THE VISUAL PREFERENCE, AESTHETIC JUDGEMENT, AND MOOD RESPONSE TO HUMAN-CENTRIC LIGHTING IN OFFICE SPACES

by

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Title: The Visual Preference, Aesthetic Judgement, and Mood Response to Human-Centric Lighting in Open Office

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THESIS ABSTRACT

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Architecture lighting is a significant visual stimulus that impacts the occupants' moods and aesthetic experiences within the office environment. Lighting uniformity, luminance distribution, and direct/indirect lighting have been discussed in other studies. Still, the combined effects of lighting parameters on human mood and visual aesthetic experience are unclear. This research took an exploratory mixed-method approach to explore how human-centered lighting design affects occupants' moods, visual aesthetic judgment, and visual preferences in open office spaces. Six spatial lighting patterns of open office workstations were analyzed using image content analysis of selected film scenes. Then six rendered images were presented to 60 participants via an online survey to determine their preferences, interests, and aesthetic judgments. The result indicates that the overall low average luminance environment, equipped with work view region lighting, which also has a higher luminance ratio, is visually preferred(LS-3). With the higher overall average luminance environment, people preferred the overall uniform luminance without desk area lighting with a low luminance value (LS-4).

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CHAPTER I

INTRODUCTION

"A feeling for light and lighting starts with visual imagination,
just as a painter's talent does"
Richard Kelly

Architectural Lighting is an interior design element that impacts occupant mood and aesthetic Judgement of a space. Over 90% of office employees spend most of their time indoors (Klepeis et al., 2001) and 17% of them consider lighting to be one of the most important aspects of indoor comfort (Ducker, 1999). The most recent studies on human-centric lighting design focus on the impacts of light on both visual and non-visual sensory experiences. Visual experiences include performance and comfort while non-visual experiences include circadian rhythms, sleep quality, and mental health (K. Houser et al., 2020; K. W. Houser & Esposito, 2021). John Flynn's seminal study (Flynn et al., 1973) found four visual experience dimensions that are significant in the occupants' impressions of the lighting environment. They include visual preference, visual aesthetic judgment, perceived spaciousness, and perceived clarity. Essentially, the visual aesthetic experience depends on the dimension of visual aesthetic judgment and visual preference, which also impacts mood response (Flynn et al., 1979; Flynn, 1988; J. A. Veitch, 2001).

The current Illumination Engineering Society (IES) and the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED™) standards for buildings require specific lighting performance criteria related to glare management and light levels, which are essential for visual performance and energy-efficient design(LEED, 2019; IES, 2020).

Previous studies have demonstrated substantial non-visual effects of lighting qualities on occupants' cognitive faculties, visual perceptions, and visual comfort (Durak et al., 2007; Hawkes et al., 1979; Houser & Esposito, 2021; Loe et al., 1994; Stokkermans et al., 2018).). Several recent studies have revealed positive effects of indoor lighting-related aesthetic experience, daylight availability, daylight fractal patterns, lighting spatial patterns, and lighting brightness distribution on occupancy mood and indoor wellbeing (Abboushi et al., 2019, p. 2008; Elzeyadi, 2021; Loe et al., 1994; J. Veitch et al., 2008). However, minimal studies have addressed the visual impacts of indoor lighting on mood, spatial perception, and visual aesthetic experience in office environments. Moreover, further research must examine the relationship between indoor lighting and occupants' moods, mental wellbeing, and lighting-related visual aesthetic experiences.

1.1 Research Problem

Previous studies concerning lighting design have generally underlined the importance of the appropriate range of light level illuminance, glare prevention, and color rendering index (CRI) in the work environment. Most studies have emphasized the combined effects of light levels, correlated color temperature (CCT), and CRI on human mood; others have focused on the impact of light attributes on visual comfort, visual performance, perception, and cognitive performance. Only several studies have discussed the lighting aesthetic quality that is pivotal to indoor environment quality (IEQ) standards, such as visual preferences, aesthetic judgments, and lighting view quality (Abboushi et al., 2019; Elzeyadi, 2002a, 2021; J. A. Veitch, 2001).

These factors warrant further attention because in indoor working spaces, occupants' moods are closely related to their visual aesthetic experiences; occupants' moods are frequently assessed based on their subjective impressions, aesthetic judgments, and visual preferences in relation to indoor lighted scenes (Flynn et al., 1979; Veitch 2001). However, occupants' visual aesthetic experiences of lighting environments are not merely influenced by light levels, brightness, CCT, and lighting distribution; rather, they are also influenced by the synthesized effects of all lighting parameters in the field of vision (Durak et al., 2007; Hawkes et al., 1979; K. W. Houser & Esposito, 2021; Loe et al., 1994; M. Stokkermans et al., 2018). Though some studies have discussed the lighting uniformity, luminance distribution, and direct/indirect lighting in terms of lighting visual quality, it still remains unclear in terms of lighting visual aesthetic quality (Chraibi et al., 2017; K. W. Houser & Esposito, 2021; Loe et al., 1994; G. Newsham et al., 2004). Furthermore, examining each of the lighting parameters and their combined impact on human emotions is exceptionally challenging.

Scenes in feature films that depict office environments offer convenient reference materials. Film lighting primarily focuses on the audience's visual aesthetic experience and its impacts on human mood (Bordwell, 1989; Bordwell & Thompson, 2016; Shimamura, 2014). Film lighting design successfully conveys mood to spectators by manipulating the lighting attributes. These attributes include softness (soft or hard), altitude, direction (front, side, back), focus, texture (depth and patterns), movement, intensity, and contrast (shade). Therefore, to understand how lighting impacts occupants' moods in the work environment, this study film office scenes as the inspiration materials for generating lighting assessment visual materials to investigate human moods, visual preferences, and aesthetic judgments in real office environments.

1.4 Research Scope and Objective

The architectural setting of this research is a contemporary office working environment, specifically an open-office workstation (figure 1.1). It exclusively investigates visual perceptions of lighting environments, specifically in terms of visual preferences, visual aesthetic judgements, and moods. Subsequently, this research explores the parameter of lighting spatial patterns.

The research objectives (figure 1.2) are as follows: First, examine six different lighting spatial patterns from selected film scenes featuring office spaces. Second, simulate those lighting spatial patterns as interior rendered images (visual stimuli) that each correspond to Flynn's theory and feature different lighting patterns and brightness distributions (Flynn et al., 1973). Lastly, investigate the impact of the six lighting spatial patterns on occupants' visual preferences, aesthetic judgments, and mood responses.

Figure 1.1:

Research Scope Diagram

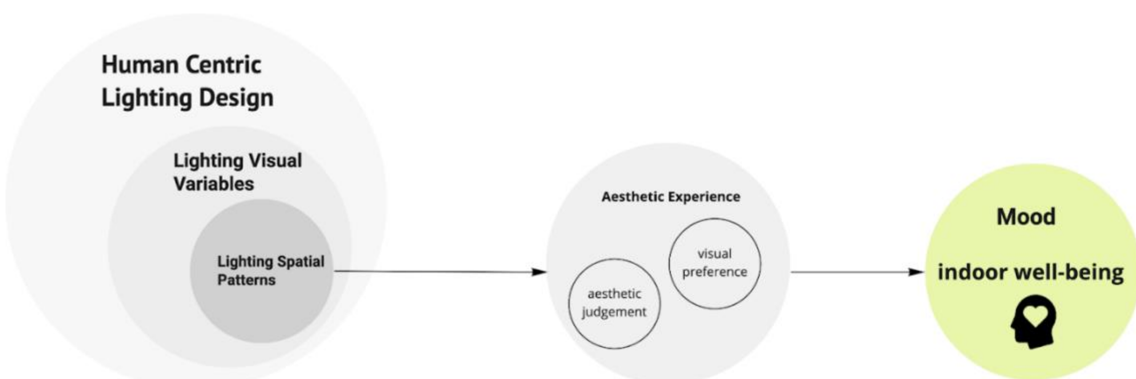
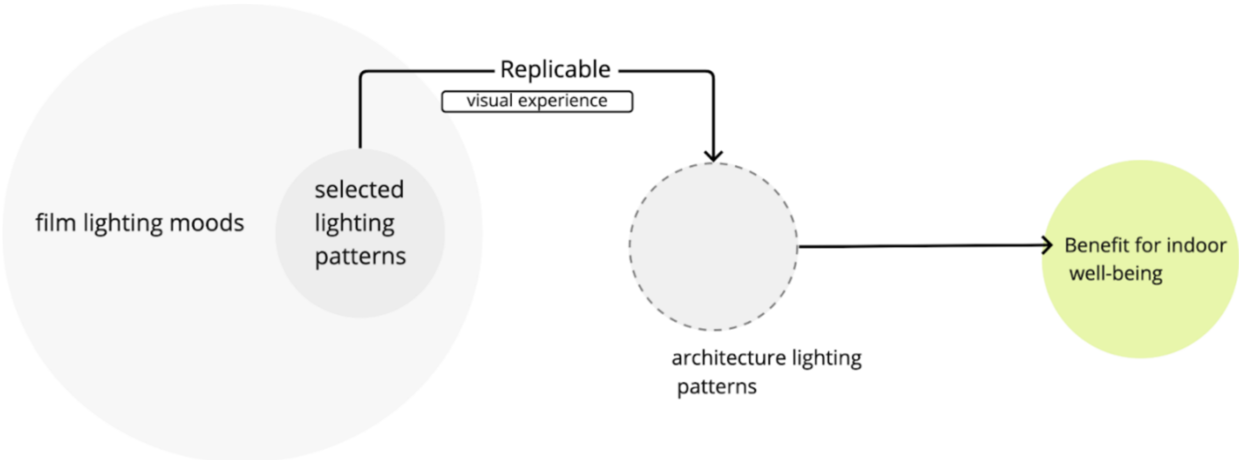


Figure 1.2:

Research Objective Diagram



1.3 Research Question

This research investigates how human-centered lighting design can affect occupants' moods, visual aesthetic judgments, and visual preferences regarding office space lighting. Specifically, this study aims to answer the following questions:

1. What spatial lighting patterns are employed in film scenes depicting office spaces that can be applied to contemporary office spaces?
2. What are occupants' preferred lighting patterns based on environments simulated from film scenes?
3. How do lighting brightness patterns impact occupants' moods, visual preferences, and aesthetic judgments?

1.4 Research Significance

This study will provide insights regarding the relationship between occupants' moods and an illuminated environment by further testing and developing Flynn's research framework concerning subjective impressions of lit environments. This study aims to incorporate the contemporary office interior design context. Meanwhile, the study introduces film scenes as sources of lighting design inspiration for the first time in architectural research to explore human-centric lighting design and the potential of lighting modes. The discovery of lighting modes that evoke positive moods among office workers may be relevant to lighting design practitioners, architects, and interior architects.

CHAPTER II

LITERATURE REVIEW

This literature review summarizes previous studies that relate to the influence of lighting on human visual preferences, aesthetic judgments, and moods. Section 2.1 delineates the background of human-centered lighting to provide context to the research questions concerning human psychology, physiology, and neurology. Lighting stimuli concern human-centric lighting designs and their impacts on human psychology, physiology, and neurology in previous studies; this section also discusses the dearth of research concerning indoor well-being in relation to lighting. Section 2.2 reviews the literature regarding psychological approaches to indoor lighting and the neglect of visual aesthetic judgments and visual preferences. Section 2.3 summarizes various lighting variables discussed in previous studies and presents the few studies investigating lighting spatial patterns' impacts on indoor occupants' moods, visual perceptions, and aesthetic judgments; those studies are summarized in Section 2.4. Lastly, Section 2.5 introduces previous studies regarding film lighting and elucidates the film lighting parameters that influence spectators' moods.

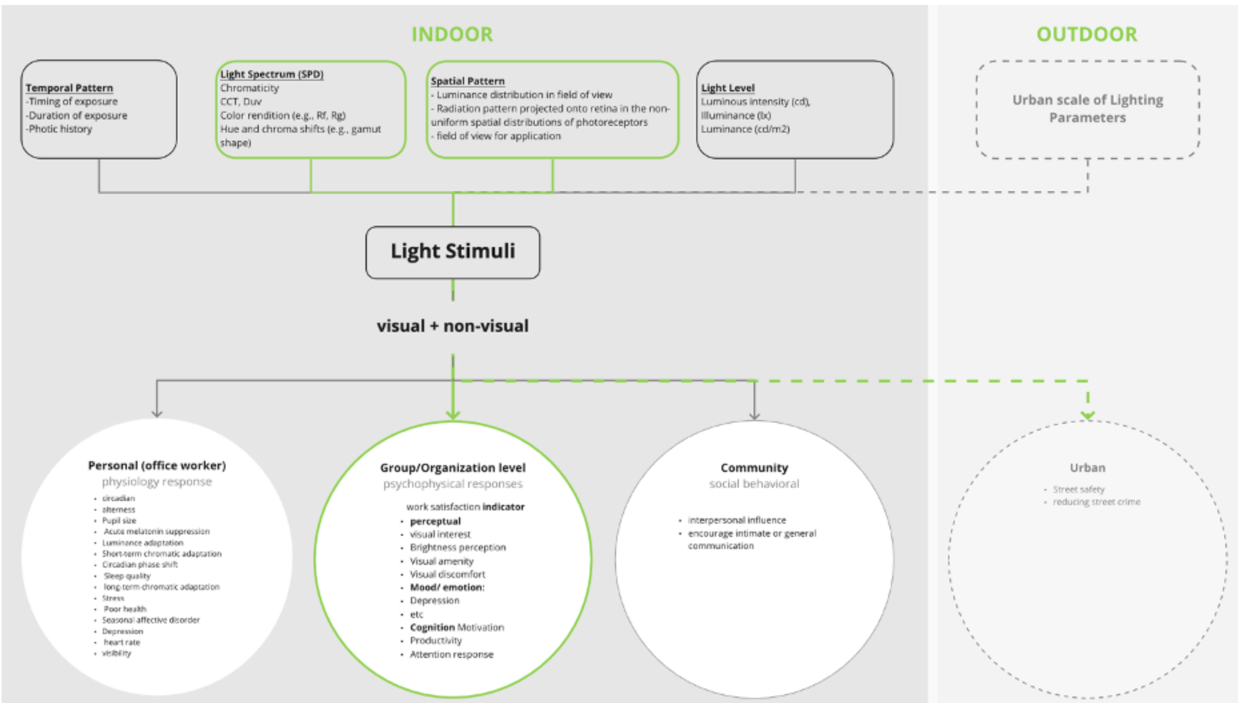
2.1 Human-Centered Lighting Design

Scientists and lighting designers have studied light and its influence on humans for decades to attempt to optimize indoor lighting (Flynn et al., 1979; Knez & Enmarker, 1998; Kuller & Wetterberg, 1993; McCloughan et al., 1999; J. A. Veitch, 1998). Recent literature has provided integral epistemological insights into human-centered lighting design (Figure 2) to help practitioners, designers, and industries with their lighting (K. W. Houser & Esposito, 2021). Houser summarized four types of light stimuli, namely light level, light spectrum, light temporal patterns, and light spatial patterns, which influence humans psychologically, physiologically, and socially through visual and non-visual pathways.

In terms of human physiological lighting responses, non-visual pathways include circadian and neuroendocrine responses (Hebert, 2009). Non-visual stimuli light spectral power distribution (SPD) refers to the radiant power emitted by the light source in each wavelength within the visible electromagnetic spectrum range. The range of 360 – 1000 nm light spectral power influences the circadian efficiency and circadian action factor, which exceeds the visible light spectral power range of 380 – 700 nm (Bellia et al., 2011). The subsequent study found that lighting intensity and lighting exposure timing exert non-visual impacts on human circadian, acute, and long-term effects, thereby stimulating photobiological cells (Lucas et al., 2014; Souman et al., 2018). Beyond non-visual pathways, psychological responses to illuminated environments include visual perceptions, subjective impressions, and moods (Boyce, 2010; Flynn & Spencer, 1977; Hawkes et al., 1979; Kuller & Wetterberg, 1993).

Figure 2.1:

Human-Centered Lighting Epistemological Diagram



2.2 The Psychological Approach to the Lighting Environment

The psychological approach to lighting is significant to office workers' wellbeing; vast studies have found that visual comfort, lighting perception, visual interest, and mood are aspects of lighting quality that influence workers' wellbeing (Flynn et al., 1979; Kuller & Wetterberg, 1993; Steidle & Werth, 2014; J. A. Veitch, 2001). A fundamental component of the psychological approach to lighting research involves evaluating visual perceptions and emotional responses to lighting (Elzeyadi, 2002; J. Veitch et al., 2008; J. A. Veitch, 2001).

A Canadian research team led by Veitch further reviewed the previous study and proposed the psychological mechanism model (figure 2.2)), which posits that occupants' moods are influenced by lighting based on perceived control, attention, environmental appraisal, and affect, or aesthetic experience (J. A. Veitch, 2007). Additionally, Flynn's theory of aesthetic judgment (figure 2.4) and visual preference is also crucial to evaluating aesthetic experiences. Furthermore, a recent study confirmed that the psychological approach to lighting design(figure 2.3) can be classified into two categories: the image-forming pathway and the non-image-forming pathway (de Kort & Veitch, 2014). Specifically, the image-forming pathway encompasses visual performance, visual experience, and visual comfort. Research in the past five decades has provided important information concerning the effects of lighting on visual performance and visual comfort.

