 2007).

Figure 1

Outline of the M-R Model



Note: Outline of the M-R Model. Adopted from An approach to environmental psychology (p. 96), by Mehrabian and Russell (1974), the MIT Press.

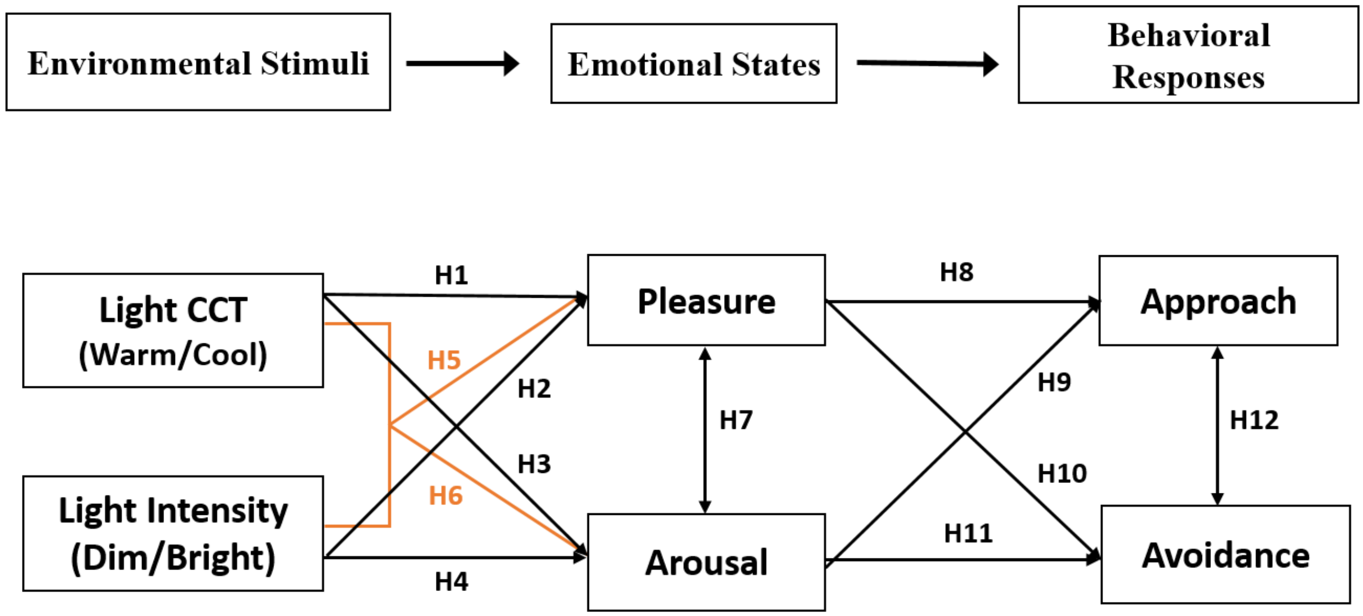
Mehrabian (1976) elucidated that a person's behavioral responses are incited by all environmental stimuli and classified them into two contrasting behaviors, such as approach and avoidance, in the M-R model as shown in Figure 1 (Mehrabian & Russell, 1974). The M-R model was not found to be significantly correlated with behavior in studies, where there are supportive results for pleasure and arousal (Robert & John, 1982; Ward & Russell, 1981). Research showed that behavioral intentions influence behaviors of people at retail stores and their desire to purchases more than their pleasure or arousal stages. For instance, Robert and John (1982) and Park and Farr (2007) defined two primary dimensions of emotional states: pleasure and arousal (Pae, 2009). These studies considered the physical environment as the first component of the M-R model (S) and behavioral response with aspects of approach-avoidance (R) as the third component of the M-R model. Approach-avoidance behaviors are considered to have four aspects: Approach behaviors refer to all positive aspects, including the desire to remain, desire to explore, desire to work, and desire to affiliate. In contrast, avoidance behaviors refer to the opposite (Lee, 2019, p. 46).

The review of studies on lighting for retail environments and interior spaces (indoors) and its effect on behavioral intentions revealed similarities in environmental settings preferences (Lee, 2019). As maintained by the classical view, the emotional effects of satisfaction are characterized by pleasant, low-arousal emotions, whereas those of dissatisfaction are unpleasant and/or high-arousal (Oliver, 1997). This approach maintains that an individual's perception of a given environment results from emotional states created by the surrounding environments (Mehrabian, 1976). Pleasure and arousal are the emotional states induced by physical environments (Baker et al., 1992; Mehrabian & Russell, 1974; Russell & Pratt, 1980). Even though the M-R model was applied in many studies on lighting's effects on users in built environments (Park, 2001; Park & Farr, 2007), no published studies were found on the effect of lighting in transitional spaces on individuals' emotions and behavioral responses. Therefore, the extent to which an individual is willing to stay in the environment and feel pleasant refers to pleasure; however, the extent to which an individual feels stimulated relates to arousal feelings (Das, 2013).

However, there have been limitations to building a theoretical framework for intermediate environments such as transitional space between interiors and exteriors because they have not been considered (Flynn & Spencer, 1977; Park, 2001; Park & Farr, 2007). Besides light intensity (dim or bright), the current study also investigates how light's CCT (warm or cool) affects the lighting preference and emotional state of an individual in a transitional space. Furthermore, a newly developed conceptual model was amended to examine the relationship between the lighting conditions in a transitional space and emotional states and behavioral responses (see Figure 2).

Figure 2

The Conceptual Model for the Study



2.6. Summary

This chapter reviewed previous literature that supports the development of the proposed hypotheses. It considered existing findings on transitional spaces, explained the importance of light's CCT and light intensity in terms of effect on emotional states, and conceptualized approach-avoidance theory. It also discussed the theoretical foundation (i.e., the M-R model) related to measurements of emotional states. However, there remains a gap in the literature on the correlation between lighting in transitional spaces and emotional states' influence on behavioral responses. Finally, a conceptual model for the study was provided. The next chapter discusses the methodology of the current study.

CHAPTER III

METHODOLOGY

3.1. Introduction

A description of the experimental setup and lighting conditions is presented in this chapter, including the participants and data collection instruments. The research methodology is identified on the basis of the aspects of the case study as an urban transitional space. The methods used for data analysis are explained. Last, the study's data analysis procedure is presented in this chapter, which starts with a review of the data collection process and manipulation checks. Next, the characteristics of respondents and their demographic information are reported.

For measuring the reliability of the scales, Cronbach's alpha was calculated for each lighting condition and each measurement scale (Nunnally, 1978). SPSS statistical software was used to analyze data and evaluate hypotheses. The final section includes a summary of the findings of the study.

3.2. PAD Theory

Three basic emotional states, known as PAD (Pleasure-Displeasure, Arousal-Nonarousal, and Dominance-Submissiveness) and introduced by Russell (1989), mediate approach-avoidance behavior and are used to measure affective experiential states (Oliver, 2014). Previously, Russell and Pratt (1980) and Robert and John (1982) had claimed that emotional responses were not significantly related to dominance, but rather pleasure or arousal. The classical view (Mehrabian & Russell, 1974) suggests that satisfaction is characterized by pleasant emotions and dissatisfaction by unpleasant or high-arousal effects (Oliver, 1997). This approach maintains that an individual's perception of a given environment results from emotional states created by the surrounding environments (Mehrabian & Russell, 1974). Pleasure and arousal are emotional states induced by physical environments (Baker et al., 1992; Mehrabian & Russell, 1974; Robert & John, 1982; Russell & Pratt, 1980). Therefore, the extent to which individuals are willing to stay in the environment and feel pleasant refers to pleasure, and the extent to which an individual feels stimulated relates to arousal feelings (Baker et al., 1992).

