Influence of Environmental Design Factors on Perception and Performance of Indoor Occupants

by

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DISSERTATION ABSTRACT

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Doctor of Philosophy in Architecture

Title: Influence of Environmental Design Factors on Perception and Performance of Indoor Occupants

This dissertation presents a series of empirical studies that explore the complex relationship between design elements of indoor environments and the psychological and physiological responses of occupants. The research examines various factors, including sky conditions, view types, window shading conditions, façade design elements like patterned solar screens, and the layout of office spaces, particularly within the framework of Activity-Based Working (ABW) environments.

The initial phase of the study focuses on how environmental and contextual factors such as sky conditions and space functions influence indoor occupant perception. Findings reveal that sky conditions and space functions impact indoor occupant perception which then impacts environmental adaptation in the form of window blind use. A consistent preference for half-closed blinds was observed, reflecting a universal desire to balance privacy with natural views. The dissertation then progresses to analyze the perceptual impact of façade designs, demonstrating that traditional solar screen patterns, such as mashrabiyas, influence occupants' views and perceptions of privacy. Moreover, these screens' pattern complexity and occlusion percentage intricately affect satisfaction and view quality, emphasizing the need for a harmonious balance between functional and perceptual considerations in design.

Further investigation into the human-built environment relationship led to the study of the impacts of environmental design on indoor occupant performance. Specifically, in office

environment design via virtual reality simulations, the research assesses the impact of ABW office environments on cognitive performance and satisfaction. Quieter, privacy-conducive spaces such as Focus Rooms are shown to promote better performance and higher satisfaction, highlighting the inadequacy of Open Offices for focus-requiring tasks.

The dissertation highlights the complexity of design and environmental factors in shaping occupant perception, environmental adaptation, and performance, advocating for a human-centric approach in architectural and interior design. It calls for future research to further explore the longitudinal effects of these design interventions and to consider the integration of emergent technologies for enhancing our understanding of environmental design psychology.

Overall, the dissertation provides compelling evidence that thoughtful design can improve the quality of indoor environments, optimizing both the well-being and productivity of occupants. As the nature of workspaces continues to evolve post-pandemic, this research offers valuable insights for creating adaptive, supportive environments in line with the diverse needs of an ever-evolving workforce. This dissertation includes previously published material co-authored with Dr. Siobhan Rockcastle.

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DEDICATION

To Sumitha and Devadatta Satumane, my beloved anchors, With love that knows no bounds and sacrifices as countless as the stars, Supported by the unyielding strength of your belief in me, Each step I have taken is imprinted with your guiding light. This milestone, a testament to our joint journey, belongs as much to you as to me.

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CHAPTER 1

GENERAL INTRODUCTION

1.1. Background to the Problem

The traditional approach to sustainability in architecture has predominantly focused on environmental considerations such as energy efficiency, responsible sourcing of materials, and resource conservation. However, for true sustainability to be achieved, it must extend beyond ecological concerns to encompass human-centric aspects as well. This requires designing spaces that not only focus on environmental and resource protection but also promote the health, happiness, and overall well-being of indoor occupants.

In today's world, where individuals spend a significant portion of their lives indoors, a profound understanding of how people perceive and interact with the built environment becomes critical. Indoor spaces wield considerable influence over our daily experiences, shaping not only our behaviors and performance but also our overall well-being. Thus, addressing the intricate relationship between individuals and their physical surroundings demands a comprehensive design approach; one that views sustainability not merely as an environmental exercise but as a holistic framework that prioritizes human wellness.

To achieve sustainable buildings, it is essential to ensure energy efficiency, occupant satisfaction, and overall well-being. Achieving these goals requires a deeper understanding of the complex relationship between humans and their built environment. Firstly, it is essential to comprehend the factors influencing human perception, as this insight is crucial for grasping how the built environment shapes human experiences. Subsequently, understanding how these perceptions influence human behavior, environmental adaptation, and performance becomes pivotal. Environmental and contextual factors play a significant role in shaping perception, which in turn affects behavior and satisfaction. The combination of environmental design and perception ultimately impacts performance outcomes.

1.2. Research Problem

In contemporary society, a substantial portion of our daily lives is spent indoors. Research consistently shows that people spend a significant amount of time indoors, ranging from 60% to 90% (Saraga 2020; Berry 1991; Celia Henry Arnaud 2019; Kelley and Gilbert 2013a; Rivas et al. 2019; Tiwari, Pandey, and Sharma 2010; Hänninen and Goodman 2019; Kelley and Gilbert 2013b). Whether it's our residences or workplaces, the design and quality of these indoor spaces profoundly influence our perception, behavior, and overall well-being. The intricate blend of architectural design and environmental context determines our experiences and interactions within these spaces.

The design of indoor environments holds immense power in shaping human perception. Factors such as spatial layout, material selection, incorporation of natural elements, and manipulation of color and light can profoundly impact the ambiance and functionality of a space. A well-thought-out design can create environments that inspire productivity, comfort, and social interaction, whereas poor design may lead to discomfort and even health issues. Several studies have demonstrated the significant influence of indoor design and quality on our perception, behavior, and well-being. (Obeidat and Obeidat 2022) and (Y. S. Lee and Guerin 2009) both found that sustainable interior design and high-quality office furnishing can positively impact behavior and satisfaction. (Salonen et al. 2013; Mewomo et al. 2023) identified specific factors such as air quality, thermal comfort, and visual and acoustic comfort as crucial for health and productivity. (Shan, Melina, and Yang 2018; Dreyer et al. 2018) further emphasized the importance of these factors in educational and office buildings, respectively. These studies collectively underscore the critical role of indoor design and quality in shaping our well-being and behavior.

In addition to design considerations, external and contextual factors also significantly influence our perceptions. Environmental variables like weather conditions and outdoor scenery can influence mood and satisfaction levels. Several studies have demonstrated the significant impact of outdoor environments and view quality on our well-being. (Hadavi 2017; Hadavi, Kaplan, and Hunter 2017) found that satisfaction with public spaces and the presence of green or social spaces in the neighborhood are key factors in mental well-being. (Marselle et al. 2014) and (Rodriguez et al. 2021) both highlighted the restorative and positive effects of natural environments and dynamic views on emotional well-being. (Batool et al. 2020) and (Fikfak, Zbašnik-Senegačnik, and Drobne 2022) further emphasized the importance of visual connection to the outside and the presence of greenery in urban environments. (Buchecker and Degenhardt 2015) and (Kaplan 2001) emphasized the role of nearby outdoor recreation and the presence of natural elements in the view from home in enhancing well-being. These findings collectively highlight the substantial influence of outdoor environments and view quality on our perception, behavior, and overall well-being. Moreover, the intended function of a space and the dynamics among its occupants play a crucial role in shaping our perceptions and experiences within that space (Ulfa Auliyah and Loebis 2019; Marín-Restrepo, Trebilcock, and Gillott 2020; DeLucia 2008; Kalyani Wankhede and Amit Wahurwagh 2017; Eva-Christina Edinger 2014; Baras and Moreira 2011; Ropo and Höykinpuro 2017; "Perceived Openness-Enclosure of Architectural Space" 1974). While each factor independently influences perception, their collective relationship influences our experiences in indoor environments. Our overall perception of the indoor environment is the result of environmental, contextual, and design factors.

Perception serves as the lens through which individuals interpret and engage with their surroundings. Moreover, individuals' perceptions of indoor spaces can shape their emotional responses and subsequent behaviors in determining the social dynamics and functionality of indoor spaces (Yildirim, Akalin-Baskaya, and Celebi 2007; G. Franz 2006; Han, Moon, and Hyun 2019; Yongli Ren et al. 2014; Dazkir and Read 2011; X. Zhang, Lian, and Ding 2016; Tuszyńska-Bogucka et al. 2020; Bower, Tucker, and Enticott 2019). Furthermore, perception directly impacts individuals' performance within indoor environments. Studies have shown that environmental factors such as noise levels, temperature, and layout can influence cognitive function and task performance (Liu et al. 2020; Torresin et al. 2018; Shi et al. 2023; Kamarulzaman et al. 2011; Andargie and Azar 2019; I. Balážová, G. Clausen, and D. Wyon 2007; Brink et al. 2022; Min 2014). Therefore, understanding how perception influences performance is crucial for optimizing the design of indoor spaces to support cognitive functioning and task execution.

Perception serves as a fundamental aspect of human experience, shaping our feelings, behaviors, and performance within indoor spaces. Understanding how perception influences individuals' interactions with their environment is essential for creating spaces that promote well-being and productivity. Despite its significance, the intricate relationship between humans and their built environment, particularly concerning perception, remains underexplored. One such area is the influence of the built environment on perceptions of privacy and access to views. The impacts that the perception of privacy and access to views have in influencing indoor occupant behavior and environmental adaptation, and lastly the impacts of indoor environment design on performance.

1.3. Research Questions

At the University of Oregon, I contributed to original research aimed at advancing the understanding of the intricate relationship between people and the built environment, particularly focusing on promoting human-centric design principles and sustainable architecture. The studies were driven by a set of key research questions, each targeting different aspects of this complex relationship:

- **Investigating Environmental Factors:** One of the primary focuses was to explore the influence of environmental factors on indoor occupant perception and preference. This involved examining variables such as the type of view, sky conditions, and patterns of daylight, aiming to uncover how these elements shape individuals' perceptions within indoor spaces.
- **Examining Contextual Factors:** Another crucial aspect of this research involved analyzing the impact of contextual factors on indoor occupant perception and satisfaction. This included studying variables such as space function and façade design to understand how the surrounding context influences individuals' perceptions and successive environmental adaptations.
- **Exploring Design Effects on Performance:** Additionally, I delved into exploring how indoor environmental design choices impact indoor occupants' performance. By examining the impact of indoor environment design, I aimed to explain the relationship between design decisions and occupants' performance within indoor spaces.

This research was driven by a common overarching goal: to contribute to the advancement of knowledge and practices in creating environments that prioritize both human well-being and ecological sustainability.

1.4. Significance and Innovation

Building upon a substantial foundation of existing research, this dissertation presents a series of experiments that investigate the complex relationship between indoor occupants and the built environment. The findings from the initial experiments shaped the subsequent stages of inquiry, methodically refining the research scope and leading to three distinct investigative phases outlined in chapters three through five. Initially, the research adopts a broad approach, investigating how environmental and contextual factors influence the perceptions of indoor occupants and how, in turn, these perceptions drive environmental adaptation within the built environment. The exploration then transitions to the role of façade design, particularly solar screens, examining how design variables influence indoor occupant perception and satisfaction. The last study focused on the specific impacts of indoor environment design on occupant performance within work settings.

The first phase is critical, as it assessed the impact of factors such as sky conditions and views across six varied space functions, divided into two categories of privacy settings. Eight environmental adaptation scenarios were employed to measure their effects on occupant perception.

While most related studies have centered on office environments, there is a notable gap in the investigation of environmental adaptation in the form of window blind usage within residential and educational contexts and their broader programmatic applications. This phase bridges the gap by examining window blind and shading usage in relation to comprehensive environmental and contextual factors. Due to the scarcity of research exploring the broader influence of environmental and contextual factors on indoor occupant perception, especially during the constraints of the COVID-19 pandemic, this study pioneered innovative methods like web-based surveys coupled with 2D static and navigable images.

Phase two, conducted concurrently with the pandemic, builds upon the initial phase by refining the research scope based on the findings from Phase 1 by broadening the research sample for more in-depth analysis. Phase three is the most groundbreaking, utilizing immersive virtual architectural environments to measure diverse aspects of indoor occupant performance in relation to carefully controlled indoor environmental design factors. This phase marks a significant stride in methodology, combining human subject studies with virtual environments using task tests to objectively quantify occupant performance in relation to environmental design factors.

Overall, these three phases not only enhance the comprehension of the human-built environment dynamic but also pioneer the development of an innovative, sustainable, and robust research methodology to propel future studies in the domain of the human-built environment nexus.

1.5. Dissertation Overview

This dissertation comprises several chapters, each exploring distinct aspects relevant to the research questions. The following section outlines the primary topics covered in each chapter, alongside the corresponding research inquiries.

Chapter 1: This chapter provides a comprehensive introduction to the research problem. It elucidates the background of the research problem, contextualizes it through tangible research questions, and outlines the significance of the study in understanding the relationship between humans and the built environment.

Chapter 2: The focus shifts from background information to existing research in the field. It summarizes previous research related to human perception, privacy, view, and environmental adaptation. It shows how indoor environmental design influences human well-being, particularly in terms of privacy, views, security, comfort, and satisfaction. The literature review also explores the impact of natural views and daylight on cognitive function and stress reduction. Additionally, it discusses concepts like privacy conceptualization and blind usage, as well as the role of window blinds in mediating privacy and view access. Furthermore, the chapter addresses changing dynamics in work environments, particularly the shift to Activity-Based Working (ABW) in response to the COVID-19 pandemic, and explores the potential of Virtual Reality (VR) in architectural research. Selected portions of this chapter include material co-authored with Dr. Siobhan Rockcastle and previously presented and published at the 2021 Architectural Research Centers Consortium (ARCC) International conference on April 7 -10 in Tucson (Virtual) and the 2023 Architectural Research Centers Consortium (ARCC) conference on April 12- 15 in Dallas.

Chapter 3: Provides a detailed overview of two experiments conducted at the University of Oregon during the COVID-19 pandemic. These experiments investigated the effects of environmental and contextual factors on indoor occupants' perceptions and preferences for environmental adaptations. Utilizing online surveys and 2D navigable architectural environments, the studies focus on sky conditions, daylight penetration, view types, and space functions, examining their influence on privacy perceptions and environmental adaptation in the form of window blind usage. The findings highlight the intricate relationship between design elements and indoor occupant perceptions, emphasizing the importance of considering both privacy needs and access to views in space design and utilization. Selected portions of this chapter include material co-authored with Dr. Siobhan Rockcastle and previously presented and published at the 2021 Architectural Research Centers Consortium (ARCC) International conference on April 7 -10 in Tucson (Virtual) and the 2023 Architectural Research Centers Consortium (ARCC) conference on April 12- 15 in Dallas.

Chapter 4: Building on the findings of Chapter 3, Chapter 4 examines the role of patterned solar screens, such as mashrabiyas, in traditional architecture. It investigates how façade design, particularly solar screens, affects indoor occupants' perceptions of privacy, view access, and satisfaction. Drawing from Experiment 3 developed from the findings of Experiments 1 and 2 discussed in Chapter 3, this chapter explores how different screen pattern types influence the perception of privacy and views. It emphasizes the need to consider not only the environmental sustainability of these screens but also their perceptual impact on occupants. The content of this chapter is intended for submission to a peer-reviewed journal.

Chapter 5: The focus of this chapter shifts from indoor occupant perception and environmental adaptation to performance and investigates the impact of environmental design, specifically office design, on employee cognitive function and satisfaction. Using human subjects research, this experiment examined the human-built environment relationship post-pandemic. It reports the results of a within-subjects study involving 41 employees of a multinational corporation. Through Virtual Reality (VR) simulations of workspaces, the study found that design factors like layout and acoustics affect employees' ability to concentrate. Quieter spaces like Focus Rooms improve performance and satisfaction, while Open Offices may hinder focus. The research suggests that a mix of private and communal areas in office design is crucial for enhancing both productivity and employee contentment. The content of this chapter is intended for submission to a peer-reviewed journal.

Chapter 6: This chapter serves as the conclusion of the dissertation, summarizing the findings of Experiments One, Two, Three, and Four, which were explained in Chapters Three, Four, and Five, respectively. It further discusses the contribution of this dissertation to the field of building sciences and design, elaborating on the implications of the findings for the design of the built environment. Additionally, it outlines future directions for further research in this area.

CHAPTER 2

LITERATURE REVIEW

The influence of the indoor environment on human well-being and comfort is significant. Perceptions of privacy and access to outdoor views can directly impact an individual's feelings of security, comfort, and satisfaction in a space. Studies have shown that these environmental factors, notably privacy and views, affect cognitive functions, concentration, and productivity. For example, exposure to natural views, especially, has been linked to enhanced cognitive functions and productivity; (Boubekri et al. 2020) found that optimized daylight and views are associated with longer sleep and better cognitive performance. Similarly, (Jamrozik et al. 2019) reported improvements in cognitive function, satisfaction, and decreased eyestrain when office workers had access to daylight and views. However, (Farley and Veitch 2001) cautioned that while nature views can boost well-being and efficiency, they do not automatically enhance student or office worker productivity. The impact of a view and the nature of the task may influence cognitive processes, as shown by studies from (Jun, Landry, and Salvendy 2013; Falschlunger et al. 2015).

Environments that offer both privacy and views are correlated with lower stress levels and better mental health outcomes (H. Salonen et al. 2014). Access to natural elements, like windows overlooking nature, has consistently shown positive effects on mental health and well-being. These benefits include reduced stress, improved recovery rates, and greater contentment among healthcare facility patients and staff (H. Salonen et al. 2014). (Dreyer et al. 2018) found that green-certified office buildings that integrate high-quality environmental features, such as sunlight and privacy, report improved well-being. Additionally, a connection to green spaces from home has been associated with a reduced risk of anxiety and depression (Braçe et al. 2020).

Views of nature are not only restorative but also contribute to stress reduction. Perceptions of privacy and access to views have been found to increase overall satisfaction and engagement with indoor spaces. Individuals are more likely to feel content and involved in spaces that accommodate their privacy needs and offer visual connections to the environment. By studying these perceptions, designers can create spaces that promote positive experiences and encourage user engagement. Understanding the role of design in shaping perceptions of privacy and views is vital. It enables designers to develop environments that foster psychological well-being and support stress reduction. Hence, researching privacy and view access perceptions is essential to understanding how indoor environment design impacts human perception, well-being, productivity, and satisfaction.

2.1. Theoretical Background on View, Privacy, and Window Blind Use

2.1.1. Conceptualizing Privacy

The concept of privacy, its classifications, and associated terminology form a foundational framework for understanding privacy as a fundamental human need and its profound impact on human behavior. Despite the absence of prior studies investigating the correlation between window blind usage and privacy, there exists a pressing need for a novel approach to explore this relationship. The initial step involves an in-depth analysis of the concept of privacy and the development of a structured framework to investigate its dynamics alongside blind use.

Existing literature in the field of privacy offers diverse perspectives on the concept, presenting frameworks to classify its different facets. Privacy, recognized as a basic human requirement, has proven challenging to define universally due to its complex and multifaceted nature (Doyal 1997). Precedent studies have highlighted the difficulty in providing a universal definition for privacy (Karst 1967; E. A. Schuster 1976; Eleanor A. Schuster 1976; Burgoon 1982; Bauer 1994), as the concept is complex, dynamic, and has a wide range of factors affecting it. However, an acceptable definition of privacy states that privacy is an achieved end state or an ideal end state (Altman 1975) that provides the perfect level of interaction with others. This can be further classified into 'desired privacy' and 'achieved privacy'.

'Desired privacy' is defined as the ideal state that offers the desired level of interaction with others based on the contact preferred at any point in time (Leino-Kilpi et al. 2001). Whereas 'achieved privacy' is defined as the real degree of contact that is a product of interaction with others (Leino-Kilpi et al. 2001). Blind use motivated by privacy occurs when the achieved privacy of a building space is not consistent with the desired privacy of the building occupant, leading to the manipulation of the blinds to increase or decrease the level of privacy in the space. The concept of privacy in individuals is classified by (E. A. Schuster 1976) into three categories.

Privacy of lifestyle: It is the privacy preferences of an individual in the context of their day-to-day living habits (E. A. Schuster 1976). It is related to the personal preference of the individual and remains consistent across different building spaces and activities. It heavily relies on the social interaction preferences of the individual. Cultural background, religion, and gender are other factors that may influence the 'privacy of lifestyle' of an individual.

Privacy of Event: It is the type of privacy preference by an individual that is determined by the nature of the activity taking place (E. A. Schuster 1976). Some activities require more privacy in comparison to other activities and the privacy requirement arising from the nature of the activity is known as 'privacy of event'. For example, under normal circumstances, activities such as bathing require more privacy than activities such as cooking or grocery shopping.

Privacy of personality: Privacy of personality is the privacy requirement linked to the individual's innermost autonomous activity and is not temporal in nature (E. A. Schuster 1976). Among the three areas of privacy that apply to an individual, the 'privacy of event' is most suitable for the investigation of the influence of privacy on window shading preference. As environmental adaptation through window blind use motivated by privacy is influenced by the activity occurring in the building space. The 'desired privacy' of the building occupants is dependent on the activity performed in a building space, however, the 'achieved privacy' provided by a space is a product of the window shading conditions and the number of people occupying the space. Intuition suggests that the difference between the 'desired privacy' and 'achieved privacy' results in environmental adaptation through window blind manipulation.

2.1.2. Views and Indoor Occupants

The desire for views among building occupants and its impact on human behavior, along with window blind use, has been extensively explored in the literature (Talbot and Kaplan 1991; MLA and Robert D. Brown MLA 2006; Collins 1975; Aries, Veitch, and Newsham 2010; R. S. Ulrich 1984; J. A. Veitch et al. 2001). The literature underscores the strong preference of building occupants for views and reveals the psychological and physiological benefits associated with them. Windows play a pivotal role in promoting occupant health and well-being, a notion supported both anecdotally and scientifically (J. A. Veitch et al. 2001) Previous studies have consistently shown that building users prefer having access to windows and views regardless of the quality of the view, emphasizing their importance (Collins 1975). Views offer occupants valuable information about the weather, time of day, and access to daylight, enhancing their overall experience (Collins 1975). Conversely, the absence of windows in office spaces has been linked to job dissatisfaction, depression, tension, and isolation (Finnegan and Solomon 1981;

Sundstrom, Sundstrom, and Eric 1986). On the other hand, views of the outdoors have been found to alleviate feelings of claustrophobia, monotony, and boredom, with natural environments proving more effective at stress recovery than urban scenes (Collins 1975; Heerwagen and Heerwagen 1986; Roger S. Ulrich 1979; 1981; Roger S Ulrich and Simons 1986; Roger S. Ulrich et al. 1991).

In addition to their psychological benefits, access to views and windows also impacts the physiological well-being of occupants. Views provide access to daylight, crucial for regulating the circadian cycle (Commission Internationale de l'Eclairage 2004; Jennifer A. Veitch 2001). While building users often adjust window blinds to regulate daylight and temperature, studies have found that the desire to maintain a view to the outdoor environment increases users' tolerance to visual and thermal discomfort (Chauvel et al. 1982; Tuaycharoen and Tregenza 2007; Inoue et al. 1988; Inkarojrit 2005a). Therefore, the literature on the influence and impacts of views underscores the strong preference of building users for views, the positive psychological and physiological impacts on occupants, and the influence of views on window blind usage.

2.1.3 Relationship Between Privacy and Views

Blind use for privacy occurs when building users close window shades to obstruct visual connection to the outdoors, while blind use for view involves opening (fully or partially) window blinds to gain visual access to the outdoor environment. This indicates that conventional shading devices such as curtains, roller blinds, and Venetian blinds serve as mediators for user interaction with window blinds, driven by opposing intentions: one to enhance visual connectivity with the outdoor environment and the other to diminish it. The user's perception of visual privacy within a building space, relative to the outdoor environment, is determined by the visibility of the indoor space from outside, with the view direction from the exterior to the interior. Conversely, the perception of access to view concerning the outdoor environment is determined by the visibility of the outdoor environment from within the indoor space, with the view direction from the interior to the exterior. This apparent inverse relationship between the user's perception of privacy and access to view might suggest that these perceptions are directly influenced by the degree of blind occlusion, positioning privacy and view as opposing ends of the same scale, as depicted in Figure 1.

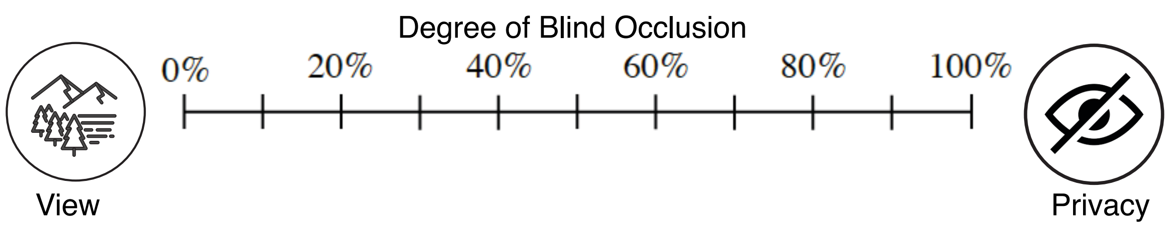

Figure 1. Blind occlusion scale

However, achieving privacy doesn't necessarily mean sacrificing access to views. Under specific conditions, specially designed shading conditions or devices can facilitate one-way visual connection from the indoor environment to the outdoors while blocking visual access from the outdoor environment to the interiors.

2.2. Expected Influence of Privacy and View on Environmental Adaptation

2.2.1. Pattern and Observations in Blind Usage

Research consistently demonstrates that window blind use is a prevalent form of indoor environmental adaptation. Studies indicate that occupants frequently utilize blinds to regulate glare, manage daylighting, and prevent overheating (Foster and Oreszczyn 2001a; Rubin, Collins, and Tibbott 1978). However, there exists a disparity between user behavior and building performance, with blinds often left unchanged for extended periods (P. James, M. Jentsch, and

A. Bahaj 2006; Sanati and Utzinger 2013). Various factors influence blind use, including building orientation, type of view, and seasonal variations (Rubin, Collins, and Tibbott 1978). In residential settings, blinds are operated differently to accommodate privacy needs and occupancy schedules (Bennet, O'Brien, and Gunay 2014). Moreover, the use of blinds is influenced by indoor and outdoor environmental conditions, such as temperature, air velocity, and solar radiation (A. Kim et al. 2019). Despite these insights, further research is necessary to comprehensively understand the factors driving blind use and its implications for indoor environmental comfort. The numerous factors motivating blind use are illustrated in Figure 2.