Figure 2.2

Linked Psychological Mechanism Proposed by Veitch et al. (Veitch et al.,2014)

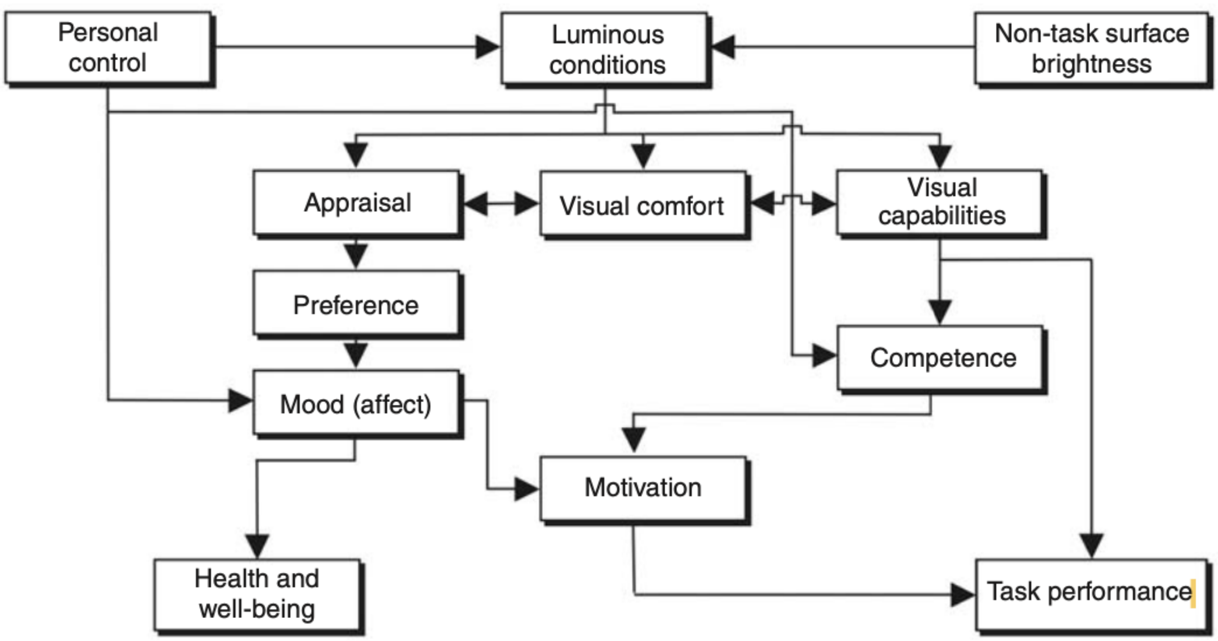


Figure 2.3

Diagram Of Pathway to Light Relevant To Psychological Functioning (de Kort & Veitch.,2014)

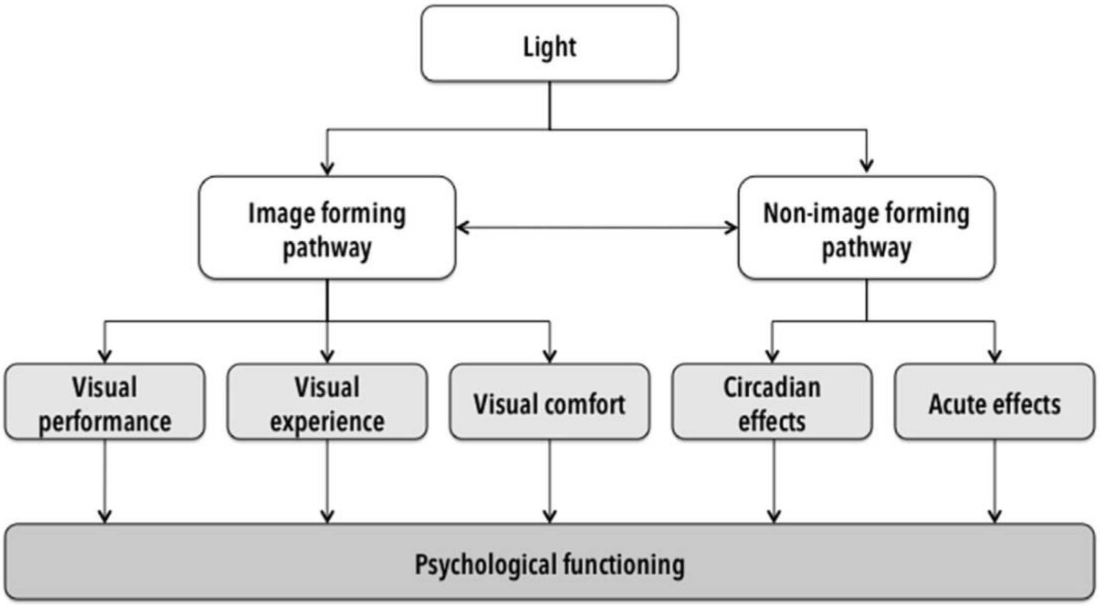
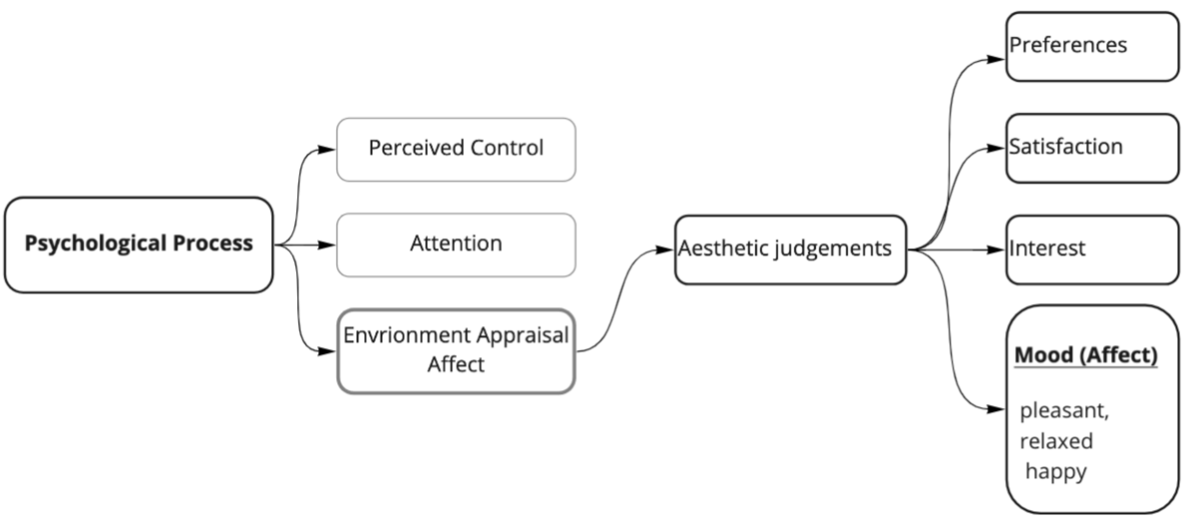


Figure 2.4

Diagram Of a Summary Of Psychological Process Of Aesthetic Judgment Path From A Serious Study Led By Veitch's Research Team (Veitch et al, 2001; Veitch et al,2007)



The study over the past five decades provided important information on the lighting of visual performance and visual comfort. The current issue is to advance the knowledge of the lighting impacts through visual experience.

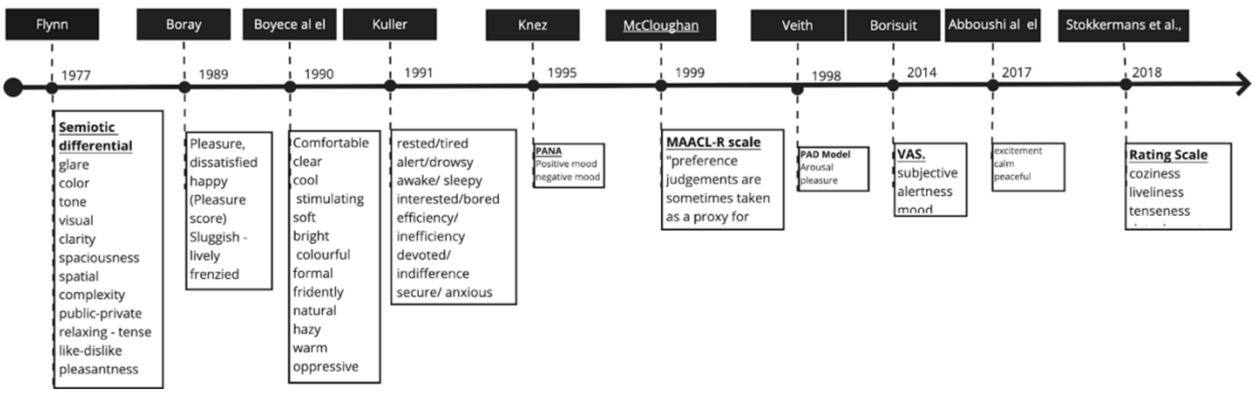
2.1.1 Lighting and Mood

The psychological methods used to assess moods and affective states have varied between studies (figure 2.5); In earlier research conducted by Kuller, emotional responses to lighting environments were evaluated via a neuropsychological method of arousal/activation theory and a self-report PAD model using three dimensions, namely pleasure, arousal, and dominance, to represent emotions (Küller et al., 2006; Mehrabian & Russell, 1974). One common emotional state evaluation model is the Positive and Negative Affect Scale (PANAS) model, which is a common evaluation model used in lighting-related environmental appraisals in previous studies (Figueiro & Rea, 2016; Knez, 1995; Knez & Enmarker, 1998; J. A. Veitch, 1998; Watson & Tellegen, 19860101). One study adapted the Visual Analogue Scale (VAS) to measure subjects' alertness, mood, and well-being in a classroom setting (Borisuit et al., 2014). In this study, moods were evaluated using a scale of alertness in relation to the lighting environment. The Profile of Mood States (POM) has also been used to evaluate four work lighting techniques by assessing intense/anxiety, depression, anger/hostility, vigor/activity, fatigue, and confusion (Hawes et al 2012). McCloughan indirectly evaluated emotional responses by assessing subjective impressions of the lighted environment with a semiotic differential (SD) and MAACL-R scale (McCloughan et al., 1999).

However, research has found that the effects of indoor lighting on mood are sophisticated, and previous studies have used different psychological assessment models to evaluate similar parameters, thereby yielding different results. For instance, earlier research conducted by Boray confirmed CCT's influence on participants' moods, but Kuller's research found no significant differences based on CCT levels, which contradicts Boray's results (1989). Overall, the methods used to evaluate moods in illuminated environments are crucial for the current lighting study.

Figure 2.5

The Mood Appraisal Models Used In Previous Studies.



2.2.2 Lighting Aesthetic Quality of Office Space

Regarding lighting aesthetics in indoor lighting environments, another aspect that has been neglected is the visual aesthetic experience of indoor lighting environments. Most research has either investigated visual comfort and discomfort or focused exclusively on light level, CCT, and light distribution. IES has established standards for office lighting that encompass a certain range of luminance and CCT. In an actual office space, lighting design is not based upon one parameter; rather, it combines multiple parameters.

Meanwhile, the field of view in the office space is typically crucial for office workers, as the working desk is where the office worker is looking at (Elzeyadi, 2011). The cubicle office space is one of the working spaces that requires high-quality lighting. Illuminating Engineering Society of North America (IESNA) has emphasized that the VDT office workstation lighting environment is more important than the luminance in the field of view, which is a more crucial lighting quality than desktop illumination (IESNA, 1993, as cited in G. R. Newsham & Veitch, 2001). In past decades, limited research has focused on the lighting aesthetic experience within the cubicle workspace (K. Houser et al., 2020; J. A. Veitch & Newsham, 2000).

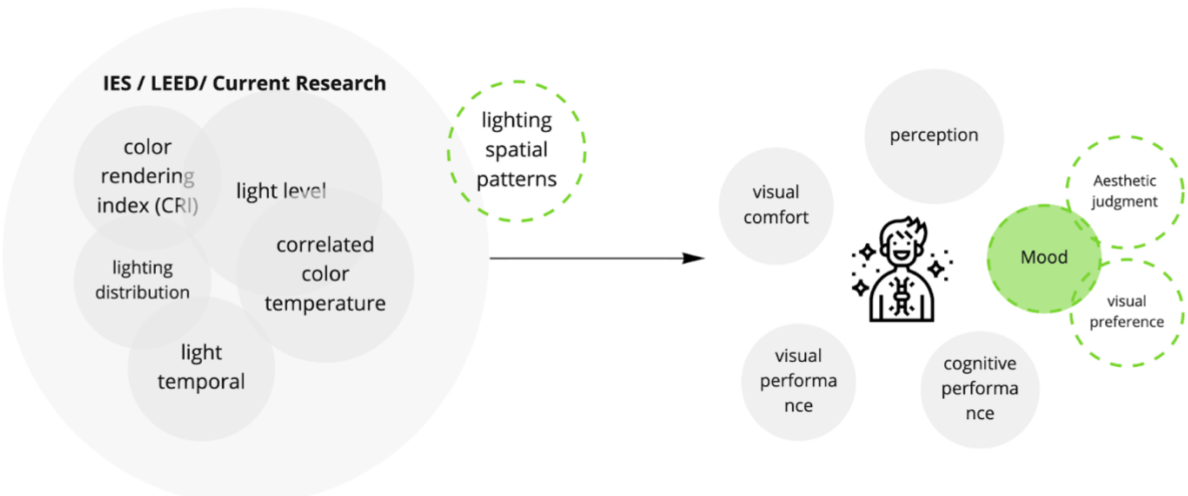
A series of studies conducted by Veitch and Newshan found that participants preferred unified office ambience light and the average luminance lighting background; however, VDT is lower than recommended in cubicle workstation lighting (2000). Their later research found that partition vertical lighting is preferred (2002). More recent research has found a correlation between indoor lighting brightness patterns and workers' visual preferences in their cubicle workstations (Elzeyadi, 2011). Another study corroborated the importance of natural fractal patterns projected on office spaces to enhance occupants' moods (Abboushi et al., 2019). The reviewed study addressed the importance of indoor lighting and the aesthetic experience of indoor lighting in office spaces. However, the study that focused on work lighting and aesthetic quality represents a rare investigation of workstation visual aesthetic experience.

2.3. Lighting Parameters Influence Mood, Visual Preference, Aesthetic Judgment

The parameters that influence occupants' mood, visual preference, and aesthetic judgment are summarized in figure 2.

Figure 2.6

A Diagram Of What Lighting Parameters Influence Occupants' Indoor Wellbeing



2.3.1Light Level and CCT

Correlated color temperature (CCT), light level, light distribution, spectral power distribution (SPD), color rendering index (CRI), glare, and light spatial patterns all influence human emotions (Durak et al., 2007; Galasiu & Veitch, 2006).

A vast study on the visual preference of indoor lighting is the preference of the luminance level (Boyce et al., 2006). Early studies concerning light levels and CCT's combined influences on human moods were paradoxical. Boray, Gifford, and Rosenblood found that participants' moods and spatial perceptions did not significantly change under 3000K, 4150K, and 5000K CCT lighting conditions (Boray et al., 1989 However, Kuller found that participants' responses to 1700lux lighting were more negative and that they perceived the fluorescent light as "warm white" under 3000K and perceived it as "cool white" under 5500K (Kuller & Wetterberg, 1993). Kenz later found that men and women have different mood responses to "warm white" light and "cool white" light (Knez, 1995) and that light has two stages of influence on mood: initial and long-term (McCloughan et al, 1999). The American researchers found that the preferred CCT is between 4000K and 5000K for the working environment (Manav & Yener, 1999). Manav subsequently found that participants perceive 2000 lx light as conferring more comfort, spaciousness, brightness, and saturation compared to the 500 lx light condition (Manav, 2007). Smolders and Kort assessed participants' subjective experiences and physiological arousal under 6000 K and 2700 K light and found that under the "cooler" light (2700 K), people performed better and reported more alertness and vitality (Smolders & de Kort, 2017).

A more recent study found that the preferred lighting CCT for a relaxing environment is 4404K and 6236K for a working environment (Wang et al., 2017). Yang and Jeon found that participants perceive 4000K LED light most favorably in the classroom, and there is no significant difference in perceptual satisfaction and acceptance between 3000 and 5700K light (Yang & Jeon, 2020).

2.3.2 Spectral Power Distribution (SPD)

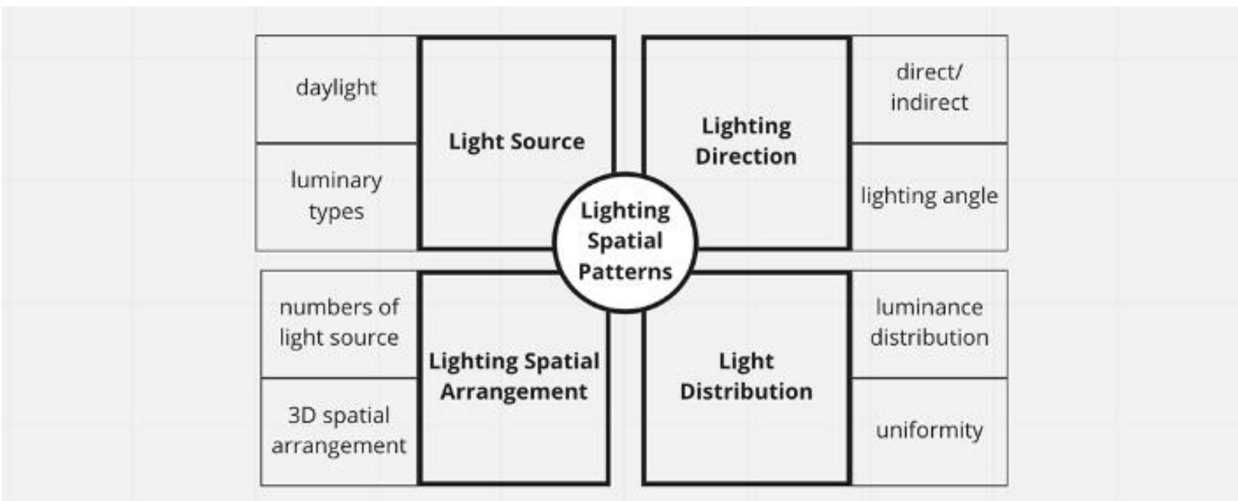
The lighting spectral power distribution (SPD) represents the following facets of light color: chromaticity, light color index (CRI), hue, and chroma shifts (K. W. Houser, 2020; K. W. Houser & Esposito, 2021; Smolders & de Kort, 2017). The color rendering index (CRI) is the most common indicator of how well the color appears on the object under illumination. Color rendering is generally influenced by the illuminant spectrum, and the range of the CRI is between 0 and 100; the value of 100 indicates that the light resource includes the full spectrum. In summary, previous studies regarding CCT and light levels were substantial, providing a solid standard for workplace lighting. However, the relationship between light levels and CCT and human visual aesthetic judgments and visual preferences remains ambiguous.

2.3.3Light Spatial Patterns

Light spatial patterns refer to spatial distributions of light within three-dimensional spaces; they are one of the stimuli that influences the lit environment's effects on human mood (K. W. Houser & Esposito, 2021; Kruisselbrink et al., 2018). Here, light spatial patterns refer to the lighting modes that do not include the light level, light-correlated color temperature, and light spectral distribution. Four characteristics were found to be crucial for the lighting modes and the psychological influences on human health (figure 2.7). Studies have revealed that specific characteristics of light spatial patterns, such as lighting direction, luminaire types, daylighting geometry patterns, luminance distribution in the horizontal plane and vertical plane, and uniformity, influence participants' visual perceptions and moods (Loe et al., 1994; Shin et al., 2015; J. A. Veitch, 1998).

Figure 2.7

Attributes Of Lighting Spatial Patterns



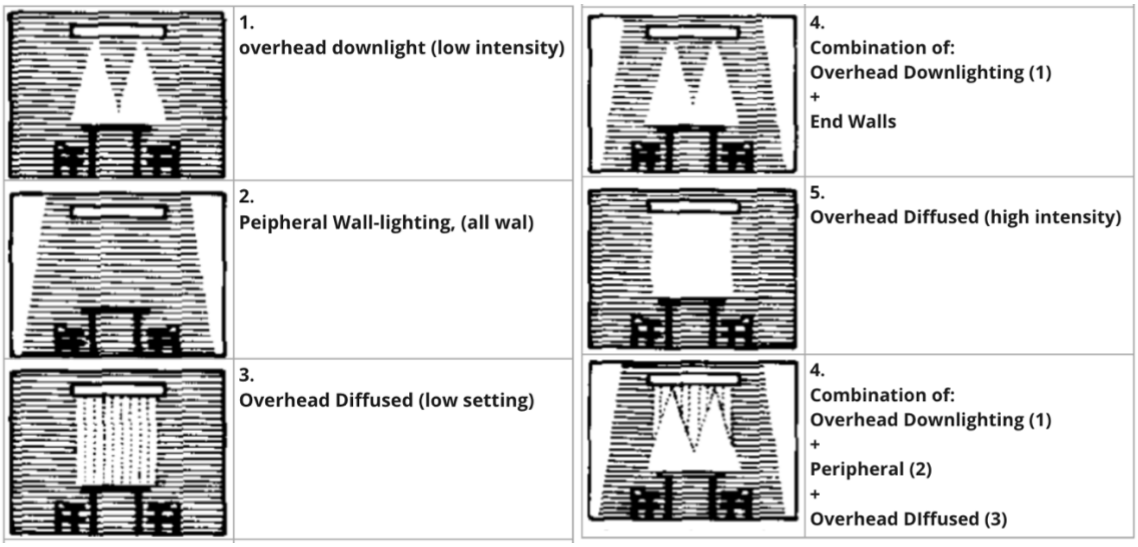
Note, Light sources encompass both daylighting and electrical lighting. Lighting direction refers to how the light is projected into space; light spatial arrangement refers to how the light source has been arranged in the indoor space and were the window opening is located; lighting distribution refers to the light's project patterns (IESNA).

Previous research concerning lighting's aesthetic qualities demonstrated that the lighting mode influences subjective impressions (Flynn, 1979). Flynn identified six lighting configurations **(figure 2.8)** corresponding to the following four modes:

1. overhead/ peripheral mode
2. uniformed/ non-uniformed mode
3. right/ dim mode
4. visual warm/ visual cool mode

Figure 2.8

Diagram of the Lighting Mode in Flynn's Study



Many studies have investigated the influence of the lighting mode or lighting quality on occupants. Loe examined the brightness distribution and concluded that subjects' preferred average luminance should be over 30 cd/m 2 within a horizontal 40-degree band. In this study, Loe also analyzed visual interest as a factor of the lighting quality, in which there is a linear relationship between visual interest and the "maximum to minimum luminance of horizontal band width 40° for all installations"(Loe et al., 1994). Ooyen investigated the influence of surface luminance on subjects' perceptions and preferences and concluded with recommendations for the following: a ratio of luminance for task (Lt), work-plane (Lwp), wall illuminance (Lw) = 10:4:3 (van Ooyen et al., 1987). Houser et al. found that horizontal illuminance directly from a linear pendant light was preferred by participants (2002).