The current study aimed to examine effects of the level of light intensity (bright/dim) and correlated color temperature of light (warm/cool) on an individuals' emotional states and behavioral responses. By comparing perceived emotional states and behavioral responses across four lighting-condition groups, it was possible to assess lighting effects on behaviors. A review of related literature supported using two main attributes of emotional states, pleasure and arousal, and approach-avoidance theory to determine the study's independent variables. Light intensity and light's CCT were proposed as the dependent variables.

Despite the fact that appropriate experimental design allows for direct manipulation of variables to compare and control, the construction is costly and time-consuming (Park & Farr, 2007; Sommer & Sommer, 1997). As an instance, developing an evidence-based design for a specific reason such as lighting condition or considering to change environmental elements needed many resources and time. Using spherical photographs is a well-documented alternative method to represent 3-D space. According to Sommer and Sommer (1997), videos, photographs, and setting models represent imitations of actual conditions intended to mimic reality without confusing individuals interacting with a virtual environment.

3.3. Case Study

The Modella Gallery on Main Street in downtown Stillwater, Oklahoma, was obtained as the case study. The interior lighting of the Modella Gallery juxtaposes the exterior lighting condition almost in day/night time. Even with daylight, it is not sufficiently welcoming and appealing to entice individuals to visit. Figure 3 illustrates the Modella Art Gallery's site plan and the transitional space location in between the gallery interior and sidewalk.

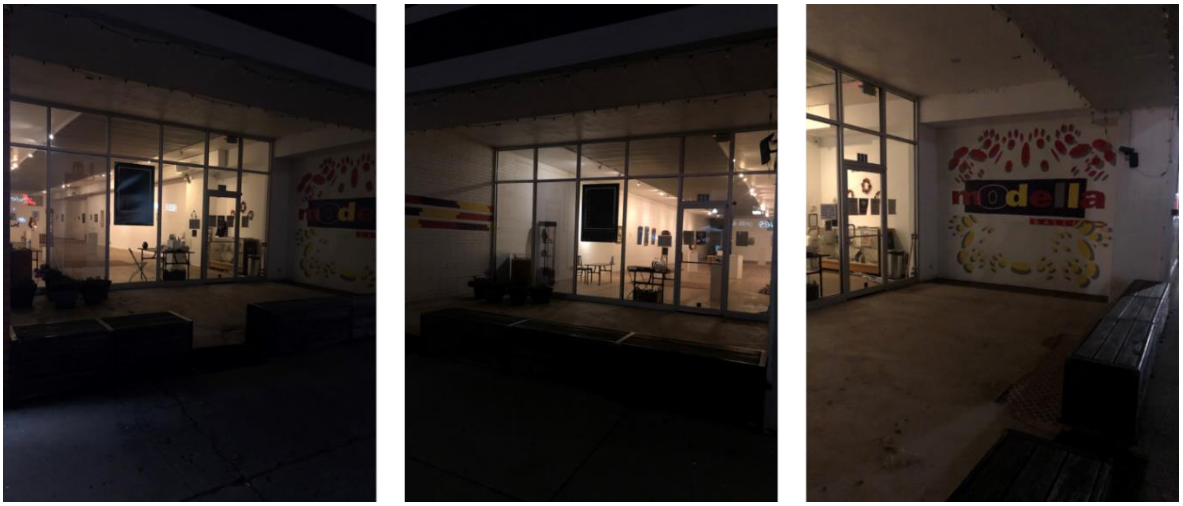
Figure 3

Modella Gallery Transitional Space

This study focused on the lighting distribution, including the light's CCT and light intensity to this transitional space in between the interior of the gallery and sidewalks as the exterior space. The experiment considered only the nighttime environment of the transitional space outside an art gallery. The space is a semi-public/semi-private place perceived as a welcoming area that draws people's attention to either go inside the gallery or stay for a while in this transitional space. The main reason is that urban transitional space could serve as a pleasant space as a public area for users to engage more with their surrounding environments and be drawn to such spaces as a new destination. Figure 4 shows the existing lighting condition of the art gallery at nighttime.

Figure 4

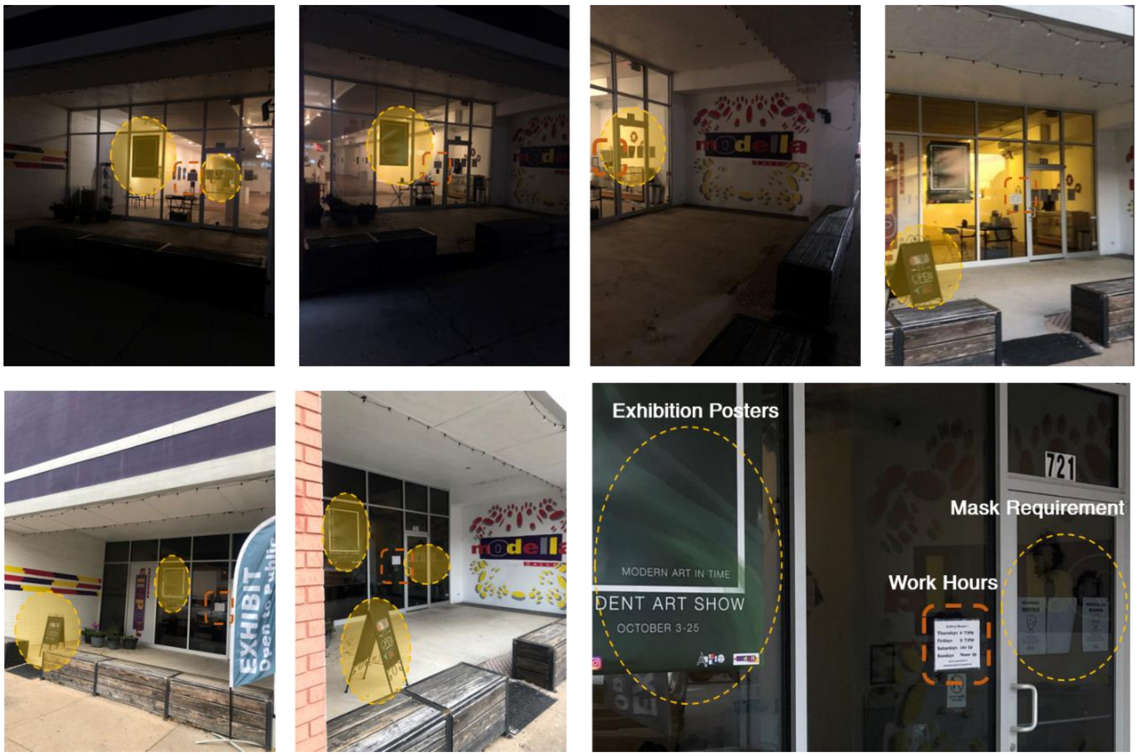
The art gallery's existing transitional space's lighting condition lacks adequate lighting distribution at nighttime. The art gallery, 26 September, 8:00 P.M.



Visual tasks in the case study were anticipated based on the observations. Wayfinding and reading door signage are impossible at the art gallery transition space at nighttime. However, the transparent façade of the gallery cannot provide enough lighting for the transitional space. Therefore, face-to-face conversations will not be satisfied there, and individuals will not consider lingering in the transitional space and prefer to leave such environments. Moreover, the gallery facilitated the transition space with simple sitting areas and applied colorful graffiti on the walls, which would not be useful at night due to the lack of proper ambient lighting in the transition environment. Figure 5 shows the lack of adequate lighting at the art gallery's transitional space between the gallery interior and exterior spaces.