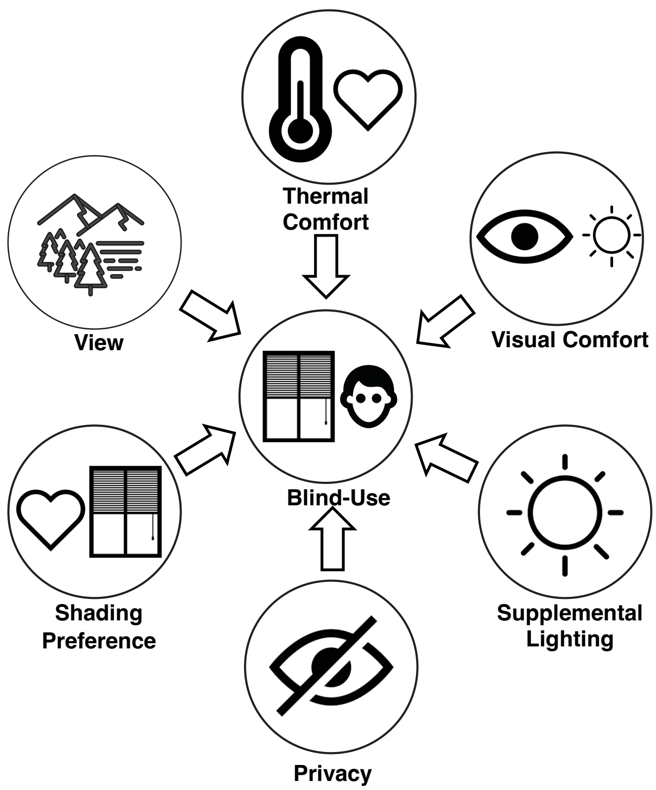

Figure 2. Factors that motivate window blind use

Previous studies examining blind use patterns in commercial buildings have identified that blinds are typically either fully opened or fully closed. (Sutter, Dumortier, and Fontoynont 2006; Foster and Oreszczyn 2001a; Haldi and Robinson 2009). The research on the interactions between office occupants and window opening revealed that the most common adjustment to window shading devices occurred immediately after the occupant's arrival (Haldi and Robinson 2009) and after lunch (Y. Zhang and Barrett 2012; Herkel, Knapp, and Pfafferott 2008). This suggests that the occupants of office buildings pay close attention to the indoor environment when they arrive and then do not make any changes unless they leave and return. The study of high-rise office buildings in Tokyo revealed that 60% of the total number of blinds remained unchanged during the day (Inoue et al. 1988), this pattern was also observed in residential buildings where the mean occlusion was observed to be between 60 to 90% (Inoue et al. 1988; Bennet, O'Brien, and Gunay 2014).

A case study on window blinds found that building users maintained window shading positions based on careful deliberation, this was observed when 80% of the shades were returned to their original position after being manipulated by the research team (Rubin, Collins, and Tibbott 1978). The same study also found that the window shading positions were decided based on a long-term assessment of the environmental conditions and not based on short-term changes (Rubin, Collins, and Tibbott 1978). Short-term environmental changes such as cloud shading have very little impact on window shading positions (C. Lindsay and Littlefair 1992). After the window shading position is decided, they remain unchanged until a critical situation motivates the occupant to change the window shading position (Y. Zhang and Barrett 2012). Closure of window blinds in response to thermal or visual discomfort by the building occupant results in the blinds remaining at the closed position even after the source of the discomfort is gone (Drucker-Colín 1995).

2.2.2. Blind Usage Patterns by Space Function

The motivation factors for window blind use in commercial buildings differ significantly from those in residential buildings. The differences in location, occupancy schedules, space use, user demographics, density, and window size lead to varying patterns and reasons for occupants to adjust window blinds. The findings from extensive surveys that investigated the motivating factors for blind use in residential buildings (J. A. Veitch et al. 2009) and commercial (Inkarojrit 2005a) are summarized in Figures 3 and 4 respectively. These figures categorize the reasons behind the closing and opening of blinds.

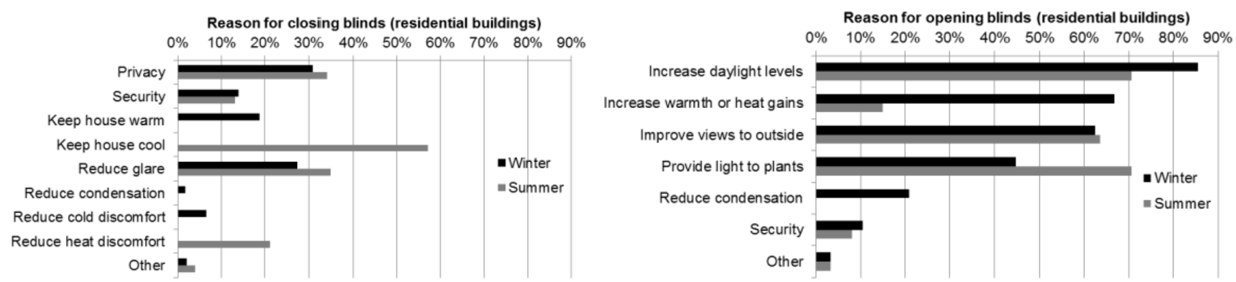

Figure 3. Blind use triggers in residential buildings (Bennet, O'Brien, and Gunay 2014; J. A. Veitch et al. 2009)

Figure 3 depicts the factors that motivate blind use in residential buildings during summer and winter conditions. The main reasons for blind closure in the summer were to keep the building cool and avoid visual discomfort from glare. Privacy was seen as the reason for closing blinds about 30% to 40% of the time depending on the season. Security was another strong motivating factor to close blinds in residences ranging from 13% to 15% in summer and winter respectively.

The main factors motivating the residential building users to open the blinds were observed to be daylighting (70%-85%), improving views of the outdoor environment (62%-65%), and providing sunlight for plants (45% -70%). Blinds were also opened in the winter to increase heat gains (65%) and to reduce condensation (22%).

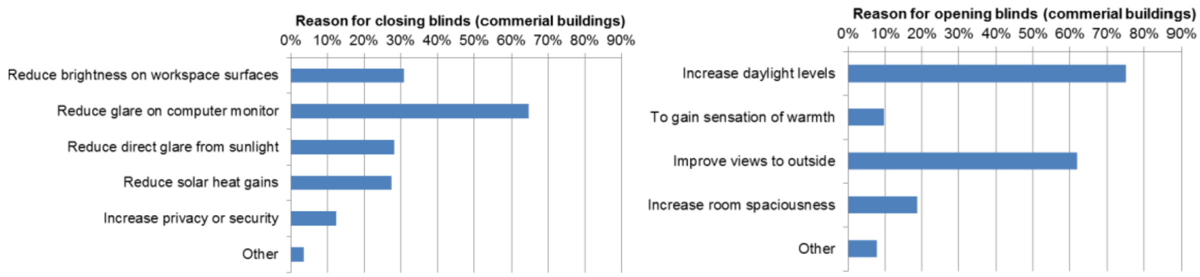

Figure 4. Blind use triggers in commercial buildings (Bennet, O'Brien, and Gunay 2014; J. A. Veitch et al. 2009)

Whereas in commercial buildings the main reasons for blind closure were seen to reduce glare from computer monitors (65%) and reduce brightness on workspace surfaces (30%). The other factors motivating the closure of blinds were observed to be glare reduction (28%), heat gain reduction (27%) and privacy/security (12%). The main factors motivating commercial building users to open the blinds were observed to be daylighting (75%) and improving views of the outdoor environment (62%). The other motivating factors for open blinds were to increase the spaciousness of the room (18%) and thermal comfort (9%).

Consequently, the blind use patterns in residential buildings show that building users close blinds for privacy, thermal comfort, and visual comfort; and open blinds to increase daylighting, improve views of the outdoor environment, thermal comfort in the winter, and provide sunlight for plants. However, the blind use patterns in commercial buildings show that building users mainly close blinds to reduce visual discomfort from glare on computer screens and working surfaces and reduce solar heat gain; and open blinds to improve daylighting, views and increasing the spaciousness. The evidence from Figures 3 and 4 demonstrates that blind use motivation factors greatly vary by space function.

2.2.3. Influence of Views on Blind Utilization

Building occupants highly value daylighting, views, and their connection to the outdoor environment facilitated by windows (Inoue et al. 1988). Regardless of the quality of the view, occupants prefer having a view rather than none to the outdoor environment (Collins 1975). Research indicates that the frequency of window shades being open remains consistent across windows with varying view quality (O'Brien, Kapsis, and Athienitis 2013). Windows and skylights serve as portals to the outdoors, providing occupants with valuable information such as weather conditions, time of day, and seasonal changes (Markus 1967), making views highly desirable. However, the view to the outdoors from building interiors is significantly influenced by blind use. Conventional window shading devices, such as curtains, Venetian blinds, and roller blinds, offer occupants the means to control the degree of blind occlusion, thus affecting both shading and view. In most cases, blind occlusion and view are inversely related, meaning that as blind occlusion increases, the outdoor view diminishes. Consequently, occupants are faced with a choice between maintaining the view and shading. Occupants are known to adjust window shading devices to regulate environmental factors such as daylight and temperature. However, the desire to preserve the view to the outdoors has been shown to increase occupants' tolerance to factors causing visual discomfort. A study examining the effects of glare on views discovered that occupants tolerate visual discomfort from daylight if the view from the window is pleasing (Chauvel et al. 1982). Other studies have established an inverse relationship between the perception of visual discomfort and the quality of the view, indicating that as the appeal of the view increases, visual discomfort from glare decreases (Inoue et al. 1988; Inkarojrit 2005a; Tuaycharoen and Tregenza 2007). Precedent studies provide evidence of occupants' need for views and the ability of high-quality views to enhance tolerance of visual discomfort and reduce blind occlusion.

2.2.4. Blind Usage Motivated by Privacy

Visual privacy is a significant factor motivating the use of blinds in buildings. While windows offer essential visual connections to the outdoors, they can also subject occupants to potential external intrusions, affecting their privacy. Studies on multi-story residential buildings indicate that privacy is a crucial aspect influencing residents' perceptions of livability (Cho and Lee 2011; Cho, Lee, and Kim 2011; J. Lee, Je, and Byun 2011; Phillips et al. 2005). The use of window shades for privacy involves occupants closing them to block the view from outside, aiming to prevent being seen or visually engaged. Individual perceptions of privacy are shaped by cultural, psychological, and physiological factors (Kennedy and Buys 2015) and can vary greatly, making the achievement of optimal privacy through space design a complex task. This diversity in privacy needs can lead to spaces that may feel isolating or, conversely, too exposed (Alkhalili et al. 2018).

Shading devices are instrumental for occupants to manage their level of visual privacy. Privacy is one of the top three reasons for shading windows, along with thermal and lighting control (Littlefair 2018). (Reinhart and Voss 2003a) found that occupants would manually override automated shades to close them for privacy during times of low ambient horizontal illuminance (less than 1000 lux). However, it was noted that shades were closed for privacy less than 4% of the time (Reinhart 2003). (Inkarojrit 2005a) observed that 12% of building occupants cited visual privacy as their reason for closing window shades. Additionally, privacy concerns were the primary motivation for blind occlusion on north-west-facing windows, with 17% of such windows closed (Inkarojrit 2005a).

2.2.5. Daylight Driven Blind Usage

Building users and architects have long favored daylight in building interiors over artificial lighting (Gunay et al. 2017). Previous studies have identified numerous benefits of daylight in buildings, including enhancing visual conditions and promoting the emotional and psychological well-being of occupants (Boubekri, Hull, and Boyer 1991). Yet, it has been observed that building users often adjust window blinds to control the amount of daylight entering the space, influenced by factors such as sunlight intensity, angle of incidence, visible solar light patterns, and visual discomfort from glare.

Glare, defined as visual conditions that cause unpleasant sensations or reduce the ability to distinguish details due to unfavorable luminance distribution or extreme contrasts, is thought to be a primary motivation for blind use by building occupants, beyond just preventing overheating (Reinhart and Voss 2003a). Studies show that occupants adjust window blinds to block direct sunlight (Reinhart and Voss 2003a; Gunay et al. 2017; Maniccia et al. 1999), and this behavior is often observed when light intensity reaches levels that cause discomfort. For example, (Reinhart and Voss 2003b) documented instances where occupants in a German office building closed window blinds when direct sunlight exceeded 50 W/m2. Furthermore, bright light causing glare on visual display units (VDUs), such as computer screens, was a significant reason for adjusting blinds (Eilers, Reed, and Works 1996).

Explorations into the relationship between external illuminance, the angle of daylight incidence, and blind usage have yielded mixed results. Some research noted more blind occlusion at smaller incident angles of sunlight to the façade (CRT Lindsay 1989), while others found no clear pattern between shading device usage and incident irradiance (Mahdavi and Pröglhöf 2008). These inconsistencies suggest that other variables may also play a role in how and why blinds are adjusted.

The intensity of external illuminance has been recognized as a trigger for using window blinds in buildings. Blinds are commonly employed when solar radiation exceeds 300 W/m2 (Foster and Oreszczyn 2001b), and one study observed that half of the window shades were closed in an office building when external vertical illuminance reached 10,000 lux at temperatures below 26°C, a threshold which dropped to 3,000 lux when temperatures were higher (Sutter, Dumortier, and Fontoynont 2006).

Daylighting research is increasingly considering the qualitative aspects of light, such as sunlight penetration, which is essential for indoor comfort. (Leather et al. 1998) found that solar penetration positively influences job satisfaction and the intent to remain with an employer. Occupants tend to adjust blinds to limit solar penetration (Rea 1984), and when sunlight penetration exceeds 50 W/m2, blind occlusion correlates with the depth of solar penetration into the space (Newsham 1994). Therefore, qualitative features of sunlight penetration are directly connected to the quantitative aspects of solar radiation intensity.

2.3. Effects of Blind Use on Indoor Occupants

2.3.1 Objective Impacts of Blind Usage

Previous studies have extensively examined the impacts of building user behavior on building energy use. A substantial portion of energy consumption in buildings is attributed to systems such as heating, ventilation, lighting, and plug loads, all of which are directly affected by the presence and behavior of building users (Yang, Santamouris, and Lee 2016). Occupants frequently adjust the indoor environment to achieve favorable thermal and lighting conditions, with window adjustments being one of the most common adaptive actions taken (Barlow and Fiala 2007). Window blinds, in particular, are used to regulate natural lighting and solar heat gain, with these adjustments having a direct impact on the energy consumption of building systems. Although window blinds are closed in response to various environmental and subjective factors, electric lighting and mechanical cooling/heating systems are often used to maintain comfortable conditions.

Analysis of the 2001 US Residential Energy Consumption Survey indicated that occupant behavior accounted for approximately 47% of the variation in energy consumption for cooling (Steemers and Yun 2009). Furthermore, research (Reinhart and Voss 2003b) demonstrated that the use of opaque exterior shading devices could lead to a 70% reduction in energy used for cooling. Another study investigating the effects of shading devices on residential cooling energy consumption reported a 9% reduction when typical shading devices were installed on previously unshaded windows (Laouadi 2010).

The use of window blinds also affects lighting energy consumption in buildings. Closed window blinds block daylight from entering the interiors, resulting in increased reliance on electric lighting to maintain adequate lighting levels. Numerous studies have shown that daylighting can significantly reduce lighting energy consumption in buildings, potentially resulting in overall energy savings of 30% to 50% in non-domestic buildings (Yun, Shin, and Kim 2010). (Slater 1987) further confirmed that a daylit commercial building consumes 30-40% less energy for lighting than one lit solely by electricity. Additionally, (E. S. Lee, DiBartolomeo, and Selkowitz 1998) found a 21% reduction in cooling and lighting energy use, along with a 13% decrease in peak cooling loads during summer, with the implementation of active shade control. Therefore, the use of window blinds significantly influences building energy consumption for both lighting and cooling, directly affecting the overall energy efficiency. This highlights the important role of window blind usage in promoting energy-efficient buildings and enhancing occupant satisfaction with the indoor environment.

2.3.2. Experiential Impacts of Blind Use

Windows serve as a crucial link for building occupants to visually connect with the outdoors and to bring daylight into interior spaces. The significant role of windows in promoting occupants' health and well-being has been extensively documented (J. A. Veitch et al. 2001). Daylight within buildings is known to profoundly affect various aspects of occupant health, including visual, emotional, and psychological well-being (Boubekri, Hull, and Boyer 1991). Additionally, daylighting and views of the natural environment provide social and psychological benefits (Tregenza and Wilson 2013; Waite-Chuah 2012), such as alleviating feelings of claustrophobia and monotony and offering chances for mental refreshment (Collins 1975). As window blinds are used to adjust the level of openness of windows, they inevitably affect occupants' exposure to daylight and their visual connection with the exterior.

The impact of windowless environments on work attitudes has been studied, showing a direct link between the lack of windows in workplaces and negative outcomes like job dissatisfaction, feelings of isolation, depression, tension, and claustrophobia (Finnegan and Solomon 1981; Sundstrom, Sundstrom, and Eric 1986). Moreover, the degree of sunlight penetration through windows has been associated with job satisfaction and employees' likelihood of staying with their employer (Leather et al. 1998). These insights highlight the essential role that windows and views play in influencing the psychological health and performance of employees.

The influence of windows and daylight extends to the physiological health of occupants as well. Daylight is known to have non-visual effects on human physiology (Commission Internationale de l'Eclairage 2004; Jennifer A. Veitch 2001), contributing to the regulation of circadian rhythms. Regular cycles of light and darkness are vital for maintaining these rhythms (Rosenthal et al. 1985), which are fundamental for overall health. Nonetheless, the occlusion of blinds, influenced by environmental and situational factors, restricts access to daylight and views outside, thus depriving occupants of the positive benefits that windows provide.

2.4. Impacts of Environmental Design on Indoor Occupant Performance

2.4.1. Need To Study Work Environments and Occupant Performance

The design of physical work environments (PWEs) is constantly evolving to keep up with the varying nature of work. While the role of PWEs is everchanging, the Covid-19 pandemic forced all non-essential jobs to online platforms, where most of the work was done outside traditional office spaces. Dedicated home offices and ad hoc home workstations formed the primary location for remote-centric work. 'Work from home' offered employees the opportunity to work from the convenience of their homes, have greater control over their workday, and save time normally spent on commuting to work (Ipsen, Kirchner, and Hansen 2020a). As the world emerged from the pandemic, a reluctance to return to traditional PWEs was evident, with a notable 23% of the American workforce preferring to work remotely (Saad and Hickman 2021), and a substantial 78% expressing a desire for remote work arrangements to continue in some capacity (H. Salonen et al. 2014). This hesitancy poses potential challenges for both the individual employee and employers at large. A comprehensive survey in Europe involving 5,748 workers revealed that remote working conditions led to feelings of isolation, diminished productivity, and suboptimal working conditions, underscoring the complexities of a complete shift away from PWEs(Ipsen, Kirchner, and Hansen 2020b). The desire to return to an office-centric work environment is influenced by many factors. Studies have shown that the perceived quality of pre-covid work environments is a strong determiner of an employee's desire to return to the workplace (Hobbs, n.d.).

Before the pandemic, PWEs were enhanced by amenities aimed at promoting health and wellness, such as onsite dining, fitness centers, and recreation areas. However, the work-from-home experience has redefined wellness to include benefits such as reduced commute times, personalized workspaces, and flexible seating attributes employees have grown to value and now anticipate in PWEs (“Collaborative & Social Space Design After COVID-19” 2020; McLaurin, n.d.). The expectation is clear: employees seek office spaces that provide flexibility, privacy, and control over their work environment, with the freedom to socialize as needed. To align with these evolving expectations, many employers are turning to the Activity-Based Working (ABW) office model, which is a flexible work arrangement that allows employees to choose where and how they work based on their specific tasks (Fincke et al. 2020).

2.4.2. Activity-Based Working (ABW) Environments.

The ABW (Activity-Based Working) model presents a spectrum of workspace configurations, enabling employees to choose settings that align with their tasks and preferences. This approach has been associated with improved well-being, performance, and motivation (Fincke et al. 2020), and has led to increases in employee satisfaction, productivity, and health (Nicky Mosselman, A. Gosselink, and M. Beijer 2010). With the adoption of ABW growing in both large and small firms (Linda Rolfö 2018; Oyg\" ur, Karahan, and G\" oçer 2022; Candido et al. 2018; \" Ohrn et al. 2021; Babapour 2019; van der Voordt 2004; Hodzic et al. 2020; Wohlers and Hertel 2016), it's essential to consider its impact on workplace design and its influence on employee experience and performance.

Today's office is a dynamic ecosystem where design is integral to enhancing employee performance and well-being. The ABW approach transforms workplaces to synchronize well-being with performance optimization (J. Hanze 2015). ABW workspaces offer a variety of spatial options to accommodate different activities, empowering employees to choose work settings that resonate with specific tasks and personal preferences (Candido et al. 2018). This includes dynamic areas for collaboration, quiet zones for focused work, meeting rooms for in-person or hybrid interactions, casual spaces for socializing, and learning centers for development. Becker suggests that such environmental diversity not only increases convenience but is also critical for job satisfaction, thus promoting efficiency and enhancing the work experience (Becker, Soucek, and Goritz 2022). Moreover, office design elements such as comfort, ergonomics, and layout are known to influence productivity and employee satisfaction (Osimani et al. 1997; M. Hansika and B. Amarathunga 2016).

While the benefits of ABW are significant, challenges such as space underutilization and distractions inherent to open settings are noted (G. Ditchburn 2014; Hoendervanger et al. 2016). Office environmental conditions like noise, lighting, temperature, and air quality impact performance, with these factors also affecting comfort perception, cognitive function, and job satisfaction (Kamarulzaman et al. 2011; Roelofsen 2002). The design of an office can profoundly influence job attitudes, inspire creativity, and reflect company values (Cheung and Zhang 2020; Ornstein 1989). Strategic office design, thus, becomes an investment in human capital, fostering environments that cater to both functional and psychological needs, promoting creativity and productivity.

Open Offices, a core feature of ABW, vary widely in their presence across organizations, tailored to support various activities. While they enable flexibility and capacity, they are also linked to potential negative effects on health, satisfaction, and productivity (James, Delfabbro, and King 2021). The distractions in Open Offices can challenge concentration, leading to increased stress and poorer health and social dynamics (James, Delfabbro, and King 2021). Privacy loss and frequent interruptions are particularly problematic (Hedge 1982), exacerbated by the visibility of multiple desks and orientations away from the room's interior (Sailer, Koutsolampros, and Pachilova 2021). Individual differences in environmental stimulus processing and task complexity further affect satisfaction and productivity (Maher and von Hippel 2005). The design challenge lies in balancing privacy and collaboration within these spaces (Roper and Juneja 2008). For tasks requiring deep focus, such as analytical work or programming, the distractions in Open Offices can be especially detrimental (Nobuyoshi 1993). The literature suggests a strategic workspace design to minimize distractions and meet diverse task requirements (Hedge 1982; Banbury and Berry 2005; S. Y. Lee and Brand 2005).

2.4.3. Metrics to Evaluate Occupant Performance

Precedent research into employee performance often employs both subjective and objective assessments. Subjective methods, which involve self-reporting and personal evaluations, allow for personal reflections on job performance. The validity of self-reported metrics has been substantiated by studies that found correlations with other performance indicators (Ramos-Villagrasa et al. 2019; Carlos and Rodrigues 2015). Nonetheless, the reliability of these subjective assessments is sometimes challenged, with calls for more rigorous metrics given the complexity of subjective evaluations (Forth and McNabb 2008; Pradhan and Jena 2016). Employing both subjective self-assessments and objective measures can yield a fuller understanding of employee performance.

Objective assessments, on the other hand, provide quantifiable and justifiable appraisals of performance. These include criteria-based evaluations considering factors such as work quality and teamwork (Okoli, Ewah, and Chukwu 2023; R. Islam and Shuib bin Mohd Rasad 2006). Such metrics are supported by research identifying factors like institutional affiliation and motivation as influential to performance (Halim Kazan and Sefer Gumus 2013). Cognitive efficiency has also been a focus, with tools developed to gauge this aspect of performance, acknowledging the connection between cognitive demand and job effectiveness, as well as the importance of mental well-being (Heikkinen et al. 2021; J. Kim et al. 2015; Bridger and Brasher 2011; Miller et al. 2019a; Cote and Miners 2006; Miller et al. 2019b). While subjective evaluations provide nuanced, individualized insights, objective methods allow for standardized, broader application, facilitating benchmarking and progress tracking within a transparent and accountable system.

2.5. The Role of Virtual Environments

Virtual reality (VR) is gaining traction in the field of architecture and engineering as a tool to visualize and represent 3D architectural environments and interiors (Heikkinen et al. 2021; J. Kim et al. 2015; Bridger and Brasher 2011; Miller et al. 2019b; Cot'e and Miners 2006). VR facilitates the virtual exploration of three-dimensional spaces at the human scale, offering a cost-effective and timely alternative to the construction of physical prototypes. The capacity of VR to enable the evaluation of numerous architectural variations rapidly and from a single physical location emphasizes its utility for designers. Advances in visual display technology and VR head-mounted displays (HMDs) have enhanced resolution, brightness, refresh rates, and contrast ratios, yielding more realistic and immersive experiences for users and providing researchers with an instrument to precisely assess visual and auditory perceptions.

However, concerns persist regarding the use of VR HMDs as proxies for testing in real environments. Recent studies have revealed no significant difference in participants' task performance (Heydarian, Carneiro, et al. 2015), subjective evaluation of daylit environments (Chamilothori, Wienold, and Andersen 2019a), and perceptual responses (Cauwerts 2013; Chessa et al. 2019; Murdoch, Stokkermans, and Lambooij 2015; Chamilothori, Wienold, and Andersen 2019a), between physical spaces and their representation in immersive VR, supporting the use of VR as a research tool. A study by Haydarian that used VR headsets to investigate the task performance between virtual and similar physical office environments found no significant differences in performance between the two environments (Heydarian, Carneiro, et al. 2015; Heydarian, Pantazis, et al. 2015). The perceptual accuracy of the highly realistic visual environments produced by VR HMDs has been evaluated in relation to real-world lighting conditions by numerous lighting studies (Chamilothori, Wienold, and Andersen 2019b; Higuera-Trujillo, López-Tarruella Maldonado, and Llinares Millán 2017; Abd-Alhamid et al. 2019; Chen, Cui, and Hao 2019; Kuş 2019). The study by Rockcastle et al. found that although the luminance range of VR HMDs are limited, they offer a reasonable alternative in recreating well-lit real-world lighting scenes in the VR environment (Rockcastle et al. 2021). VR HMDs have also been used to study user's lighting preferences for office-related tasks by allowing participants to manipulate window blinds and architectural lights in VR environment (Heydarian, Pantazis, et al. 2015) indicating the prevalence of VR as a research tool in architecture and lighting studies.

Studies investigating the subjective impressions of space and light have found photographs (Cauwerts 2013) and renderings (Hendrick et al. 1977) to be a promising medium for research. However, in addition to the simulation accuracy of the VR scene, the perception of presence of the participant in the virtual environment is essential in developing a virtual environment that can accurately simulate a real space (de Kort et al. 2003; Diemer et al. 2015).

2.6. Summary of Literature

This literature review has outlined the impact of environmental design on indoor occupants' perceptions of privacy and accessibility to views, underscoring their indispensable role in enhancing comfort, cognitive performance, productivity, and mental health. However, these advantages are not universally consistent in boosting productivity, prompting a nuanced understanding of environmental influences. Access to natural views and daylight, as demonstrated in (H. Salonen et al. 2014; Braçe et al. 2020) studies, contributes to decreased stress and improved healthcare outcomes, underscoring the necessity for design considerations that harness these elements to cultivate spaces that elevate user satisfaction and engagement.