Another study confirmed the photometric measurement of the proportion of direct and indirect influences on the lighting environment but did not find evidence for the different proportions of direct and indirect influence on subjects' affect and impressions (Fostervold & Nersveen, 2008). Evidence suggests that the direction of the light impacts the atmosphere of the work environment by rendering the space differently (Hansen et al., 2020). De found that the increased wall luminance level increased subjects' perceptions of visual attractiveness in a mock office room (de Vries et al., 2018). Later, Subsequently, Viries et al. confirmed that the larger portion of indirect lighting can increase the ceiling lighting luminance's uniformity and the open-office's brightness, as well as the attractiveness of a mock-up office room (2021).

Overall, existing research has recognized the critical role of lighting spatial patterns. Factors such as lighting uniformity, lighting direction, and brightness distribution found that influence subjects' indoor well-being have been explored. However, the research gap the lighting spatial patterns are huge that rarely to concluded as lighting quality metrics.

2.4 Film Lighting and Architectural Lighting

2.4.1 Film Mood Aesthetic Experience

The film lighting can influence the spectator's mood and emotion as one of the primary stimuli (Anderson et al., 2005; Bordwell & Thompson, 2016; Eisenstein et al., 1947; Plantinga, 2012). The study found the spectator's mood response to the film through aesthetic experience with two-level features: the low-level aesthetic features, such as luminance, color, shot duration, temporal structure, visual activity (attention), and the high-level aesthetic feature, including narrative attributes (Shimamura, 2014). Tarvainen found the parameters of low-level features can be quantitative studies and found the low-aesthetic feature brightness able to rate the mood of film without any other information of the scene, genre, or the narrative (Tarvainen et al., 2015).

2.4.1 Film Lighting Parameters

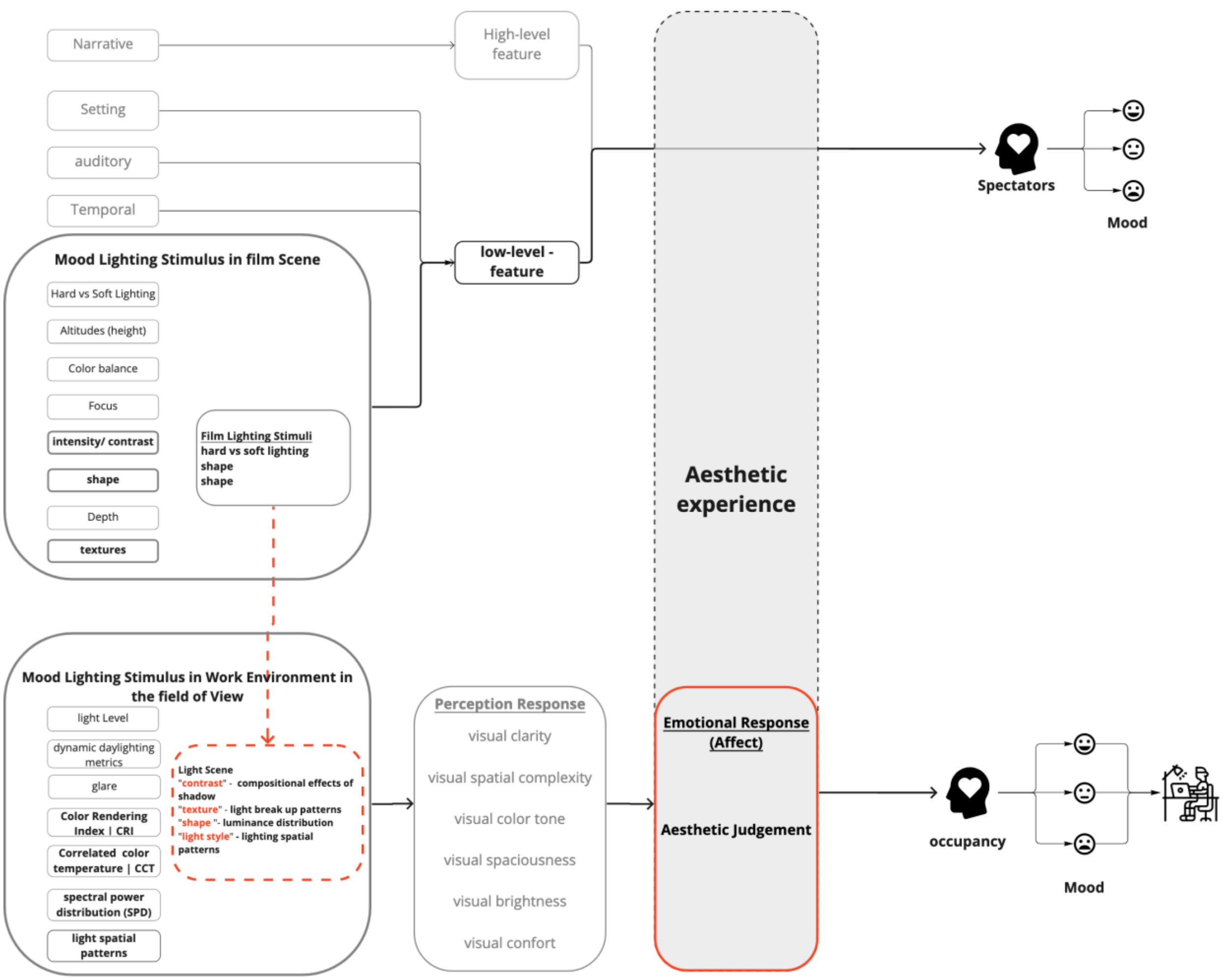
The previous theoretical study and industrial application suggest the film lighting's primary mood factors are: hard and soft light, altitude (height), direction (from the front, side, back), focus (confined or wide), texture (Break up patterns), movement, intensity/contrast (compositional effects of shadow) (Brown, 2019; Shimamura, 2014). Tarvainen, Westman, and Oittinen found that brightness is associated with the Tense Arousal (TA) psychological model in which dark scenes evoke a tense mood, and the bright and slow clip evokes a calm mood (Tarvainen et al., 2015). Polish film lighting style psychological influences on the viewer include the low-key light-evoked lightheartedness, emotion, and the high-key lighting of felt suspense (Poland, n.d.). Though some of the studies quantitatively examined the brightness and three lighting styles' impacts on spectators' mood, the empirical study on the light spatial patterns is very limited.

2.5 Conceptual Model

Figure 5 illustrates the conceptual model of the relationship between the lighting variables that influence office occupants' moods and film lighting variables; both architectural lighting variables and film lighting variables affect human moods in terms of aesthetic experience.

Figure 2.9

Research Conceptual Framework



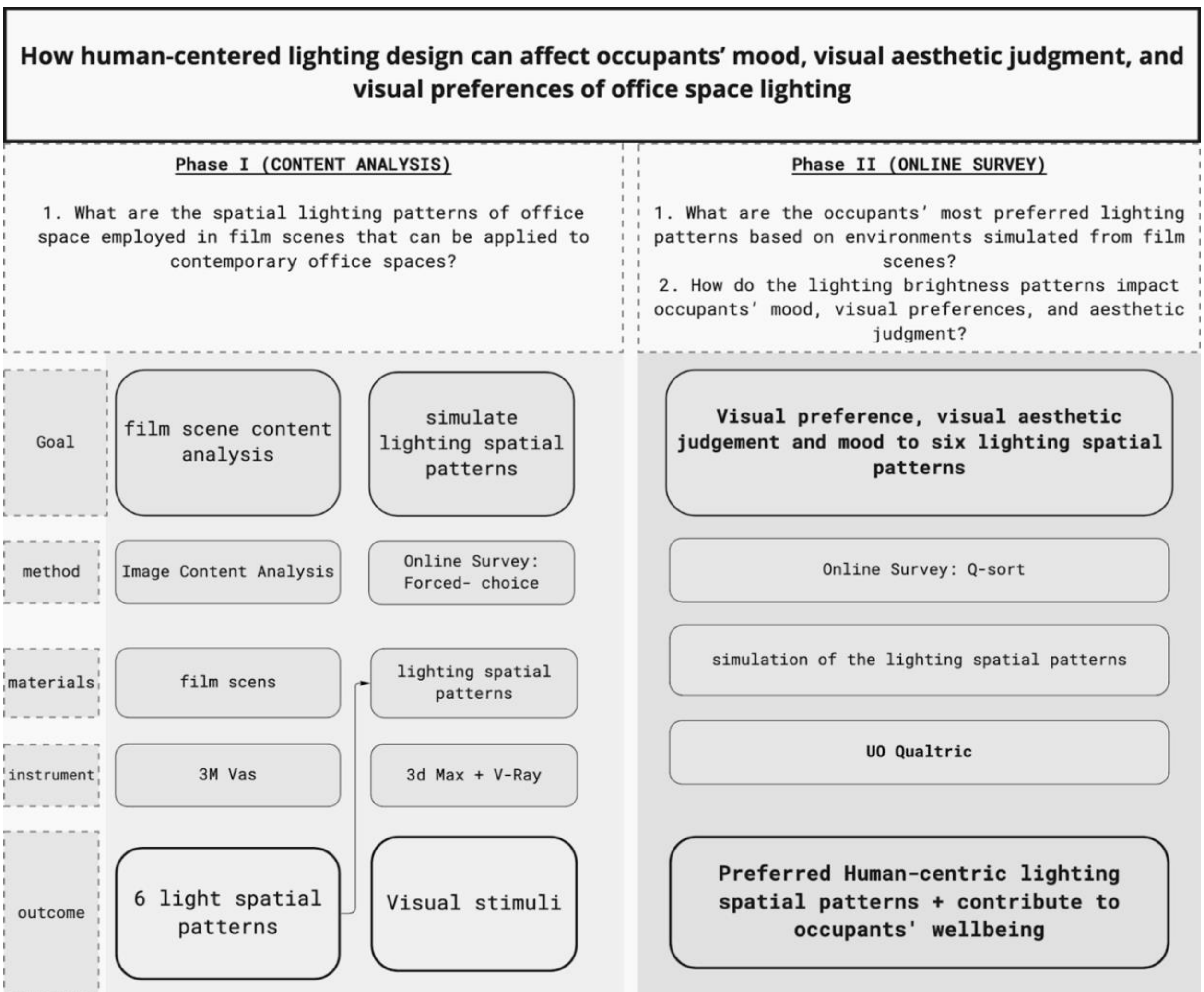
CHAPTER III

METHOD DESIGN

This study employs a mixed-methods approach involving two phases (figure 3.1). In phase 1, an image content analysis is conducted to generate the study's stimuli, and in phase 2, a survey questionnaire access participants' preferences, aesthetic judgement and mood responses to the generated stimuli.

Figure 3.1

Method Design Process Diagram



Specifically, in phase 1, a picture content analysis and visual attention analysis are performed on six different lighting spatial patterns from selected film scenes featuring office spaces. The six lighting spatial patterns are further simulated to create six interior rendered images (stimuli) that each correspond to Flynn's theory and feature different lighting patterns and brightness distributions (Flynn et al., 1973). In phase 2, a survey design employing an online questionnaire is distributed to participants (18 and older) to assess their moods and aesthetic judgments of the stimuli designed in phase 1. The objective of the survey is to investigate the impact of the six lighting spatial patterns on occupants' visual preferences, aesthetic judgments, and mood responses.

3.1.0 Phase 1: Film Lighting Scenes Content Analysis and Lighting Spatial Patterns

As noted in the literature review (2.4.1), film lighting can influence the spectators' moods and emotions, as one of the primary stimuli that share the same psychology mechanisms with architectural lighting design: aesthetic experience (Boardwell, 1991; Grodal, 2005; Bordwell and Tompson, 2017, Plantinga, 2012, Veitch 2001). The lighting designs used in film scenes are mood-oriented designs. To investigate what spatial patterns of offices employed in film scenes can be applied to contemporary office spaces, phase one uses a qualitative method to conduct a content analysis with two parts; the first part involves the office film scene selection, and the second part is the film scene image analysis.

3.1.1 Office Films Selection

The research selected featured office lighting scenes as the lighting design inspiration. A total of 21 film scenes were selected (Table 3.1). Since the film scenes are not in HDRI image format files, a content descriptive analysis and 3M™ Visual Attention Software (VAS) were employed for the jpeg film scene image files.

Table 3.1

Film list of selected film scenes

No	Film Title	Year of
1	Spectre (2015)	2015
2	Hudsucker Proxy (1994)	1994
3	Kingsman: The Secret Service	2014
4	High-Rise	2015
5	The Intern	2015
6	Her	2013
7	Nosedive (Black Mirror)	2016
8	Casino Royale	2006
9	OfficeSpace	1999
10	A Clockwork Orange	1971
11	Severance	2022
12	500 days with Summer	2009
13	The Wolf of Wall Street	2013
14	Playtest (Black Mirror)	2016
15	The Double	2014
16	The Secret Life of Walter Mitty	2013
17	Blade Runner 2049	2017
18	Blade Runner	1982
19	Severance Season 1	2022

3.1.2 Content Analysis

The VAS refers to biometric technology that simulates human brain-eye interactions and predicts subconscious gazing behavior. The VAS was utilized in the built environment for the architectural images and the building facades' design (Lavdas, Salingaros and Sussman, 2021; Salingarosand and Sussman, 2020). Five visual factors were yielded by VAS: 1) area of interest, 2) heatmap, 3) hotspots, 4) gaze sequence, and 5) visual features (including image intensity, red/green color contrast, blue/yellow color contrast, and faces). In this research, we only obtained the analysis results regarding visual features for the six most representative film scenes (table 3.4).

3.1.3 Lighting Spatial Patterns

Results from the content analysis are summarized in table 3.2 and in Table 3.3. The evaluation of the 21 film scenes corresponded six lighting spatial patterns (LSP) that were discussed in Flynn’s research; the six lighting spatial patterns correspond to the current working environment of a contemporary context.

Table 3.2:

The 3M VAS Image Analysis Results Of Edge, Intensity, And Contrast For Six Film Scenes.

Film Scene type	Edage	Intensity	Image Contrast	
			Red-Green	Blue-Yellow
Film Scene 1	26	13	22	22
Film Scene 2	32	16	27	21
Film Scene 3	26	13	21	17
Film Scene 4	33	16	27	22
Film Scene 5	20	*11*	18	14
Film Scene 6	24	13	31	17

Table 3.3

Film Scene Image Analysis Result Summary. From the Top to Bottom, the Film Scene Represented Six Lighting Spatial Pattern 1 (LS-1) to Lighting Spatial Patterns Six (LS_6)

Film Scene	Combined	Edges	Intensity

Table 3.4

Six Lighting Spatial Patterns That Were Inspired by 22 Selected Featured Office Scenes From Film and TV Shows and Categorized Into Six Lighting Modes

Light Mode	Office Lighting Film/TV Scene				
LSP-1: Down lighting (high intensity)					
LSP-2: Down lighting (low intensity) + Peripheral Lighting + Desk Level Lighting					
LSP-3:Down lighting (low intensity) + Diffuser Pendant Light + Desk Level Lighting					
LSP-4: Down lighting (medium intensity) + Diffuser Pendant Light + Peripheral Lighting					
LSP-5: Down lighting (high intensity) + Diffuser Pendant Light + Peripheral Lighting + Desk Level Lighting					
LSP-5: Down lighting (medium intensity) + Diffuser Pendant Light + Wall Illuminated + Desk Level Lighting					

3.2.0 Phase II, The Relationship Between Visual Preferences, Aesthetic Judgements, and Human Moods and Lighting Spatial Patterns

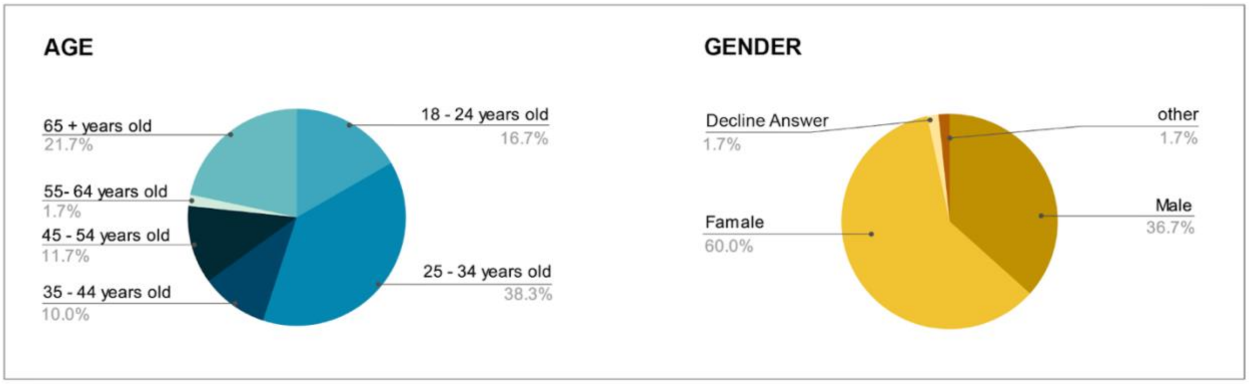
Phase two of this study addressed the following questions: 1) What are the occupants' preferred lighting patterns based on environments simulated from film scenes? and 2) how do lighting brightness patterns impact occupants' moods, visual preferences, and aesthetic judgments?

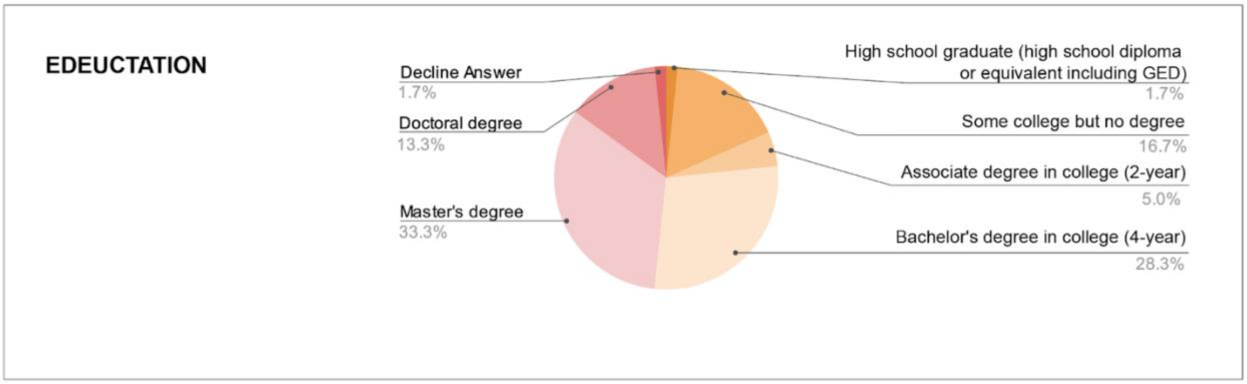
3.2.1 Participants

To perform statistical analysis and minimize the noise in the data set, 27 participants did not finish the survey, and their responses were eliminated later in the data analysis. Of those 27 people, two people exited the survey questionnaire as they disagreed with the consent form. Participants were recruited via research distribution emails sent through the architecture department newsletter and the professional network's list serve (e.g., the Society of Building Science Educators). A total of 60 participants (31 females, 22 males, one participant who was non-binary, and one who declined to indicate their gender) who are currently living and studying in the U.S. The demographic information is summarized in three pie charts (figure 3.2). The first chart shows that 16.7% of participants are 18-24 years old, 38.3% of participants are 25-34

Figure 3.2

Sample Characteristic Diagram with Pie Chart.





years old, only 10% of participants are 35-44 years old, 11.7% of participants are 45-54 years old, only two participants are 55-64 years old, and 21.7% of participants are older than 65. Regarding the education level,16.7% of participants had completed some college, 28.3% of participants held a bachelor's degree, 33.3% held a master's degree, 13.3% of participants held a doctoral degree, and one participant declined to answer. This study was approved by the Institutional Review Board (IRB) of the University of Oregon for graduate researchers. Each participant signed a consent form that confirmed their willingness to participate in this experiment.