Figure 5

Signage and sitting areas of the art gallery at nighttime.



Because the current study investigated the transitional space's lighting condition at nighttime, daylight was excluded. A Rico Theta S camera and Cupix[2] software was used to capture and develop the 3-D panoramic tour of the environment. Adobe Photoshop was employed to manipulate each scenario's lighting condition. Four different panoramic experiences were created, and participants were randomly assigned to one of the four lighting conditions: (a) dim light with cool color temperature, (b) dim light with warm color temperature, (c) bright light with warm color temperature, and (d) bright light with cool color temperature. Each lighting experience contained one spherical image (360°). Each of these four experiences was evaluated by three Oklahoma State University design experts in lighting, interior design, and color to

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[2] Cupix Web Player

confirm all that created images well represented the specific transitional space with designated lighting solutions. In addition, a pre-test was conducted to examine the validity and reliability of computer stimuli's manipulation based on 60 participants' perceptions. Respondents were asked to verify the lighting conditions based on their perception of light CCT and light intensity.

3.4. Lighting Condition

The current study's lighting conditions were demonstrated by documenting existing lighting conditions of the art gallery. In comparing the four lighting conditions, I manipulated the CCT of light and the light intensity of existing illumination to represent four different levels of lighting in the transitional space. The current experimental research implemented a 2 (bright light, dim light) × 2 (warm color temperature, cool color temperature) factorial design to identify the effect of lighting intensity and light's CCT on emotional states in a transitional environment. Four different lighting conditions have been defined for the digital perspectives: (a) bright lighting with warm color, (b) dim light with warm color, (c) bright lighting with cool color, and (d) dim lighting with cool color.

A CIE Chromaticity diagram was employed to define the color of light. To explain "warm" color light, a CCT between 2500 K and 3500 K with reddish and yellowish color was selected. "Cool" color light represented a CCT of 5000 K and higher with a blueish and whitish color (Siess & Wölfel, 2019). Studying the effects of interior and street lightings on individuals are important, but not less important is investigating the effect of lighting design in urban transitional spaces which is a literature gap. The current study bridges this gap by evaluating the effect of urban transitional spaces' lighting on pleasure and arousal states and the willingness to approach or avoid. In terms of reproducing the real color of light sources in a rendered environment, it is required to know what color a blackbody is at various temperatures (Rea & Freyssinier-Nova, 2008). The investigation is to convert light's CCT (k) to reds, greens, and blues (RGBs), which can characterize the color of the light source (Helland, 2017). I employed the established table of converted CCT to RGBs, including chromaticity values (k/RGB), to set the light's desired CCT and light levels in the computer simulation (see APPENDIX A).

In terms of determining dim or bright illumination, the IESNA lighting handbook was adapted to evaluate low and high levels in outdoor environments, especially at thresholds such as transitional spaces. As a result, recommended illuminance targets for outdoor environments range between 50 and 300 lux; (DiLaura et al., 2011, p. 4.33). Table 1 shows an angle of four spherical image lighting environment.

Table 1

Four Lighting Conditions

Lighting Conditions	Preview of One Angle of the Spherical Image (360°)
Cool Color 5500k Bright Lighting 300 lux	

Lighting Conditions	Preview of One Angle of the Spherical Image (360°)
Cool Color 5500k Dim Lighting 50 lux	
Warm Color 3200k Bright Lighting 300 lux	
Warm Color 3200k Dim Lighting 50 lux	

3.5. Participants

Participants were recruited from a southwestern university in the United States of America and consisted of students, professors, and design professionals. Sixty participants, 22 men (33.0%) and 44 women (67.0%), were randomly assigned to the four spherical image (360°) experiences: The inclusion criteria were (a) had a normal or corrected vision and (b) did not have any visual impairment such as color blindness. Participants were asked to state on the prequestionnaire if they had a visual impairment, and I was notified while monitoring each experiment. It was determined before contacting study participants that I would need permission to use human subjects from Oklahoma State University Institutional Review Board (see APPENDIX B). In return for their participation, they received a chance to win an Amazon gift card worth US $25.

3.6. Study Procedure

At first, an email was sent to participants, including the survey link that outlined general information about the study task, potential risks, and voluntary participation. Upon experiencing the spherical image (360°) tour, participants reviewed the consent form, and they were asked to sign it electronically in order to either continue or leave the study. Then participants were asked to fill out the pre-questionnaire collecting their demographic information. An introductory video was attached to the survey illustrating the virtual navigation of a 360° path developed by Cupix software before entering the virtual path.

By clicking on the given link, participants were assigned randomly to one lighting condition of four within the randomization function of the Qualtrics3 platform that obtained the survey's link. Finally, the designed stimuli were opened within a provided link depicting the

[3] Qualtrics XM // The Leading Experience Management Software

assigned lighting condition in a new tab. Once participants declared their readiness for filling out the post-questionnaire, they returned to the survey link and clicked on the continue button to move on to the post-questionnaire. The post questionnaire presented a series of questions to identify the effect of lighting intensity and the light's CCT on emotional states and behavioral responses (see APPENDIX C).

To boost individuals' purpose of staying in a transitional space, I established a scenario, trying to encourage participants to visit an Art Gallery while virtually navigating the spherical image (360°). The scenario was as followed:

> *"You are walking along an urban street at night. Before going home, you want to spend more time being outside. You see the space in-between an Art Gallery's interior store and the sidewalk (also known as a transitional space*), and you think about whether you want to spend time there based on the lighting. If you wanted to, you would be able to sit on the two box seats in the entrance. Please, evaluate your feelings based on your virtual experience using the spherical image with the specific lighting condition.*
>
> ** Transitional spaces are those in-between areas that act as a new destination in public realms or any built environments."*

To investigate the lighting preferences in an urban transitional space based on the study variables, participants were asked to walk through a spherical virtual path on the Qualtrics and Cupix platform on their mobile phones or computers and rate the lighting condition on a 5-point Likert scale.

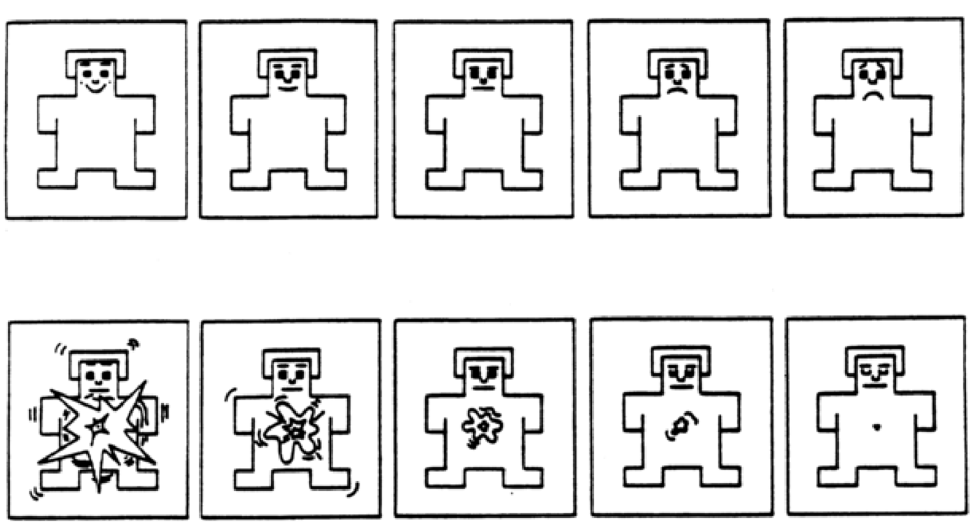
3.7.Measurements and Scales

Mehrabian and Russell's pleasure-arousal scales were used for emotional state measurements (Mehrabian & Russell, 1974). The arousal scales have four adjectives, including *aroused*, *excited*, *bored*, and *calm*. Adjectives for the pleasure scales are *pleased, satisfied, happy*, and *relaxed*. Rating the specific lighting condition was accomplished using a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

To assess levels of emotion, participants were also asked to rate their level of emotional feelings (the degree to which they felt aroused [ready to start an active] and pleased) on the basis of the Self-Assessment Mankin Scale pictographic scales (Geethanjali et al., 2017) (See Figure 6). The emotional states of pleasure and arousal were measured on the basis of the subjects' observation conditions within a lighted environment by computer stimuli techniques. Approach and avoidance were measured with the respondents' experiences of lighting conditions correlating the levels of pleasure and arousal feelings.