Privacy is dissected into 'desired' and 'achieved' states, with the differentiation often reflected and regulated through the use of window blinds, a concept elaborated by (E. A. Schuster 1976). Occupants' strong preference for window access is well-documented, with its absence noted to adversely affect well-being. The complex interaction between privacy and access to views reveals that, while blinds fulfill a function of privacy, they can also obstruct views, a design challenge that may be addressed by innovative shading solutions without compromising either aspect. Usage patterns of window blinds, influenced by an array of factors, including building orientation, view type, and seasonal changes, vary across different settings, reflecting the diverse functional needs of commercial and residential spaces.

As we emerge from the COVID-19 pandemic, the transformation of physical work environments (PWEs) reflects a shift in workplace norms, with a marked preference for remote work arrangements and the attendant benefits such as autonomy and no commute. The subsequent redefinition of workplace wellness has led to the adoption of Activity-Based Working (ABW) models. These models offer diverse and flexible workspaces tailored to individual tasks and preferences, fostering improved well-being, performance, and motivation. Despite their apparent advantages, ABW environments face challenges, including the potential for space underutilization and the distractions associated with open office designs. This review emphasizes that strategic office design is a vital investment in human capital, significantly affecting employee performance and satisfaction. Incorporating both subjective self-assessments and objective performance measures, such as the Stroop Test, allows for a comprehensive evaluation of employee performance in various ABW settings.

Finally, the exploration into virtual reality (VR) highlights its emerging role in visualizing and representing architectural spaces for research purposes, exemplified by the practical application of devices like the Oculus Quest 2. This tool is recognized for its utility, affordability, and comprehensive feature set, which align with the study's requirements and reflect its potential as a promising medium for architectural and lighting research. Thus, the review concludes that environmental design profoundly influences indoor occupant experiences, demanding continual and holistic consideration of privacy and views.

CHAPTER 3

THE INFLUENCE OF ENVIRONMENTAL FACTORS ON PERCEPTION

This chapter presents the findings from two experiments conducted to explore the influence of environmental and contextual factors on indoor occupant perception, environmental adaptation preferences, and satisfaction. The results from these experiments were initially presented at the 2021 Architectural Research Centers Consortium (ARCC) International Conference on April 7-10 in Tucson (Virtual) and the 2023 ARCC Conference on April 12th-15th in Dallas. These conference papers serve as a prelude to the main experiments of the current dissertation, which will be published in two separate journals. Professor Siobhan Rockcastle played a significant role in these papers by assisting in the development of research questions and scope, designing the studies, and interpreting the results. While I served as the primary contributor to the studies, conducting data collection and analyses, and drafting the manuscript, Professor Rockcastle provided invaluable editorial review and contributions to the manuscript structure and interpretations.

The intricate relationship between environmental elements such as sky conditions, daylight penetration, and view types, and their influence on perceptions of privacy and access to views were explored in this chapter. Additionally, the consequential effects of these perceptions on environmental adaptation, particularly within the context of window blind usage henceforth referred to as blind use in this dissertation were examined. With the employment of window blind usage as a metric, the levels of privacy desired by individuals and their subsequent impact on access to views were assessed. Insights presented in that chapter are derived from two comprehensive experiments conducted at the University of Oregon, which examined how contextual factors such as space function shape preferences for privacy and views. Furthermore, it is revealed how these perceptions drive environmental adaptations, specifically manifesting in window blind usage. The influence of environmental factors and façade design variables on these perceptions was also analyzed, offering valuable insights into their intricate dynamics.

3.1. Methodology

To understand the human-built environment relationship a series of three experiments were designed to investigate the influence of Environmental factors such as Sky condition and view type; Contextual factors such as Space Function and Façade design on the perception of Indoor Occupants such as perceptions of Privacy, Views, and Satisfaction. As the three experiments were conducted during the COVID-19 pandemic, developing a remote experimental method was essential to be supportive of social distancing protocols and to allow access to a larger and diverse sample of participants.

In all three studies, 3D modeling program Rhino was utilized to craft highly detailed digital representations of various interior spaces. These virtual models were rendered to simulate different space functions and privacy expectations, furnished, and contextualized to match their intended functions. Rendering software like Twinmotion was employed to produce lifelike visual conditions, incorporating varied window shading devices, view types, and environmental lighting conditions. The result was a comprehensive set of images depicting each space under multiple scenarios.

The surveys were designed to be administered online for broad accessibility. A systematic approach was taken to design questionnaires that would measure preferences and perceptions of the virtual scenes. A combination of visual stimuli and descriptive texts was used to prompt participant responses, utilizing both preference ranking systems and Likert scales to capture a spectrum of perceptions. While the core survey components remained consistent, each study introduced specific questions and scales reflective of its particular focus. A multifaceted participant recruitment strategy ensured a diverse demographic across studies. Social media outreach and on-campus recruitment, including the use of Posters and lecture announcements, were instrumental in engaging participants. The anonymity of responses was guaranteed, and ethical considerations were addressed with Institutional Review Board (IRB) approvals.

3.2. Impact of Sky Conditions and Daylight

The pilot study conducted in the first experiment aimed to explore the broad effects of environmental factors on the perceptions of occupants within indoor spaces. This was contextualized within six distinct space functions to assess how different environments might influence occupant perceptions. Figure 5 presents a graphical representation of the categories of variables tested and Figure 6 visually represents the iterations of each variable tested.

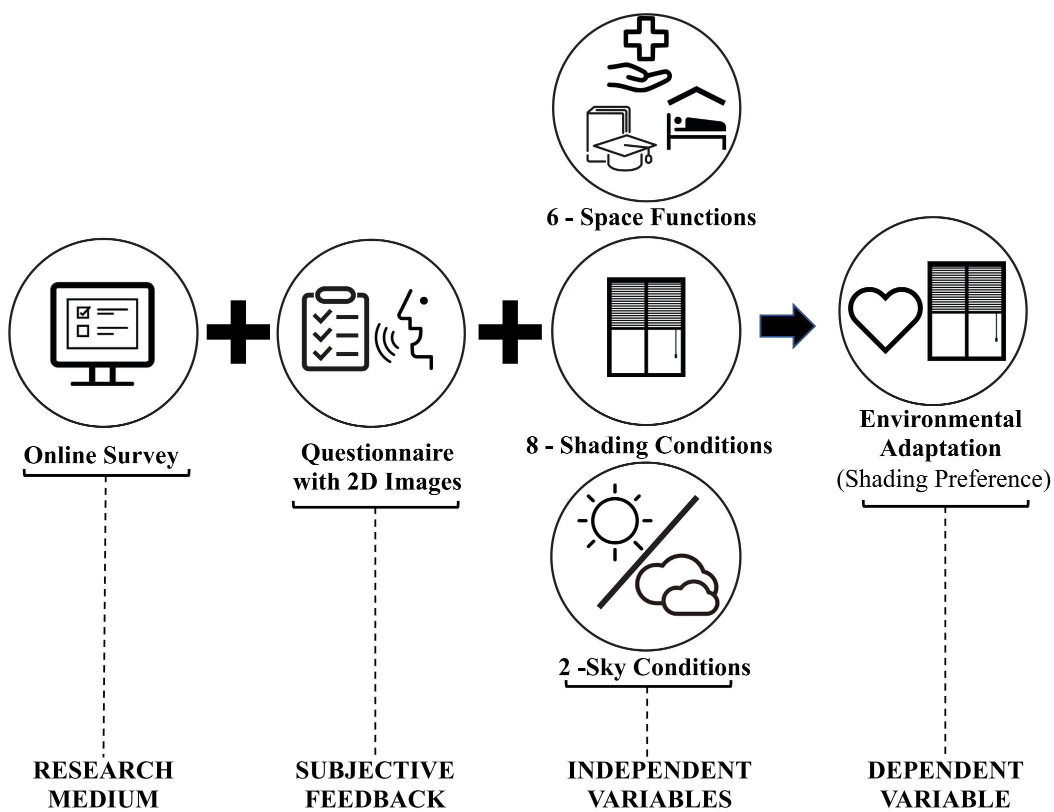

Figure 5. Experimental design for Experiment 1

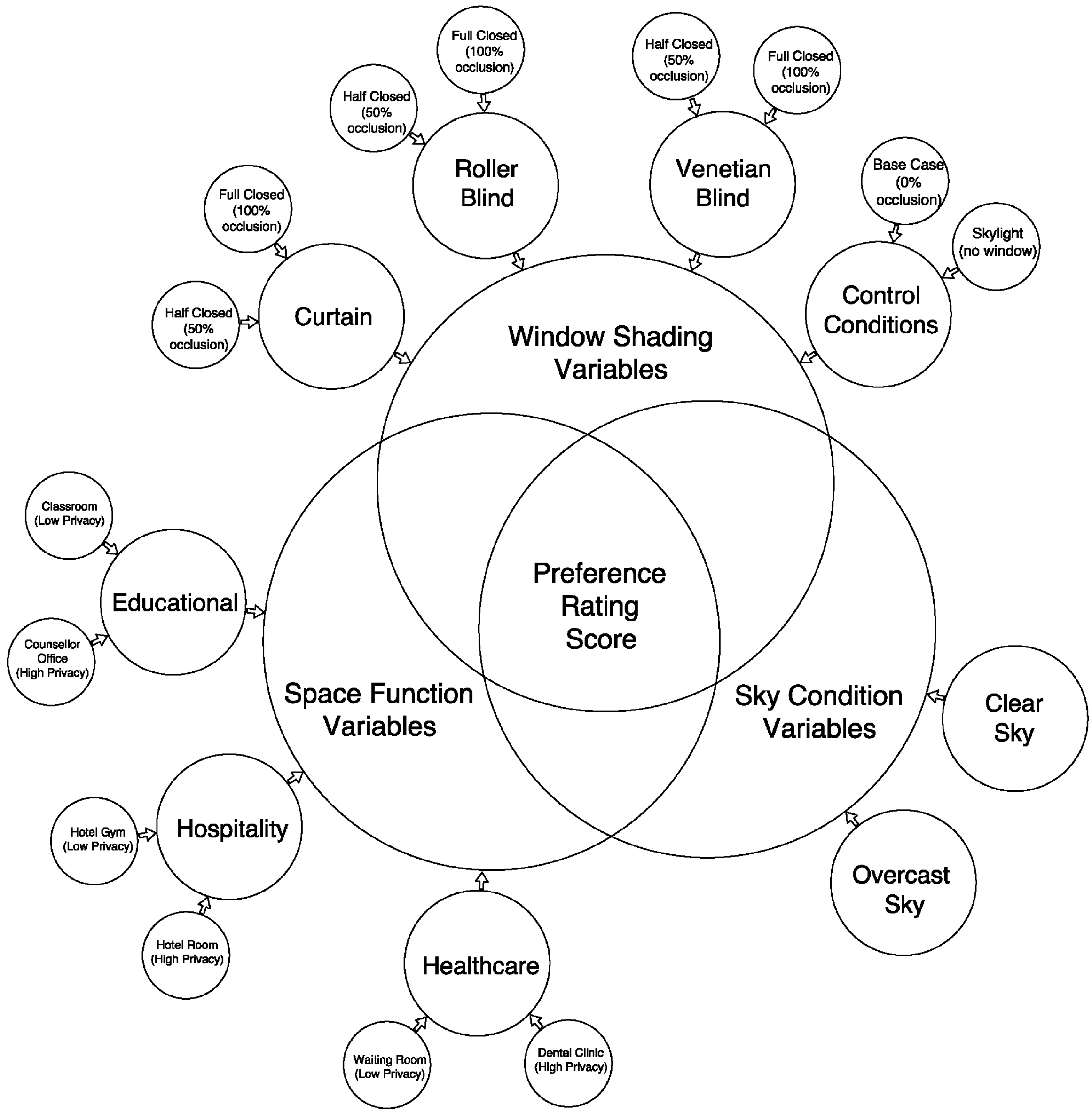

Figure 6. Visual representation of tested variable categories and their iterations

The study was structured around three main categories of variables:

- **Sky Conditions:** This variable included different weather scenarios such as clear and overcast sky conditions to simulate various natural lighting conditions and their psychological impacts.
- **Window Shading Conditions:** This variable included three of the most commonly used shading devices simulated in two shading conditions each in addition to the base case

without any shading device and a skylight.

- **Space Functions:** Six space functions were selected to represent ubiquitous spaces in educational, hospitality, and healthcare settings. This differentiation would help identify the unique demands and expectations for privacy and views in each type of space.

The study utilized a digitally modeled south-facing building shell situated on the first floor, offering a view of a typical urban setting through the south-facing window. The building shell served as the basis for simulating six distinct space functions, as depicted in Figure 7, and eight different window shading conditions, as illustrated in Figure 8.

To accurately represent each space function, appropriate furniture was selected to align with the space descriptions provided at the outset of each question set. The six space functions chosen for the study encompassed a diverse range of settings, including classrooms, counselor offices, hotel rooms, hotel gyms, waiting rooms in clinics, and dental clinics, as depicted in Figure 7. These selections were made to ensure representation across the education, hospitality, and healthcare sectors, while also encompassing varying levels of privacy within each sector. Within these space functions, two distinct levels of privacy were identified:

- **High-privacy spaces:** These areas were designed for a maximum occupancy of two individuals at any given time, such as hotel rooms, school counselor offices, and dental clinics.
- **Low-privacy spaces**: These settings typically accommodate more than two people simultaneously.

Figure 7. Space function variables examined

This categorization aimed to capture the diverse privacy needs within each sector and facilitate a comprehensive analysis of privacy preferences across different environments.

The textual description of each of the space functions spaces accompanying the images in the questionnaire and a description of the virtual scene is listed below.

- **Classroom:** Textual description: “This is a classroom designed for school children, commonly utilized by students, teachers, and supporting staff members.” The classroom space was selected to represent a typical school classroom with a typical occupancy of 15 to 20 students. The classroom space was designed to represent a structured environment specifically arranged to foster learning and interaction. This space includes a strategic placement of desks and tables oriented towards a central focal point which is a digital display, to facilitate the presentation of instructional content.
- **Waiting Room in Clinic:** Textual description: “This space serves as the waiting area within a private clinic, where patients wait to be examined by a doctor. It is typically frequented by patients and service staff.” The waiting room was designed to represent an area for people to sit and wait before their appointment with the doctor. This space is furnished with comfortable seating, such as chairs and benches, arranged to

accommodate individuals and families. Activities within this waiting room are oriented towards making the waiting experience as pleasant as possible for patients. This includes access to reading materials like magazines and health pamphlets.

- **Hotel Gym:** Textual description: “Attached to a hotel, this gymnasium is primarily used by guests for exercising and working out. It is commonly accessed by hotel guests and service staff.” The hotel gym is designed as a versatile fitness space for hotel guests to workout and exercise in a semi-public setting. This environment is equipped with a variety of exercise machines, free weights, and designated areas for stretching and yoga. Activities within this gym are designed to accommodate a range of fitness levels and preferences.
- **Counsellor Office:** Textual description: “This is an office and discussion space where the school counselor assists students with academic and personal issues or concerns. It is typically occupied by the counselor and a student.” The counsellor’s office was designed as a private and welcoming space tailored to support individual counseling sessions. This environment is furnished with comfortable seating arrangements, such as chairs and a small couch, aimed at creating a relaxed atmosphere conducive to open communication. Activities within this space are focused on providing emotional and psychological support to students. These include one-on-one counseling sessions where students discuss personal or academic challenges, as well as address common issues such as stress management, social skills, and peer relationships.
- **Dentist Clinic:** Textual description: “Within a dentist's clinic, this room is where all dental procedures are performed on patients. It is typically utilized by the dentist and a patient during appointments.” The dentist's clinic is designed as a professional and

hygienic space tailored to facilitate dental treatments and ensure patient comfort. The clinic is equipped with modern dental chairs that provide optimal accessibility for dental procedures while offering comfort to patients. The layout includes well-organized stations for dental tools and equipment, ensuring efficiency and sterility. The design incorporates bright, clean colors and efficient lighting to create a welcoming yet clinical atmosphere. Activities within this clinic are focused on providing a comprehensive range of dental services. These include routine check-ups, cleaning, x-rays, fillings, extractions, and more specialized treatments like orthodontics and cosmetic dentistry.

- **Hotel Room:** Textual description: "This represents a standard hotel room equipped with an attached bathroom, intended for short-term occupancy by hotel guests." The hotel room is conceptualized as a multifunctional and comfortable space designed to provide guests with a sense of home away from home. This environment features a comfortable bed with high-quality linens, a work area with a desk and chair, and a seating area for relaxation. Activities within this hotel room are oriented towards maximizing guest comfort and convenience.

To mimic widely used window shading devices like curtains, roller blinds, and Venetian blinds, eight distinct shading conditions were devised. For each of the three window shading devices, two conditions were created:

- **Half Closed (HC):** Here, the shading device covers half of the window area, resulting in 50% blind occlusion.
- **Full Closed (FC):** In this setting, the shading device completely covers the window area, providing 100% blind occlusion.

These eight shading conditions are depicted in Figure 8. Six of them illustrate unique configurations using curtains, roller blinds, and Venetian blinds in both semi-open (50% occlusion) and closed settings (100% occlusion). The remaining two conditions represent the base case with no shading device and a skylight.

Figure 8. Window shading variables examined

Two versions of the questionnaire were developed, each corresponding to one of the two sky conditions, to observe the impact of weather on window shading preferences. The first condition represents a "clear sky," characterized by bright daylight and clear visibility of outdoor objects and people. The second condition simulates an "overcast sky," replicating the lighting conditions of a heavily clouded sky, where outdoor objects and people are less distinct. To simplify, these conditions will be abbreviated as CS for "clear sky" and OS for "overcast sky." Both sky conditions are depicted in Figure 9, specifically showcasing the classroom space.

Figure 9. Sky condition variables examined

The online survey tool utilized a random assignment process to allocate participants to one of two versions of the survey: either the "clear sky" condition version or the "overcast sky" condition version. Participants were not informed about the existence of two versions of the survey, and the sky condition was not explicitly disclosed to them. Subsequently, participants were instructed to rank the 8 window shading conditions in the context of each space function. The total number of completed responses obtained was n=15 for the clear sky conditions (CS) and n=15 for the overcast sky conditions (OS). Although the sample size is limited, it functioned as a pilot study to identify potential effects and establish the foundation for a more extensive future experiment.

Influence of sky condition and space function on perception

In the initial phase of data analysis, window shading conditions were categorized based on the type of shading and the average preference ranking score (PRS). The data was divided into two groups representing both clear sky (CS) and overcast sky (OS) conditions, with their respective average PRS displayed in Figure 10.

The parallel bar graphs illustrate the average PRS according to sky condition and space function. A cursory examination of the data suggests that particular window shading types and conditions are favored for specific space functions. For instance, curtains, roller blinds, and Venetian blinds in the half-closed (HC) setting are preferred in classrooms, counselor offices, and dentist clinics, indicating the need for a balance between outdoor views and privacy in these areas. Conversely, curtains in both HC and full closed (FC) settings are equally favored in hotel rooms, suggesting curtains as the preferred shading option for this space type. Venetian blinds in the HC setting and the absence of shading devices (base case) are preferred in hotel gyms, emphasizing the importance of maintaining a view in this setting. Similarly, for waiting rooms, HC Venetian blinds, curtains, and the base case were preferred, highlighting the significance of outdoor views in such spaces.

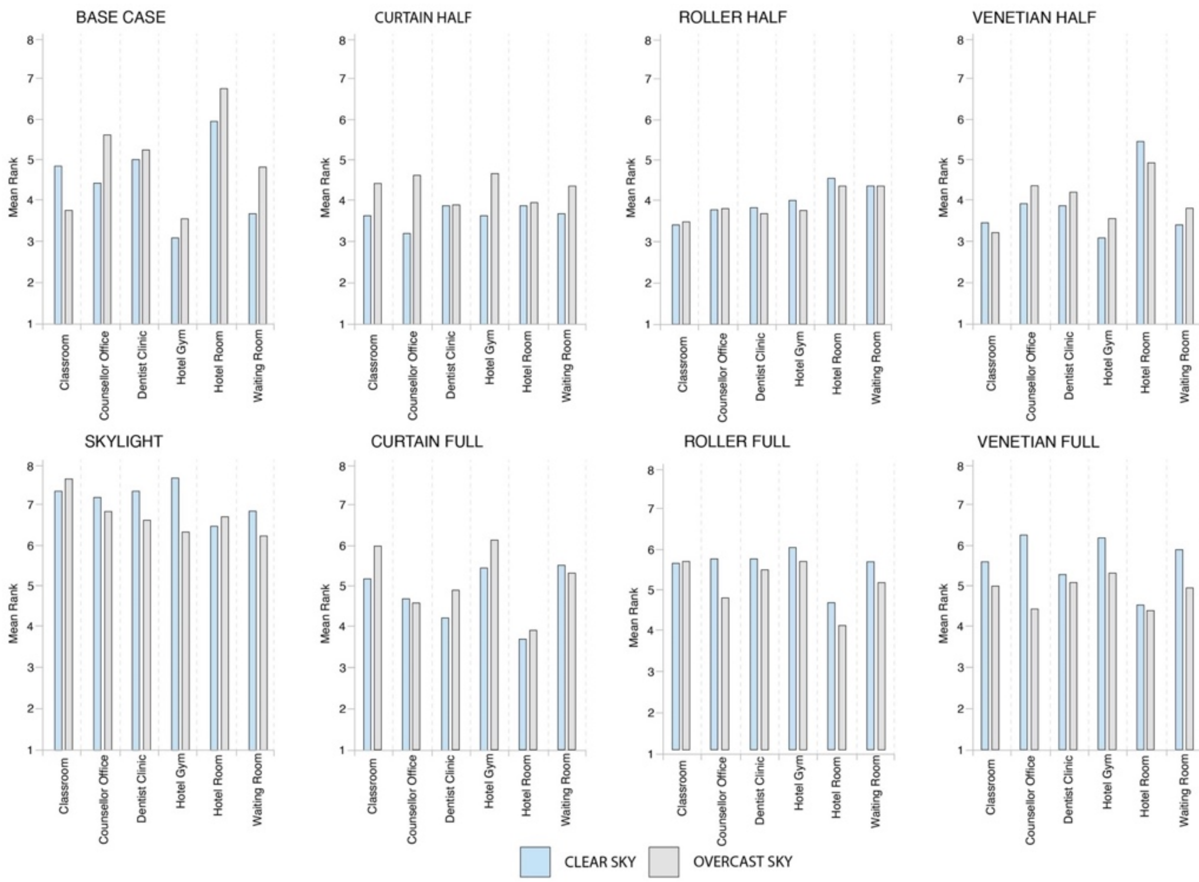

Figure 10. Mean preference ranking score of window shading conditions

Notably, roller blinds in the HC setting emerge as the most favored window shading condition, with minimal variation observed between space types. The mean PRS for this shading condition ranges from 3.5 in classrooms to 4.3 in waiting rooms, with less than 0.4 variation between sky conditions. Additionally, HC shading conditions were generally more preferred than FC shading conditions across all space functions, indicating a preference for a combination of privacy and outdoor views.

As hypothesized, HC shading conditions were ranked higher than FC shading conditions for space functions with lower privacy requirements (e.g., classroom, hotel gym, waiting room), while FC shading conditions were favored for programs with higher privacy needs (e.g., counselor office, hotel room, dentist clinic). This suggests a direct correlation between the degree of blind occlusion and the privacy requirements of each space function.

The most discrepancy in preferred occlusion degree is observed between hotel gyms and hotel rooms across the three shading types. Notably, the base case shows the highest variability in mean PRS between both sky conditions across the six space functions, with CS yielding a PRS of 3 and OS a PRS of 3.5, and the lowest PRS of 6 for CS and 6.7 for OS.

The base case, providing unobstructed outdoor views, magnifies the impact of weather conditions on participants' preference ranking decisions, thus explaining the high variability in mean PRS between sky conditions. Skylights are consistently the least preferred window shading condition across all space functions and sky conditions, with minimal variation observed between space types. The mean PRS for skylights ranges from 6.8 for CS and 6.3 for OS in waiting rooms to 7.4 for CS and 7.6 for OS in classrooms.

Impact of Sky Conditions and Space Function on Preference Score Distribution

In the second phase of data analysis, window shading conditions were categorized, and the distribution of preference ranking score (PRS) values was compared for each space typology. A non-parametric two-tailed Mann-Whitney U test was employed to compare the differences in PRS distribution between the clear sky (CS) and overcast sky (OS) conditions, considering the independent nature of the two groups and the non-normal distribution of the data. The PRS of CS (n=15) was compared against the PRS of OS (n=15) for each of the six space functions and eight window shading conditions, with the results depicted in Figure 11.

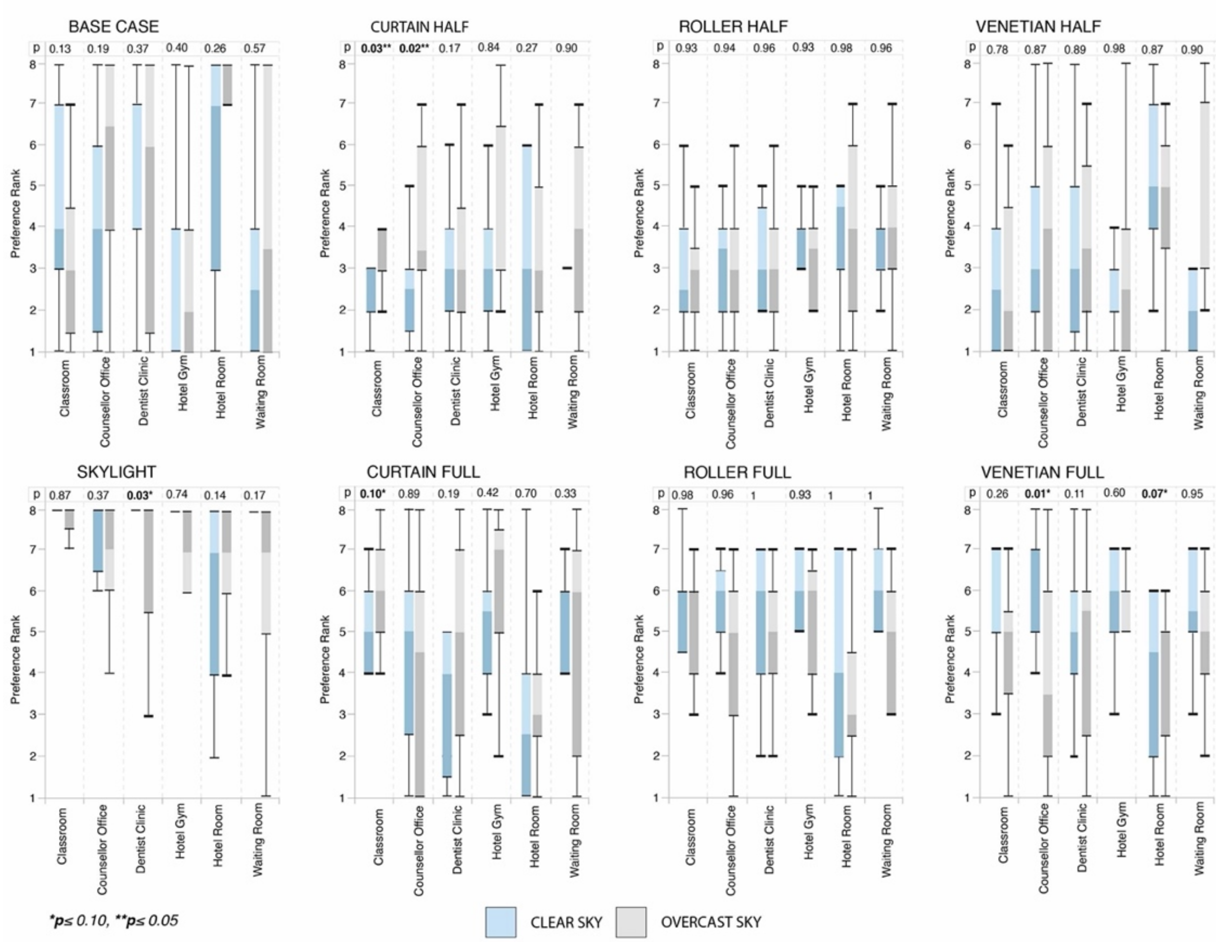

Figure 11. Preference ranking distribution and Mann-Whitney U test results

The findings revealed widely distributed scores in some cases, indicating greater variability among the sample scores, while other conditions exhibited narrower distributions, suggesting greater consistency.