3.2.2 Research Setting

Based on the content analysis, the author designed a cubicle workstation in an open office without any window openings so that participants only focus on the indoor lighting. The office space was modeled in the Autodesk 3ds-Max and further simulated the image with the V-ray 5 plugin for 3ds-Max. The virtual lighting environment image was proved to be valid to assess visual perceptions of the lighting environment (Murdoch et al., 2015; M. G. M. Stokkermans et al., 2015). To mimic a real office working environment, five workstations were modeled within the view. Each workstation accounted for human comfort and privacy, using a height of 52 inches (figure 3.3). In previous studies, most of the experimental office settings resembled laboratory spaces, which does not reflect real indoor office designs. To correspond to the contemporary work office environment, this research designed a workstation that more closely aligns with current office designs. In addition, to minimize the visual influence of the interior design, all of the lighting spatial patterns were applied to this same interior setting(table 3.6).

Figure3.3

Plan of Open Office with Luminaire Arrangement

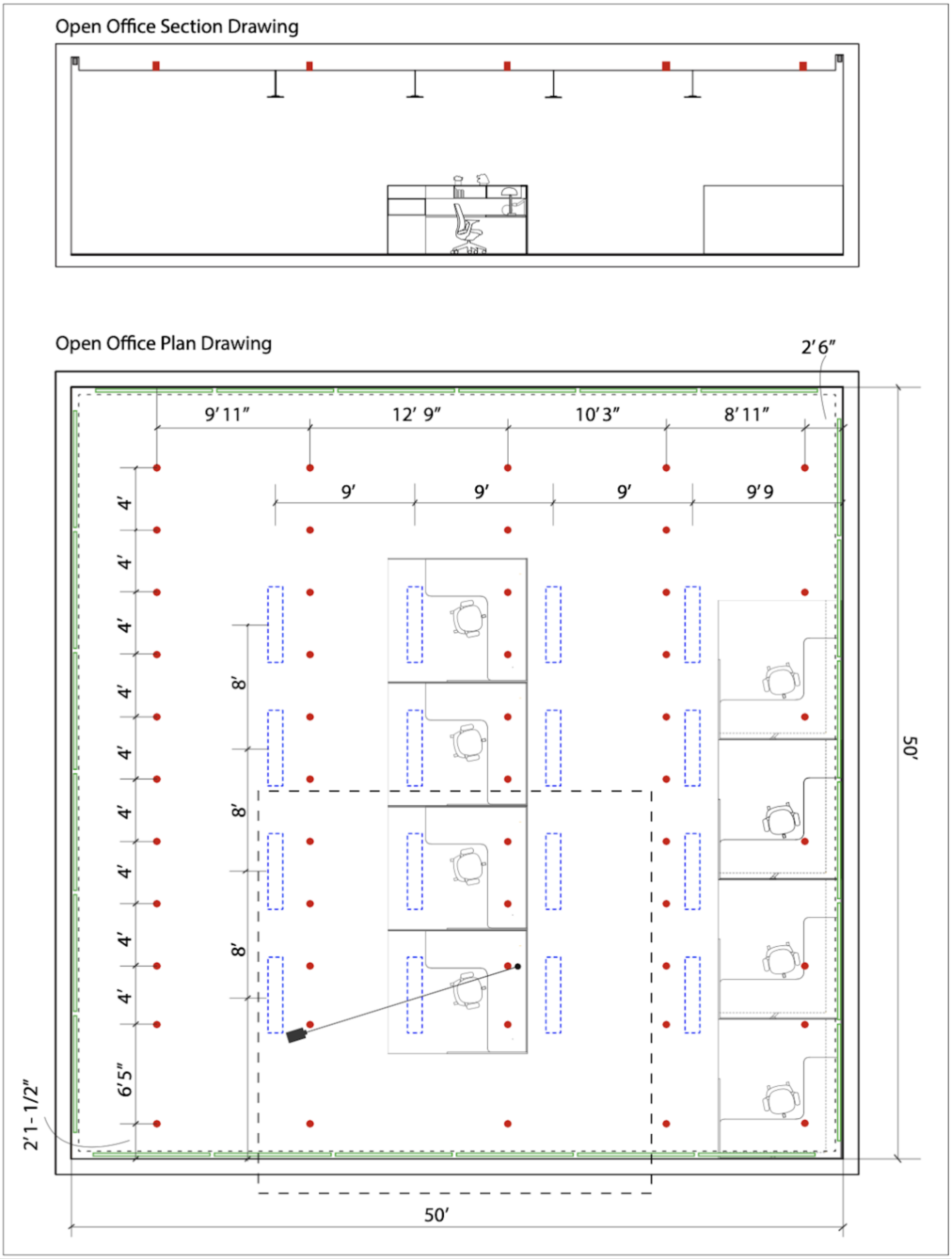


Figure3.4

Enlarged plan drawing and section drawing of workstation open office with material location and description

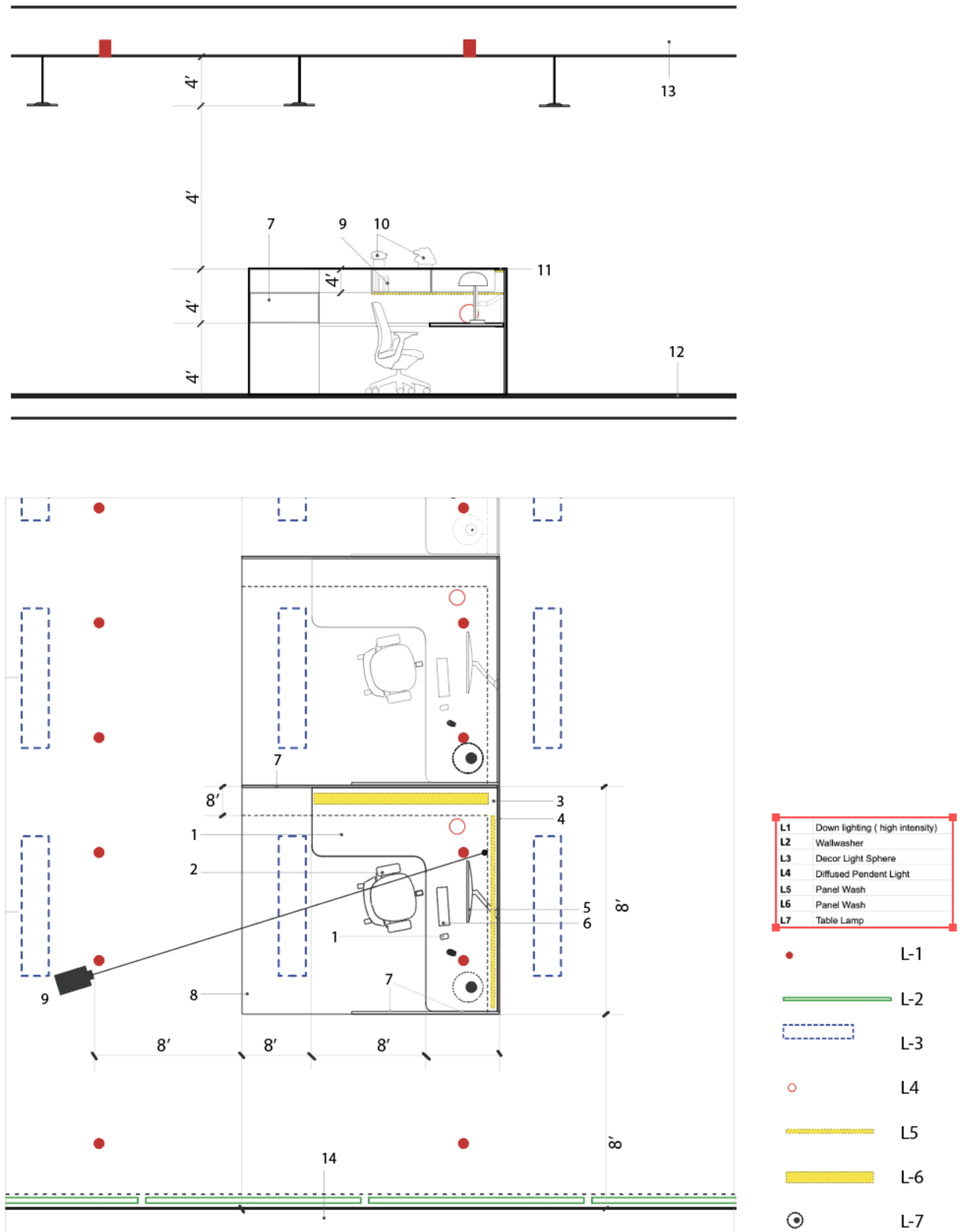


Table 3.4

V-Ray Luminary Configuration Sheets

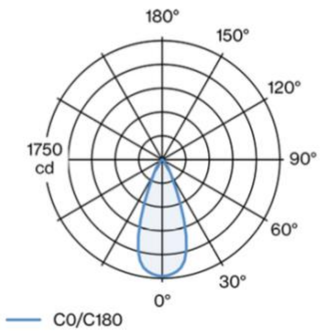
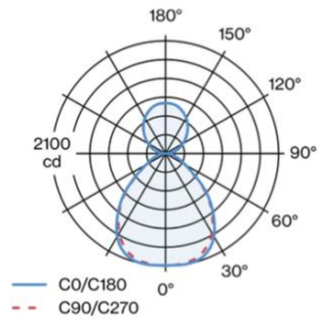
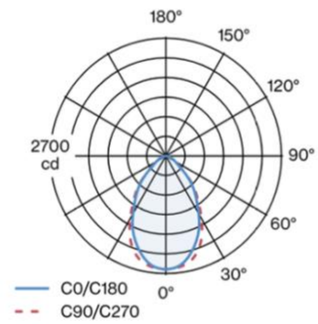
Light Type	Downlight	Diffused Pendent Light	Wallwasher
Light Distribution Sheets			
lighting dimension (mm)		length 1520 mm width 320 mm	length 2356 mm width 108 mm
Pruduct Name		TASK 1500 suspended by XAL	FRAME 100 trim MID LUMEN by XAL
Luninair Materiasl	White Coat	Black Coat	White Coat
CRI	CRI ≥ 80	≥ 80	≥ 80

Table 3.5

V-Ray Materials Setting Up Detail

Office Interior Finishing			
No.	**Name**	**Materials**	**Color/ Texture**
1	**Desktop**	powerd coting	white
2	**Ergonomic Chair**	fabric + plastic	green + white
3	**Shelf Storage**	verneer	white Oak
4	**Vertical Panel**	verneer	white Oak
5	**Mounted Monitor**	plastic	dark grey
6	**Keyboard**	plastic	dark grey
7	**Tinted Glass**	translusent glass	green, yellow, red
8	**Carpet**	carpet	lien
9	**Book Cluster**	white paper	
10	**House Plant**	Plant	Green
11	**Shelf**	verneer	white Oak
12	**Flooring**	wood	dark oak veneer
13	**Ceiling**	piaster	beige
14	**Wall**	piaster	beige

Table 3.6

Lighting Setting Up in Each Lighting Spatial Patterns Rendering Image.

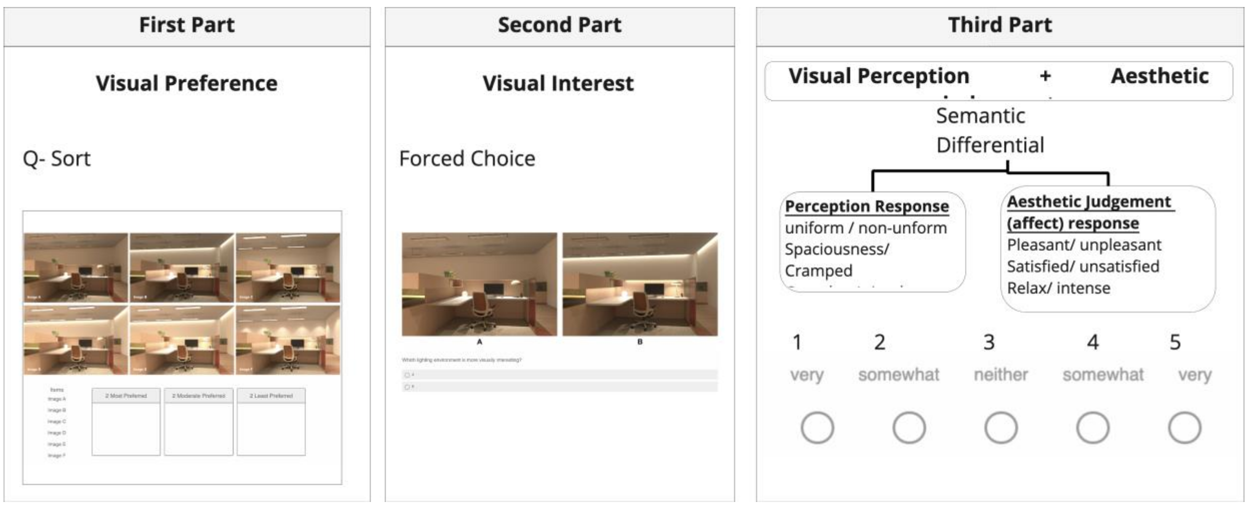
Lighting Spatial Pattersn	Name	Lighting Mode	Luminary Type	Intensity (lm)	Arrangement	Direction
	**LS-1**	Down lighting (high intensity)	Downlight	1600	recessed ceiling center	down
	**LS-2**	Down lighting (low intensity)	Downlight	900	recessed ceiling center	down
		Peripheral Lighting	Wallwasher	800	recessed ceiling peripheral	down
		Desk Level Lighting	Table Lamp	300	table	down
			Decor Light Sphere	200	table	sperical
			Panel Wash	211	partication panel	down
	**LS-3**	Down lighting (low intensity)	Downlight	500	recessed ceiling center	down
		Diffuser Pendant Light	Wallwasher	800	recessed ceiling peripheral	down
		Desk Level Lighting	Diffused Pendent Light	3000	ceiling	down
			Table Lamp	300	table	down
			Decor Light Sphere	200	table	sperical
			Panel Wash	211	partication panel	down
	**LS-4**	Down lighting (medium intensity)	Downlight	900	recessed ceiling center	down
		Diffuser Pendant Light	Diffused Pendent Light	3000	ceiling mounted	down
		Peripheral Lighting	Wallwasher	800	recessed ceiling peripheral	down
	**LS-5**	Down lighting (medium intensity)	Downlight - Centeral	1600	recessed ceiling center	down
		Diffuser Pendant Light	Diffused Pendent Light	3000	ceiling mounted	down
		Wall Illuminated	Wallwasher	800	recessed ceiling peripheral	down
		Desk Level Lighting	Table Lamp	300	table	down
			Decor Light Sphere	200	table	sperical
			Panel Wash	211	partication panel	down
	**LS-6**	Down lighting (medium intensity)	Downlight - Centeral	900	recessed ceiling center	down
		Diffuser Pendant Light	Downlight - Sephieral	900	recessed ceiling peripheral	down
		Wall Illuminated	Diffused Pendent Light	3000	recessed ceiling peripheral	down
		Desk Level Lighting	Table Lamp	300	table	down
			Decor Light Sphere	200	table	sperical
			Panel Wash	211	partication panel	down

3.2.2 Survey Design

The online survey design employed an online questionnaire that utilized the UO Qualtrics survey instrument. To optimize the visual stimuli's influence on the participants, the questionnaire required participants to use a personal computer, desktop, or large-screen tablet to answer the survey questionnaire. In addition, to minimize noise in the data, the survey required all participants to adjust the screen brightness to over 40% and to keep the screen brightness consistent during the survey. A diagram showing the process of survey design is in figure 3.5.

Figure 3.5

Survey Design Process



3.2.2 Experimental Procedure

Specifically, each of the survey parts are as follows:

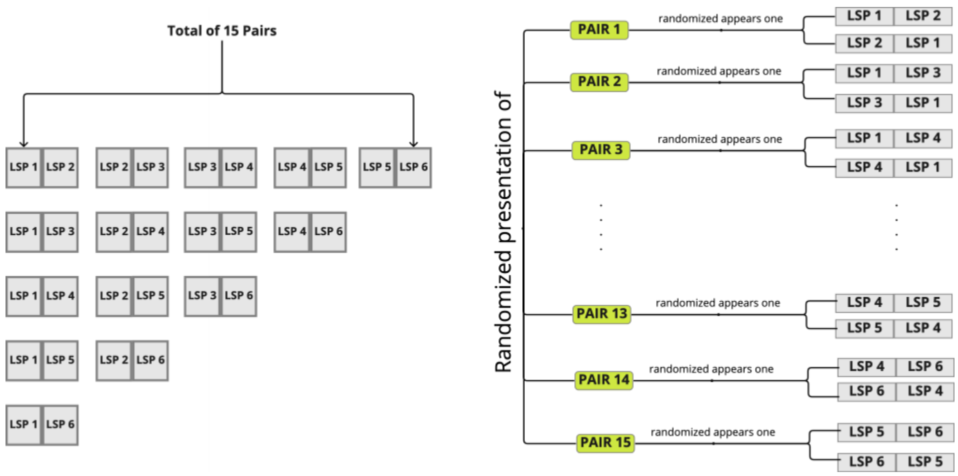
1) A qualitative Q-sort methodology was employed in this part to assess the visual preferences for the six lighting spatial patterns. In this question, six images were presented on the screen at the same time to allow the participants to sort the images into three categories: Most Preferred, Neutral, and Least Preferred. To optimize the stimuli quality, participants were able to familiarize themselves with the larger images by clicking on each image.

2) A Two-Alternative Timed Forced Choice Response (FCR) was employed. This method was successfully used to assess visual interest in sunlight patterns in previous studies (Abbushi, 2019).

In this research, participants were asked to select one image that they felt was visually interesting. The six lighting environments generated a total of 15 pairs. Each pair presented two different images side-by-side; participants needed to choose their preferred image in 18 seconds. In this section, the sequences of each pair presented to the participants are randomized so that the experimental results will not be influenced by the sequences of each pair (figure 3.6).

Figure 3.5

The Left Is the Logical of 15 Pairs Two Alternative Forced Choice Generated From Six Lighting Rendering Images. The Right Shows a Diagram of the Sequence of 15 Pairs of Randomized Logic



3) The third section in the survey was designed with a five-point semantic differential scale to assess six types of lighting environments with the following pairs of adjectives: relaxed-tense, pleasant- unpleasant, spacious-cramped, unsatisfying-satisfied, uniform-non-uniform, and complex- simple (John Flynn, 1973). In this study, three pairs of adjectives were used to evaluate visual perceptions of the lighting environment: spacious-cramped, uniform-non-uniform, and complex-simple. The mood (aesthetic judgement) was indicated by the following factors: pleasant-unpleasant, satisfying-unsatisfying, and relaxed-tense. Participants were guided by instruction text (Appendix C).

To maximize the effects of the visual stimuli, each image fit 80% of the participant's screen. During a pretext survey design, the smaller image was not as clear as the larger one. In a previous study, researchers found that the people who did not finish the survey frequently used a small screen for the survey (Rockcastle, 2016).

CHAPTER IV

DATA ANALYSIS AND RESULT

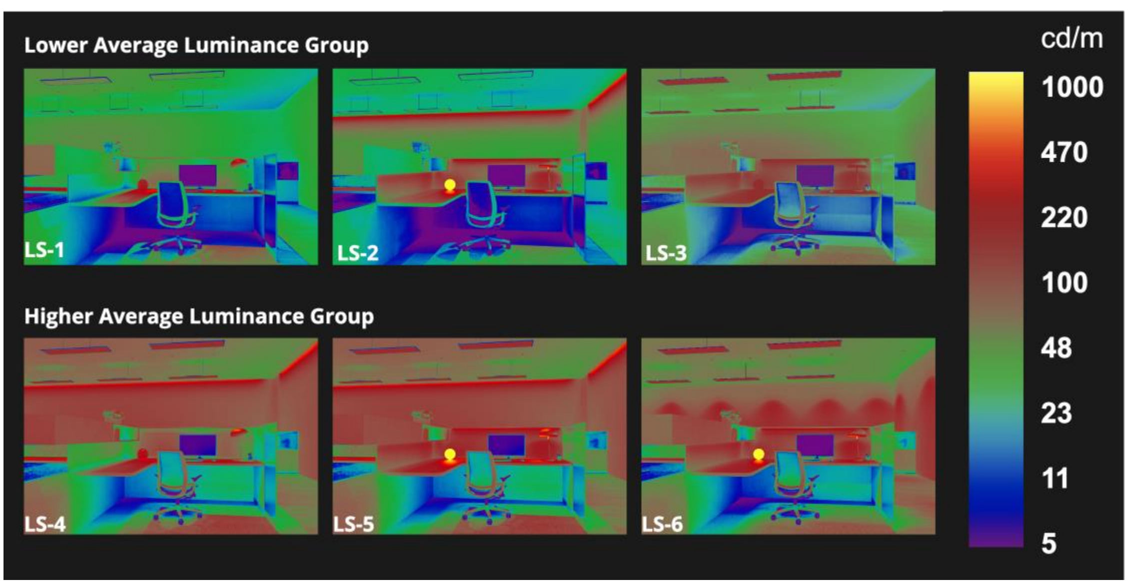
The following sections describe the results of this research: First part shows the analysis result delineate the photometric measurement results and lighting brightness pattern features. Second part shows the data analysis identified the significant effects of visual perception on subjects' visual aesthetic judgments. The third part shows the analyzed result of the visual preferred environment relationship between visual perceptions and moods.