Figure 6

The Self-Assessment Mankin pictographic Scale (SAM) used to rate the dimensions of emotions; pleasure (top panel) and arousal (bottom panel). Adopted from (Bradley & Lang, 1994).



3.8. Data Collection

Using an online survey, 66 questionnaires were obtained from respondents. The respondents included 22 men (33.0%) and 44 women (67.0%) with ages ranging from 19–51 years and older, with an average of 35 years. Table 2 represents the frequency distribution of general characteristics of respondents. As for educational level attained, nine (13.63%) graduated from high school, 12 (18.0%) graduated from college or university, and 45 (68.18%) had a graduate degree. In addition, the participant groups included 32 (48.48%) who visit public places 1–3 times per week, 14 (21.21%) who visit public places 1–3 times per month, 18 (27.27%) who visit public places more than 5 times per month, and two who visits public places at other intervals (3.03%). While almost half of the responses concluded individuals prefer to visit public spaces frequently, the number of people who claimed they visit public spaces infrequently was undeniable.

Table 2

Characteristics of Participants

Characteristics	Frequency	%
Gender		
Male	22	33
Female	44	67
Age		
19–30 years	32	53.3
31–40 years	20	33.3
41–50 years	7	11.7
51 and older	1	1.7
Education		
High school	9	13.63
College or bachelor degree	12	18
Graduate degree	45	68.18
Visit public places		
1–3/day	32	48.48
1–3/month	14	21.21
More than 5/month	18	27.27
Other	2	3.03

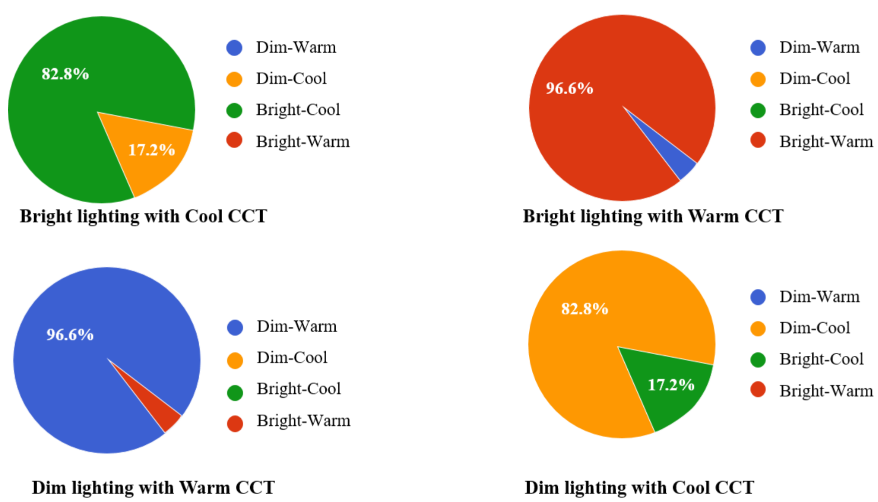
3.9. Data Analysis

3.9.1. Manipulation Checks

To ensure that perceived CCT of light and light intensity worked as expected, before creating the 360° virtual tour, I designed a pre-test with all four lighting conditions. Participants were asked to list the name of each image under its light color according to their perceptions. Figure 7 illustrates the results of 66 participants' responses verifying lighting color categories. The light color of spherical images (360°) was manipulated by Adobe Photoshop software to represent the four lighting conditions (Dim-Warm, Bright-Warm, Dim-Cool, Bright-Cool) of the gallery's entrance. All four lighting conditions were developed on the basis of respondents' opinion and validated within the pilot study. The pilot study included an online pre-survey, asking 60 respondents to verify the lighting conditions (1. Dim-Warm, 2. Bright-Warm, 3. Dim-Cool, 4. Bright Cool) of each four spherical images based on their perceptions of light.

Figure 7

Survey Results of Light Color Manipulation



3.9.2. Reliability of Measures

Cronbach's alpha was calculated for each lighting condition: (a) warm-dim lighting, (b) warm-bright lighting, (c) cool-dim, and (d) cool-bright lighting, and it was performed for each measurement scale of arousal, pleasure, and approach to test their reliability. Cronbach's alpha could not be calculated for avoidance because it was a single-item measurement. The values varied from .629–.921, almost satisfying the cutoff value of .70. However, two values of BW and BC lighting conditions did not meet the cut-off of 0.70, which meant that most of the measurement scales had good internal consistency except for approach in bright warm and bright cool lighting (Table 3) (Nunnally, 1978).

Table 3

Cronbach's Alpha Coefficients for the Reliabilities of Scales

Measure	WD	BW	DC	BC	*M*
Pleasure	0.826	0.905	0.890	0.843	0.866
Arousal	0.793	0.848	0.770	0.747	0.790
Approach	0.814	0.629	0.921	0.661	0.756

Note. WD = dim lighting with warm correlated color temperature (CCT); BD = bright lighting with warm CCT; DC = Dim lighting with cool CCT; BC = bright lighting with cool CCT.

3.10. Summary

In this chapter, a 2 × 2 factorial design experiment that examines four lighting conditions using a spherical image (360°) was proposed. Data collection method and research site selection were discussed.

CHAPTER IV

RESEARCH FINDINGS

4.1. Introduction

The study's findings are presented in this chapter, which starts with a review of the data collection process and manipulation checks. Next, the characteristics of respondents and their demographic information are reported. Then statistical analysis and results of the hypotheses testing are presented in this chapter section. First, Hypotheses 1–6 were tested by running an analysis of variance (ANOVA) and confidence intervals (CIs) of the mean differences of variables. Next, Process Model 1 (Hayes, 2017) was conducted to evaluate the interaction of light intensity and CCT of light. Also, a bivariate correlation test was used to investigate the predicted relationships in Hypotheses 7–12.

4.2. Results

The results of ANOVA provided support for rejecting the null for hypothesis 1; however, there were no evidence to reject the null in Hypotheses 2–4. As mentioned in H_1, the light with warm CCT significantly increases the feeling of pleasure, $F(1, 30) = 26.039$, $p < .001$. The prediction in H_2 was that the light with cool CCT would lead to a higher feeling of arousal.

However, there was a significantly negative relationship between lighting with cool CCT and the feeling of arousal, such that when the light was cool, the level of arousal was lower, $F(1, 29) = 17.398$, $p < .001$. Also, the interaction between the light CCT and light intensity on pleasure and arousal was not significant, $F(15, 30) = 1.269$, $p > .05$; $F(10, 29) = 1.594$, $p > .05$. The results indicated a significant positive relationship between the light intensity and the feelings of pleasure and arousal, $F(19, 30) = 6.694$, $p < .001$; $F(25, 29) = 3.581$, $p = .001$. The results of the ANOVA tests for both pleasure and arousal can be seen in Table 4 and Table 5, respectively.