For the base case shading condition, the PRS exhibited wide distribution across all space functions, with upper quartiles extending to PRS 8 and lower quartiles to PRS 1. The medians for CS and OS within each space function differed considerably. This indicates considerable variability in preference for the base case according to space function and sky conditions among participants. However, despite these differences in distribution, the p-values from the Mann-Whitney U test did not indicate a significant difference ($p \leq 0.05$ or $p \leq 0.1$) between the two sky conditions for any of the space functions under the base case window condition.

The PRS distribution patterns observed in the curtain HC, Venetian blind HC, and curtain FC shading conditions were notably similar. These conditions exhibited greater variability in PRS distribution in the OS condition compared to the CS condition across all space functions, except for the hotel room. In the CS conditions, the PRS distribution was relatively narrower and skewed towards higher values, indicating a higher preference. Conversely, the OS conditions showed greater variability in PRS, with scores shifting towards lower values, suggesting that the preference for curtain HC, Venetian blind HC, and curtain FC shading conditions was lower during overcast sky conditions compared to clear sky conditions.

However, the opposite trend is observed only in the hotel room space function, where greater variability is seen in the CS conditions, with a shift towards lower PRS. The Mann-Whitney U test results for the curtain HC shading condition showed a statistically significant difference between OS and CS conditions for the classroom and counsellor office space functions, with p-values of 0.03 and 0.02, respectively. This demonstrates the impact of sky conditions on preference ranking scores in the context of the classroom and counsellor office space functions.

In the case of Venetian blinds and roller blinds in the FC condition, the PRS values are similar and widely distributed for the OS condition compared to the CS condition. However, the distribution is shifted towards higher PRS, indicating that FC Venetian blinds and roller blinds are more preferred during overcast sky conditions. The Mann-Whitney U test found a significant statistical difference between OS and CS conditions for the counsellor office in the FC setting for Venetian blinds and roller blinds, with p-values of 0.01 and 0.07, respectively. The distribution of PRS was observed to be the most consistent in the roller blind HC condition across all space functions and sky conditions, showing very little variation in the medians between the CS and OS conditions, indicating that sky conditions have the least impact on preference ranking scores for this shading condition.

The skylight condition consistently scored the lowest PRS across all the window shading conditions. Among the two sky conditions, the skylight was the least preferred in the CS condition due to the distinctive and bright sunlight patterns formed on the floor in the test images, resulting from direct sunlight penetration. The pronounced sunlight observed during clear sky conditions may be contributing to the difference in preference rankings between the sky conditions. The PRS distribution in the OS condition shows some variation, with their medians located at a low score of seven. The Mann-Whitney U test found a significant statistical difference between OS and CS conditions for the dentist clinic, with a p-value of 0.03.

Effect of Sky and Shading Conditions on Preference Ranking Score Allocation

In the third stage of data analysis, the window shading conditions tested were grouped based on space function, and the distribution of PRS was examined for each shading condition. The Kruskal-Wallis one-way analysis of variance test was utilized to compare the differences in PRS distribution between the eight window shading conditions for each of the six space functions. As the eight groups were independent and the data was not normally distributed, the Kruskal-Wallis test was deemed appropriate.

Figure 12 illustrates the wide variation observed in the PRS distribution based on space function and window shading conditions. A closer examination of the data revealed distinct patterns in the preference for certain shading devices and shading conditions for specific space functions.

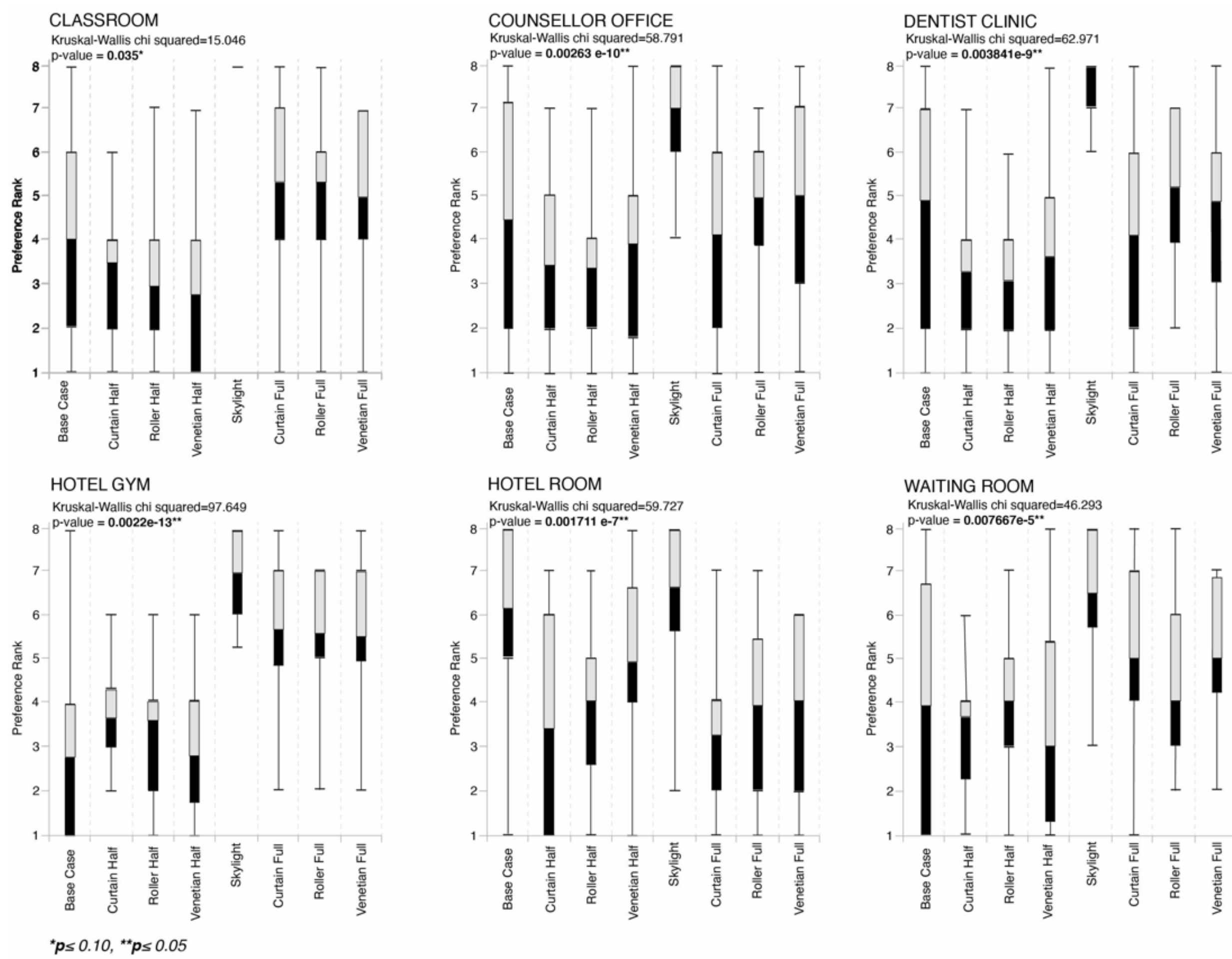

Figure 12. Preference ranking distribution and Kruskal-Wallis test results

In the classroom program, HC shading conditions were highly preferred compared to the same shading devices in the FC setting, with a difference of about 2 preference ranks. The PRS distribution of OS conditions for all window shading conditions was lower than CS conditions, except in the base case.

Similarly, in the hotel gym space function, the PRS distribution pattern mirrored that of the classroom, with the "half closed" shading conditions being highly preferred over the "full closed" setting. However, unlike the classroom, the PRS distribution of OS conditions for all window shading conditions was higher than CS conditions.

Regarding the hotel room space function, the PRS distribution indicated that FC window shading conditions were highly preferred over their HC counterparts. This suggests that a higher degree of blind occlusion is desired in the hotel room compared to the other five space functions, likely due to the high level of privacy required in the space.

The results of the Kruskal-Wallis test revealed statistically significant differences in the preference ranking scores between the eight shading conditions and six space functions. The obtained p-values were significant for all space functions, indicating that there is a statistically significant difference in PRS between window shading conditions for the six space functions in our study. Additionally, these results provide evidence that preference for window shading type and degree of blind occlusion are influenced by the space function.

The results of this study highlight the impact of environmental conditions like sky conditions and contextual factors such as space function on participants' preferences for window shading types and their degree of occlusion. Analysis of mean preference ranking scores revealed distinct preferences across different space functions. For instance, curtains, roller blinds, and venetian blinds in the half-closed setting were favored in spaces like classrooms, counselor offices, and dentist clinics, where occupants value both a view of the outdoors and privacy.

In contrast, the preference for Venetian blinds in the half-closed setting and the base case for the hotel gym program suggests that privacy is not a primary concern in this space, and occupants prioritize having a view of the outdoors. Across all space functions and sky conditions, the roller blind in the half-closed setting was highly preferred. This suggests that the half-closed roller blind effectively balances privacy concerns by partially obstructing the view from the outdoors while still allowing daylight to enter.

Consistent with the hypothesis, half-closed window shading types were preferred over fully closed types for program types with a lower privacy requirement, while fully closed types were preferred for spaces with a higher privacy requirement. This highlights the direct relationship between the degree of blind occlusion and the privacy needs of a space defined by its space function.

Moreover, the analysis of preference ranking scores for clear sky and overcast sky conditions revealed greater variability in scores under overcast conditions, with a tendency towards lower preference ranking scores. The consistently low preference ranking for the skylight condition under clear sky conditions indicates a preference for side-lit windows over direct sunlight through skylights. The statistically significant differences found in the preference ranking scores between different shading conditions and space functions emphasize the influence of these factors on window shading preferences. This suggests that recommendations for blind use cannot be generalized across different space functions, and studies need to encompass a broader range of programmatic use types to develop more accurate models and guidelines for shading device design.

3.3. Impact of Exterior Views and Space Functions

Impact of View Type

The second study aimed to build upon the findings of the first study by investigating the influence of different window view types on occupants' perceptions of privacy and view. The environmental and contextual variables tested in this study are shown in Figure 13.

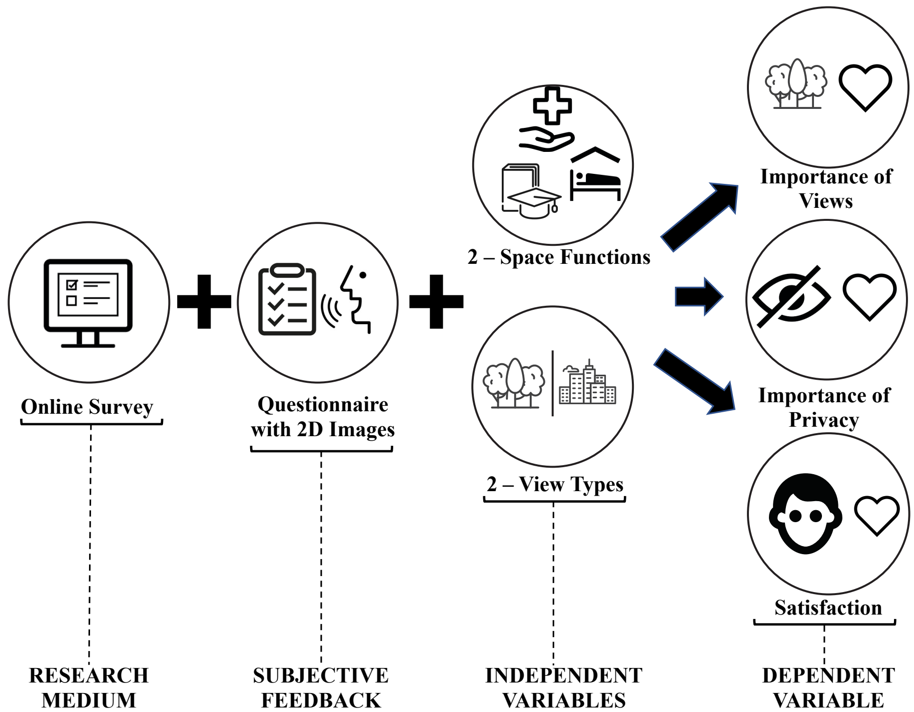

Figure 13. Experimental design for Experiment 2

In this experiment, 2D navigable images of virtual architectural spaces were utilized to create realistic representations of indoor environments. The 2D navigable images offered an interactive viewing experience, allowing users to explore the virtual environment dynamically and engagingly. Users can pan across the image to view different areas, zoom in to see fine details, or zoom out to gain a broader perspective. The images were presented in 4K resolution and participants were able to view the images for as long as they desired. The survey was specifically designed to be completed on devices with larger screens, such as computers or tablets, to ensure that participants could fully engage with and accurately assess the visual content presented. Prior to participation, individuals were informed that the survey required viewing on a larger screen for optimal interaction with the scenes. Additionally, the survey tool was equipped with a device identifier feature. This feature automatically detected attempts to access the survey from a mobile phone or any device with a smaller screen, and would prevent the survey from being taken on such devices. This protocol was implemented to maintain the integrity of the visual assessments and to ensure consistent viewing conditions for all participants.

The materials and color palettes chosen for creating these virtual environments were meticulously selected to authentically simulate a typical setting appropriate for each space function. While the luminance ranges in both environments were designed to be perceived as similar, this study did not quantitatively measure the exact luminance values in each environment. Participants were asked subjective questions about their perceptions of privacy and view quality in response to these virtual spaces. A total of 150 participants were recruited on campus through posters and announcements within large lectures.

Participants in the study were distributed across various age ranges as follows: 81 participants were aged 18 to 25, 48 participants were aged 26 to 35, 10 participants were aged 36 to 45, 5 participants were aged 46 to 55, 3 participants were aged 56 to 65, and 3 participants were aged over 65. Among these participants, 63 identified as male, 69 as female, and 18 as non-binary. All participants were affiliated with the University of Oregon and had a UO account and email ID to ensure the authenticity of participants. Participants accessed the survey using a QR code provided in the recruitment materials. Upon completion of the survey, participants were compensated with a $5 Amazon gift code, which was delivered to their @oregon.edu email address. Importantly, no personally identifiable information was collected during the study to ensure participant privacy. The study received ethical approval from the Institutional Review Board of the University of Oregon, study number 00000309, ensuring compliance with research ethics guidelines.

The virtual spaces were digitally modeled to simulate two distinct space functions: a typical Hotel room and a typical Waiting room. These space functions were chosen to represent different levels of expected privacy, with the hotel room designed for high-privacy scenarios and the waiting room designed for low-privacy scenarios. The degree of privacy was determined based on the typical occupancy of each space; the hotel room was intended for occupancy by 1-2 closely related individuals, while the waiting room was designed for occupancy by 1-6 unrelated individuals. The virtual environment for both space function are illustrated in Figure 14.

Figure 14. Space function variables examined

Furthermore, two different window view types were incorporated into the virtual spaces: Forest view and Urban view. These view types were selected to introduce variability in the environmental content visible through the windows of the simulated spaces. In each space, namely the Hotel room and Waiting room, participants were presented with one of two window views: an Urban view or a Forest view. These views were designed to introduce variations in the environmental content visible through the windows of the simulated spaces. The Urban view was created to depict a moderately dense urban environment. It featured elements such as a wooden bench, a planter box, sidewalks, and people standing and walking in the foreground. In the background, there was a view of a road with buildings. This view aimed to represent an urban setting with typical urban infrastructure and activities. On the other hand, the Forest view was designed to simulate a natural environment. It included a wooden bench and planter box in the foreground, similar to the Urban view. However, in the background, the view consisted of a lawn surrounded by a dense cover of trees. This view aimed to evoke a sense of being in a peaceful and natural setting, contrasting with the urban environment depicted in the Urban view. Both the views are illustrated in Figure 15.

Forest View Urban View

Figure 15. Outdoor view variables examined

It's important to note that while both views were designed to have consistent proportions between the foreground, background, and sky, they were not intended to be high-quality views. Instead, they aimed to provide participants with distinct visual stimuli representing different types of environments: urban and natural.

The survey methodology involved presenting participants with four panoramic images representing different virtual architectural spaces: (a) Hotel room with a Forest view (b) Hotel room with an Urban view, (c) Waiting room with a Forest view, (d) Waiting room with an Urban view. Each image was accompanied by a text description of the space function, providing context for the participants. Participants were then asked to respond to three statements about the virtual scene they were viewing, using a 5-point Likert scale:

- Considering the function of the space, ‘Privacy from the outdoors is important’.
- Considering the function of the space, ‘Having a view is important’.
- ‘I find the view to be desirable’.

The Likert scale ranged from 1 to 5, with 1 indicating 'strongly disagree' and 5 indicating 'strongly agree'. The midpoint of the scale was labeled as 'Neutral', indicating neither agreement nor disagreement with the statement. In the design of the study, the questions were meticulously crafted by the researcher to probe the significance that indoor occupants assign to views and the functionality of their space. This set of questions was informed by insights garnered from prior experiments. Moreover, they were intentionally structured to be straightforward, minimizing the potential for varied interpretations. This process was repeated for each of the four images, presented in random order to avoid any bias related to the order of presentation. After data collection, its distribution was examined to determine if it followed a normal distribution. Since the data was found to be non-normally distributed, the Wilcoxon signed-rank test for paired samples was selected for comparative statistical analysis. Additionally, box and whisker plots were used to visually examine the distribution of participants' responses to each statement across the four images. This analysis aimed to provide insights into participants' perceptions of privacy, the importance of having a view, and the desirability of the view, based on the different space functions and window view types presented in the survey.

Importance of privacy in relation to space function

To analyze the impact of space function on occupants' perception of privacy, the responses to question 1: 'Considering the function of this space, privacy from the outdoors is important' were examined. Participants' responses, recorded on a 5-point bipolar Likert scale, were converted into numerical Privacy Scores (PS). A PS of 1 indicated a low level of importance for privacy, while a PS of 5 indicated a high level of importance for privacy.

After converting the Likert scale responses to numerical values, the PS values were grouped according to space function. Then, the distribution of PS values for each space function was plotted as seen in Figure 16. This analysis aimed to visualize how occupants' perceptions of privacy vary across different space functions, providing insights into which spaces prioritize privacy from the outdoors more than others.

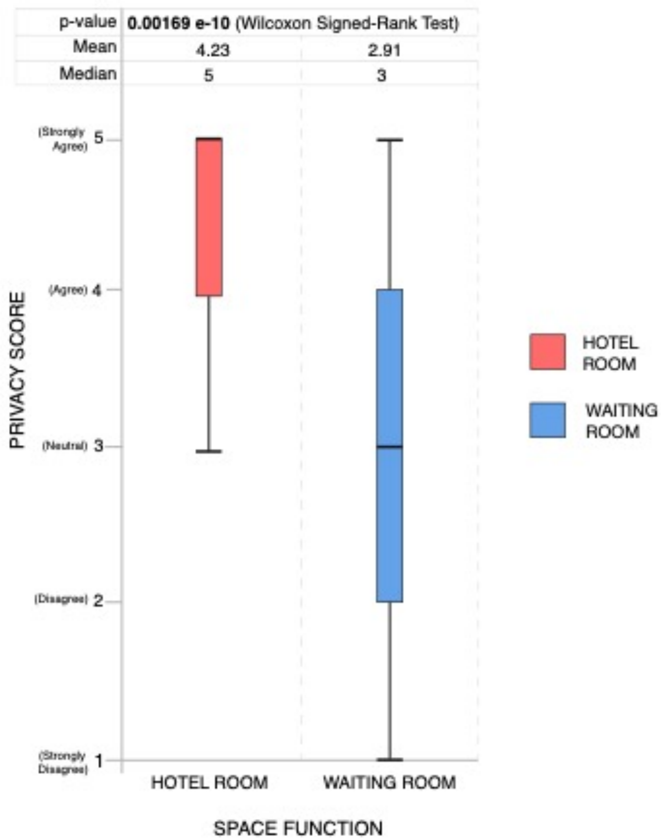

Figure 16. Distribution of privacy scores for Hotel and Waiting room environments with Wilcoxon signed-rank test analysis

Figure 16 illustrates the distribution of Privacy Scores (PS), revealing differences between Hotel rooms and Waiting rooms. The PS distribution for Hotel rooms demonstrates a tighter range, suggesting a consensus on the importance of privacy compared to the more varied distribution seen in Waiting rooms. This indicates a higher level of agreement among participants regarding privacy significance in Hotel rooms versus Waiting rooms.

The noteworthy PS value of 4.23 for Hotel rooms underscores the considerable importance placed on privacy from the outdoors in this setting. Conversely, the lower PS value of 2.91 for the Waiting room implies a relatively lower priority on outdoor privacy in this context. These findings highlight how the function of a space influences occupants' perceptions of privacy.

Further analysis was conducted using a Wilcoxon signed-rank test to examine the statistical difference between PS distributions for Hotel rooms and Waiting rooms. The test aimed to evaluate the null hypothesis, which assumes equal medians for both samples. Results yielded a highly significant p-value <0.0001 (0.00169 e-10), indicating a substantial difference in PS between the two types of spaces. This statistical significance underscores the impact of space function on occupants' privacy perception. The higher PS observed in spaces with a 'high privacy' requirement, such as Hotel rooms, and the lower PS in spaces with a 'low privacy' need, such as Waiting rooms, confirm our initial hypothesis. These findings underscore the necessity of considering space function in indoor environment design to effectively meet occupants' privacy requirements, irrespective of the view content.

Importance of view in relation to space function

The investigation into the relationship between space function and occupants' perceived importance of views involved participants rating their agreement with Question 2: ‘Considering the function of the space, having a view is important.’ Responses were collected using a 5-point Likert scale and translated into a numerical 'View Score' (VS), as depicted in Figure 17.

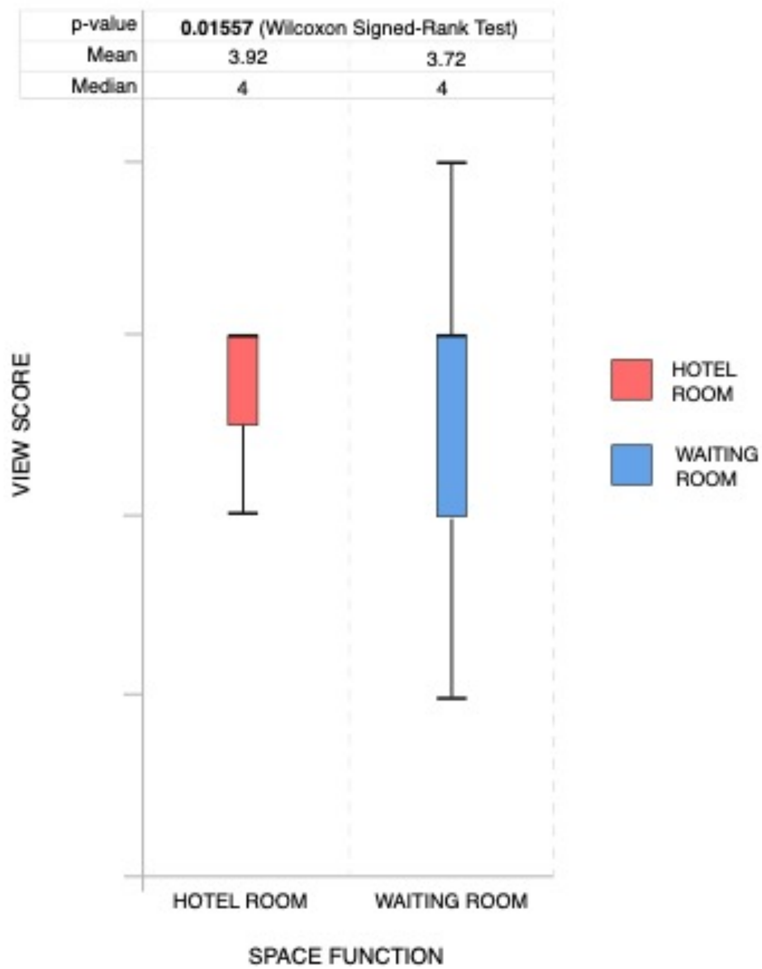

Figure 17. View score distributions and Wilcoxon signed-rank test outcomes for Hotel and Waiting room space functions

Analysis of the data revealed that the mean VS for the Hotel room (3.92) exceeded that of the Waiting room (3.72). A Wilcoxon signed-rank test yielded a p-value of 0.015, rejecting the null hypothesis and confirming the significance of this disparity. This result underscores how space function influences the perceived importance of having a view, regardless of the specific content of the view.

View preference between Urban and Forest view

The section examined responses to Question 3: 'I find the view to be desirable.' Similar to the preceding questions, participant responses were captured using a 5-point Likert scale and transformed into a numerical 'View Preference Score' (VPS). The VPS for both Hotel rooms and Waiting rooms, categorized by view type, were aggregated and reorganized. The distribution of VPS scores is visualized in Figure 18.