4.1.0 Photometric Measures and Independent Variables

Based on the content analysis, six film scene images were produced, representing six spatial lighting patterns (LS). A photometric analysis was conducted on the six light scenes to characterize each spatial lighting pattern. The six lighting scenes used Photosphere software to analyze the High Dynamic Range Images that were produced in the rendering process. Luminance data and false-color images that resulted from this analysis (figure 4.1) are summarized in Table 4.1 and Figure 4.3. Meanwhile, a histogram diagram summarized six lighting scenes luminance means value in figure 4.4.

Figure 4.1:

False-Color Images of The Lighting Scenes



For each lighting scene, this research has measured three view region luminance values. Loe et al. found that luminance levels over 30 cd/m² are preferred in the field of view within a 40-degree wide horizontal band (1994). Based on Loe's findings, this research has defined three important regions to investigate (Figure 4.2): 1) the lighting in the view of the ceiling and wall, defined as the background lighting environment; 2) the lighting in the view of the vertical partition panel and desk surface, defined as the "work view region," which was a significant factor in a previous study regarding visual preferences and moods among office workers(G. R. Newsham & Veitch, 2001; J. A. Veitch & Newsham, 2000). In addition, the investigation of VDT task lighting research regarding subjects' preferences related to the direction of vertical illumination versus desk surface lighting ratio did not indicate the same ratio as in this research. This research only interprets the work view area's average luminance as one of the factors that may influence subjects' visual preferences, visual aesthetic judgments, and moods. According to the defined view region, the study defined one of each lighting pattern ratio work area view luminance ratio. Two ways to define the ratio are applied below.

1. Ratio 1(R0): the average luminance value work view region over the ceiling and wall view region
2. Ratio 2 (R): the average luminance value work view region over the ceiling and whole view region

By comparing R0 and R(table 4.3), the results suggest that the value changes in each lighting environment of R0 and R are nearly parallel; therefore, this research will only consider the R as a factor for later discussion and as one of the features of lighting brightness patterns.

Table 4.1

The Photometric Measurement of Luminance Results

Lgiht scene type	Whole View	Average Luminance (cd/m2)			R0	R
		Ceiling & Wall Region	Work View	FLoor View		
LS-1	34.2	37.3	42.9	44.2	1.25	1.15
LS-2	45.5	52.6	90.4	17.2	1.99	1.72
LS-3	51	47.8	96.8	29.7	1.90	2.03
LS-4	77.5	102	68.6	47.6	0.89	0.67
LS-5	87.8	103	126	47.4	1.44	1.22
LS-6	73.8	82.5	109	43.4	1.48	1.32

Note. *R0 indicates the ratio of average work view region luminance to whole image*

Figure 4.2:

The Defined View Region of The Workstation Lighting Scene

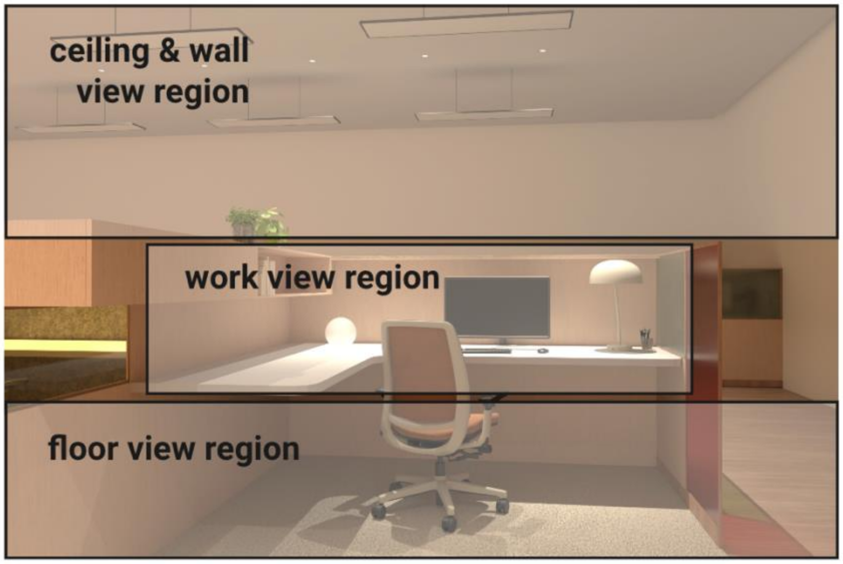


Figure 4.3:

R0 and R Value Mark and Line Diagram Shows on the Left, the Right Is the Bar and Line Diagram Shows the Changes of Luminance. Shows the Trend of the R0 and R in Each Lighting Scene view average luminance, R indicates the ratio of work area average luminance over wall and ceiling view average luminance.

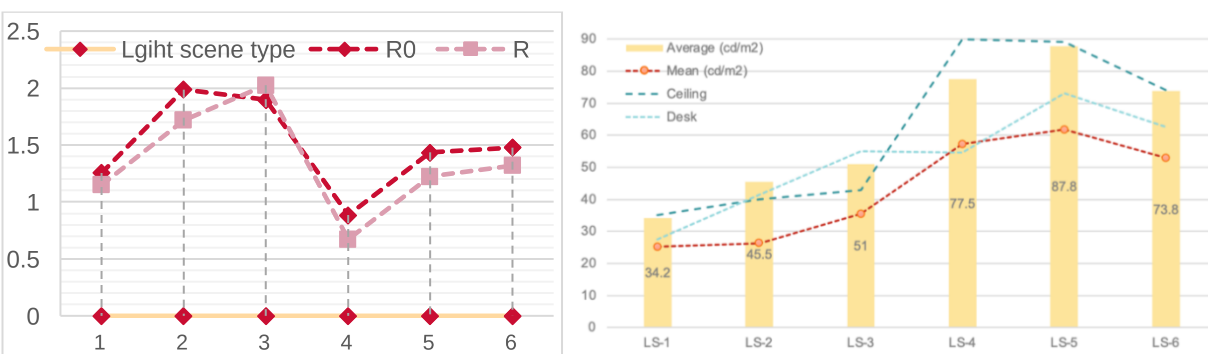
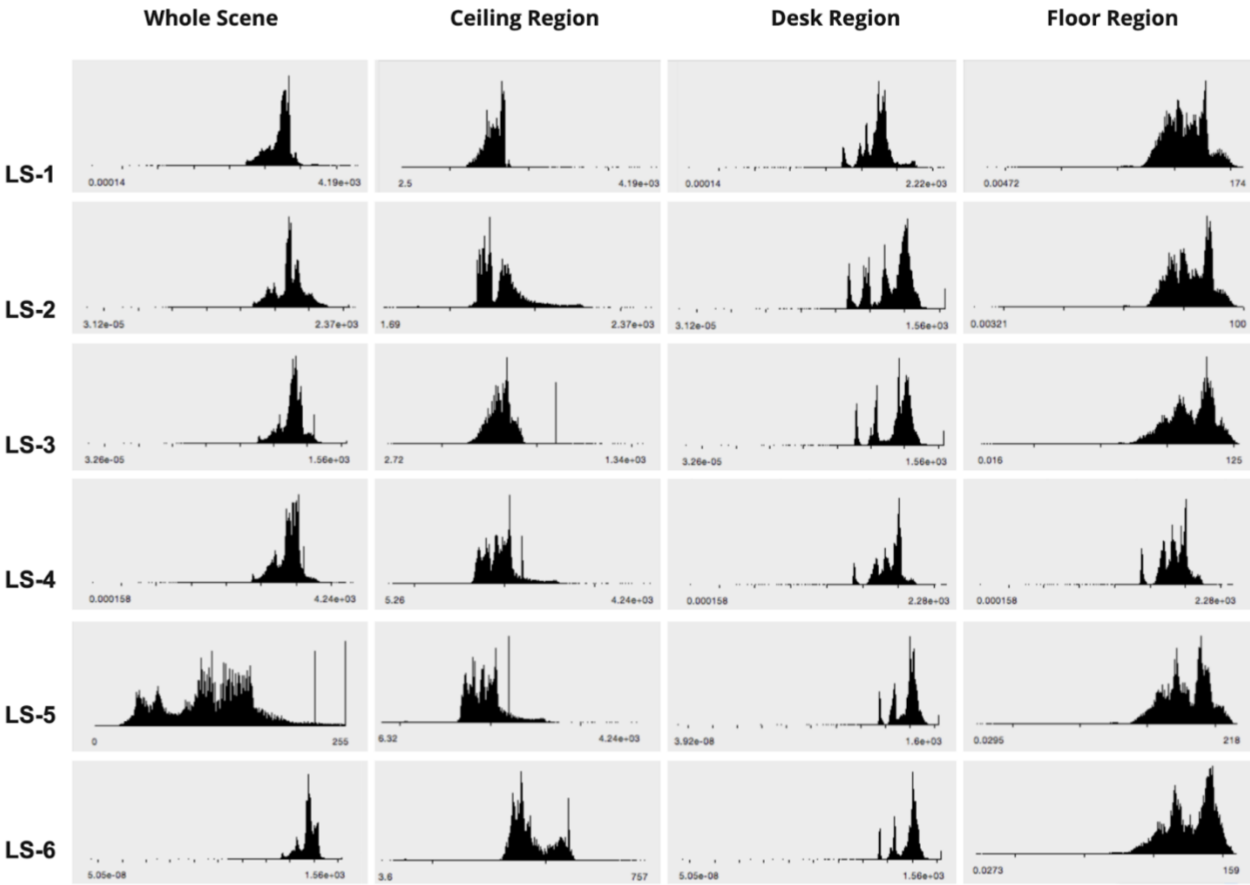


Figure 4.4:

Luminance Histogram Figure

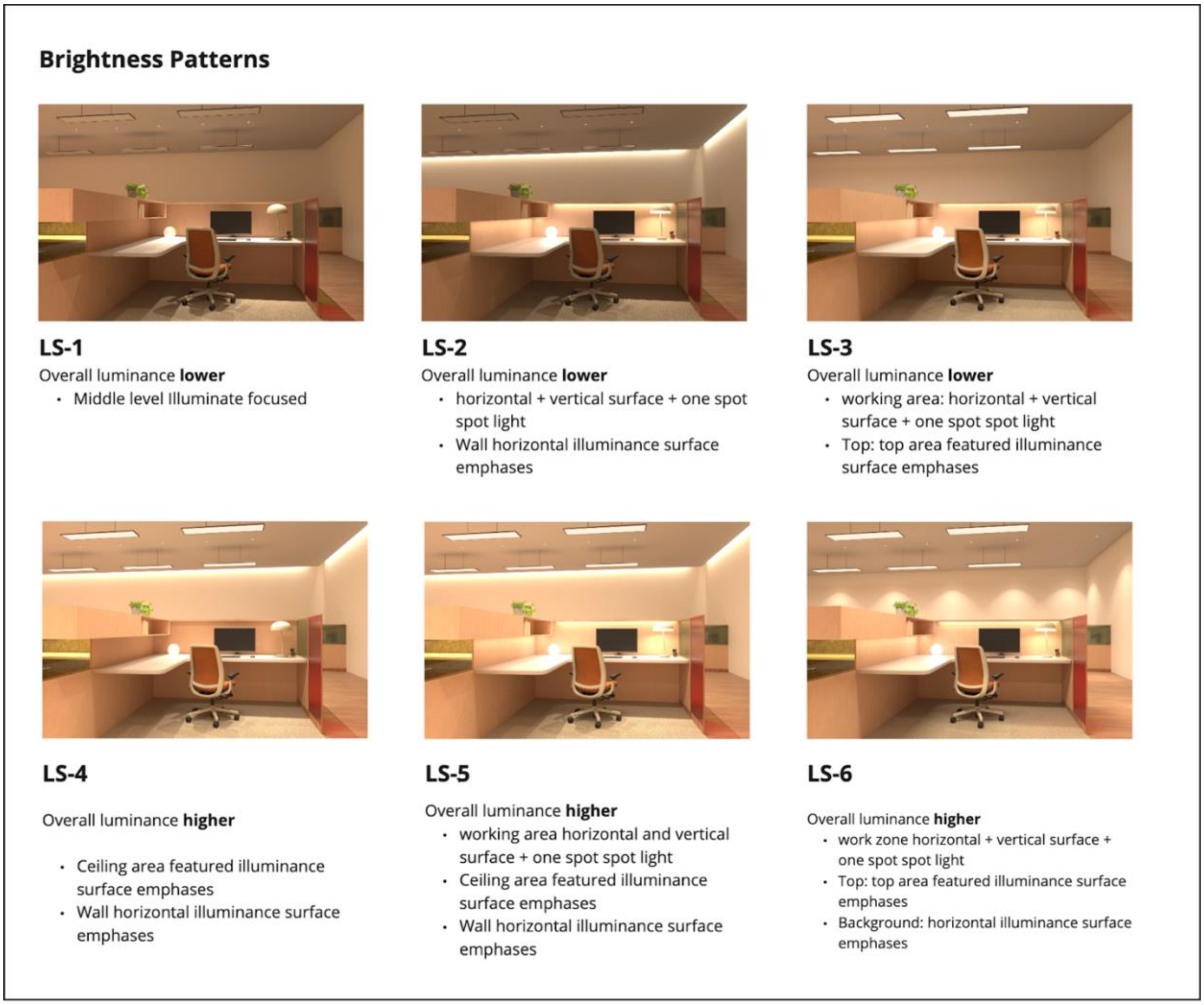


Resulting from the content analysis and the photometric measurement, the six lighting environment brightness patterns can be summarized as follows (figure 4.5): A total of two groups of lighting brightness patterns emerged; the first group featured lower average luminance, and the second group had higher average luminance.

For the low setting, LS-1 is defined as the default brightness pattern only downlight, with the work area desk surface being illuminated. The LS-2 lighting appearance has the lighting distributed on a vertical surface, and the brightness is highlighted by a peripheral linear shape. The LS-3 ceiling area was highlighted, and the pendant luminaire shape appeared. Additionally, the work area was illuminated.

Figure 4.5:

Lighting Scenes Brightness Pattern Features



The high-setting group features added diffused pendant lighting for all three lighting scenes, and the pendant light appeared in the field of view. In this group, LS-4 lighting patterns appeared to be more evenly distributed on vertical surfaces in the view. Comparing LS-4 with LS-5, LS-5's work area lighting was turned on, and the brightness was more intense when compared with the far back wall. The LS-6 featured its unevenly distributed curve shape lighting brightness on the back wall.

4.2 Visual preference & Visual Interest

Subjects' responses to visual preferences were analyzed with non-parametric statistics, including a Friedman Test (when the subjects' responses are not normally distributed with the Shaprio-Wilk test). The data set has been re-coded so that the range of evaluation is from 1 to 6; 1 represents the most preferred; 2 represents secondary preference; 3 means moderately preferred; 4 represents the second most moderately preferred; 5 represents the second least preferred; and 6 means the least preferred. The overall ranking result from the test reveals that the LA-3 is the most preferred (mean= 2.55, sd=1.71); the second most preferred lighting scene is LS-4 (means= 2.9, SD= 1.47). Subjects preferred LS-1 the least (means= 4.55, SD= 1.58). An overall ranking is summarized in table 4.2 and table 4.3.

Table 4.2:

Mean And Standard Deviation Of The Total Dependent Variables Per Lighting Spatial Patterns.

	LS-1	LS-2	LS-3	LS-4	LS-5	LS-6
Mean	4.55	3.13	2.55	2.9	3.98	3.88
N	60	60	60	60	60	60
Std. Deviation	1.578	1.712	1.171	1.469	1.6	1.833
Minimum	1	1	1	1	1	1
Maximum	6	6	5	6	6	6
Median	5	3	2	3	4	4

Table 4.3:

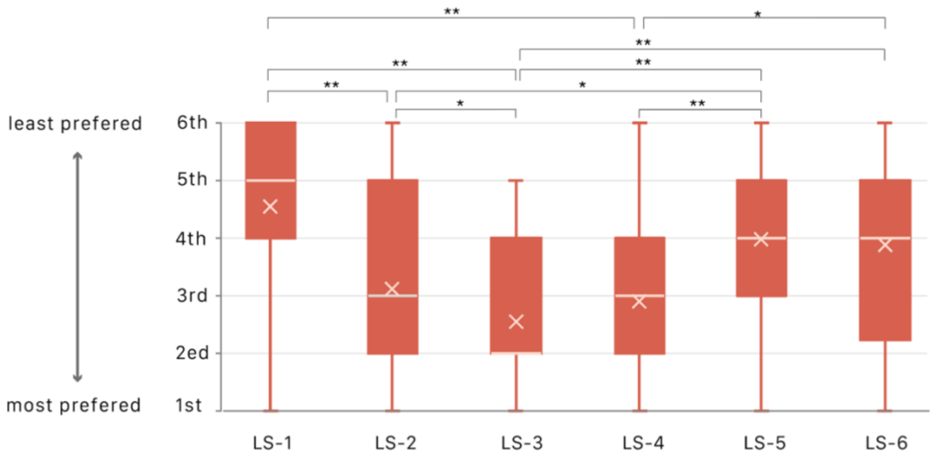
Friedman Test Means Ranking Result

Rank Order	Lighting Scenes	Mean	Std. Deviation	Std. Deviation
1	LS-3	2.55	1.171	1.171
2	LS-4	2.9	1.469	1.469
3	LS-2	3.13	1.712	1.712
4	LS-5	3.98	1.6	1.6
5	LS-6	3.88	1.833	1.833
6	LS-1	4.55	1.578	1.578

Note, The overall ranking order 1 present most preferred, 6 indicate leas preferred

Figure 4.6:

The Plot-Box Diagrams Show the Visual Preferences Related to the Lighting



Note, The means ranks as preference level are represented as 1-6 that indicate most preferred to least preferred. * indicate $p<0.05$, ** indicate $p<0.01$.

Table 4.4

Wilcoxon Signed-Rank Test Results Regarding Subjects' Visual Preference Responses to Six Lighting Scenes.

	LS-1	LS-2	LS-3	LS-4	LS-5	LS-6
LS-1	1.000					
LS-2	**-4.969****	1.000				
LS-3	**-5.447****	**-2.170***	1.000			
LS-4	**-4.159****	-.714	-1.460	1.000		
LS-5	-1.612	**-2.053***	**-4.243****	**-3.865****	1.000	
LS-6	-1.711	-1.913	**-3.559****	**-2.859***	-.124	1.000

Note. Highlighted bold values indicate the significance and $p < 0.05$ represented by *, $p< 0.01$ represented by **

A statistically significant difference in perceived preference emerged depending on the type of lighting scene, $\chi^2(5) = 49.37$, $p < 0.01$. A series of Wilcoxon signed-rank tests as pairwise tests were performed afterwards to determine whether specific pairs of lighting scenes were significantly different. A total of 15 pairs of lighting scenes were performed with Wilcoxon signed-rank tests; the result of each pair is summarized in table 4.4 and a plot-box table diagram in Figure 4.6.

The significant difference observed from the lighting environment with desk area focus task lighting LS-3 (Mean=2.55, SD=1,71) is the most preferred working environment when compared to LS-1 (z= -5.45, p <0.01) , LS-2 (z= -2.17, p<0.05), LS-5 (z= -4.24, p <0.01), and LS-6 (z= –3.56, p<0.01).