Table 4

Factorial ANOVA With Interaction Effects of Light Intensity by CCT of Light on Pleasure

Source of variation	***df***	**Mean square**	***F* value**	**Sig (*p* value)**
(Intercept)	1	370.777	1182.434	.00
Light Intensity	19	2.476	6.694	.00
Light CCT	1	9.631	26.039	.00
Light Intensity × CCT	15	0.469	1.269	.28
Error	30	0.370		
Total	66			

Note. ANOVA = analysis of variance; CCT = correlated color temperature; Sig = significance.

Table 5

Factorial ANOVA with interaction effects of light intensity by CCT of light on Arousal

Source of Variation	**df**	**Mean square**	***F* value**	**Sig (*p* value)**
(Intercept)	1	437.369	1182.434	.00
Light INTENSITY	25	2.476	6.694	.01
Light CCT	1	9.631	26.039	.00
Light Intensity × CCT	10	0.865	1.594	.158
Error	29	0.543		
Total	66			

Note. ANOVA = analysis of variance; CCT = correlated color temperature; Sig = significance.

In addition, running a one-way ANOVA for the four lighting conditions showed that the dim lighting with warm CCT condition had the highest scores for pleasure and the bright lighting with warm CCT condition had the highest scores for arousal. The mean and standard deviations of different conditions in terms of pleasure and arousal can be seen in Table 6 and Figure 8 and Figure 9.

Table 6

Mean and Standard Deviation Scores for Pleasure and Arousal

Lighting group	*M**	*SD*	*n*
Dim/warm lighting			
(Pleasure)	3.214	1.261	14
(Arousal)	2.881	1.159	14
Bright/warm lighting			
(Pleasure)	3.126	0.780	19
(Arousal)	3.035	1.185	19
Dim/cool lighting			
(Pleasure)	2.500	1.090	16
(Arousal)	2.437	1.059	16
Bright/cool lighting			
(Pleasure)	2.411	1.011	17
(Arousal)	2.333	0.993	17

*5-point Likert-type scale: 1 = *completely disagree* and 5 = *completely agree*.

Figure 8

Mean Comparison Between Four Lighting Groups on Pleasure

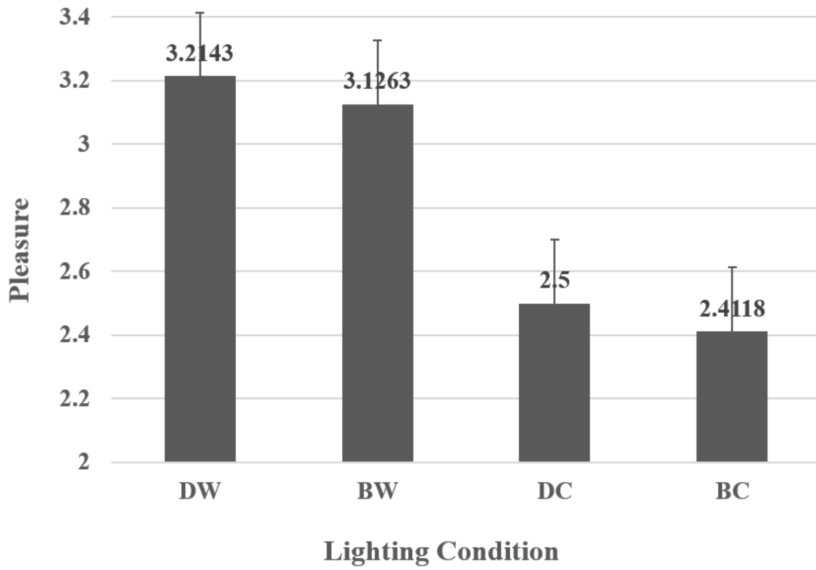
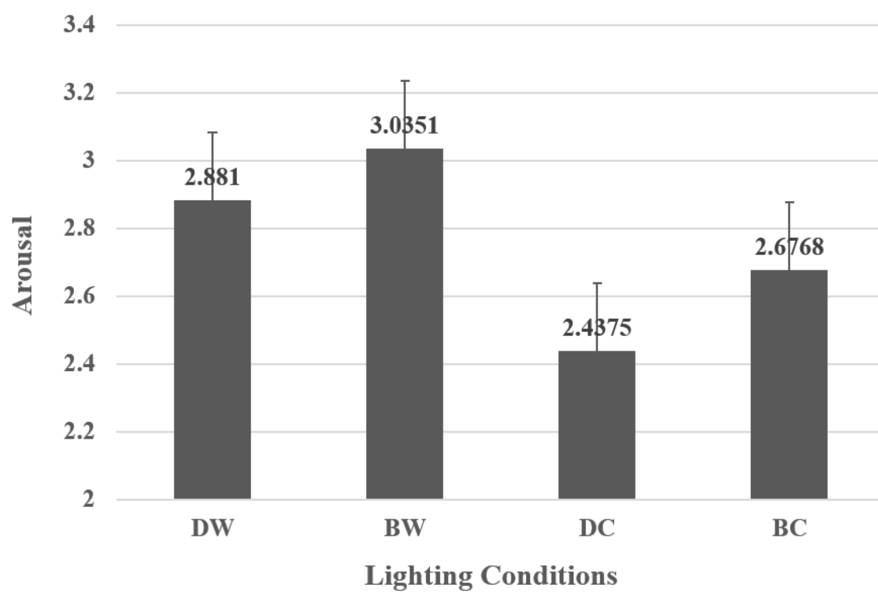


Figure 9

Mean Comparison Between Four Lighting Groups on Arousal.

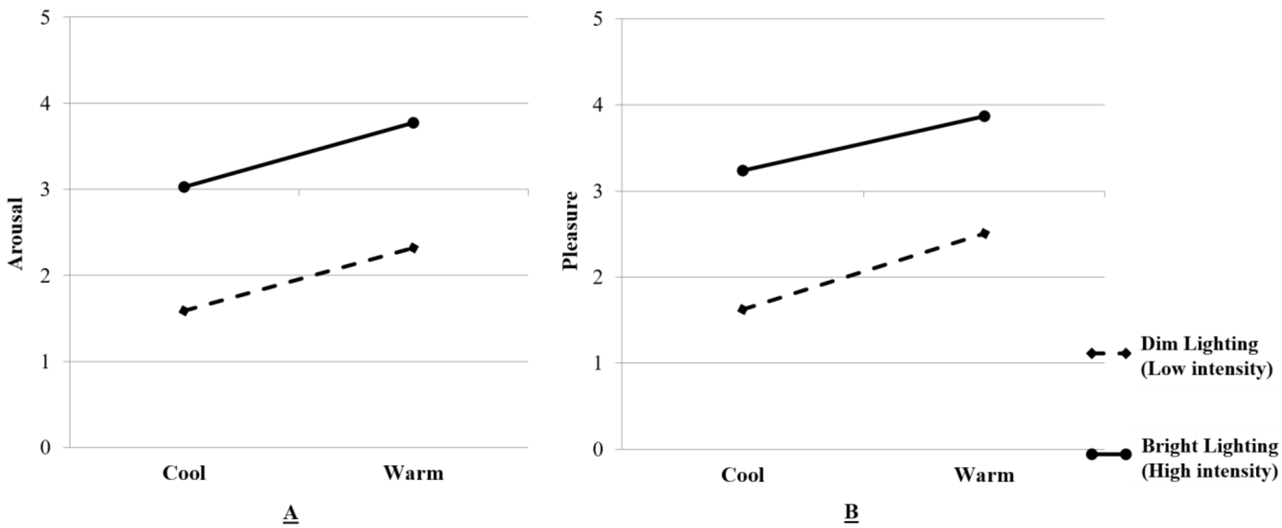


To further test the hypotheses for interactions and main effects, I ran a moderation analysis with 5,000 bootstrapping samples (Process Model 1; (Hayes, 2017) to test Hypotheses 1–4. The results were consistent with the ANOVA results reported above; furthermore, they provided enough evidence to reject the null hypothesis for H_1 which indicates that feelings of pleasure substantially increased when the lighting has a warm CCT. However, the results for H_2 were not in line with the predicted effects and were significant in the opposite direction. Also, the results for H_3 and H_4 did not show significant interaction effects and the null hypotheses for H_3 and H_4 were not rejected.