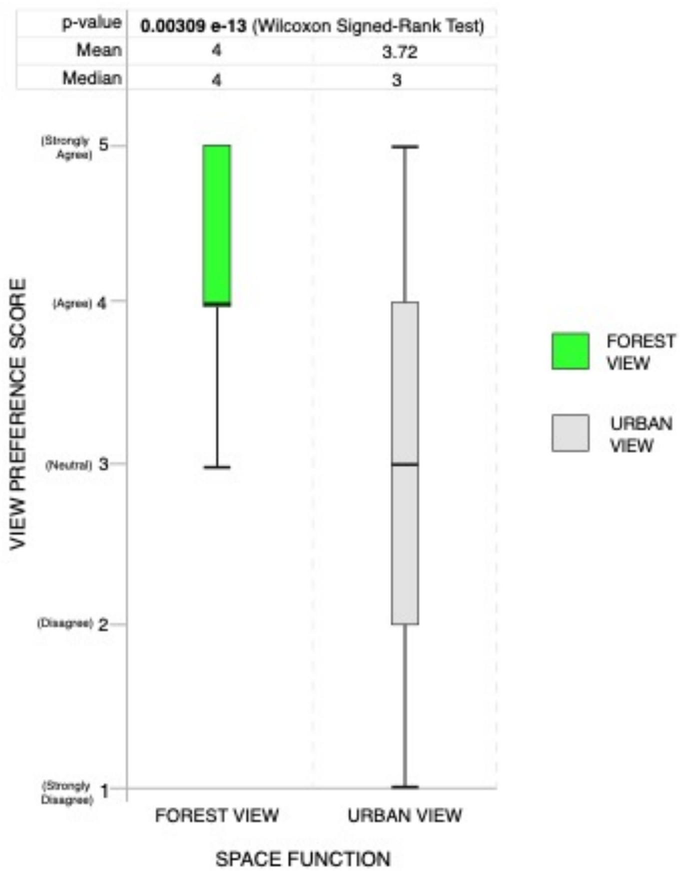

Figure 18. Comparative distributions of view preference scores for Forest and Urban views with Wilcoxon signed-rank test analysis

A brief examination of the VPS distribution for the Forest view reveals a tightly clustered distribution, with a standard deviation (SD) of 0.83 and a mean score of 4. The elevated mean VPS for the Forest view indicates that participants generally found this view desirable, while the narrow distribution suggests a high level of agreement among participants.

In contrast, the VPS distribution for the Urban view appears more widely dispersed, with a standard deviation of 1.211 and a mean of 3.72. The lower mean VPS for the Urban view suggests that participants did not find it as desirable as the Forest view. A Wilcoxon signed-rank test for paired samples yielded a p-value <0.0001 (0.00309 e-13), rejecting the null hypothesis and confirming a significant statistical difference in VPS between the Forest view and Urban view.

View Preference by Space function

Following the overview of view preference by view type, a more detailed analysis of the VPS scores was conducted to explore the impact of space function on view preference. The VPS scores for the Forest view and Urban view were segregated and reorganized according to the space function. Subsequently, the VPS distributions for the Forest view and Urban view within Hotel rooms and Waiting rooms were plotted and juxtaposed, as illustrated in Figure 19

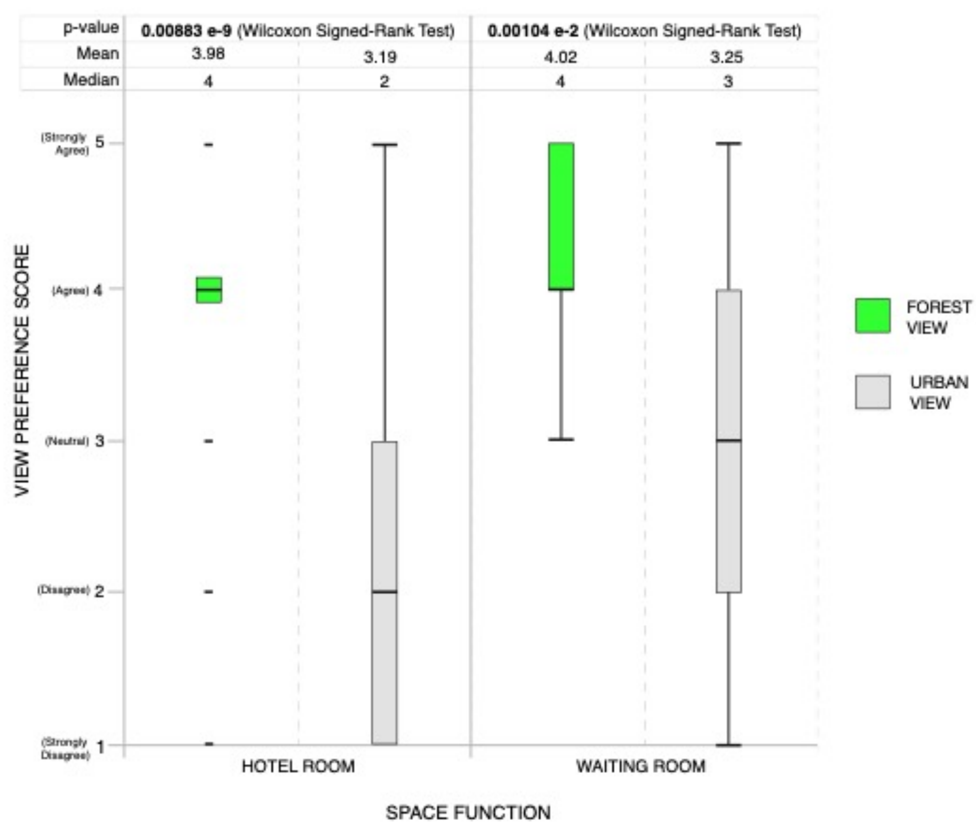

Figure 19. View preference scores across room types and views: a Wilcoxon signed-rank analysis of Hotel and Waiting rooms with Forest and Urban views

A quick examination of the VPS distributions in Figure 19 reveals distinct patterns. Firstly, the Forest view scores exhibit tighter clustering within Hotel rooms compared to Waiting rooms. This discrepancy suggests a stronger consensus among participants regarding the desirability of Forest views in Hotel rooms than in Waiting rooms. Conversely, the lower VPS for Urban views in Hotel rooms reflects their diminished desirability in this context, whereas higher VPS scores in Waiting rooms indicate a greater preference for Urban views in such spaces.

Furthermore, the VPS for both Forest view and Urban view is marginally higher in Waiting rooms than in Hotel rooms. This implies that participants found both types of views more appealing in Waiting rooms than in Hotel rooms. This slight increase in VPS scores for both view types in Waiting rooms may suggest occupant's greater receptiveness to views in a setting less constrained by privacy concerns.

The observed differences in VPS between Forest view and Urban view appear more distinct in Hotel rooms than in Waiting rooms. This might suggest a preference for Forest views over Urban views among participants, though further research would be required to confirm this trend. Moreover, the reduction in VPS for both view types in Hotel rooms, relative to Waiting rooms, could indicate a somewhat lesser focus on view quality in these settings. These findings tentatively support the idea that the function of a space may influence occupant view preference, pending further investigation.

3.4. Summary of Findings

The results from the first two experiments demonstrate the impact of contextual factors, such as space function and view type, on the perception of indoor environments. Initially, participants consistently attributed greater importance to privacy in Hotel rooms compared to

Waiting rooms. This suggests that individuals view Hotel rooms as more private spaces, expecting a certain level of privacy from the external environment. In contrast, Waiting rooms are perceived as shared spaces where privacy holds lesser importance, leading to greater variability in expected privacy levels. Space function emerged as a crucial variable influencing participants' perceived importance and expectations regarding privacy. In the subsequent stage of analysis, participants rated the importance of views slightly higher in Hotel rooms than in Waiting rooms, with greater consensus observed in Hotel rooms. Again, space function was found to have a statistically significant impact on participants' perceived importance of views.

The third stage of data analysis delved into participants' view preferences between Urban and Forest views. Participants consistently rated Forest views as more desirable than Urban views, with greater consensus observed for Forest views. While Forest views were widely regarded as highly desirable, opinions on Urban views varied more widely. This discrepancy was further explored with regard to space function, indicating somewhat higher importance ratings for both view types in Waiting rooms compared to Hotel rooms. This might imply a greater receptivity to views in Waiting rooms, possibly influenced by generally lower privacy concerns in such spaces. However, these results should be interpreted with caution, as other variables may also play a role.

Discrepancies between expected and realized privacy levels often lead to occupant dissatisfaction and may necessitate modifications to achieve desired privacy and views. However, such modifications, like adjusting window blinds, can have adverse effects on occupants' psychological and physiological well-being, restricting access to views and daylight essential for health and well-being. Thus, variables such as space function and view type must be carefully considered during the design of built spaces.

CHAPTER 4

THE INFLUENCE OF FAÇADE DESIGN ON PERCEPTION

The performance of solar screens in the built environment is well-documented in the context of energy use, thermal comfort, and visual comfort. The solar screen system in hot climates, the veranda roof pattern in Iranian architecture, and Persian geometric patterns have demonstrated significant improvements in the energy efficiency of buildings (Elzeyadi 2017; Rezaian et al. 2014; N. Emami, A. Khodadadi, and P. V. Buelow 2014). In residential settings, these screens effectively reduce solar heat gains and boost energy performance (Elzeyadi 2017). Furthermore, design details such as perforation size and depth have been proven to affect daylighting and energy efficiency significantly, showcasing the functional value of these screens beyond aesthetics (Sherif, Sabry, and Rakha 2012). However, there's a gap in understanding how these design factors influence the perceptions of indoor occupants, particularly concerning privacy.

Patterned solar screens serve a dual purpose in traditional architecture: ensuring privacy and allowing views. Historically, architectural scholars have celebrated these screens also known as Mashrabiyas, for their clever design that allows for selective visibility without compromising seclusion (Kenzari and Elsheshtawy 2003; Babaei, Soltanzadeh, and Islami 2013; Alelwani, Ahmad, and Rezgui 2020). Their intricate geometric patterns not only offer aesthetic charm but also influence modern façade design. Despite this historical significance, contemporary research on these screens focuses more on their environmental benefits rather than the subjective experience of privacy they provide to occupants. While earlier studies recognize the role of solar shading in enhancing privacy (Littlefair 2018), the majority of the research emphasizes their function in glare reduction and solar heat gain management (Elzeyadi 2017; Chi, Moreno, and

Navarro 2017; Grobman, Capeluto, and Austern 2017). Moreover, the prevalent focus has been on internal shading devices within shared office environments (Reinhart and Voss 2003a; Inkarojrit 2005b; Foster and Oreszczyn 2001b), which means the impact of external shading and its varied typologies on privacy perception remains under-investigated.

This oversight suggests an opportunity for further research. As patterned screens are integrated into contemporary architectural designs, it is crucial to comprehensively study their impact not just on environmental sustainability but also on the nuanced perceptions of privacy they create for building occupants. This calls for a new focus in research that explores the full potential of these screens in modern applications.

4.1. Methodology Overview

The third experiment, building on the findings presented in Chapter 2, probes the influence of façade design on perception. Here, façade design is specifically about the use of solar screens as shading devices for windows. There have been multiple recent studies examining the influence of shading systems on the experience of indoor spaces and occupants (Chamilothori 2019; Chamilothori et al. 2019; Abboushi et al. 2021). The focus was to examine how design elements like pattern, orientation, occlusion percentage, and the style of the pattern affect the occupant's perception of privacy, view quality, and overall satisfaction indoors. The experiment aimed to understand the role of façade design in shaping indoor perceptions, especially concerning privacy and satisfaction. It sought to answer questions related to the impact of solar screen patterns on privacy and view, how occlusion percentages influence these perceptions, which pattern types enhance views, and how traditional Mashrabiya patterns compare to contemporary designs in shaping these perceptions.

To investigate these questions, two primary sets of screen patterns were developed, drawing inspiration from solar screen precedents. The first set featured grid patterns with both horizontal and vertical elements, as shown in Figure 20. The second set consisted of linear patterns with only vertical elements, as depicted in Figure 21. The vertical patterns and grid patterns were chosen to represent different stratifications of the view. Vertical patterns create a vertical stratification of the view plane, while grid patterns provide both horizontal and vertical stratification. These varying stratifications were selected to examine their impact on the perception of views and privacy.

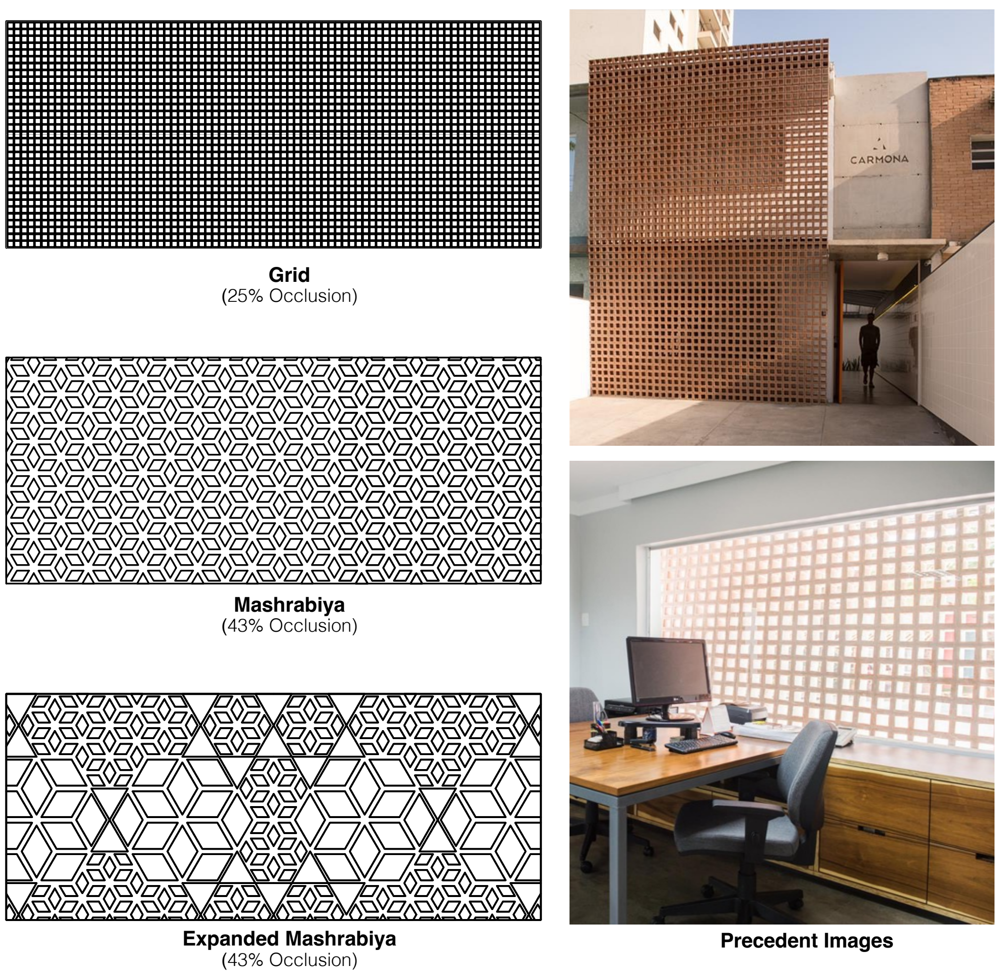

Figure 20. Grid patterns tested and precedent solar screens used to develop them

Precedent Image Source (“C A R A + Co. Studio on Instagram: 2024)

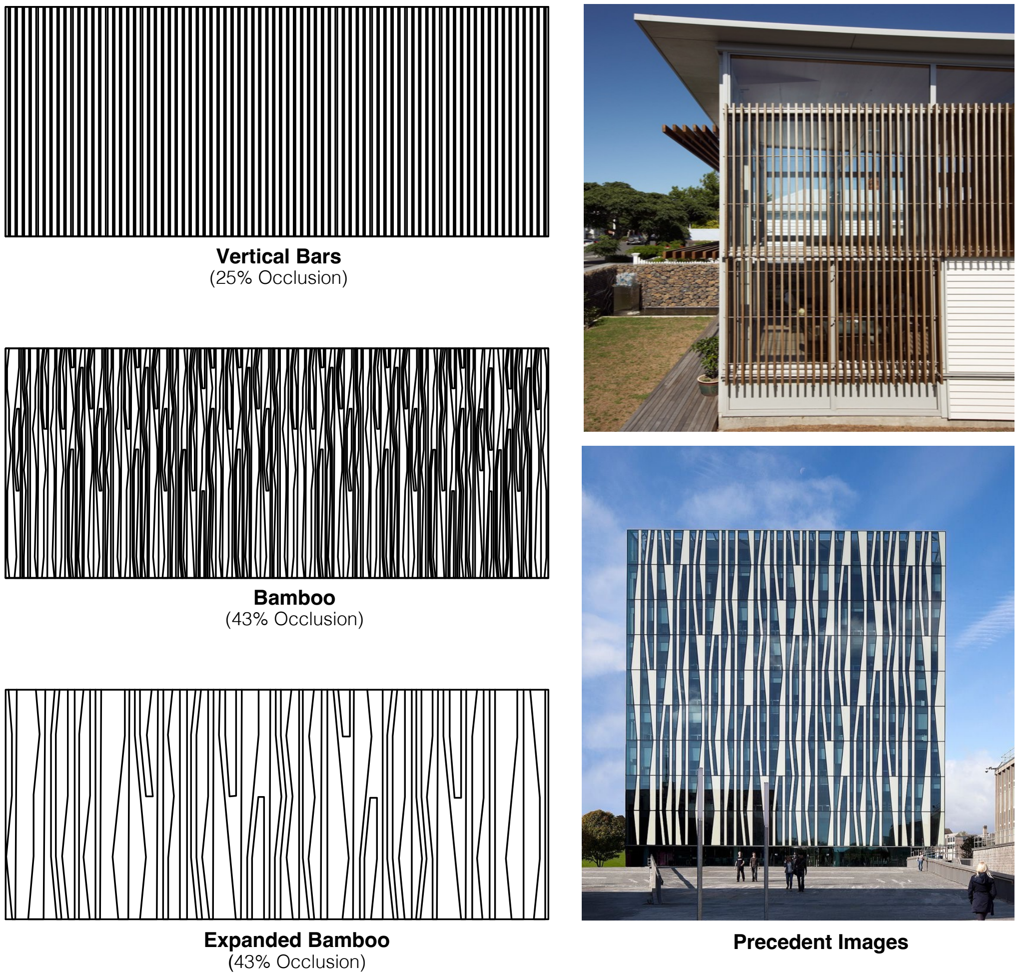

Figure 21. Linear patterns tested and precedent solar screens used to develop them

Precedent Image Source ("Mountain View," n.d.; "University of Aberdeen New Library / Schmidt Hammer Lassen Architects | ArchDaily," n.d.)

The 'Grid' and 'Vertical Bars' patterns were symmetrical with uniform apertures. The 'Mashrabiya' and 'Bamboo' patterns introduced slight organic variations in aperture size and distribution. Lastly, the 'Expanded Mashrabiya' and 'Expanded Bamboo' patterns featured highly organic variations, with considerable diversity in aperture size and arrangement. Figures 20 and 21 illustrate the six-screen patterns examined in this study.

Following the methodology of experiments one and two, the research targeted a diverse participant pool of 120 individuals. Participants in the study were distributed across various age ranges as follows: 51 participants were aged 18 to 25, 48 participants were aged 26 to 35, 10 participants were aged 36 to 45, 5 participants were aged 46 to 55, 3 participants were aged 56 to 65, and 3 participants were aged over 65. Among these participants, 50 identified as male, 65 as female, and 5 as non-binary. All participants were affiliated with the University of Oregon and had a UO account and email ID to ensure the authenticity of participants.

Recruitment efforts focused on the University of Oregon's academic community, employing a multifaceted outreach strategy including promotional posters and targeted announcements during lectures. Participants accessed the survey via QR codes displayed on posters and received a standard $5 Amazon gift voucher as compensation, sent to their official university email address after completion of the survey. To uphold privacy considerations, the study protocol strictly prohibited the collection of personally identifiable information. The research design and methods received thorough review and approval from the Institutional Review Board (00000309) at the University of Oregon, ensuring compliance with ethical standards.

To accommodate various experimental conditions, the sample was evenly distributed across four distinct survey configurations, each engaging 30 unique participants. The surveys incorporated computer-generated 2D navigable panoramic images, simulating virtual architectural spaces, paired with subjective questions. This approach aimed to assess the influence of screen pattern design, view types, and space functions on occupants' perceived importance for privacy, view, and overall contentment with the indoor environment as seen in Figure 22.

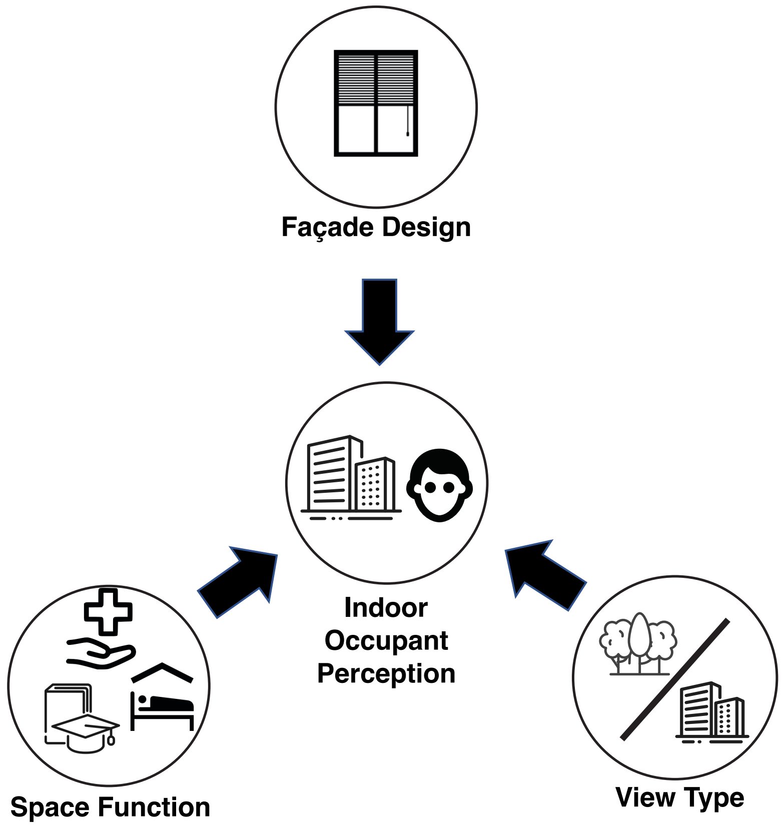

Figure 22. Environmental, contextual, and façade design factors examined in Experiment 3

To establish realistic and relatable contexts, virtual spaces were rendered to represent two distinct spatial functions: a 'Hotel Room' and a 'Waiting Room.' The hotel room model simulated a private space, tailored for individuals or pairs with a close personal connection, thus reflecting a heightened expectation of privacy. Conversely, the waiting room model depicted a transient space accommodating a broader range of individuals, typically one to six, with no personal affiliation, representing a more public setting with lower privacy expectations.

Each space (Hotel and Waiting room) was rendered with one of two window views: an 'Urban view' and a 'Forest view', as depicted in Figure 23.

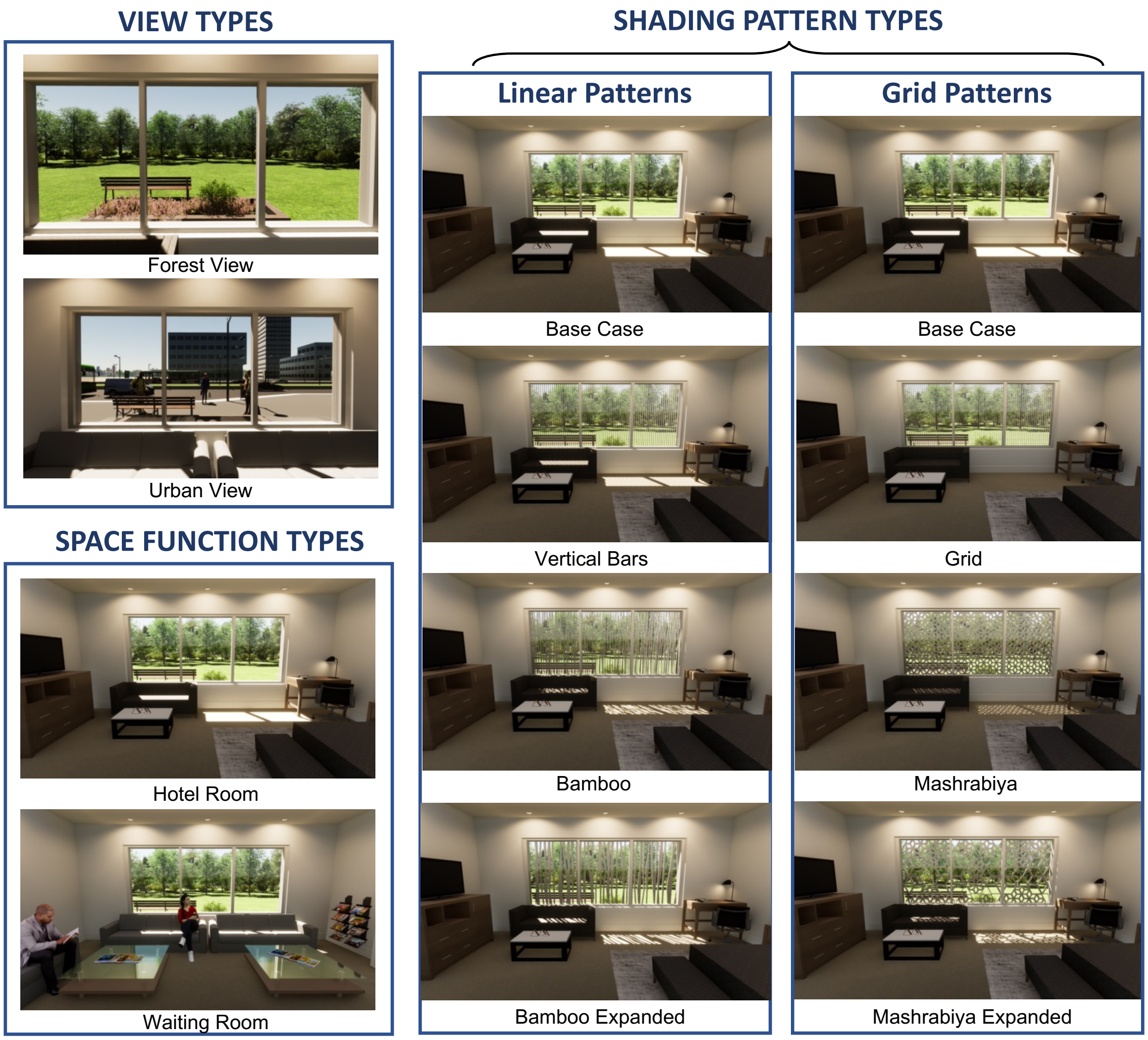

Figure 23. Visual representation of study variables

The 'Urban view' depicted a moderately dense urban environment with elements such as a wooden bench, planter box, sidewalks, and people (standing/walking) in the foreground, and buildings in the background. The 'Forest view' featured a lawn surrounded by dense tree cover, with a wooden bench and planter box in the foreground. While both views maintained consistent intermediary layer proportions between the foreground, background, and sky, they were deliberately designed to not be 'high quality' views.