Regarding the LS-4 with higher luminance and wall horizontally illuminated plus diffuse pendant lighting is significant more preferred when compared to LS-1 (z= -4.16, p <0.01), LS-5 (z= -3.87, p <0.01) and LS-6 (z= -2.86, p <0.05). However, the comparison between LS-3 and LS -4 shows no significant difference from the result. There is no indication of a significant difference between LS-2 (Mean= 3.13 , SD= 1.71) and LS-4 (Mean= 2.9, SD= 1.47). The result shows a significant difference between LS-2 (Mean= 3.13 , SD= 1.71) and LS-3 (Mean= 2.55 , SD= 1.17). The result also indicates that the default lighting environment (LS-1) setting is significantly less preferred (Mean= 4.55, SD=1.578) when compared with LS-2, LS-3 (z= -5.447, p<0.01), and LS-4 (z= -4.159, p<0.01).

4.3 Visual Interest of the six lighting scenes

The visual interest in the lighting spatial patterns was measured with FRC methods based on the previous study regarding accessing visual interest in daylighting patterns (Abushis et al., 2019). Therefore, subjects’ visual interest in different lighting scenes in this research followed the same way that re-coded the data into the percentage of lighting conditions chosen for the chances the lighting condition appeared. Since the data are not normally distributed so that were not able to conduct the T-test, the re-coded data used a non-parametric Friedman signed-ranking test (table 4.5) to determine the significant effects of the visual interest responses. The results reveal that subjects' visual interest in different lighting scenes was statistically significantly different, $\chi^2(5) = 48.20$, $p < .001$. Meanwhile, the mean values and the participants' distributions of visual interest in lighting scenes are shown in Figure 4.7.

Table 4.5

Mean Rank and standard deviation (SD) of the visual interest response to per lighting scenes.

Ranks	Lighting Scene	Mean Rank
1	LS-6	4.17
2	LS-2	3.97
3	LS-3	3.86
4	LS-4	3.74
5	LS-5	3.04
6	LS-1	2.23

Means represent the percentage of the lighting scenes have been chosen over total times it appears

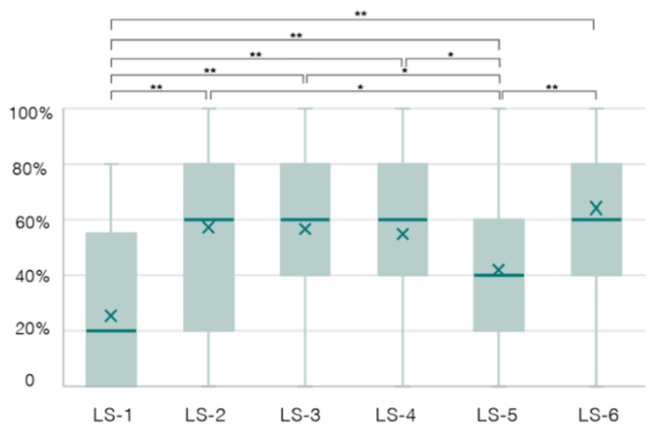
Test Statistics

Test Statistics		
N	60	60
Kendall's Wa	0.161	0.161
Chi-Square	48.204	48.204
df	5	5
Asymp. Sig.	<.001	<.001

a. Kendall's Coefficient of Concordance

Figure 4.7:

Boxplot Diagram Shows the Mean Of The Distribution Of Participants' Visual Interest To Each Lighting Scene.



To know exactly which pair of lighting scenes' visual interests were significantly different, a Wilcoxon signed-ranking test was conducted for 15 pairs of lighting scenes. A summary of the test results is presented in Table 4.7. In general, the visually more interested lighting scenes LS - 2 (means= .58, SD= . 31), LS-3 (means= .56, SD= . 27), LS-4(means= .55, SD= .28. 31), and LS6 (means= .64, SD= . 28). The results detected significant differences for pairs with LS-1 and LS- 2. Specifically, for the lower brightness lighting scenes that only had downlight (LS-1), the results indicate significantly less visual interest compared to the rest of the lighting scenes: LS-1 to LS-2 (z= -5.51, p < 0.01), LS-1 to LS-3 (z= -4.69, p < 0.01), LS - 1 to LS - 4 (z = - 4.01, p < 0.01), LS-1 to LS-5 (z= -2.15, p<0.05), and LS- 1 to LS -6 (z= -4.94, p<0.01). Similar to LS-1, the higher brightness lighting scene with all types of lighting turn on (LS-5) is significantly less visual interest from all other lighting scene types: LS-5 to LS-2 (z= -2.03, p<0.05), LS-5 to LS-3 (z=-2.56, p<0.05), LS-5 to LS-4 (z=--4.01, p<0.05), and LS- 5 to LS -6 (z= -3.90, p<0.01). There is no significant difference between LS-2, LS-3, and LS-4.

Table 4.6:

Mean And Standard Deviation (SD) Of The Subject's Response Of Visual Interest Per Lighting Spatial Patterns.

Scene Type	N	Mean	Std. Deviatior	Mini	Max	Percentiles 25th	50th(Median)	75th
LS-1	60	0.26	0.29	0	0.8	0	0.2	0.55
LS-3	60	0.56	0.25	0	1	0.4	0.6	0.8
LS-4	60	0.55	0.27	0	1	0.4	0.6	0.8
LS-6	60	0.64	0.28	0	1	0.4	0.6	0.8
LS-2	60	0.58	0.31	0	1	0.2	0.6	0.8
LS-5	60	0.42	0.29	0	1	0.2	0.4	0.6

Table 4.7:

Wilcoxon Signed-Rank Test Results of Subjects' Visual Interest Responses To Six Lighting Scenes.

	LS-1	LS-2	LS-3	LS-4	LS-5	LS-6
LS-1	1.000					
LS-2	**-4.969****	1.000				
LS-3	**-5.447****	**-2.170***	1.000			
LS-4	**-4.159****	-.714	-1.460	1.000		
LS-5	-1.612	**-2.053***	**-4.243****	**-3.865****	1.000	
LS-6	-1.711	-1.913	**-3.559****	**-2.859***	-.124	1.000

Note. Highlighted bold values indicate the significance and p < 0.05 represented by *, p< 0.01 represented by **

4.4 Visual Perception and Aesthetic Judgment

The visual perception (represented by spacious/cramped, uniform/non-uniform, and complex/simple) and mood (represented by relaxed/ intense, pleasant/unpleasant, and satisfied/unsatisfied) were analyzed using Friedman's two-way analysis, which is a non-parametric test and an alternative version for non-normally distributed data T-tests. Subjects' perceptions of spaciousness, uniformity, and complexity in six lighting environments were significantly different: spacious/cramped $\chi^2(5) = 12.99$, $p < 0.05$, uniform/non-uniform $\chi^2(5) = 20.15$, $p<0.05$, and complex/simple $\chi^2(5) = 60.04$, $p < 0.01$. The following pairwise comparisons with Bonferroni corrections were performed, and statistical significance was accepted at a *p*-level of < .0003 for both visual perceptions and mood responses. A summary of the resulting layout in table 4.8, table 4.9 and figure 4.8.

Table 4.8:

Pairwise Comparisons Adjusting Significance Bonferroni Correction For Six Lighting Scenes' Mood Responses Of Complex/Simple.

Comples/ Simple	LS-1	LS-2	LS-3	LS-4	LS-5	LS-6
LS-1	1					
LS-2	2.342	1				
LS-3	1.757	-0.586	1			
LS-4	**3.928***	1.586	2.171	1		
LS-5	4.66	2.318	2.903	0.732	1	
LS-6	**6.197****	**3.855***	**4.44****	**2.269****	1.537	1

Note. The significance is highlighted with bold value. $p < 0.05$ represented by * and $p< 0.01$ represented by **

Table 4.9

Mean And Standard Deviation (SD) Of the Subject's Response Of Visual Perception and Mood Per Lighting Spatial Patterns.

Lighting Scenes	N	Relaxed/ Intense			
		Max	Min	Mean	Std. Deviation
LS-1	60	1	4	1.83	0.942
LS-2	60	1	4	1.93	1.006
LS-3	60	1	5	2.6	1.028
LS-4	60	1	5	3.47	1.241
LS-5	60	1	5	3.97	1.262
LS-6	60	1	5	2.85	1.233

Lighting Scenes	N	Spacious / Cramped			
		Max	Min	Mean	Std. Deviation
LS-1	60	1	4	2.63	1.008
LS-2	60	1	5	2.2	0.935
LS-3	60	1	4	2.23	0.871
LS-4	60	1	5	2.32	0.983
LS-5	60	1	5	2.53	1.112
LS-6	60	1	5	2.48	1.142

Lighting Scenes	N	Pleasant / Unpleasant			
		Max	Min	Mean	Std. Deviation
LS-1	60	1	5	2.43	1.155
LS-2	60	1	5	2.03	0.991
LS-3	60	1	5	2.38	1.027
LS-4	60	1	5	2.9	1.231
LS-5	60	1	5	3.4	1.265
LS-6	60	1	5	2.5	1.282

Lighting Scenes	N	Complex/ Simple			
		Max	Min	Mean	Std. Deviation
LS-1	60	1	5	3.72	1.01
LS-2	60	1	5	3.07	1.118
LS-3	60	1	5	3.22	0.865
LS-4	60	1	5	2.75	1.174
LS-5	60	1	5	2.57	1.254
LS-6	60	1	5	2.33	1.16

Lighting Scenes	N	Satisfied / Unsaetisfied			
		Max	Min	Mean	Std. Deviation
LS-1	60	1	5	2.68	1.066
LS-2	60	1	5	2.18	0.948
LS-3	60	1	5	2.6	1.012
LS-4	60	1	5	2.7	1.124
LS-5	60	1	5	3.18	1.214
LS-6	60	1	5	2.45	1.048

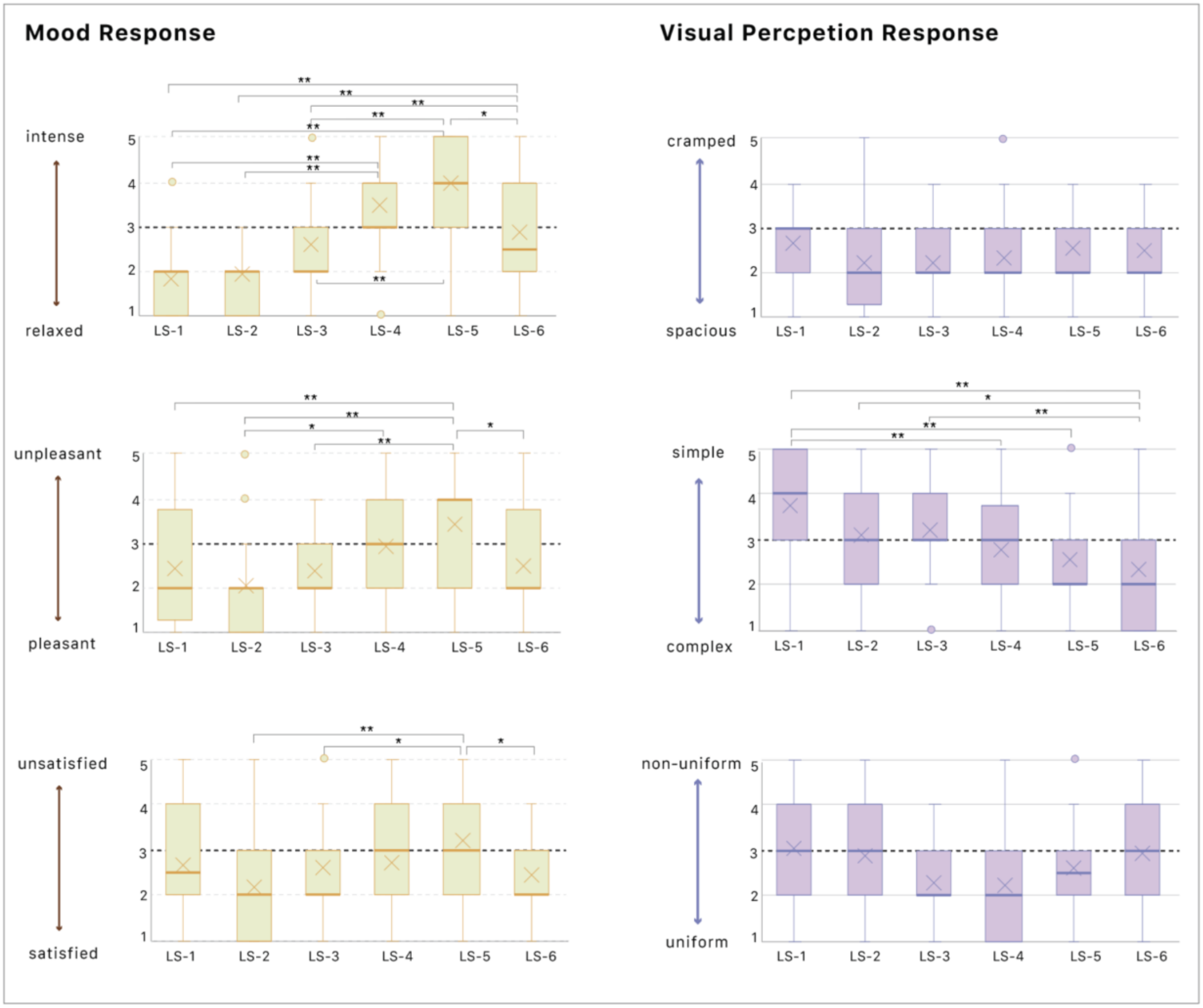
Lighting Scenes	N	Uniform/ Non-uniform			
		Max	Min	Mean	Std. Deviation
LS-1	60	1	5	3.02	1.157
LS-2	60	1	5	2.85	1.205
LS-3	60	1	4	2.28	0.922
LS-4	60	1	5	2.23	1.125
LS-5	60	1	5	2.62	1.166
LS-6	60	1	5	2.95	1.294

In the visual perception of spaciousness, most subjects perceived all types of lighting scenes spacious, which is no significant difference observed from the pairwise comparison. There is a sign that people perceive LS-3 (means= 2.28, SD= .92), LS-4 (means=2.23, SD= 1.12), and LS-5 (means= 2.62, SD= 1.17) more visually uniformed. The LS -1, LS-2, and LS- 4 are more in between.

Regarding visual perception complexity of different lighting scenes, result only reveals subjects' perception of complex/simple for LS-6 to LS-1 ($p < 0.001$), LS-6 to LS-2 ($p < 0.003$), LS-6 to LS-3 ($p < 0.001$), LS-5 to LS-1 ($p < 0.001$), LS-4 to LS-1 ($p < 0.003$), as well as LS-4 to LS-3 ($p < 0.003$).

Figure 4.8:

Pox-Box Shows Visual Perception and Mood Access Result and Its Reponses Distributed.

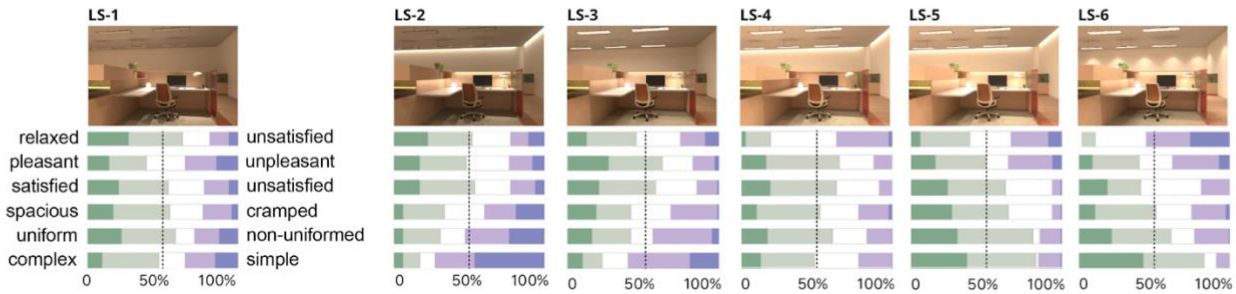


Note, the semantical differential ranges from 1 - 5. Such as relaxed/ intense rating, and the numbers represented by 1- very relaxed, 2 - somewhat relaxed, 3 neither relaxed nor intense, 4 somewhat intense, 5 - very intense.

The results also indicate that subjects' mood responses to six lighting scenes were significantly different for the mood of relax/intense χ^2 (4) = 42.21, $p < 0.01$, pleasant/unpleasant χ^2 (5) = 105.24, $p < 0.01$, and satisfied/unsatisfied $\chi^2(4) = 12.99$, $p < 0.05$. Regarding the subjects' mood responses to six lighting environments, the pairwise comparisons are summarized in table 4.10.

Figure 4.9:

Stack Bar Chart Shows Visual Perception and Mood Appraisal For Each Lighting Scenes And Where The Responses Are Distributed.



Subjects felt that LS-5 (means= 3.97, SD =1.26 had a more intense lighting environment, but no significant difference emerged when compared with LS-4 (means= .3.47, SD= 1.24), which people rated as neither intense nor relaxed. Regarding participants' responded to lighting scenes in terms of pleasant/unpleasant, LS-5 (means= 3.4, SD= 1.27) significantly unpleasant work lighting environments. The test found that people felt that LS-2 (means= 2.03, SD= .99) , and LS-3 (means= 2.38, SD= 1.03) are more pleasant. However, no significant differences were detected among them. The subjects' responses to LS-1 (means=2.34, SD= 1.16) were more ambiguous than the population distributed between pleasant and unpleasant. LS- 3 was rated as significantly more pleasant when compared with LS-4(means=2.9, SD=1.23).

Subjects felt more satisfied with LS-2 (means= 2.18, SD= .95), LS-3 (means= 2.6, SD= 1.01), and LS-6 (means= 2.45, SD= 1.05). For LS 5, they were significantly less satisfied compared to LS -5 ($p < 0.001$) and LS-3 ($p < 0.003$).

Table 4.10,

Pairwise Comparisons Adjusting Significance Bonferroni Correction for Six Lighting Scenes' Mood Responses

Relax/Intense	LS-1	LS-2	LS-3	LS-4	LS-5	LS-6
LS-1	1.000					
LS-2	-0.049	1.000				
LS-3	-2.733	-2.684	1.000			
LS-4	**-5.855***	**-5.807****	-3.123	1.000		
LS-5	**-8.027****	**-7.978****	**-5.294****	-2.171	1.000	
LS-6	**-3.538****	**-3.489****	**-0.805****	-2.318	**-4.489****	1.000

Pleasant / Unpleasant	**LS-1**	**LS-2**	**LS-3**	**LS-4**	**LS-5**	**LS-6**
LS-1	1					
LS-2	1.781	1				
LS-3	0.659	-1.122	1			
LS-4	-1.366	**-3.147 ***	-2.025	1		
LS-5	**-4.001***	**-5.782 ****	**-4.66****	-2.635	1	
LS-6	-0.146	-1.927	-0.805	1.22	**3.855 ***	1

Satisfied/ Unsatisfied	**LS-1**	**LS-2**	**LS-3**	**LS-4**	**LS-5**	**LS-6**
LS-1	1					
LS-2	1.952	1				
LS-3	0.342	-1.61	1			
LS-4	-2.733	-1.976	-0.366	1		
LS-5	-2.757	**-4.709****	**-3.098***	-2.733	1	
LS-6	1.073	-0.878	0.732	1.098	**3.83***	1

Note. The significance is highlighted with bold value. $p < 0.05$ represented by * and $p < 0.01$ represented by **

CHAPTER V

DISCUSSION

In contemporary work environments, mental well-being is deeply tied to the visual environment. The psychological approach to lighting emphasizes the importance of visual preferences within psychological mechanisms (J. A. Veitch, 2001). The overall results of this exploratory study revealed two lighting spatial patterns (LS-3 and LS-4) that were significantly preferred among the six lighting patterns developed from selected film scenes. In addition, subjects' mood appraisal for the LS-3 spatial patterns indicated shows a trend that the participants felt more relaxed, pleasant, and satisfied. In addition, subjects' mood appraisal for the LS-3 spatial patterns indicated shows a trend that the participants felt more relaxed, pleasant, and satisfied. The analysis of visual interest in relation to office indoor lighting did not reveal a robust statistical trend for specific lighting spatial patterns, but the least visual interest seams were associated with the monotonous default low illuminance setting. In addition, subjects' responses to the visual perception of visual spaciousness, visual complexity, and visual uniformity do not show statistical differences among the six lighting scenes. Among the six spatial lighting patterns, only subjects' visual complexity indicates a strong trend that LS-1 was perceived as simpler than others, and LS-6 was perceived as more complex than other lighting spatial patterns. The following sections discuss the results in detail.