With regard to examining the interaction effect between the light CCT and light intensity among the feelings of pleasure and arousal, the main effects of intended CCT of light and intended light intensity were significant. As can be seen in Figure 10, the results of the moderation analyses show that the interactions of Light intensity and the CCT of light were not significant for pleasure and arousal ($b = -1.07$, $t = -.683$, $p > .05$, 95% CI [−.2203, .4488]; $b = -.002$, $t = -.0157$, $p > .05$, 95% CI [−.3691, .3633]. This means that the effect of CCT on pleasure or arousal did not vary with different levels of light intensity. However, as can be seen in Figure 10B, when the light intensity was low (dim), the effect of light CCT on pleasure tended to be stronger even though not significant. This effect is in line with the predictions in the moderation hypothesis (H_5) and evidence might be found to reject the null with a larger sample size.

Figure 10

Interaction Effect for Emotional States (Pleasure/Arousal) by Light CCT by Light Intensity



The results of the bivariate correlation analysis provided support to reject the null hypothesis for H_7–H_{12}. In line with predictions in H_7, the results showed a significant positive correlation between pleasure and arousal, $r(64) = .809$, $p < .001$. The results also indicated that both pleasure and arousal were significantly and positively correlated with approach, $r(64) = .784$, $p < .001$; $r(64) = .80$, $p < .001$, which gives evidence to reject the null hypotheses for H_8 and H_9. As predicted in H_{10} and H_{11}, the results showed that the feelings of pleasure and arousal were negatively and significantly correlated with avoidance, $r(64) = -.615$, $p < .001$; $r(64) = -.609$, $p < .001$. And last, the negative relationship between approach and avoidance predicted in H_{12} was supported and the null hypothesis could be rejected, $r(64) = -.471$, $p < .001$. The correlations can be seen in Table 7.

Table 7

Descriptive Statistics and Correlation Results

	Arousal	Pleasure	Approach	Avoidance
Arousal	1			
Pleasure	0.809**	1		
Approach	0.800**	0.784**	1	
Avoidance	−0.609**	−0.615**	−0.471**	1

*$p < .01$, **$p < .001$; $N = 66$.

4.3. Summary

The effects of light's intended CCT on emotional states and behavioral responses were analyzed in this chapter. The correlations between light intensity and CCT of light, Pleasure and arousal were also analyzed. The findings substantiated some of the hypotheses that had been proposed. The following chapter will discuss the results, consequences, and limitations of the current research.

CHAPTER V

DISCUSSION AND CONCLUSIONS

5.1. Introduction

An overview of the study's key findings and conclusions is provided in this chapter. It also discusses the implications from both practical and theoretical standpoints. Finally, the current study's limitations are presented, as well as suggestions for future research.

5.2. Discussion of Findings

The primary goal of this study was to determine the effects of different lighting conditions on emotional states (pleasure and arousal) and behavioral intentions (approach and avoidance) as the proximate behaviors. The current study utilized the S-O-R paradigm (M-R model; Mehrabian and Russell (1974) within the framework of environmental psychology and perspectives from research on interior and exterior design juxtaposition.

To investigate overall lighting preference from among four different lighting conditions in an urban transitional space, participants were asked to rate their feelings of pleasure or arousal (ready to begin an activity) within the lighting condition they were assigned to experience. On the basis of respondents' reported feelings, the most preferred lighting condition was warm CCT of lighting, which was considered the preferable illumination due to the higher rate of pleasure and arousal.

Recent studies have confirmed that light and color are key elements of interior design that have a significant impact on the perception of space, emotions, and behavioral responses (Baron et al., 1992; Gifford, 1988; Lee, 2019; Pae, 2009; Park & Farr, 2007; Yang, 2015). According to Wu and Wang (2015), based on the emotional reaction of consumers, warm light with bright light gives people more joy, pleasure, happiness and relaxation than a cool light environment. In addition, Russell (2008) found that CCT with warm light tended to produce a stronger impression of affection, while Miwa and Hanyu (2006) suggested that people in low light tended to have a higher rate of communication.

Even though it was expected that the intensity of light would moderate the effect of light CCT on the level of pleasure or arousal in an urban transitional space, the results were not significant. This shows a need to enhance the manipulations and the sample size. The findings of this study demonstrated that participants had higher feelings of pleasure and arousal in the lighting condition with warm CCT rather than cool CCT. It appears that most respondents would approach an urban transitional space with warm lighting and avoid remaining in an urban transitional space within cool lighting conditions regardless of the level of light intensity.

In reference to the study objectives and hypotheses, it is reported that the subjects would approach and remain in an urban transitional space with warm lighting, mostly when they feel pleased and aroused because of the lighting condition. The ANOVA results (see Table 4 and Table 5) have shown that the CCT of light has a significant main effect on the subjects' evaluations upon the four lighting conditions for both pleasure and arousal.

Results from Process Model 1 (see Figure 10) demonstrate that there is a positive relationship between the CCT of light and the participants' rating of the levels of pleasure and arousal and that there are significant main effects. However, the interaction effects of light intensity and CCT of light are not significant. Having a stronger effect of warm CCT on pleasure in the dim (low intensity) condition in Figure 10A shows that the interaction effect is in line with predictions, it probably turns to a significant effect with a larger sample size and the plots cross each other.

5.4. Strengths, Limitation, and Future Research Direction

The current study confirms the assumption that there are differences in how the level of light intensity and CCT of light would affect individuals' emotional states in advance their decision making specifically in urban transitional spaces. The main strengths of the current study ware the pre-test of lighting perception before the main virtual experience, and also the use of computer stimuli that provided a tangible experience of the existing environment for individuals.

A few limitations could have affected this research methodology, analysis, and its results. One potential limitation of the study was the utilization of simulated area rather than field expertise and therefore the actual atmosphere owing to the pandemic. Another limitation of this study is that the sample size was not large enough to evaluate the interaction effects of light intensity and CCT of light on pleasure and arousal emotional states. It is recommended that the future research use a larger sample size. Moreover, even though I tried to simulate the real world as closely as possible by having a virtual tour in a real transitional space, future research could run field studies with different lighting conditions. Future research could also use secondary data sets of visitors' experiences in different lighting conditions, which may provide more objective results.

In terms of the expected CCT of light, Lee (2019); Lin and Yoon (2015) and Park and Farr (2007) found a significant difference in the effect of CCT of light intensity on pleasure and arousal, whereas the current study estimates the impact of light intensity on pleasure and arousal, as well as approach and avoidance. It is possible that there are additional moderators, or it might depend on the characteristics of the place. Further research might be done to see how lighting with a warm CCT and low intensity (dim lighting) affects emotional states and the rate at which people approach urban transitional spaces. Additional moderators such as gender, culture, and age may be used to better understand the lighting preferences.