Four virtual environments were created, pairing each space function with both types of views to fabricate distinct scenarios:

- Hotel Room with a Forest View
- Hotel Room with an Urban View
- Waiting Room with a Forest View
- Waiting Room with an Urban View

These were further categorized into two primary view-based groups: those with forest views and those with urban views. Each group was then visually modified with two sets of solar screen patterns: Linear and Grid patterns, resulting in four specialized versions of the survey for systematic evaluation. The survey design was structured into eight sections, each containing images and questions presented in a randomized order to participants. A page within the survey typically showcased the written description of the space's intended functional use, followed by the navigable panoramic 2D images of the architectural setting as depicted in Figure 24. After viewing a series of images, participants engaged with a questionnaire comprising four statements aimed at assessing their perceptions of the virtual environments. These statements were meticulously crafted to capture participants' judgments, taking into account both visual and textual descriptions. Participants were instructed to rate their agreement with each statement using a bipolar Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), with 3 indicating a neutral stance.

The statements presented were as follows:

- 'The window shading condition enhances the view.'
- 'The window shading condition provides adequate privacy from the outdoors.'
- 'This window shading condition suits the purpose of the room.'
- 'Considering the window shading condition and function of the space, I would be comfortable using this space.'

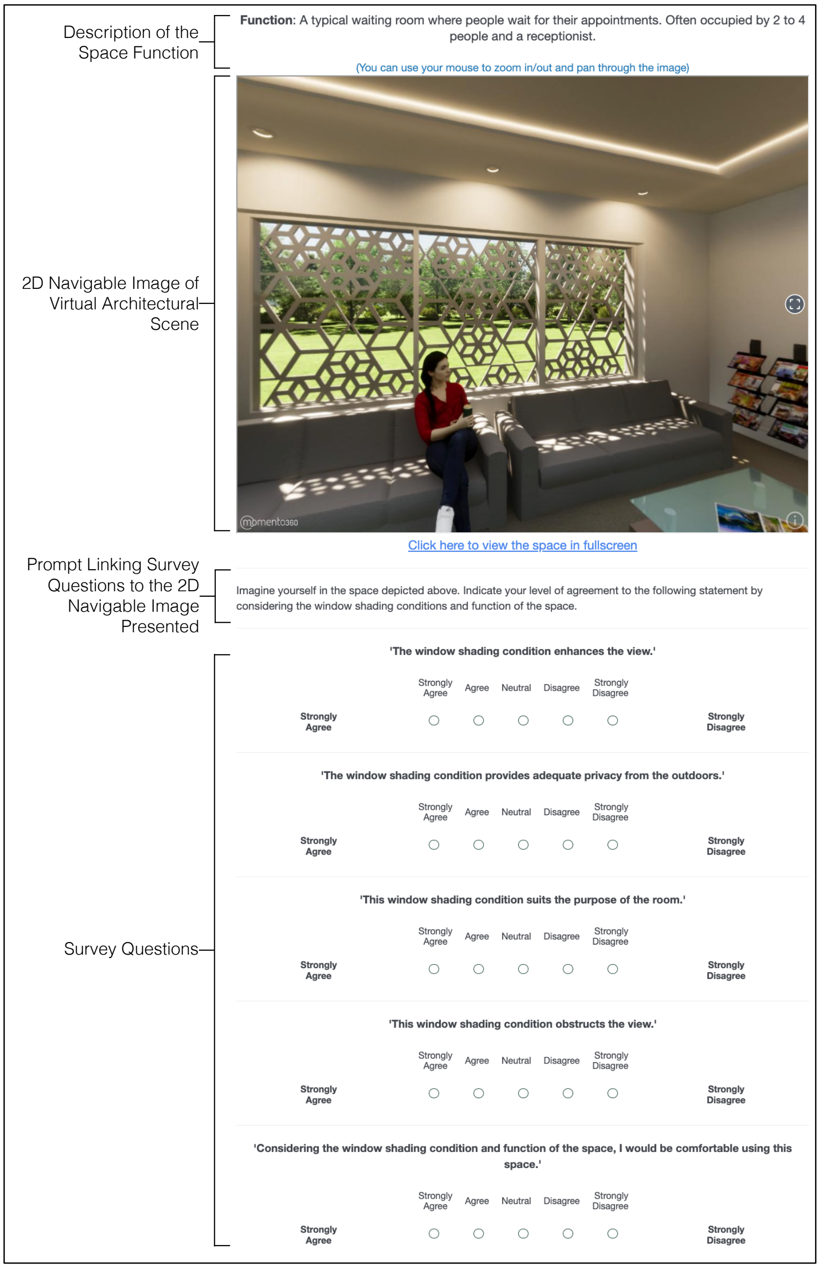

Figure 24. Typical survey page

To assess the influence of screen patterns, types of views, and space functions on occupants' perceptions of privacy, views, compatibility, and satisfaction; the responses to the four questions were converted into numerical Privacy Scores (PS), View Scores (VS), Compatibility Scores (CS), and Satisfaction Scores (SS). The magnitude of the numeric score is indicative of how well the screen pattern is able to contribute to the perception of the specific attribute; for example, a low Privacy score of 1 indicates that the screen pattern is inefficient at providing indoor occupants with privacy in relation to the outdoors, whereas a high score of 5 indicates that it addresses the privacy needs of indoor occupants very well. Therefore, a high score indicates a high degree of presence of the ‘attribute’ whereas a low score indicates a low degree of presence of the ‘attribute’ in relation to the screen patterns and perceptions.

4.2. Perception of View to Screen Pattern Types

Responses to the statement "The window shading condition enhances the view" were evaluated through View Scores (VS) and are illustrated in Figure 25, organized by screen pattern types, view types, and space functions. Firstly, a Wilcoxon signed-rank test with continuity correction was conducted to perform pairwise comparisons of View scores between Forest View and Urban View for each pattern type. This non-parametric test was selected because the data was not normally distributed. The results indicated no significant impact of view type on View scores for all pattern types, except for the Bamboo pattern in the Waiting Room Space function, where a significant difference was observed with a p-value of 0.006. Next, the data analysis employed the Kruskal-Wallis Rank Sum Test to compare view scores across different contexts and screen patterns as the data was not normally distributed.

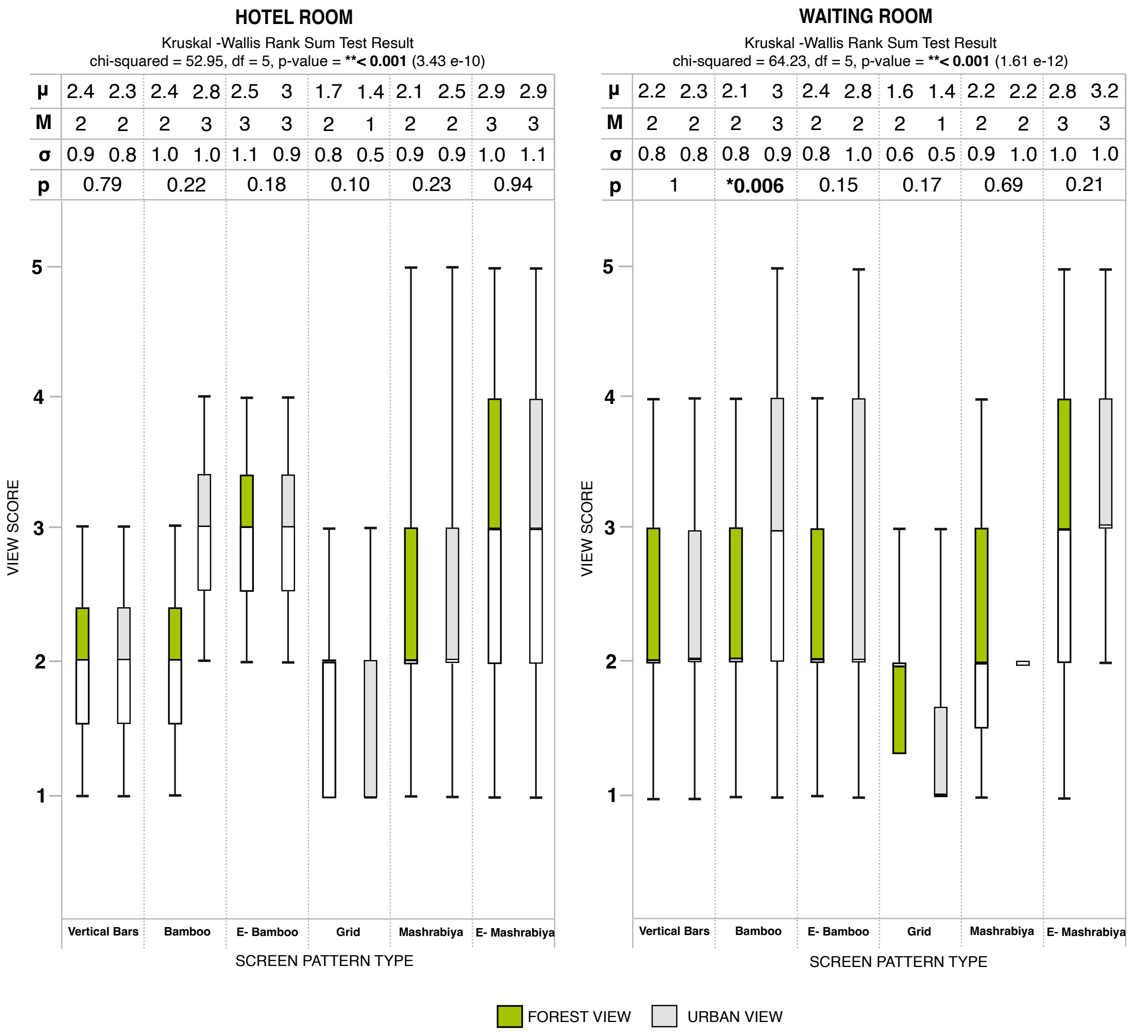

Figure 25. View score distribution

Disparities were observed in View Scores between hotel and waiting room contexts, indicating that the purpose and environment of a room influence how occupants perceive the value of views. In hotel rooms, the view scores for various screen types, whether for forest or urban views, generally showed no significant differences, suggesting that the type of view minimally impacts occupants' valuation of their surroundings. However, the bamboo pattern stood out, scoring higher in urban settings. This preference could be attributed to its design, which complements the vertical features of urban architecture, thus potentially enhancing the view. This hypothesis is supported by a statistically significant Kruskal-Wallis test result, which yielded a chi-squared value of 52.95 with 5 degrees of freedom and a p-value < 0.001 (3.43e-10), indicating strong statistical evidence that not all screen types perform equally in enhancing views in hotel rooms. Other patterns, such as the expanded Mashrabiya, showed a broader range of scores, suggesting a split in participant preferences. These divergences highlight the sensitivity of occupants to design elements in relation to their environment.

In waiting rooms, the variability in view scores was more pronounced, indicating a stronger link between the type of view and the perceived effectiveness of screen patterns in enhancing views, particularly in urban settings. The bamboo and expanded bamboo patterns displayed tighter score distributions in forest settings, whereas urban views showed greater score dispersion. This variability suggests a lack of consensus among occupants about which designs best enhance urban views. Conversely, the expanded Mashrabiya pattern consistently received high scores across different views and functions, suggesting that its design might transcend the specific influences of view type. This interpretation is further validated by a Kruskal-Wallis test result in waiting rooms, showing a chi-squared value of 64.23 with 5 degrees of freedom and a p-value <0.0001 (1.61e-12), confirming differences in how various screen patterns are perceived in different settings. The grid pattern's consistently low scores across both contexts may reflect its role in creating a more enclosed experience, minimizing outdoor views, and fostering an inward-focused atmosphere. These results highlight diverse design preferences: screen patterns with larger openings (yielding higher scores in forest views) are preferred for their connection to nature, while denser patterns (resulting in lower scores in urban views) are favored for their ability to mitigate urban visual noise. The evidence suggests that the purpose and environment of a room influences how occupants perceive the value of views, with design elements playing a crucial role in this perception.

4.3. Perception of Privacy to Screen Pattern Types

Responses to the statement "The window shading condition provides adequate privacy from the outdoors" were analyzed, yielding Privacy Scores (PS) as depicted in Figure 26. Data were categorized based on screen pattern types, view types, and space functions to clarify the influence of these variables on perceived privacy. A higher PS indicates a greater perceived level of privacy by indoor occupants.

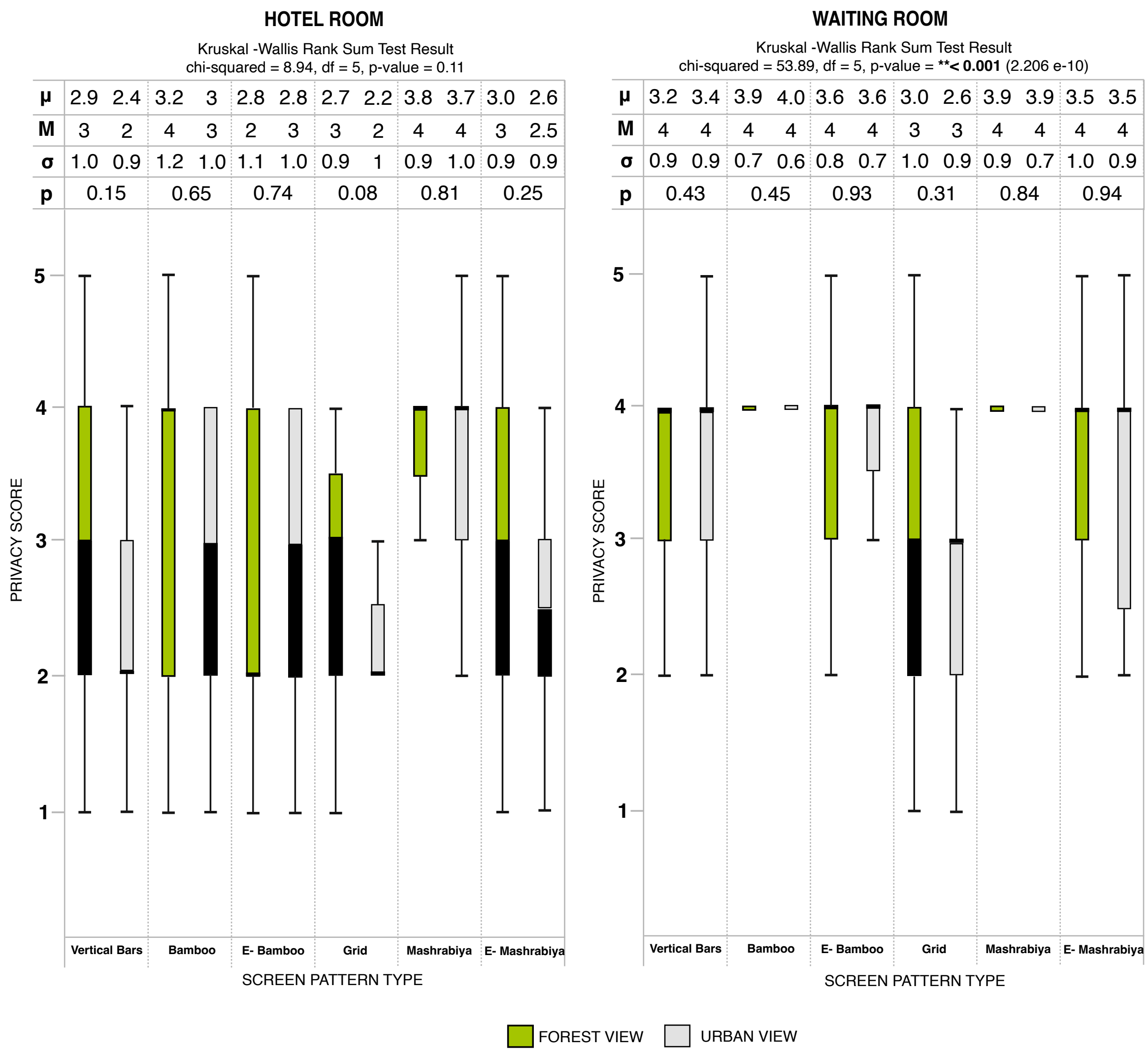

Figure 26. Privacy score distribution

Analysis of Privacy scores reveals significant variations in privacy scores based on the pattern type, supported by statistical testing. Firstly, a Wilcoxon signed-rank test with continuity correction was conducted to perform pairwise comparisons of Privacy scores between Forest View and Urban View for each pattern type. This non-parametric test was selected because the data was not normally distributed. The results indicated no statistically significant differences in Privacy scores between Forest view and. Urban view for all pattern types. Next, it was observed that waiting rooms consistently scored higher in privacy across all screen patterns compared to hotel rooms. This suggests that waiting areas might naturally impose a heightened sense of privacy due to their specific functional requirements. This finding is statistically substantiated by a Kruskal-Wallis test in the waiting room context, which yielded a chi-squared value of 53.89 with 5 degrees of freedom and a p-value <0.0001 (2.206e-10), indicating strong statistical evidence of significant differences in privacy perceptions across different screen patterns in waiting rooms.

Conversely, in hotel rooms, the Kruskal-Wallis test resulted in a chi-squared value of 8.94 with a p-value of 0.11, suggesting no significant differences in privacy scores across screen patterns. This indicates more uniform privacy perceptions among hotel occupants, perhaps due to a universally moderate expectation of privacy regardless of the screen pattern used.

Bamboo and Mashrabiya patterns scored highly in privacy and displayed a narrow distribution in waiting rooms, underlining their effectiveness in conveying privacy in such settings. However, their performance varied in hotel rooms, with lower scores and a wider distribution, possibly reflecting a lesser concern with external privacy breaches. This aligns with the overall finding that hotel room occupants have uniform privacy expectations across various screen patterns. Symmetrical patterns like grids and vertical bars, which tend to blend with the background, captured less attention from indoor occupants compared to more organic patterns. In contrast, organic versions of symmetric patterns, such as bamboo and Mashrabiya, consistently scored higher across all space functions and view types, showcasing their ability to provide a perception of privacy compared to more regularized patterns.

This analysis underscores the influence of screen patterns, space function, and view types on indoor occupants' perception of privacy in the built environment. The evidence from the Kruskal-Wallis tests highlights the particularly strong impact of space function on privacy perceptions, especially in waiting rooms where the need for privacy is more pronounced and consistently met by specific patterns.

4.4. Compatibility of Screen Pattern Types

Responses to the statement "This window shading condition suits the purpose of the room" were quantified through a Compatibility Score (CS), with data categorized by screen pattern type, view type, and space function, as depicted in Figure 27.

The higher the CS, the more strongly indoor occupants believe that the screen pattern aligns with the room's purpose, given the view type and space function. Firstly, a Wilcoxon signed-rank test with continuity correction was conducted to perform pairwise comparisons of Compatibility scores between Forest View and Urban View for each pattern type. This non-parametric test was selected because the data was not normally distributed. The results indicated no statistical impact of view type on Compatibility scores for all pattern types.

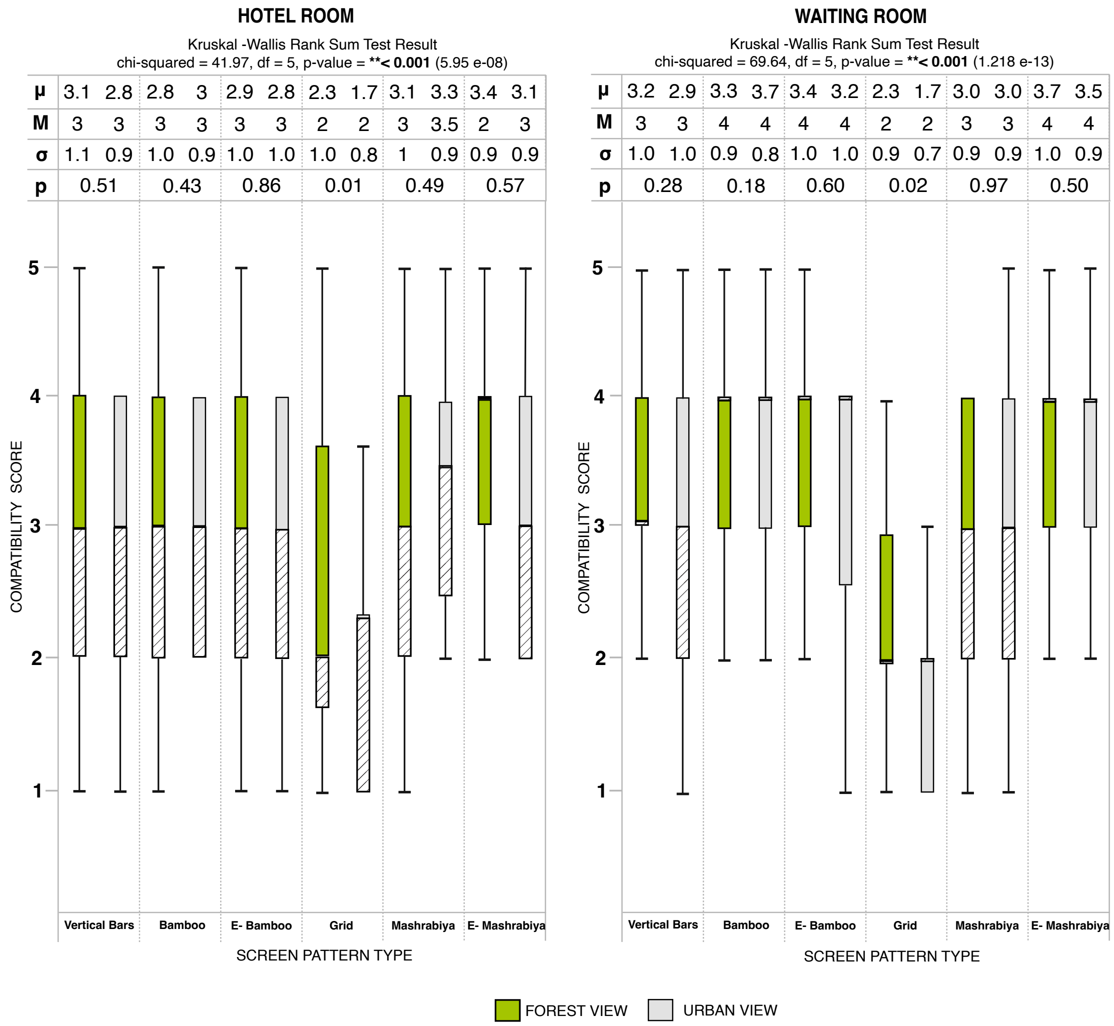

Figure 27. Compatibility score distribution

In hotel rooms, the Kruskal-Wallis Rank Sum Test indicates significant variability in compatibility scores across different screen patterns, with a chi-squared value of 41.97, 5 degrees of freedom, and a p-value < 0.0001 (5.95e-08). This statistical evidence suggests that while some patterns are viewed as highly compatible across various settings, others differ in perceived suitability. Most screen patterns showed minimal variation in their scores, indicating a general perception of their adaptability for both forest and urban views, regardless of the room's function. This suggests these patterns are versatile and may be regarded as universally adaptable to various room settings. Grid patterns, however, received the lowest CS across all patterns, view types, and space functions, implying that they are less favored by occupants and may not meet their preferences for window shading in hotel settings.

Similarly, in waiting rooms, the statistical analysis revealed significant differences in compatibility scores between screen patterns with a Kruskal-Wallis test result of a chi-squared value of 69.64, 5 degrees of freedom, and a p-value < 0.0001 (1.218e-13). Bamboo patterns rated significantly higher in waiting rooms compared to hotel rooms for both view types, suggesting their particular suitability for waiting room environments. This highlights their effectiveness and preference in contexts where a calming or more natural aesthetic may be valued. The expanded Mashrabiya pattern stood out with the highest CS across all view types and space functions, signaling its status as a universally compatible screen pattern. This pattern is seen as flexible enough to be employed across a broad spectrum of space functions and view types, indicating its design excellence and broad applicability.

The statistical evidence from the Kruskal-Wallis tests underscores the impact of screen pattern types on the perceived compatibility with room functions in both hotel and waiting room settings. These results highlight diverse design preferences and the importance of selecting screen patterns that align with the specific environmental and functional needs of different room types.

4.5. Perception of Satisfaction with Screen Pattern

Participants' responses to the statement "Considering the window shading condition and function of the space, I would be comfortable using this space" were quantified as a Satisfaction Score (SS). The distribution of SS for each screen pattern type, organized by view types and space function, is depicted in Figure 28.