5.1.0 DISCUSSION

5.1.1 Visual Preference

The result shows statistic evidence that subjects most preferred LS-3 and LS-4. This result indicates the subjects' visual preference for the spatial lighting patterns features for an overall higher average luminance setting LS-4 (Lavg= 77.5 cd/m^2) with diffuse pendant lighting that provided an adequate amount of light in the field of view without work view area lighting on. Meanwhile, the result indicates that subjects preferred to work in the lighting environment with a higher overall average luminance setting LS-3 (Lavg=51 cd/m^2), with the lighting more evenly distributed on the wall surface.

Regarding LS-4, which belongs to the higher overall luminance group, also the group has a higher ceiling and wall average luminance level; In this group, comparing LS-4 and the other two lighting spatial patterns, LS-4's work view region average luminance is the lowest. A former study found that subjects preferred lower brightness levels of the desk when the wall brightness was higher (Chraibi et al., 2017). This result seems in line with Chrraibi et al. research but needs robust statistical evidence by adding more lighting modes that manipulated only one attribute for a workstation office setting.

The photometric measurement result shows that the two most preferred lighting brightness patterns that work view area over wall & ceiling ratio (R) are largely different. LS-4 has an (R= 2.03) highest average luminance ratio (R= 2.03), but LS-3 (R= 0.67) has the lowest ratio among those six lighting spatial patterns. This difference between the two most preferred lighting spatial patterns indicates that the lighting luminance ratio value may not be the only factor influencing occupants' visual preference. Regarding the lighting mode, the LS-3 is emphasized the work view region lighting, which has a relatively darker background; the LS-4 has a linear wall wash background. Synthesizable considering the R values, the overall average luminance, and the lighting shape appear in the file of view, the result of visual preference is possibly not influenced by any single factor of them.

In addition, a difference was observed that the two least visual preferred lighting scenes' work view region average luminance is largely different from each other which LS-1(L_{avg}=42.9 cd/m²) is the lowest one among the six lighting spatial patterns and the LS-5 has the highest average luminance (L_{avg}=126 cd/m²) among the six lighting spatial patterns. In a previous study, Van Ooyen et al. found that preferred working plane luminance for non-VDT work ranged from 45- 105 cd/m², and preferred the range of wall luminance was 30-60 cd/m², in which the two least preferred work view region average luminance value is indeed not within the preferred luminance range as Van Ooyen concluded (1987). However, the visual preferred wall average luminance values are not in line with Van Ooyen et al. research. A possible reason might due that subjects may consider the workstation lighting environment in an open office the lighting within the view towards the desk region is more important than the wall luminance while Van Ooyen et al research set in a two-personal work office where the wall is much nearer to the view of view.

Overall, the statistical result had fulfilled one of this research aims that the lighting inspired by film scenes be possible to provide human-centered lighting design. Indeed, this study's limitation is that the film scene selection and analysis is lacking in statistical evidence as it uses a qualitative method. However, it is worth further investigation with a quantitative method for film scene selection and analysis before summarizing the lighting spatial patterns. A possible way is to utilize a large number of the same office-setting film scenes to evaluate subjects' visual preferences, visual interests, and aesthetic judgment.

5.1.2 Visual Interest

The results indicate a strong trend in which participants felt that the most visually interesting lighting scene was the high setting with unevenly distributed curve-shaped lighting, as in LS-6 (Mean= .64, SD= 0.28). Meanwhile, the result of this type of lighting brightness pattern might corresponds to what Abboushi et al.’s research found is most visually interesting and relaxing for office workers (2019). The LS-6 brightness pattern might be different from what Abbushi defined as the fractal patterns of daylighting; it still possible be worthy of further investigation.

One notable trend is that subjects rated LS-3 and LS-4 are visually preferred and visually interesting. Meanwhile, the LS-1 and LS-5 are visually less preferred and visually less interesting. Compared with visual interest and visual preference result, some questions were raised; 1) is visual interest has a relationship with visual preference? Is visual interest can be a possible factor of visual preference that they have a positive correlation? As an exploratory study, the finding is worth further investigation.

Statistically, the subjects are visually interested in LS-3, LS-4, and LS-6, but only LS-6 is visually not visually preferred. One possible reason why the LS-6 was visually interesting but participants were not preferred in the meantime possibly was that in a workstation work environment, subjects possibly preferred a lighting environment to help concentrate on work, not considering the far back wall luminance visual interest. Therefore, regarding the subject's visual preference and visual interest response to LS-6, one question might be significant to explore: whether the office setting may be a possible factor influencing visual preference. A further investigation can consider employing the same lighting spatial patterns in different work planes (with partition panel and without partition panel) to test the visual preference and visual interest.

5.1.3 Visual perception and mood

Regarding the assessment of relaxation/intensity, the result shows a trend that participants felt first groups (low average brightness setting) lighting spatial patterns more relaxed, which this group featured for a lower average luminance background view area and brighter work view area. This might consistent with Van Ooen's study, which found that dark surroundings with brighter desktops make people feel relaxed, however, statistic evidence needed (1987).

Regarding perceptions of the lighting environment, the statistical results do not indicate a significant difference in visual spaciousness and uniformity in the six lighting scenes. This because of a lack of reference lighting scenes or a benchmark that the subject's response does not show statistically significant differences. Meanwhile, using the 5-point semantic differential rating scale in this research might not be the ideal case because the evaluation scale narrowed the subjects' response distribution for a semantical differential rating scale. For this reason, it was, se that hard to observe thea significant difference in perceptions between the six scenes. However, regarding the perception of lighting complexity, it statistically shows that subjects tend to perceive the default setting (LS-1) as simpler, and the LS-6 is perceived as more complex among the six lighting scenes. An alternative explanation possible is that subjects felt that without the luminaires shown in the field of view, the scene might be perceived as simpler. This indication might correspond to the study that found wall uniformity influences occupancy desk luminance preferences (Chraibi et al., 2017).

CONCLUSION

Regarding human-centric lighting design, this research has revealed that two light spatial patterns were significantly preferred among the six lighting spatial patterns. The first lighting spatial pattern (LS-3) that the overall low average luminance environment, equipped with work view region lighting, which also has a higher luminance ratio (R), is visually preferred. In terms of the higher overall average luminance environment (LS-4), people preferred the overall uniform luminance without desk area lighting with a low luminance value (R). The study also indicated that subjects’ aesthetic judgment (mood repones) and the lighting spatial patterns (LS-3) within lower overall average illuminance and only equipped with diffused pendant lighting and desk area lighting triggered visually felt more pleasant, relaxed, and satisfied.

5.3 LIMITATION

The limitations of this research are elucidated through the lens of research objectives, method design, and findings. Regarding subjects' visual perception of six lighting spatial patterns, one limitation may explain why this study was not able to reach a conclusive finding for this part; The survey question designed for accessing subject's visual perception of each lighting spatial pattern rendering images has not provided a benchmark lighting scene for participants to compare with. In other words, because of participants not being able to refer to a base case, subject evaluation of the six lighting scenes directly may lead to no accurate responses. Meanwhile, utilizing online surveys to evaluate the visual perception of the lighting environment may differ from physical experiences since the participants' use of personal computers to fill out the survey may influence their perceptions responses, which their computer screen size, pixel quality, and screen brightness could possibly influence their visual perception to the rendering images.

Film scene analysis: Regarding architectural human-centric lighting and film lighting, several limitations exist. First, this study only gathered a limited number of film scenes to conduct a qualitative content analysis. To achieve robust research findings, a quantitative means to gather an adequate amount of film scenes is necessary. The objective of this study was to explore film scene lighting to provide inspiration for lighting design and to further evaluate the subjects' visual preferences, visual aesthetic judgments, and mood. Although this exploratory research may be limited for multiple reasons, it is possible to achieve progress in this direction.

Regarding the population and statistical analysis, one crucial limitation of this research is that the participants' ages and educational backgrounds were not evenly distributed due to a lack of funding. Particularly, the participants who are aged from 18 years old to 24 years old occupied (16.7%) might have no experience with office work, which means this group population could be very different responses to the office lighting environment. In further research, the recruitment can target the office workers who are the major occupants of office space. Another limitation of the population is that the sample size was relatively small and that subjects' responses were not evenly distributed. It also leads to a limitation that is not able to perform correlation analysis, such as the correlation between visual preference and visual interest correlation between visual aesthetic judgment and visual preference.

The virtual rendering image that found subjects' visual preference and visual interest significantly different from other environments possible due to the brightness is largely different from the other four lighting scenes. A further improvement could involve designing rendering images whose overall luminance is controlled in a certain range or designing a different group for different luminance levels. As exploratory research, this research is limited to not adding a comparison group to compare the different conditions of diffuse pendant luminary as a factor influencing visual preference for direct/ indirect lighting.

Furthermore, the research highlights a photometric measurement issue that should be addressed due to technological limitations. Further improvements should be considered. For example, the simulation of the lighting environment may measure the lighting parameters first rather than the photometric measurement of the HDR image. As a result, the information gathered from the HDR image may omit some significant factors of lighting brightness patterns, such as image contrast uniformity.

5.4 FUTURE RESEARCH

The result from the study shows the two most preferred lighting spatial patterns provided a possibility for further research, which able to investigate the visual preference of lighting environment by manipulating different attributes in the view of files, such as the lighting uniformity, lighting contrast, and lighting average luminance ratio of wok-plane to wall ratio. In this study, we also defined the working view to background view luminance ratio as very likely to be an important metric influencing the visual aesthetic experience for a workstation in an open office. To examine how exactly the work view to background view luminance ratio relationship to the visual preference, further study can set a constant ratio value to perform a correlation analysis.

Regarding the result of visual interest and visual preference, interesting trends indicate a possibility that visual interest may have a relationship with visual preference. In further research, the research can perform a correlation analysis between visual interest and visual preference. This study shows the possibility that spatial lighting patterns inspired by film scenes might be employed in a real office lighting design. In order to have robust evidence of the possibility of employing spatial lighting patterns from film scenes, a quantitative method can be employed in the future.

Lastly, future research can design a comparison study of both film scenes and the rendering image that employs spatial lighting patterns, visual preference, visual interest, and visual aesthetic judgment. In terms of lighting design in cinematography and architecture design, there are many potential avenues to explore. Further investigation of different spatial types should be pursued and may not be limited to office lighting scenes.

APPENDIX A

PARTICIPANTS RECRUITING EMAIL AND POSTER

Hi all,

I am Dan Qin, a Master of Science in Architecture student at the School of Architecture and Environment. I am conducting a research study to assess the human visual preference and aesthetic judgment of human-centric lighting design. I invite volunteers to participate in a quick 10–15-minute online survey. In the survey, you will be presented with an architectural scene with different lighting conditions and asked to answer questions related to the study. The information from your participation will advance my understanding of the relationship between occupant mood and indoor lighting in an office environment. For more information, see the attached poster.

Please click the link below to access the survey.

Link: https://oregon.qualtrics.com/jfe/form/SV_8q5nis4pHDDNKtw

Required:

- You are **18 years** or **older**
- Participants should take the survey on a **laptop/tablet/PC**. (any device with a big screen)
- Your participation is **voluntary** and **anonymous**

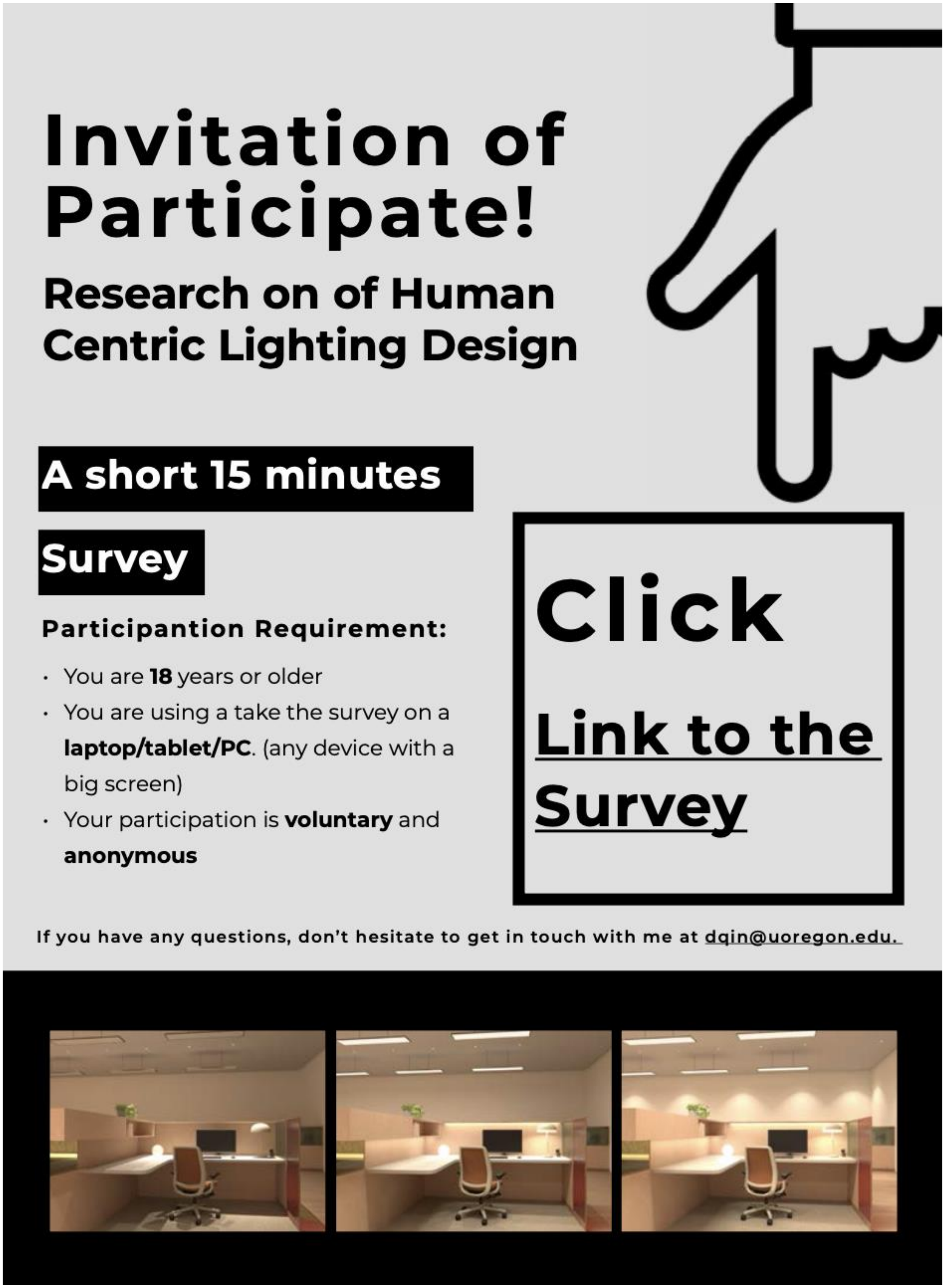
(Please note: this survey is an online questionnaire. Please make sure your internet on good condition.)

If you have any questions, don't hesitate to get in touch with me at dqin@uoregon.edu.

Thank you!

Best Regards,

Dan Qin
M.S Architecture 2022
E: dqin@uoregon.edu


Invitation of Participate!
Research on of Human Centric Lighting Design
A short 15 minutes
Survey
Participantion Requirement:
• You are 18 years or older
• You are using a take the survey on a laptop/tablet/PC. (any device with a big screen)
• Your participation is voluntary and anonymous
Click
Link to the Survey
If you have any questions, don't hesitate to get in touch with me at dqin@uoregon.edu.

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY OF OREGON | Research Compliance Services

EXEMPT DETERMINATION

June 23, 2022

Dan Qin

dqin@uoregon.edu

Dear Dan Qin:

The following research was reviewed and determined to qualify for exemption.

Type of Review:	Initial Study
Study Title:	The Visual Preference, Aesthetic Judgement, and Mood Response to Human-Centric Lighting in Office Spaces
Principal Investigator:	Dan Qin
Parent Study ID:	STUDY00000586
Transaction ID:	STUDY00000586
Documents Reviewed:	• Exempt Determination Application form, Category: IRB Protocol; • Consent Form, Category: Consent Form; • Research Plan, Category: IRB Protocol; • Visual Stimulus Materials , Category: Data Collection Materials;
Approval Date:	6/23/2022
Effective Date:	6/23/2022
Expiration Date:	6/22/2023

For this research, the following determinations have been made:

- This study has been reviewed under **the 2018 Common Rule** and determined to qualify for exemption under **Title 45 CFR 46.104(d)((2)(i) Tests, surveys, interviews, or observation (non-identifiable)).**

The research is approved to be conducted as described in the approved protocol using the approved materials. Approved materials can be accessed in the protocol workspace in the IRB module of the research administration portal (RAP).

All changes to this research must be assessed to ensure the study continues to qualify for exemption. Research Compliance Services has developed specific guidance to help you understand when a modification is required before a change can be implemented. It is your responsibility to ensure modifications are submitted when required and approval secured before implementing changes to the protocol

Continuing Review is not required for this study. **An institutional approval period has been established based on your application materials.** If you anticipate the research will continue beyond the approval period, you must submit a **Continuing Review Application** at

Page 1 of 2

least 45-days days prior to the expiration date. A closure report must be submitted once human subject research activities are complete. Failure to maintain current approval or properly close the protocol constitutes non-compliance.

With the submission of your request, you agreed to uphold the responsibilities of the Principal Investigator and have agreed to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB module of the RAP.

If you have any questions regarding your protocol or the review process, please contact Research Compliance Services at ResearchCompliance@uoregon.edu or (541)346-2510. The University of Oregon and Research Compliance Services appreciate your commitment to the ethical and responsible conduct of research with human subjects.

Please consider completing our user satisfaction survey. It only takes a few minutes, and we would like to hear about your experience working with our office!

Sincerely,

Research Compliance Services
on behalf of the Committee for Protection of Human Subjects

cc: Ihab Elzeyadi

APPENDIX C

SURVEY QUESTIONNAIRE CONSENT FORM

Q1.1 **The Visual Preference, Aesthetic Judgement, and Mood Response to Human-Centric Lighting in Office Spaces**

This graduate researcher at the University of Oregon is conducting a research study to assess the human visual preference and aesthetic judgment of human-centric lighting design in office spaces. The information gathered from your participation will help architects, interior architects, and lighting designers to further understand human-centric lighting design from the occupants' perspective.

To participate in this experiment, you will be asked to answer questions about interior scenes presented to you on your screen. The intent of this study is to examine the occupant's subjective visual preference, perception, and mood under different lighting conditions.

Description of the Study Procedure:

Your participation is voluntary and should take approximately 20 minutes. This survey supports ongoing research at the University of Oregon in the Department of Architecture. No identifiable information will be collected through this survey, and your responses will be anonymous.

Risk/Discomforts of Being the Study

Participants taking part in this study will experience minimal psychological risks, meaning they will experience no more physical or psychological discomfort than they do in ordinary life. However, due to the repeated presentation of the image, participants may become visually fatigued or bored. Participants can stop the survey at any time without any consequence to minimize the risk or discomfort.

Confidentiality:

All participants' confidentiality will be strictly protected. The collected information will not be made available to any facilities, universities, or anyone outside the immediate research team. No personally identifying information, such as participant's name, email address, or any other identifiable information, will be collected or used in the study or publications. All participants' responses will be coded and combined with those of other participants and statistically analyzed. Only statistical trends and correlation data summary will be reported.

Voluntary Participation/Withdrawal:

Your participation is voluntary and should take approximately 20 minutes. You can terminate your participation at any time during the survey process.

Your Responsibility:

If you take part in this research, you will be responsible for:

If you decide to participate, please chose "Yes, I…."

Follow the instructions presented in the surveys and complete the questionnaire in one session.

Your vision is normal, or you can see the screen normally by wearing corrected lenses   You are using a desktop or laptop computer to answer the question with a screen brightness of over 40% but not glaring.