5.3. Implications and Conclusion

This research adds to the body of knowledge about illumination in urban transitional environments. To begin with, the current study contributes to a better understanding of lighting in urban transitional spaces, such as thresholds and interior/exterior juxtapositions. Lighting has not been studied in urban transitional spaces; many studies in lighting have examined interior illuminance conditions and their influences on emotional states or behavioral responses (Pae, 2009; Park & Farr, 2007).

This research contributes to retail, interior, and urban design developments as well as to the literature of lighting by considering the role of transitional spaces and lighting in these spaces. Lighting conditions, particularly in interior and outdoor juxtapositions and urban transitional spaces, are design variables independent of built environment characteristics. As a result, urban designers and interior designers who work with clients who are comparable to the study's sample might benefit from the study's findings, using them to better understand the effect of lighting characteristics on their clients' willingness to approach and avoidance. In addition, the virtual tour of the spherical images (360° image) method used for the experiment can be useful for designers and merchandisers to create a spherical tour to design and simulate the actual environment. This spherical virtual tour method helps designers control for other environmental factors and eliminate confounding effects that might affect the users' emotional states or decision-making. Thus, designers can have an accurate understanding of their clients' behavior and decision-making. On the other hand, some businesses that might prefer to prevent people from lingering in their stores' or galleries' transitional spaces will also be able to use the results of this research.

In conclusion, given that Lee (2019); Lin and Yoon (2015); Yang (2015), and Park and Farr (2007) suggest that lighting temperature affects pleasure and arousal, CCT of light is likely to have a greater impact on pleasure and arousal. The present study confirms previous findings that distinct levels of pleasure and arousal exist, as well as how people choose to approach or avoid an urban transitional space due to its lighting conditions. Further studies should focus on urban transitional spaces, retail stores, and public realms, among other interior areas. Depending on the function of the space, as well as the purpose and activities in each type of space, lighting preferences and perceptions may differ.

The finding from the current study demonstrate that correlated color temperature of light (CCT) is likely to have a greater impact on the level of pleasure and arousal. However, previous studies on the effect of illumination in indoors indicated that arousal will be increased in lighting with low intensity (dim lighting), this research results showed that level of light intensity have a reverse influence in urban transitional spaces. Regardless of the CCT of light, bright lighting is more approaching and arousing (ready to start an activity). It might be because of the characteristic of urban transitional spaces to be closer to the public realms rather than indoors, and arousal will be strengthening in bright lighting condition with cool CCT.

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APPENDICES

APPENDIX A

Physical Activity Coding and Circulation Pattern. [Kelvin to RGBs]

Kelvin	Red (R)	Green (G)	Blue (B)	Kelvin	Red (R)	Green (G)	Blue (B)
1000	255	56	0	6100	255	244	242
1100	255	71	0	6200	255	245	245
1200	255	83	0	6300	255	246	247
1300	255	93	0	6400	255	248	251
1400	255	101	0	6500	255	249	253
1500	255	109	0	6600	254	249	255
1600	255	115	0	6700	252	247	255
1700	255	121	0	6800	249	246	255
1800	255	126	0	6900	247	245	255
1900	255	131	0	7000	245	243	255
2000	255	138	18	7100	243	242	255
2100	255	142	33	7200	240	241	255
2200	255	147	44	7300	239	240	255
2300	255	152	54	7400	237	239	255
2400	255	157	63	7500	235	238	255
2500	255	161	72	7600	233	237	255
2600	255	165	79	7700	231	236	255
2700	255	169	87	7800	230	235	255
2800	255	173	94	7900	228	234	255
2900	255	177	101	8000	227	233	255
3000	255	180	107	8100	225	232	255
3100	255	184	114	8200	224	230	255
3200	255	187	120	8300	222	230	255
3300	255	190	126	8400	221	229	255
3400	255	193	132	8500	220	229	255
3500	255	196	137	8600	218	227	255
3600	255	199	143	8700	217	227	255
3700	255	201	148	8800	216	226	255

3800	255	204	153	8900	215	225	255
3900	255	206	159	9000	214	225	255
4000	255	209	163	9100	212	224	255
4100	255	211	168	9200	211	223	255
4200	255	213	173	9300	210	223	255
4300	255	215	177	9400	209	222	255
4400	255	217	182	9500	208	221	255
4500	255	219	186	10000	207	221	255
4600	255	221	190	10100	207	220	255
4700	255	223	194	10200	206	220	255
4800	255	225	198	10300	205	218	255
4900	255	227	202	10400	207	218	255
5000	255	228	206	10500	207	217	255
5100	255	230	210	10600	206	217	255
5200	255	232	213	10700	205	216	255
5300	255	233	217	10800	204	216	255
5400	255	235	220	10900	204	215	255
5500	255	236	224	11000	203	215	255
5600	255	238	227	11100	202	214	255
5700	255	239	230	11200	202	214	255
5800	255	240	233	11300	201	213	255
5900	255	242	236	11400	200	213	255
6000	255	243	239	11500	200	212	255

Note: Adopted from RGB to color temperature – Andreas Siess (andi-siess.de).

The values as a handy python dictionary[4]

[4] RGB to color temperature – Andreas Siess (andi-siess.de)

APPENDIX B

IRB Approval

Oklahoma State University Institutional Review Board

Date:	03/05/2021
Application Number:	IRB-21-117
Proposal Title:	THE EFFECT OF LIGHTING ON EMOTIONAL STATES AND BEHAVIORAL INTENTIONS IN URBAN TRANSITIONAL SPACES
Principal Investigator:	Maral Esmaeili
Co-Investigator(s):	Heather Carter
Faculty Adviser:	Heather Carter
Project Coordinator:	
Research Assistant(s):	
Processed as:	Exempt
Exempt Category:	

Status Recommended by Reviewer(s): Approved

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in 45CFR46.

This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.

The final versions of any recruitment, consent and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any unanticipated and/or adverse events to the IRB Office promptly.
4. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,
Oklahoma State University IRB

APPENDIX C

Pre- & Post- Questionnaires

STUDY TITLE: The Effect of Lighting on Emotional States and Behavioral Intentions in Urban Transitional Spaces.
RESEARCHER: Maral Esmaeili

CONSENT FORM: You are being asked to participate in this research study, you have the right to be informed about the study procedures, so you can decide whether you want to participate. After reading these procedures below, you will be asked if you consent to participate in the study. If you consent, you will be asked demographic questions before you enter the designed simulated environment through your computer. If you do not consent, the survey will be automatically concluded. This study has received approval from the Oklahoma State University Institutional Review Board (also known as the IRB).

WHAT ARE MY RIGHTS AS A PARTICIPANT?
Participation in this study is voluntary. You may stop at any time.

WHY IS THIS STUDY BEING DONE?
This research is being conducted to get a better understanding of the effects of the lighting conditions on an individual's perceptions of an urban transitional space. After viewing a spherical image of an Art Gallery, you will be asked questions about your experience. The session will be conducted online on your personal computer and is expected to take approximately 15 minutes.
WHAT ARE THE BENEFITS OF BEING IN THE STUDY?
Benefits as a participant are that you will experience and learn to work with virtual navigation through a spherical image.

WILL COMPENSATION BE OFFERED TO PARTICIPANTS FOR THEIR PARTICIPATION?
Your input is very valuable to us, and we welcome your participation. At the end of the survey, you will be asked whether you want your name to be included in a drawing for a $25 Amazon e-gift card.