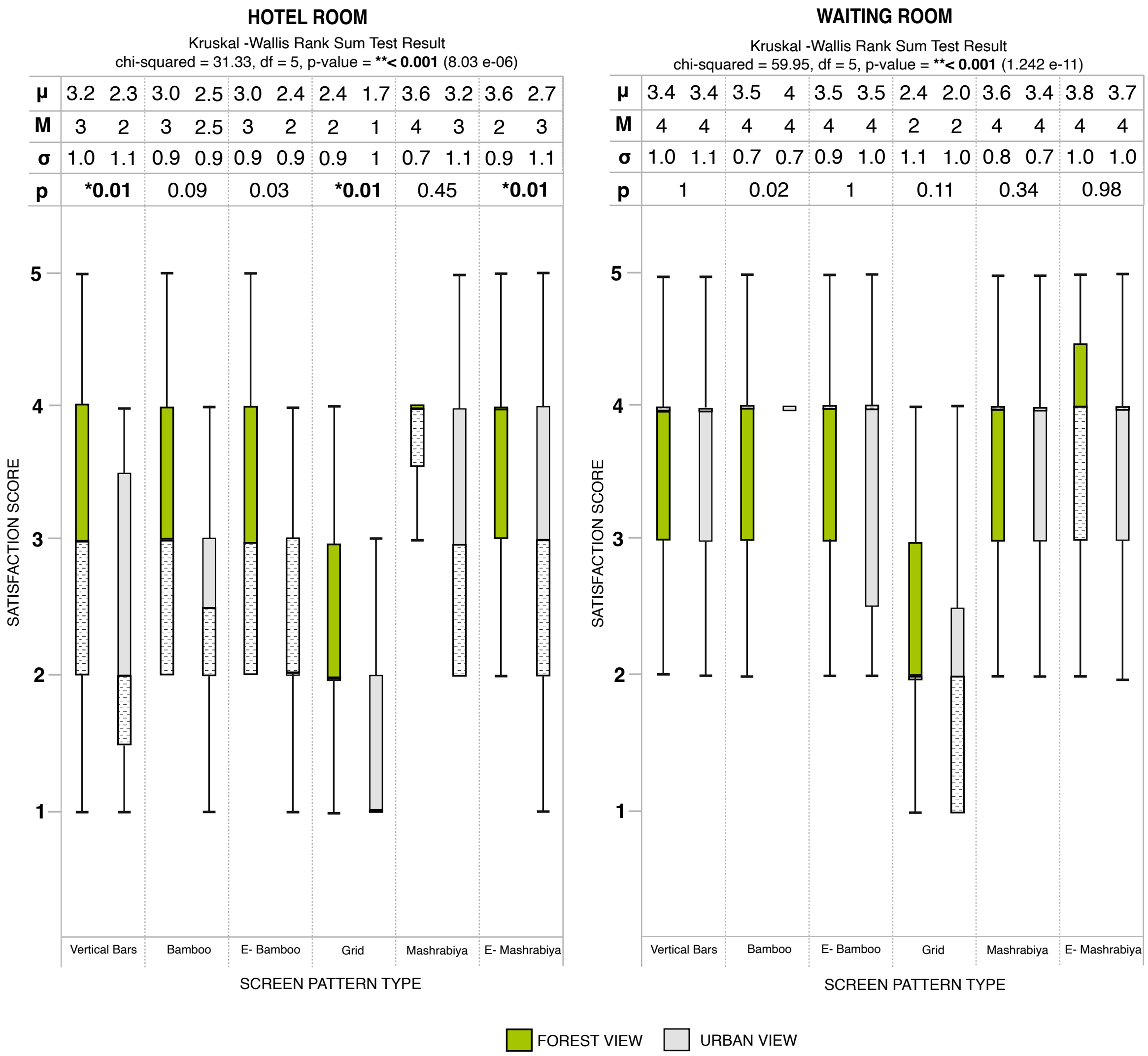

Figure 28. Satisfaction score distribution

The higher the SS, the greater the occupants' perception of Satisfaction. Firstly, a Wilcoxon signed-rank test with continuity correction was conducted to perform pairwise comparisons of Satisfaction scores between Forest View and Urban View for each pattern type. This non-parametric test was selected because the data was not normally distributed. The results indicated no statistically significant differences in Satisfaction scores for all pattern types in Hotel Room and Waiting room, except for the Vertical bars, Grid and Expanded Mashrabiya in the Hotel Room space function, where a significant difference was observed with a p-value of

0.01. Further analysis using the Kruskal-Wallis Rank Sum Test reveals significant differences in satisfaction scores that are influenced by both the space function and the type of view. In hotel rooms, the statistical results indicated a chi-squared value of 31.33 with 5 degrees of freedom and a p-value of less than 0.001 (8.03e-06), which confirms significant variability in satisfaction scores across different screen patterns.

In waiting rooms, the Kruskal-Wallis test showed a chi-squared value of 59.95, also with 5 degrees of freedom, and a p-value < 0.0001 (1.242e-11), highlighting even more pronounced differences in satisfaction scores across screen patterns than observed in hotel rooms. This suggests that screen patterns play a more critical role in the waiting room environment, potentially due to heightened awareness of shared space and privacy needs by occupants. Unlike in hotel rooms, the type of view (forest vs. urban) seems to have minimal impact on satisfaction in waiting rooms. The grid pattern emerged as the least favored, receiving the lowest satisfaction scores across both space functions and view types, particularly in urban settings where its performance was notably poorer. This trend suggests that grid patterns may be less effective at meeting the aesthetic or functional needs of occupants in these environments. Conversely, the Mashrabiya and Expanded Mashrabiya patterns consistently achieved high satisfaction scores across all view types and space functions, indicating that these patterns provide a high level of satisfaction and are preferred by occupants. Their design and the privacy they offer might contribute to their favorable reception. The statistical evidence from the Kruskal-Wallis tests substantiates that the satisfaction derived from different screen patterns is influenced by the space's function. These findings underscore the necessity for thoughtful selection of screen patterns to align with the specific preferences and expectations of space users, particularly in environments where function and aesthetic value are important.

4.6. Impact of Occlusion Percentage on Perception

To delve deeper into the influence of screen pattern design on indoor occupant perception, screen patterns were categorized based on their occlusion percentage, and their View Scores and Privacy Scores were compared against a base case, as illustrated in Figure 29. The hypothesis proposed a linear relationship between occlusion percentage and privacy perception and an inverse relationship with view access perception. Screen patterns were grouped into three categories: 0% occlusion for the base case (no window screen), 25% occlusion for the 'Vertical Bars' and 'Grid' patterns, and 43% occlusion for the regular and expanded versions of the 'Mashrabiya' and 'Bamboo' patterns.

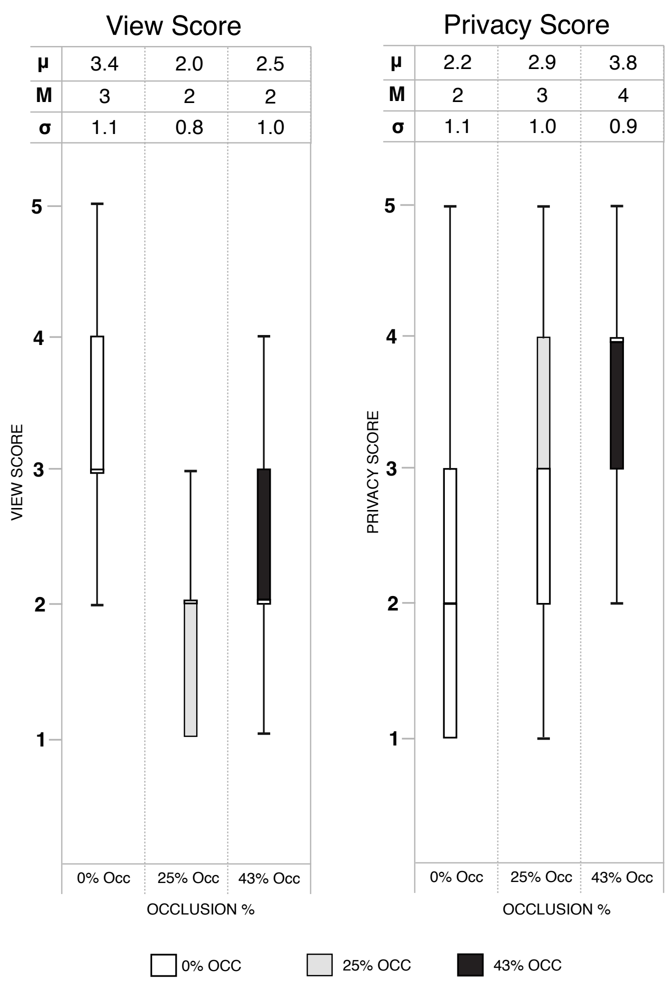

Figure 29. Relationship of occlusion percentage with view and privacy scores for screen patterns

The Friedman test was conducted to evaluate differences in perceived view quality across the three occlusion percentages. The results indicated a statistically significant difference in view scores across the occlusion levels, with a chi-squared value of 171.57, df = 2, and a p-value < 0.0001 (2.2e-16). This finding challenges the initial hypothesis that higher occlusion would invariably reduce view quality. Interestingly, the category with 43% occlusion exhibited higher view scores compared to the 25% occlusion category, suggesting that factors other than mere occlusion percentage, such as the design of the screen, play a clear role in influencing view perception.

Kendall's W was calculated to quantify the effect size, yielding a value of 0.41, which indicates a moderate level of agreement among participants. This suggests that while there is some consistency in how occlusion impacts view scores, individual perceptions still vary. Pairwise comparisons using the Wilcoxon signed-rank test, adjusted with the Bonferroni correction, revealed significant differences between all pairs of occlusion levels. These results affirm that different occlusion percentages distinctly affect view perceptions among indoor occupants.

Similarly, the Friedman test for privacy scores across the occlusion percentages also showed a chi-squared value of 171.57, df = 2, and a p-value < 0.0001 (2.2e-16), demonstrating a significant effect of occlusion on privacy perceptions. Higher occlusion percentages linked with increased perceptions of privacy, aligning with the hypothesis. Pairwise comparisons further supported these results, with significant differences identified between each pair of occlusion levels, indicating that increments in occlusion percentage meaningfully enhance privacy perceptions. The tight distribution of privacy scores in the 43% occlusion category compared to the more varied scores in the 25% occlusion category suggests a stronger consensus among participants about the privacy benefits of higher occlusion.

These analyses underscore the impact of occlusion percentage on perception within indoor environments. Contrary to initial expectations, higher occlusion does not necessarily detract from view quality if the screen design is appropriately considered. Moreover, the clear linear relationship between increased occlusion and enhanced privacy perception confirms the importance of considering occlusion levels when designing spaces to meet specific privacy needs. The significant statistical findings from the Friedman test and pairwise comparisons provide robust support for these conclusions, highlighting the critical role of screen pattern design in shaping indoor occupant perceptions.

4.7. Impact of Pattern Types on Perception of View

To examine the impact of pattern style on the perception of view, the patterns were categorized based on their style into Grid Patterns and Vertical Patterns, and their View Scores were compared against the base case, as seen in Figure 30. The findings highlight the influence of screen pattern types on indoor occupants' perception of views. As anticipated, the highest view scores were recorded in the base case scenario without any screen intervention. However, when comparing the view scores of Grid-based patterns to Vertical patterns, Vertical patterns exhibited notably higher view scores. This underscores the Vertical patterns' capacity to enhance view perception compared to Grid-based patterns. Interestingly, the type of view did not affect the perception of view in the Base case and Grid-based patterns, with similar view scores observed for both Forest and Urban views. However, this was not the case for Vertical Patterns, where Urban view scores surpassed Forest view scores. This difference highlights Vertical patterns' ability to further amplify view perception, particularly in Urban settings. This enhancement in Urban settings can be attributed to the visual alignment of vertical members within the screen pattern with the vertical elements present in the composition of urban views, such as buildings and streetlight poles. This alignment renders Vertical patterns more congruent with the content of urban views, thereby augmenting the overall view perception in these settings.

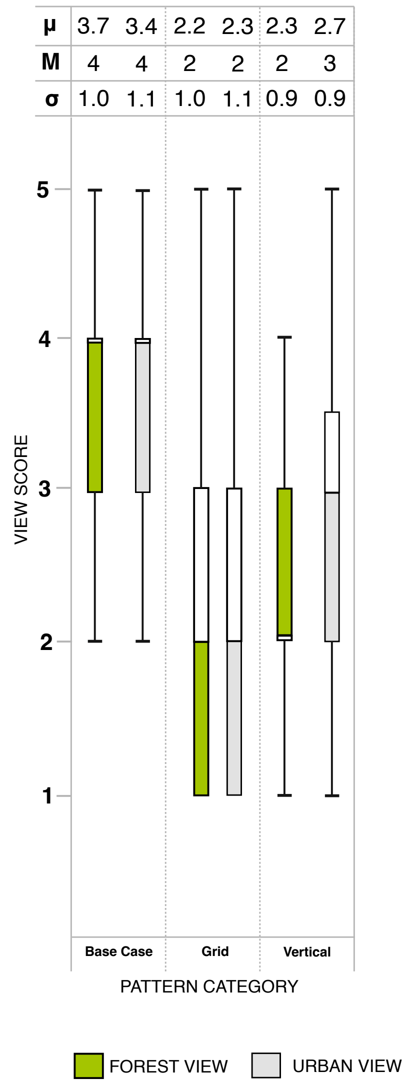

Figure 30. Comparison of view scores between grid and vertical screen patterns

The Kruskal-Wallis rank sum test indicated a statistically significant difference in view scores among the screen patterns ($\chi2(2)$=9.1842, p= 0.01). To identify specific differences between the screen patterns, pairwise comparisons using the Wilcoxon rank sum test with Bonferroni correction were conducted. The results showed no significant difference between the Base case and the Grid pattern (p=0.432), a significant difference between the Base case and the

Vertical pattern (p=0.015), and no significant difference between the Grid pattern and the Vertical pattern (p=0.186). These findings suggest that the Vertical pattern leads to different perception of views compared to the Base case, while the Grid pattern does not significantly differ from either the Base case or the Vertical pattern.

4.8. Perception of View and Privacy as per Screen Pattern Type.

As a secondary stage of analysis, the View scores and Privacy scores of each screen pattern, including the base case, were compiled and depicted in Figure 31.

μ	3.4	1.8	2.4	3.1	2.7	3.6	2.7	3.3	1.6	2.7	2.3	3.9	3.1	3.2
M	4	2	2	3	3	4	2	4	1	2	2	4	3	3
σ	1.1	0.8	0.8	1.0	1.0	1.0	1.0	1.0	0.6	1.0	1.0	0.9	1.0	1.0
p	0.8		1.0		0.9		0.5		0.9		1.1		1.1	

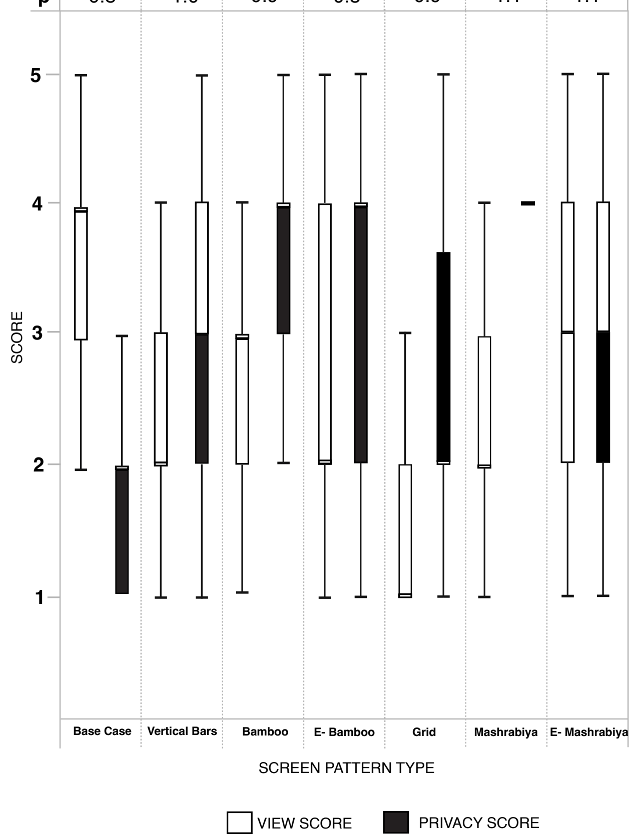

Figure 31. Privacy and view scores for all screen patterns tested

The aim was to identify screen patterns capable of striking a balance between privacy and view, thereby offering indoor occupants a sense of privacy without compromising on view access.

As anticipated, the most difference between View and Privacy scores was observed in the Base case, with an average View score of 3.4 and a Privacy score of 1.8. Interestingly, the expanded versions of organic patterns such as 'Mashrabiya' and 'Bamboo' exhibited equally high scores for both privacy and view. This underscores their effectiveness in providing indoor occupants with a blend of privacy and view. However, upon closer inspection, the regular organic patterns 'Mashrabiya' and 'Bamboo' showcased higher privacy scores than view scores, indicating their ability in providing a sense of privacy but falling short in enhancing view access. The tight distribution of privacy scores for 'Mashrabiya' underscores their effectiveness in ensuring privacy perception with minimal variation. In contrast, the regular Grid pattern performed inadequately in both view and privacy scores, emerging as the least efficient pattern in providing either a sense of privacy or view enhancement. Similarly, Vertical Bars also displayed poor performance, with low privacy and view scores, albeit slightly higher than those of the Grid pattern. The analysis highlights the inadequacy of regular patterns such as Grid and Vertical Bars in providing adequate privacy or view enhancement. Conversely, regular organic patterns provide a sense of privacy but fall short in enhancing views. On the other hand, Expanded Organic patterns such as Expanded Mashrabiya and Expanded Bamboo emerge as highly efficient options, effectively delivering both privacy and enhanced views, thus offering a balanced environment for indoor occupants.

4.9. Overview of Window screen patterns and perception.

In order to provide a comprehensive assessment of the impact of screen patterns on indoor occupant perception, Privacy Scores (PS), View Scores (VS), Compatibility Scores (CS), and Satisfaction Scores (SS) were compiled and depicted in Figure 32.

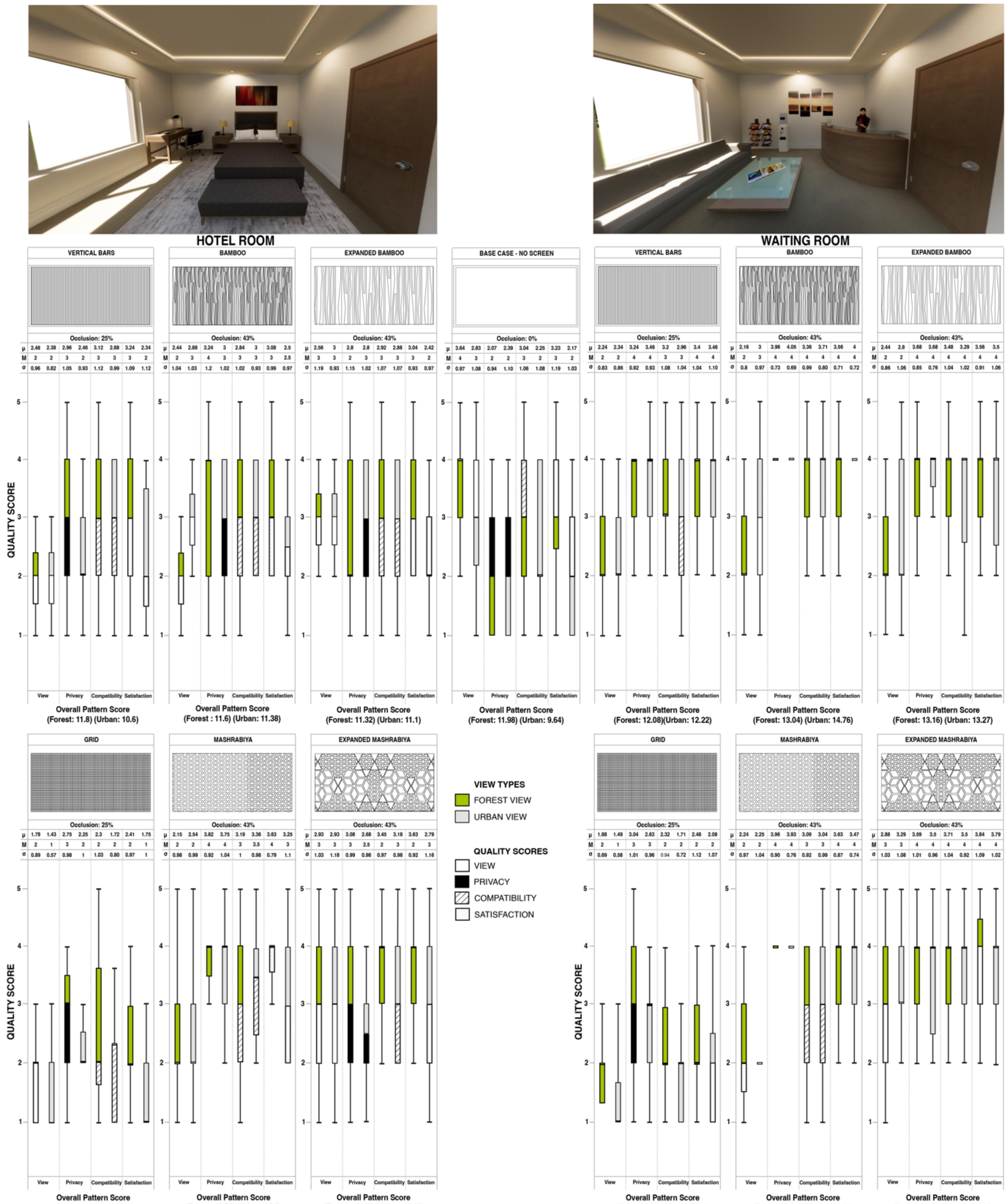

Figure 32. Summary of view, privacy, compatibility, and satisfaction scores for screen patterns

To offer an overall evaluation, two composite scores were devised for each screen pattern:

Overall Pattern Score for Forest view (OPS-F) and Overall Pattern Score for Urban view (OPS-U). The OPS-F and OPS-U allow for a comprehensive evaluation of how screen patterns are perceived, with differences between these scores indicating the influence of view type on perception. A higher score indicates greater suitability of a screen pattern for a particular view type. The initial examination of the base case revealed a clear disparity between OPS-F and OPS-U, with OPS-F consistently higher. This aligns with previous findings demonstrating indoor occupants' preference for Forest views over Urban views (Satumane and Rockcastle, n.d.).

Analyzing the Overall Pattern scores across different view types and space functions reveals a discernible pattern. In hotel room settings, OPS-F tends to be higher than OPS-U for most screen patterns, while the reverse is observed in waiting room settings. This suggests that screen patterns are generally better received in hotel rooms with Forest views and in waiting rooms with Urban views. This association underscores the intrinsic compatibility between hotel rooms and Forest views, as well as waiting rooms and Urban views, with privacy playing a strong role in this dynamic.

One screen pattern that consistently exhibits a notable difference between OPS-F and OPS-U across both space functions is the 'Grid' pattern, with a difference of 2.08 in hotel rooms and 1.61 in waiting rooms, with OPS-F being higher. This indicates that 'Grid' patterns are better suited for Forest views than Urban views, reflecting their inefficacy in creating a positive perception among indoor occupants. Conversely, some of the highest OPS scores were observed in 'Expanded Mashrabiya' and 'Expanded Bamboo' patterns, regardless of view type or space function indicating that they are positively perceived by indoor occupants.

'Mashrabiya' and 'Expanded Bamboo' demonstrated similar OPS-F and OPS-U scores across both space functions, indicating their ability to provide a consistent perceptual experience for occupants, irrespective of view type or space function. This suggests the versatility and effectiveness of these patterns in meeting indoor occupants' needs and preferences.

4.10. Summary of Findings.

In this chapter, the relationship between façade design; specifically the use of patterned solar screens and their impacts on the perception of privacy, view quality, and satisfaction within indoor environments was explored. The findings offer an understanding of how various factors, including pattern complexity, occlusion percentage, and the space function and views interact to shape the perception of indoor occupants. The evidence gathered suggests that the subjective experience of privacy is influenced by the style of the solar screen patterns, with traditional designs like Mashrabiyas frequently scoring higher in privacy perception compared to their more contemporary counterparts. Notably, patterns with organic variability, such as 'Expanded Mashrabiya' and 'Expanded Bamboo,' consistently scored well across privacy, view enhancement, and overall satisfaction, highlighting their dual efficacy in maintaining seclusion while providing views.

In contrast, the lower satisfaction and compatibility scores associated with regular grid patterns underline a less favorable perception among occupants. This suggests that while such patterns may have practical benefits, their aesthetic and perceptual impacts are less aligned with occupant preferences, particularly in spaces where privacy and view quality are prioritized. The influence of occlusion percentages on perception was also evident, supporting the hypothesis of a direct relation between occlusion and privacy perception. Yet, the findings also challenged preconceived notions by revealing that screen patterns with higher occlusion percentages can, counterintuitively, yield higher view scores, emphasizing the complex nature of visual perception in architectural spaces.

Furthermore, this experiment has highlighted the context-dependent nature of these perceptions. While the 'Expanded Mashrabiya' pattern emerged as a versatile choice, suited to a variety of contexts, other patterns exhibited variable suitability depending on the specific environmental and functional context of the space. As solar screens become increasingly integrated into modern architectural designs for their environmental benefits, this research indicates a pressing need to consider their psychological and perceptual impacts as well. This study contributes to a deeper understanding of how traditional elements can be adapted for contemporary use, not only to meet environmental goals but also to enhance the human perception and experience of space. In summary, the findings highlight the potential for a harmonious balance between the utilitarian and experiential aspects of façade design, advocating for a holistic approach that integrates functionality with human-centric considerations.

Bridge

To delve deeper into the relationship between humans and the built environment, Experiment Four was meticulously devised and executed. Its aim was to broaden our understanding of this relationship, shifting from its effects on perception and subsequent environmental adaptation to assessing how indoor environmental design influences the performance of occupants.

Given that Experiment Four was conceived in the post-COVID era, it presented a unique opportunity to conduct a comprehensive human-subject study. Consequently, the subsequent chapter delves into the insights gleaned from this study, shedding light on the influence of environmental design factors on human performance within the built environment.

CHAPTER 5

THE INFLUENCE OF ENVIRONMENTAL DESIGN FACTORS ON PERFORMANCE

5.1. Background

This chapter details the results from the fourth experiment of this dissertation, advancing our knowledge of the interplay between humans and the built environment. It furthers the exploration into how design factors of the environment affect perceptions and performance of individuals indoors. Focusing on three distinct workplace settings distinguished by their layout, size, occupancy, and acoustic attributes, this experiment examined their influence on occupants' performance. With the easing of COVID-19 restrictions, human subject research was once again possible, enabling this study to incorporate direct participant involvement.

5.2. Methodology

The current investigation employed a laboratory-based experimental framework, leveraging the immersive capabilities of VR technology. Participants were immersed in carefully designed virtual ABW office environments. These virtual offices were designed to be as life-like as possible to real ABW office spaces to ensure a high degree of ecological validity. To navigate these environments, subjects were outfitted with VR head-mounted displays (Oculus Quest 2), which provided a 360-degree view of the simulated office spaces. The primary experimental task involved the administration of the Stroop Color and Word Test (Stroop Test), a well-established cognitive assessment tool. This task was selected for its robustness in measuring cognitive processing speed, and attentional capacity. Participants' performance on the Stroop Test was recorded in terms of task completion time and error rate, serving as a dual-purpose measure: firstly, as an objective indicator of cognitive performance under varying environmental conditions, and secondly, as a standardized activity that participants engaged within each office environment.

Upon completion of the Stroop Test, participants provided subjective feedback on the quality of the workspace and their performance. This was accomplished through an oral questionnaire, designed to elicit qualitative data regarding the user experience within the virtual ABW settings.

The efficiency and functionality of each ABW environment in supporting performance of focus tasks were quantified through the analysis of Stroop Test performance metrics—specifically, the speed and accuracy of task execution. This quantitative data was systematically collected and presented alongside qualitative feedback from participants. A visual depiction of the experimental procedure and data collection methodology is provided in Figure 33.