You will keep the screen brightness the same during this survey questionnaire.

Contacts and Questions:

If you have questions, concerns, or have experienced a research-related injury, contact the research team at:

Dan Qin

541-6068622

dqin@uoregon.edu

An Institutional Review Board ("IRB") is overseeing this research. An IRB is a group of people who perform independent reviews of research studies to ensure the rights and welfare of participants are protected. UO Research Compliance Services is the office that supports the IRB. If you have questions about your rights or wish to speak with someone other than the research team, you may contact:

Research Compliance Services

5237 University of Oregon

Eugene, OR 97403-5237

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Q1.2 **STATEMENT OF CONSENT**

I have had the opportunity to read and consider the information in this form. I have asked any questions necessary to make a decision about my participation. I understand that I can ask additional questions throughout my participation.

I understand that by clicking "Yes, I have read the above consent and I agree to participate in this study", I volunteer to participate in this research. I meet the criteria to participate in this study: I am 18 years or older, currently living in the United States of America, and am not diagnosed with color blindness. I understand that I am not waiving any legal rights. I have been provided with a copy of this consent form. I understand that if my ability to consent or assent for myself changes, either I or my legal representative may be asked to re-consent prior to my continued participation in this study.

○ Yes, I have read the above consent and I agree to participate in this study (2)

○ No, I do not wish to participate this study (3)

Skip To: End of Survey If Q1.2 = 3

End of Block: Consent Form

Q2.1 This section will assess your visual preference for six different lighting environments in an office space. Please drag and drop the **corresponding letters** (Image A, Image B... etc.) on left side according to your ranked preferences, then rank them in order in each box. (Select only **two** images per preference)**Click on any of the images below for an enlarged view.**

2 Most Preferred	2 Moderate Preferred	2 Least Preferred
______ Image A (1)	______ Image A (1)	______ Image A (1)
______ Image B (2)	______ Image B (2)	______ Image B (2)
______ Image C (3)	______ Image C (3)	______ Image C (3)
______ Image D (4)	______ Image D (4)	______ Image D (4)

______ Image E (5)	______ Image E (5)	______ Image E (5)
______ Image F (6)	______ Image F (6)	______ Image F (6)

Q3.1 This section will assess your **Visual Interest** in **6 types** of lighting environments in the office space.

- This task is approximately **3-4 minutes** long.
- This task contains **15** slides with the same question.
- Each slide has **two images** presented side-by-side.
- You need to choose **one** of them **within 18 seconds** for each slide.

Please imagine which lighting environment is more visually interesting.

Q34.1 This section will assess your **Visual Impression** of **6 types** of lighting environments in office space.

- This task is approximately **1-2 minutes** long.
- This task contains **6** slides with the same question.
- Each slide has **one image** presented.
- Rate each image on the **bi-polar scale** according to your impression of the lighting environment.

Q34.2- Q34.7: How do you feel about the lighting condition in the image?

	very	somewhat	neither	somewhat	very	
	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	
relaxed	○	○	○	○	○	intense
pleasant	○	○	○	○	○	unpleasant
spacious	○	○	○	○	○	cramped
satisfied	○	○	○	○	○	unsatisfying
uniform	○	○	○	○	○	non-uniformed
complex	○	○	○	○	○	simple

Q36.1 What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Other (3) ____
- ○ I prefer not to say (4)

Q36.2 What is your age?

- ○ 18 - 24 years old (1)
- ○ 25 - 34 years old (2)
- ○ 35 - 44 years old (3)
- ○ 45 - 54 years old (4)
- ○ 55- 64 years old (5)
- ○ 65 + years old (6)
- ○ I prefer not to say (7)

Q36.3 What is the highest level of school you have completed or the highest degree you have received?

- ○ Less than high school degree (1)
- ○ High school graduate (high school diploma or equivalent including GED) (2)
- ○ Some college but no degree (3)
- ○ Associate degree in college (2-year) (4)
- ○ Bachelor's degree in college (4-year) (5)
- ○ Master's degree (6)
- ○ Doctoral degree (7)
- ○ Professional degree (JD, MD) (8)

○ I prefer not to say (9)

Q37.1 Thank you for your participation, the survey is complete. If you have anything to comment on, please fill in the box. If you have any questions, please email to this address: dqin@uoregon.edu

____

APPENDIX D

VISUAL STIMULI ENLARGED IMAGE

LS-1

LS-2

LS-3

LS-4

LS-5

LS-6

REFERENCES

Abboushi, B., Elzeyadi, I., Taylor, R., & Sereno, M. (2019). Fractals in architecture: The visual interest, preference, and mood response to projected fractal light patterns in interior spaces. *Journal of Environmental Psychology*, *61*, 57–70. https://doi.org/10.1016/j.jenvp.2018.12.005

Anderson, J., Anderson, B. F., Bordwell, D., & Press, S. I. U. (2005). *Moving Image Theory: Ecological Considerations*. Southern Illinois University Press. https://books.google.com/books?id=z_pab26ivMYC

Bellia, L., Bisegna, F., & Spada, G. (2011). Lighting in indoor environments: Visual and non-visual effects of light sources with different spectral power distributions. *Building and Environment*, *46*(10), 1984–1992. https://doi.org/10.1016/j.buildenv.2011.04.007

Boray, P. F., Gifford, R., & Rosenblood, L. (1989). Effects of warm white, cool white and full-spectrum fluorescent lighting on simple cognitive performance, mood and ratings of others. *Journal of Environmental Psychology*, *9*(4), 297–307. https://doi.org/10.1016/S0272-4944(89)80011-8

Bordwell, D. (1989). *Making meaning: Inference and rhetoric in the interpretation of cinema*. Harvard University Press.

Bordwell, D., & Thompson, K. (2016). *Film art: An introduction* (Eleventh edition). McGraw-Hill Education.

Borisuit, A., Linhart, F., Scartezzini, J.-L., & Münch, M. (2015). Effects of realistic office daylighting and electric lighting conditions on visual comfort, alertness and mood. *Lighting Research & Technology*, *47*(2), 192–209. https://doi.org/10.1177/1477153514531518

Boyce, P. R. (2010). Review: The Impact of Light in Buildings on Human Health. *Indoor and Built Environment*, *19*(1), 8–20. https://doi.org/10.1177/1420326X09358028

Boyce, P. R., Veitch, J. A., Newsham, G. R., Jones, C. C., Heerwagen, J., Myer, M., & Hunter, C. M. (2006). Lighting quality and office work: Two field simulation experiments. *Lighting Research & Technology*, *38*(3), 191–223. https://doi.org/10.1191/1365782806lrt161oa

Brown, B. (2019). *Motion picture and video lighting for cinematographers, gaffers and lighting technicians* (Third edition). Routledge.

Chraibi, S., Crommentuijn, L., Loenen, E. van, & Rosemann, A. (2017). Influence of wall luminance and uniformity on preferred task illuminance. *Building and Environment*, *117*, 24–35. https://doi.org/10.1016/j.buildenv.2017.02.026

de Kort, Y. A. W., & Veitch, J. A. (2014). From blind spot into the spotlight. *Journal of Environmental Psychology*, *39*, 1–4. https://doi.org/10.1016/j.jenvp.2014.06.005

de Vries, A., Heynderickx, I., Souman, J., & de Kort, Y. (2021). Putting the ceiling center stage – The impact of direct/indirect lighting on room appraisal. *Building and Environment*, *201*, 107989. https://doi.org/10.1016/j.buildenv.2021.107989

de Vries, A., Souman, J. L., de Ruyter, B., Heynderickx, I., & de Kort, Y. A. W. (2018). Lighting up the office: The effect of wall luminance on room appraisal, office workers' performance, and subjective alertness. *Building and Environment*, *142*, 534–543. https://doi.org/10.1016/j.buildenv.2018.06.046

Durak, A., Camgöz Olguntürk, N., Yener, C., Güvenç, D., & Gürçınar, Y. (2007). Impact of lighting arrangements and illuminances on different impressions of a room. *Building and Environment*, *42*(10), 3476–3482. https://doi.org/10.1016/j.buildenv.2006.10.048

Eisenstein, S., Ėjzenštejn, S. M., Ejzenstejn, S. M., Eisenstein, S. M., & Leyda, J. (1947). *The Film Sense*. Harcourt, Brace. https://books.google.com/books?id=OrSuw2LIX6QC

Elzeyadi, I. M. K. (n.d.). *Daylighting-Bias and Biophilia: Quantifying the Impact of Daylighting on Occupants Health*. 11.

Elzeyadi, I. M. K. (2002). *Designing For Indoor Comfort: A Systemic Model for Assessing Occupant Comfort In Sustainable Office Buildings*. 13.

Elzeyadi, I. M. K. (2021). *Performative Views in Architecture: Preference, Composition, and Occupant's Wellbeing*. 10.

Figueiro, M., & Rea, M. (2016). Office lighting and personal light exposures in two seasons: Impact on sleep and mood. *Lighting Research & Technology*, *48*(3), 352–364. https://doi.org/10.1177/1477153514564098

Flynn, J. E., Hendrick, C., Spencer, T., & Martyniuk, O. (1979). A Guide to Methodology Procedures for Measuring Subjective Impressions in Lighting. *Journal of the Illuminating Engineering Society*, *8*(2), 95–110. https://doi.org/10.1080/00994480.1979.10748577

Flynn, J. E., & Spencer, T. J. (1977). The Effects of Light Source Color on User Impression and Satisfaction. *Journal of the Illuminating Engineering Society*, *6*(3), 167–179. https://doi.org/10.1080/00994480.1977.10747811

Fostervold, K., & Nersveen, J. (2008). Proportions of direct and indirect indoor lighting—The effect on health, well-being and cognitive performance of office workers. *Lighting Research & Technology*, *40*(3), 175–200. https://doi.org/10.1177/1477153508090917

Galasiu, A. D., & Veitch, J. A. (2006). Occupant preferences and satisfaction with the luminous environment and control systems in daylit offices: A literature review. *Energy and Buildings*, *38*(7), 728–742. https://doi.org/10.1016/j.enbuild.2006.03.001

Hansen, E. K., Pajuste, M., & Xylakis, E. (2020). Flow of Light: Balancing Directionality and CCT in the Office Environment. *LEUKOS*, 1–22. https://doi.org/10.1080/15502724.2020.1808014

Hawes, B. K., Brunyé, T. T., Mahoney, C. R., Sullivan, J. M., & Aall, C. D. (2012). Effects of four workplace lighting technologies on perception, cognition and affective state. *International Journal of Industrial Ergonomics*, *42*(1), 122–128. https://doi.org/10.1016/j.ergon.2011.09.004

Hawkes, R. J., Loe, D. L., & Rowlands, E. (1979). A Note towards the Understanding of Lighting Quality. *Journal of the Illuminating Engineering Society*, *8*(2), 111–120. https://doi.org/10.1080/00994480.1979.10748578

Hebert, P. (2009). IES TM-18: Light and Human Heath: An Overview of the Impact of Optical Radiation on Visual, Circadian, Neuroendocrine, and Neurobehavioral Responses. *Lighting Design + Application*, *39*(8), 62.

Houser, K., Boyce, P., Zeitzer, J., & Herf, M. (2020). Human-centric lighting: Myth, magic or metaphor? *Lighting Research & Technology*, 147715352095844. https://doi.org/10.1177/1477153520958448

Houser, K., Tiller, D., Bernecker, C., & Mistrick, R. (2002). The subjective response to linear fluorescent direct/indirect lighting systems. *Lighting Research & Technology*, *34*(3), 243–260. https://doi.org/10.1191/1365782802li039oa

Houser, K. W. (2020). Lighting Standards: When is Doing *Something* , Better than Doing *Nothing* ? *LEUKOS*, *16*(4), 251–253. https://doi.org/10.1080/15502724.2020.1741963

Houser, K. W., & Esposito, T. (2021). Human-Centric Lighting: Foundational Considerations and a Five-Step Design Process. *Frontiers in Neurology*, *12*, 630553. https://doi.org/10.3389/fneur.2021.630553

Klepeis, N. E., Nelson, W. C., Ott, W. R., Robinson, J. P., Tsang, A. M., Switzer, P., Behar, J. V., Hern, S. C., & Engelmann, W. H. (2001). The National Human Activity Pattern Survey (NHAPS): A resource for assessing exposure to environmental pollutants. *Journal of Exposure Science & Environmental Epidemiology*, *11*(3), 231–252. https://doi.org/10.1038/sj.jea.7500165

Knez, I. (1995). Effects of indoor lighting on mood and cognition. *Journal of Environmental Psychology*, *15*(1), 39–51. https://doi.org/10.1016/0272-4944(95)90013-6

Knez, I., & Enmarker, I. (1998). Effects of Office Lighting on Mood and Cognitive Performance And A Gender Effect in Work-xRelated Judgment. *Environment and Behavior*, *30*(4), 553–567. https://doi.org/10.1177/001391659803000408

Kruisselbrink, T., Dangol, R., & Rosemann, A. (2018). Photometric measurements of lighting quality: An overview. *Building and Environment*, *138*, 42–52. https://doi.org/10.1016/j.buildenv.2018.04.028

Küller, R., Ballal, S., Laike, T., Mikellides, B., & Tonello, G. (2006). The impact of light and colour on psychological mood: A cross-cultural study of indoor work environments. *Ergonomics*, *49*(14), 1496–1507. https://doi.org/10.1080/00140130600858142

Kuller, R., & Wetterberg, L. (1993). Melatonin, cortisol, EEG, ECG and subjective comfort in healthy humans: Impact of two fluorescent lamp types at two light intensities. *Lighting Research and Technology*, *25*(2), 71–80. https://doi.org/10.1177/096032719302500203

Loe, L., Mansfield, K. P., & Rowlands, E. (1994). Appearance of lit environment and its relevance in lighting design: Experimental study. *Lighting Research and Technology*, *26*(3), 119–133. https://doi.org/10.1177/096032719402600301

Lucas, R. J., Peirson, S. N., Berson, D. M., Brown, T. M., Cooper, H. M., Czeisler, C. A., Figueiro, M. G., Gamlin, P. D., Lockley, S. W., O'Hagan, J. B., Price, L. L. A., Provencio, I., Skene, D. J., & Brainard, G. C. (2014). Measuring and using light in the melanopsin age. *Trends in Neurosciences*, *37*(1), 1–9. https://doi.org/10.1016/j.tins.2013.10.004

Manav, B. (2007). An experimental study on the appraisal of the visual environment at offices in relation to colour temperature and illuminance. *Building and Environment*, *42*(2), 979–983. https://doi.org/10.1016/j.buildenv.2005.10.022

Manav, B., & Yener, C. (1999). Effects of Different Lighting Arrangements on Space Perception. *Architectural Science Review*, *42*(1), 43–47. https://doi.org/10.1080/00038628.1999.9696847

McCloughan, C. L. B., Aspinall, P. A., & Webb, R. S. (1999). The impact of lighting on mood. *International Journal of Lighting Research and Technology*, *31*(3), 81–88. https://doi.org/10.1177/096032719903100302

Mehrabian, A., & Russell, J. A. (1974). The Basic Emotional Impact of Environments. *Perceptual and Motor Skills*, *38*(1), 283–301. https://doi.org/10.2466/pms.1974.38.1.283

Murdoch, M. J., Stokkermans, M. G. M., & Lambooij, M. (2015). Towards perceptual accuracy in 3D visualizations of illuminated indoor environments. *Journal of Solid State Lighting*, *2*(1), 12. https://doi.org/10.1186/s40539-015-0029-6

Newsham, G. R., & Veitch, J. A. (2001). Lighting quality recommendations for VDT offices: A new method of derivation. *Lighting Research & Technology*, *33*(2), 97–113. https://doi.org/10.1177/136578280103300205

Newsham, G., Veitch, J., Arsenault, C., & Duval, C. (2004). *Effect of dimming control on office worker satisfaction and performance*. 24.

Plantinga, C. (2012). Art Moods and Human Moods in Narrative Cinema. *New Literary History*, *43*(3), 455–475. https://doi.org/10.1353/nlh.2012.0025

Poland, J. L. (n.d.). *Lights, Camera, Emotion!: An Examination on Film Lighting and Its Impact on Audiences' Emotional Response*. 113.

Shimamura, A. P. (2014). *Psychocinematics: Exploring Cognition at the Movies*. Oxford University Press. https://books.google.com/books?id=wnjiAgAAQBAJ

Shin, Y.-B., Woo, S.-H., Kim, D.-H., Kim, J., Kim, J.-J., & Park, J. Y. (2015). The effect on emotions and brain activity by the direct/indirect lighting in the residential environment. *Neuroscience Letters*, *584*, 28–32. https://doi.org/10.1016/j.neulet.2014.09.046

Smolders, K. C. H. J., & de Kort, Y. A. W. (2017). Investigating daytime effects of correlated colour temperature on experiences, performance, and arousal. *Journal of Environmental Psychology*, *50*, 80–93. https://doi.org/10.1016/j.jenvp.2017.02.001

Souman, J. L., Borra, T., de Goijer, I., Schlangen, L. J. M., Vlaskamp, B. N. S., & Lucassen, M. P. (2018). Spectral Tuning of White Light Allows for Strong Reduction in Melatonin Suppression without Changing Illumination Level or Color Temperature. *Journal of Biological Rhythms*, *33*(4), 420–431. https://doi.org/10.1177/0748730418784041

Steidle, A., & Werth, L. (2014). In the spotlight: Brightness increases self-awareness and reflective self-regulation. *Journal of Environmental Psychology*, *39*, 40–50. https://doi.org/10.1016/j.jenvp.2013.12.007

Stokkermans, M. G. M., Chen, Y., Murdoch, M. J., & Vogels, I. M. C. L. (2015). *Effect of daylight on atmosphere perception: Comparison of a real space and visualizations* (B. E. Rogowitz, T. N. Pappas, & H. de Ridder, Eds.; p. 93940O). https://doi.org/10.1117/12.2077078

Stokkermans, M., Vogels, I., de Kort, Y., & Heynderickx, I. (2018). Relation between the perceived atmosphere of a lit environment and perceptual attributes of light. *Lighting Research & Technology*, *50*(8), 1164–1178. https://doi.org/10.1177/1477153517722384

Tarvainen, J., Westman, S., & Oittinen, P. (2015). The way films feel: Aesthetic features and mood in film. *Psychology of Aesthetics, Creativity, and the Arts*, *9*(3), 254–265. https://doi.org/10.1037/a0039432 van Ooyen, M. H. F., van de Weijgert, J. A. C., & Begemann, S. H. A. (1987). Preferred Luminances in Offices. *Journal of the Illuminating Engineering Society*, *16*(2), 152–156. https://doi.org/10.1080/00994480.1987.10748695

Veitch, J. A. (1998). Lighting Quality and Energy-Efficiency Effects on Task Performance, Mood, Health, Satisfaction, and Comfort. *JOURNAL of the Illuminating Engineering Society*, 24.

Veitch, J. A. (2001). Psychological Processes Influencing Lighting Quality. *Journal of the Illuminating Engineering Society*, *30*(1), 124–140. https://doi.org/10.1080/00994480.2001.10748341

Veitch, J. A., & Newsham, G. R. (2000). Preferred luminous conditions in open-plan offices: Research and practice recommendations. *Lighting Research and Technology*, *32*(4), 199–212. https://doi.org/10.1177/096032710003200404

Veitch, J., Newsham, G., Boyce, P., & Jones, C. (2008). Lighting appraisal, well-being and performance in open-plan offices: A linked mechanisms approach. *Lighting Research & Technology*, *40*(2), 133–151. https://doi.org/10.1177/1477153507086279

Wang, Q., Xu, H., Zhang, F., & Wang, Z. (2017). Influence of color temperature on comfort and preference for LED indoor lighting. *Optik*, *129*, 21–29. https://doi.org/10.1016/j.ijleo.2016.10.049

Watson, D., & Tellegen, A. (19860101). Toward a consensual structure of mood. *Psychological Bulletin*, *98*(2), 219. https://doi.org/10.1037/0033-2909.98.2.219

Yang, W., & Jeon, J. Y. (2020). Effects of Correlated Colour Temperature of LED Light on Visual Sensation, Perception, and Cognitive Performance in a Classroom Lighting Environment. *Sustainability*, *12*(10), 4051. https://doi.org/10.3390/su12104051