WHAT ARE THE RISKS OF BEING IN THE STUDY?
There are no reasonably foreseeable risks or discomforts associated with this study. If at any time you are uncomfortable, you may stop the interview. You will be provided with the researchers' contact information below if you have specific questions or concerns. The research team works to ensure confidentiality to the degree permitted by technology. It is possible, although unlikely, that unauthorized individuals could gain access to your responses because you are responding online. However, your participation in this online survey involves risks similar to a person's everyday use of the internet. If you have concerns, you should consult the survey provider privacy policy at https://www.qualtrics.com/privacy-statement/

CONFIDENTIALITY
Your participation is confidential; no personal identifiers will be collected during the experiment. The data will be

stored in a password-protected computer indefinitely. If you have any questions about the research project, please feel free to contact Dr. Heather Carlile Carter, Research Advisor, at heather.carlile.carter@okstate.edu, and Maral Esmaeili, Graduate Student, at 360-605-7987, maral.esmaeili@okstate.edu.

For additional information regarding human participation in research or your rights as a research volunteer, please contact the Oklahoma State University Institutional Review Board (IRB) at (405) 744-3377 or irb@okstate.edu.

CONSENT: I agree to participate in the study described above. I have made this decision based on the information I have read in this Information-Consent Letter.

○ Yes, I consent.

○ No, I do not consent.

PRE_QUESTIONNAIRE: Demographic Information

Please Indicate your gender.

○ Male

○ Female

○ Non-binary / third gender

○ Prefer not to disclose

Please select the category that includes your age.

○ 19 to 30

○ 31 to 40

○ 41 to 50

○ 51 or older

Please specify your ethnicity.

○ White/Caucasian

○ Asian

- American Indian or Alaska Native
- Native Hawaiian or Other Pacific Islander
- Black or African American
- Other
- Prefer not to disclose

What is the highest level of school you have completed or the highest degree you have received?

- High school degree or equivalent (e.g., GED)
- Some college but no degree
- Bachelor degree
- Graduate degree

How often do you visit public places (Retail store, Gallery, Café, Restaurants, etc.)?

- Never
- 1-3 days times a Week
- 1-3 days times a Month
- More than 5 times a Month
- Other

What is the extent of your knowledge in lighting design?

- ○ Practice(d) lighting design professionally
- ○ Some knowledge of lighting design
- ○ No knowledge of lighting design

Do you have a visual impairment (such as color blindness) that cannot be corrected with glasses or contact lenses?

- ○ Yes
- ○ No

Are you wearing corrective lenses (either glasses or contacts) now?

- ○ Yes
- ○ No

IntroVideo: You will now be shown the introduction video about spherical images. Please watch carefully.

The Scenario:
You are walking along an urban street at night. Before going home, you want to spend more time being outside. You see the space in-between an Art Gallery's interior store and the sidewalk (also known as a transitional space*), and you think about whether you want to spend time there based on the lighting. If you wanted to, you would be able to sit on the two box seats in the entrance. Please, evaluate your feelings based on your virtual experience using the spherical image with the specific lighting condition.

* Transitional spaces are those in-between areas that act as a new destination in public realms or any built environments.

Please first click on the link below to navigate through the spherical image, and then come back and click next to fill out the questionnaires:

[Randomly Assigned to one of the four lighting conditions]

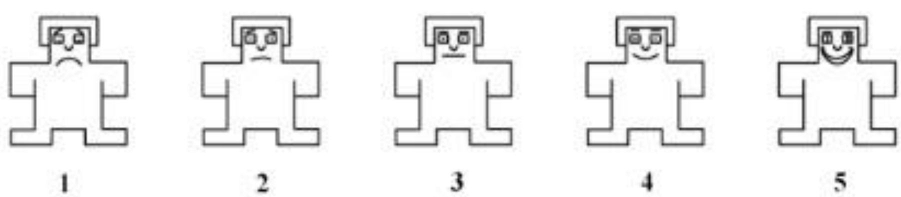
- **https://players.cupix.com/p/JfBJPmTt**
- **https://players.cupix.com/p/HyDx4nhZ**
- **https://players.cupix.com/p/8HM1MgYx**
- **https://players.cupix.com/p/MyWZf5IY**

POST-QUESTIONNAIRE

Questions	1 Completely Disagree	2 Somewhat Disagree	3 Neither Agree Nor Disagree	4 Somewhat Agree	5 Completely Agree
I felt excited while spending time in Gallery's transitional space based on its lighting condition.	○	○	○	○	○
I was bored with the lighting condition in Gallery's transitional space.	○	○	○	○	○
I felt aroused (ready for activity) while spending time in Gallery's transitional space based on its lighting condition.	○	○	○	○	○
I was satisfied with the lighting condition in Gallery's transitional space.	○	○	○	○	○
I felt pleasant with the lighting condition in Gallery's transitional space.	○	○	○	○	○
I felt sadness with the lighting condition in Gallery's transitional space.	○	○	○	○	○
I felt nervous while spending time in Gallery's transitional space whit it's lighting condition.	○	○	○	○	○
I felt happy while spending time in Gallery's transitional space with its lighting condition.	○	○	○	○	○
I would stay in this transitional space for a while before or after my visit to the art gallery based on its lighting condition.	○	○	○	○	○

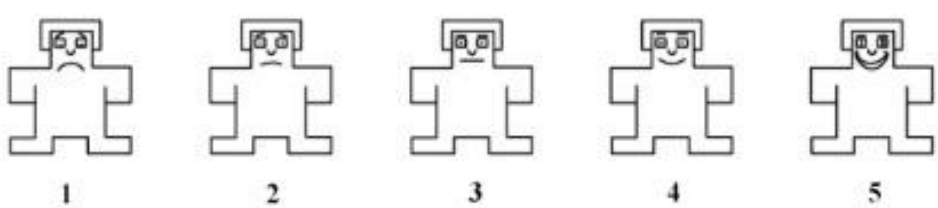
Given a choice, I would probably come back to an urban transitional space like this even though I might not go into the gallery.	○	○	○	○	○
I would not spend time in this transitional space based on its lighting condition unless I visited the art gallery.	○	○	○	○	○
I would like to see more urban transitional spaces in between streets and buildings.	○	○	○	○	○

Please select the avatar that best describes how you felt in the Art Gallery's transitional space (1 = very sad to 5 = very happy).



	1 Very Sad	2 sad	3 Neutral	4 Happy	5 Very Happy
1	○	○	○	○	○

Please select the avatar that best describes how you feel aroused in the Art Gallery's transitional space (1 = very passive to 5 = very active).



	1 Very Passive	2 Passive	3 Neutral	4 Active	5 Very Active
2	○	○	○	○	○

Overall, how much do you like the lighting condition in this space?

○ Like a great deal

○ Like somewhat

○ Neither like nor dislike

○ Dislike somewhat

○ Dislike a great deal

Do you like spending time in urban transitional spaces such as this one?

○ Yes

○ No

Would you like to be entered into a drawing to receive a $25 Amazon gift card?

○ Yes

○ No

VITA

Maral Esmaeili

Candidate for the Degree of

Master of Science

Thesis: THE EFFECT OF LIGHTING ON EMOTIONAL STATES AND BEHAVIORAL INTENTIONS IN URBAN TRANSITIONAL SPACES

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Completed the requirements for the Master of Science in Design, Housing & Merchandising at Oklahoma State University, Stillwater, Oklahoma in July, 2021.

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