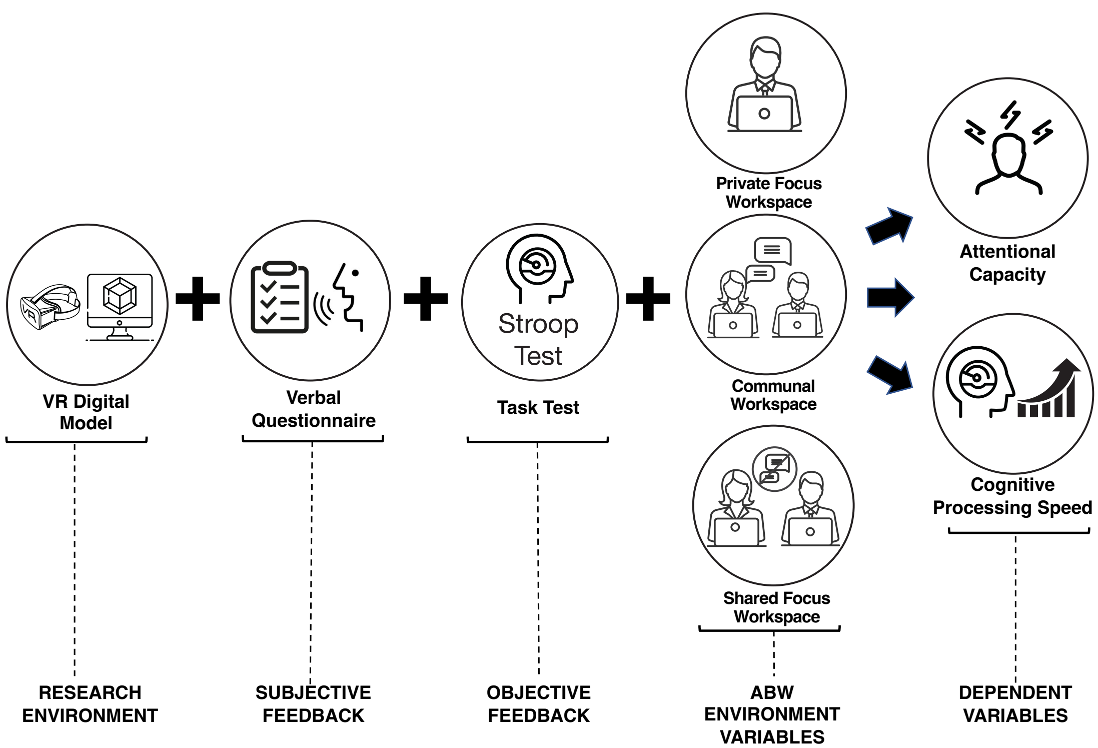

Figure 33. Schematic of research methodologies utilized

5.2.1. Participants and Recruitment

A total of 41 full-time employees were enlisted for this laboratory-based experiment from the headquarters of a multinational corporation on the West Coast. The recruitment initiative was conducted via a targeted email campaign, facilitated by the corporation's management teams to recruit potential candidates within the organization. The study's participant cohort encompassed individuals from a broad spectrum of professional disciplines, holding various roles within the corporation. Reflecting the multinational nature of the corporation, the participants represented a rich diversity of cultural and racial backgrounds. To adhere to the corporation’s strict privacy policies, sensitive personal demographic data such as age, gender, and race were not solicited or recorded.

To stimulate interest and streamline the registration process, uniform promotional materials such as digital posters and online sign-up forms were circulated through the company’s communication networks. These materials were carefully crafted to ensure consistency across departments, thereby minimizing recruitment bias. Interested employees were prompted to reserve their participation slots using an online sign-up form. Registered participants were subsequently contacted via personalized emails containing precise details of their session's location, date, and time. This direct communication was critical for ensuring that participants were thoroughly briefed and prepared for the experiment. The study protocol, identified by protocol number 00000758, was approved by the Internal Review Board at the University of Oregon, ensuring compliance with the highest ethical standards for research involving human subjects. Participation was strictly voluntary, with no compensation provided. This non-compensatory approach was strategically chosen to guarantee that participation was driven by interest, thus preserving the integrity of the data collected.

5.2.2. Study Design and Environmental Replication

This experiment explored three ABW workspace environments, specifically chosen for their prevalence in contemporary ABW office designs; to understand their impact on employee performance and experience. To standardize the experimental context for all participants, the study deployed virtual immersive architectural environments. The virtual environments were meticulously constructed to mirror their real-world ABW workspaces, ensuring that each space was accurately replicated. By opting for VR environments, the study aimed to maintain environmental and contextual uniformity for all participants. This strategic methodological choice ensured a controlled testing environment, enabling a precise evaluation of how ABW configurations influence participant behavior and cognitive performance. To create the virtual replicas, observational studies were conducted at the West Coast-based multinational corporation's headquarters. Specific ABW workspaces that exemplified the three configurations were examined in detail and various parameters, including occupancy levels, usage patterns, design elements, interior aesthetics, furniture arrangements, and the overall acoustic landscape were documented. To ensure an authentic recreation of the acoustic environments, quantitative measurements were taken at multiple points within the ABW settings. Additionally, researchers conducted qualitative assessments, categorizing the auditory stimuli into several classes: equipment noise, intelligible and unintelligible human speech, movement sounds, typing, equipment operation, and other background noise. This meticulous approach aimed to capture the complex auditory dimensions of each workspace.

5.2.3. Details of workspace configurations tested:

Open Plan Office (Open Office)

This configuration represents an open-plan office space, designed to provide individual working areas within a dynamic, team-oriented environment conducive to prolonged work periods. The architectural layout and design specifics of an Open Office are depicted in Figure 34.

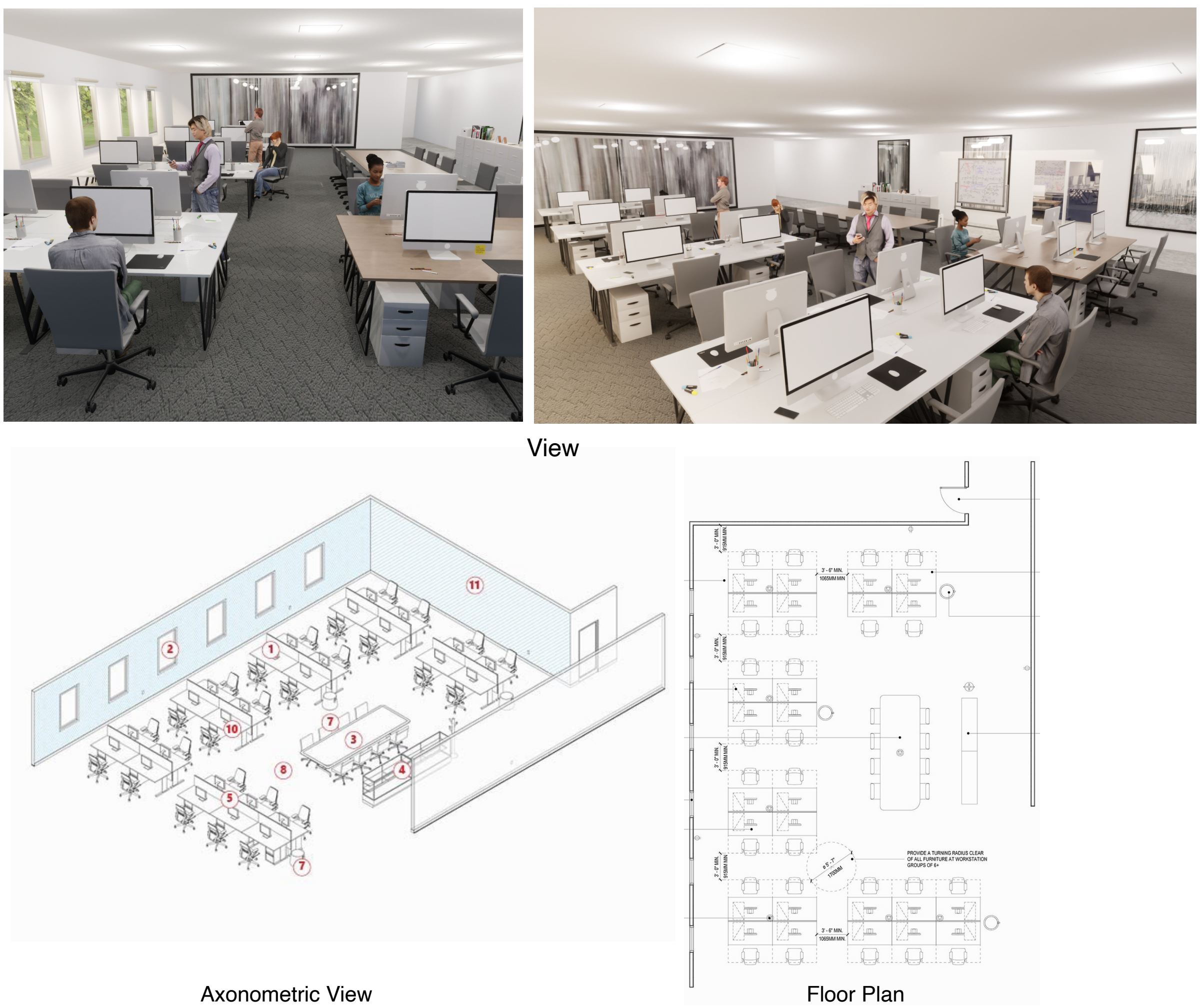

Figure 34. View, axonometric view, and floor plan of open office

It typically facilitates individual tasks in a collective setting, punctuated by sporadic collaborative interactions and impromptu discussions. The design integrates individual desks with communal amenities such as tables, whiteboards, and technological provisions for group engagements and presentations. A typical Open Office accommodates 20 to 30 individuals, corresponding to team sizes.

The Open Office's acoustic environment was characterized through in-situ observations, revealing a soundscape comprised of white noise from HVAC systems, a spectrum of human speech; both intelligible and unintelligible, and the ambient sounds of movement and typing. Sound levels in this space fluctuated between 65 and 75 decibels. To emulate this auditory environment within the study's VR simulation, a two-fold audio recording strategy was employed. Firstly, a track exemplifying typical ambient office noise was procured. Secondly, a recording of a one-sided telephone conversation was sourced. Both audio tracks were obtained from an online audio-sharing platform, ensuring they closely mirrored the observed qualitative and quantitative acoustic parameters of the open-plan office space. These recordings were then synergistically blended and integrated into the VR experience during the experimental sessions.

Individual Focus Rooms (Focus Room)

A small, enclosed office space designed for focus work and small private meetings. These rooms are designed to provide an escape from high-energy open workspaces. They are usually available for the employees on a first-come first-serve basis and can be reserved for pre-defined timeslots. The typical occupancy of Focus Rooms ranges from 1- 2 persons. The graphical representation of the space and design details is illustrated in Figure 35.

Figure 35. View, axonometric view, and floor plan of individual focus room

The Focus Room's acoustic environment was predominated by a low humming from HVAC equipment, contributing to a background white noise. Sound level measurements indicated a range of 40 to 45 decibels, reflective of a tranquil atmosphere conducive to focused work. For this study, a large meeting room was repurposed to serve as the laboratory setting. Notably, the acoustic conditions in this experimental venue naturally mirrored those documented within the focus room. This opportune similarity eliminated the need for artificial soundtracks or acoustic modifications to recreate the Focus Room's auditory environment for the experiment.

Quiet Communal Office (Quiet Offices)

A medium-sized, enclosed communal office space designed for focus work. It is designated as a quiet zone where employees work on individual tasks in a shared office space. Like the Focus Rooms, this space is designed to provide an escape from the high-energy open workspaces. However, unlike the Focus Rooms, communal focus workspaces do not require employees to make reservations to use this space and offer greater flexibility in occupancy. The typical occupancy of the shared focus space ranges from 5- 15 persons. The graphical representation of the space and design details are illustrated in Figure 36.

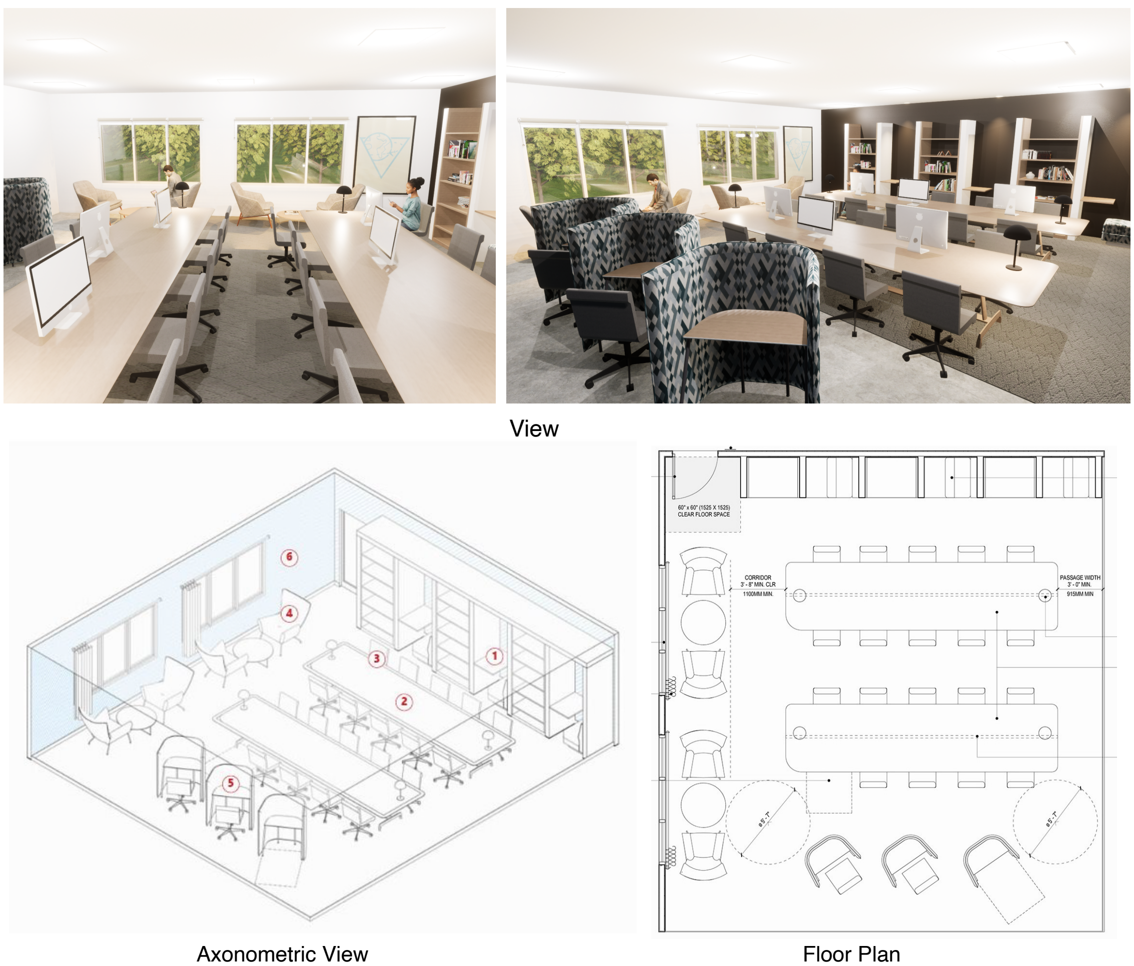

Figure 36. View, axonometric view, and floor plan of quiet offices

The acoustic profile of the Quiet Offices was characterized by an ambient blend of white noise from HVAC systems, intermittent typing, and subdued ambient office sounds. Decibel readings in this environment were recorded between 40 to 50 decibels, indicating a relatively low noise setting conducive to quiet work. For the experimental replication, the acoustic conditions of the Quiet Office space were simulated by playing a recording of ambient office noise. This recording was complemented by the intrinsic HVAC equipment noise within the testing room. The combined audio was calibrated to a consistent 45 decibels to match the observed acoustic levels of the actual office spaces, thus ensuring the authenticity of the auditory environment during testing sessions.

Cognitive Task

The Stroop Color and Word Test (Stroop Test), a widely recognized tool for assessing cognitive performance, has been utilized in numerous studies (Osimani et al. 1997; Gwizdka 2010; Erdodi et al. 2018; Amato et al. 2006; Graf, Uttl, and Tuokko 1995; Gustafson and K\" allm\’ en 1990; Van der Elst et al. 2006), affirming its validity and reliability in measuring attentional capacity and cognitive function. Within the current study, we employed the Stroop Test to objectively measure employee cognitive performance. This involved a chart featuring 54 words that spell out the names of colors, presented in incongruent ink colors. The words were arrayed across 7 rows and 6 columns and displayed on a virtual computer screen, positioned on a desk within the virtual environment (refer to Figure 37).

Participants were tasked to verbally identify the ink color of each word, beginning from the top-left corner of the chart, and proceeding horizontally from left to right before moving on to the next row, until all words were accounted for. Both the completion time and error frequency were meticulously documented. The time taken to complete the task served as a measure of cognitive processing speed, while the error count provided insight into the participant's attentional capacity.

Figure 37. Virtual depiction of the Stroop test in an ABW environment computer interface

5.2.4. Data collection and research protocol

The research methodology employed in this study involved the use of a laboratory experimental approach to address the research inquiries. The experimental procedures were carried out with volunteering employees serving as the study participants. Given the virtual nature of the study, the essential equipment, including virtual reality headsets (HMDs) and associated hardware, was installed in a dedicated large meeting room specifically designated for this research. The virtual 3D architectural environments utilized in this investigation were designed to represent three distinct configurations of ABW workspaces. These simulations were crafted with precision, employing a suite of industry-leading tools. The foundational geometry was created in Autodesk

Revit, known for its robust architectural modeling capabilities. Subsequently, the designs were further developed and realistically detailed in Twinmotion, a tool recognized for its superior virtual rendering and live VR HMD integration, allowing for an immersive and dynamic experience. The procedural flow of the laboratory experiment is comprehensively delineated in Figure 38, providing a step-by-step breakdown of the session's timeline.

Research Protocol:

The research protocol followed in this experiment is graphically represented in Figure 38.

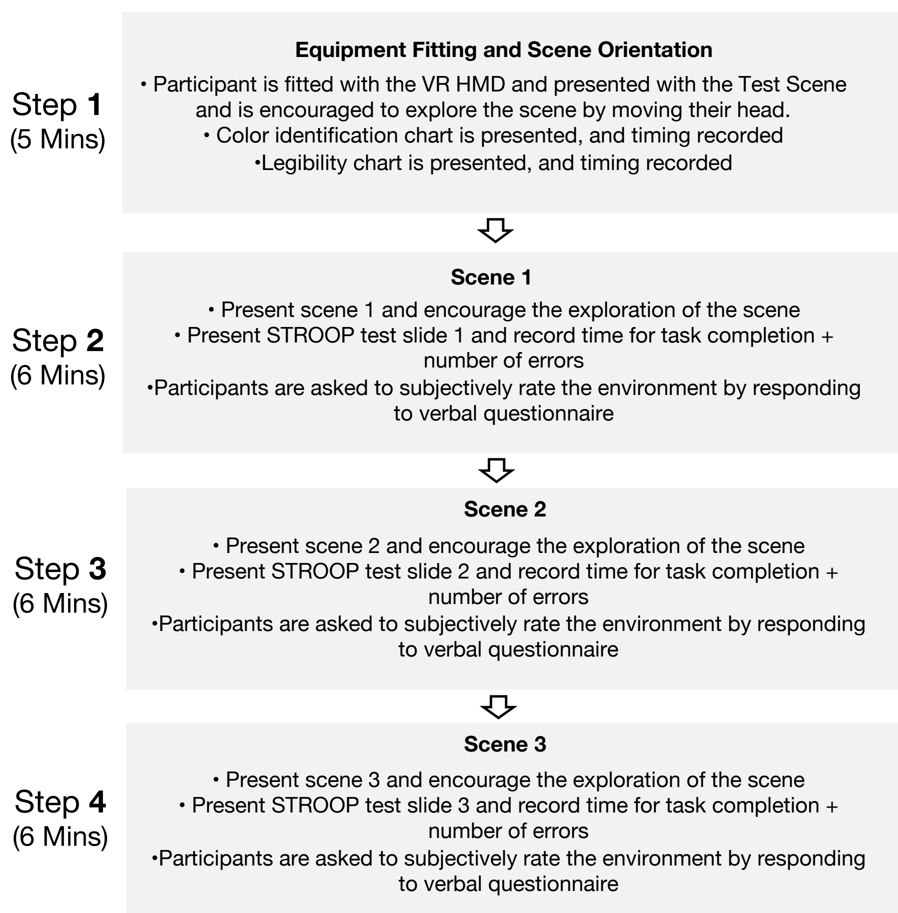

Figure 38. Typical timeline for the lab experiment session

Upon arrival at the designated test site for their scheduled 30-minute in-person session, participants received a comprehensive briefing outlining the study's objectives and the instructions for their participation.

Initial Setup and Visual Acuity Check: Participants commenced the experiment by being seated in a designated office chair and were fitted with an Oculus Quest 2 VR headset to ensure a consistent viewing environment. Next, they were immersed in a test scene to familiarize themselves with the virtual environment through head movements. This was followed by the presentation of the Pseudo Stroop test; a simulation of the traditional Stroop test designed to test the participants for visual impairments that would compromise their participation in the study. Two Pseudo Stroop test charts were presented, the first of which was a 'color identification chart' on a virtual computer screen within the virtual environment, the chart was specifically designed to evaluate the participants' color discernment accuracy by presenting a group of jumbled letters written in different colored ink and participants were then asked to identify the colors of each of the jumbled lettered words.

This step was critical not only to assess their ability to identify and differentiate colors within the virtual environment but also to confirm the absence of vision impairments such as color blindness that could influence the outcome of the study. Subsequently, participants were presented with a word identification chart within the virtual environment. The purpose of this was twofold: to confirm the clarity and legibility of text as rendered by the VR system, and to ensure that participants did not have any vision impairments that could hinder their ability to read and comprehend words. This consisted of the typical Stroop test chart featuring 54 words that spell out the names of colors but presented in black ink. The participants were then asked to read out the words. This step was critical to validate that all textual stimuli used in the study were accessible and interpretable by all participants, thus maintaining the integrity of the experimental conditions.

Exploration and Cognitive Assessment: In the second step, participants were introduced to the first ABW workspace within the VR environment. Participants were encouraged to explore this space for 180 seconds to adjust to the lighting conditions within the headset and familiarize themselves with the scene. Following the preliminary visual assessments, the Stroop Test commenced with the presentation of the first slide on the virtual display. Participants were instructed to verbally identify the color of the words depicted in the chart. The task required starting from the top left of the chart, progressing from left to right, and then moving sequentially to the next row, continuing in this manner until the chart was completed. They were also instructed to perform the task with both speed and accuracy, thus enabling the measurement of cognitive flexibility and processing speed under potentially conflicting information scenarios. The duration of task completion and error incidence were systematically recorded. Post-assessment, participants conveyed their subjective experiences and performance appraisals via a structured verbal questionnaire.

Continued Evaluation: Steps 3 and 4 maintained the experimental structure established in the initial phase, presenting participants with additional ABW environments and subsequent iterations of the Stroop Test. Just as in the first phase, response times and error frequencies were rigorously recorded. Post-test, a subjective assessment was conducted to gauge participants' evaluations of the virtual ABW workspaces. Participants were asked to respond to three specific statements regarding their satisfaction with the workspace and its conduciveness to individual, focused work. The statements were: (1) "I am satisfied with the overall workspace." (2) "This environment provides enough privacy to comfortably do individual heads-down work." (3) "This environment is suitable for individual heads-down work."

Responses were elicited using a 5-point bipolar Likert scale, with options ranging from 1 ('Strongly Disagree') to 5 ('Strongly Agree'), and each intermediate response increased incrementally by one point. These ratings were numerically quantified and subsequently used to calculate the mean scores for each statement, providing a quantitative measure of participant satisfaction and perceived workspace efficacy. The conclusion of the final assessment marked the end of the experiment. The VR headset was removed, and participants were thanked for their contribution to the research. To ensure ethical compliance, each participant was furnished with a copy of the 'Statement of Consent' for their records upon exiting the study location. The findings of this study are organized into two main sections. The first section presents the qualitative insights gathered from participants' reflections captured through an oral questionnaire, focusing on their evaluations of three distinct virtual ABW environments. The second section presents the empirical perspective, analyzing objective data, and sheds light on the participants' cognitive performance when situated within these virtual ABW workspaces.

5.3 Indoor Occupant Perceptions of ABW Environments

Participants provided qualitative evaluations of the virtual ABW environments following their direct interaction with each space while performing the focus task (Stroop Test). This experiential approach, enriched by the active completion of the focus task within the various environments, yielded in-depth perspectives on the participants' experiences and perceptions. The subjective assessments derived from these engagements provide a layered understanding of how each ABW setting influences its users.

5.3.1 Perceived Satisfaction Across ABW Environments

This section examines participants' satisfaction with three distinct ABW environments. Satisfaction was measured on a 5-point Likert scale, with options ranging from 1 ('Strongly Disagree') to 5 ('Strongly Agree'), capturing gradations of agreement with the statement "I am satisfied with the overall workspace." The aggregated satisfaction scores, reflecting higher scores as increased satisfaction, are depicted in Figure 39.

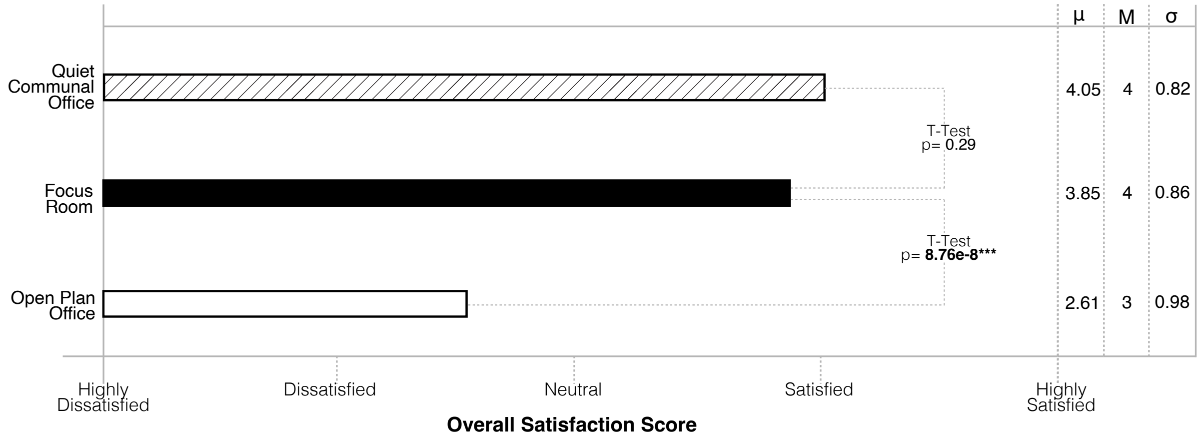

Figure 39. Comparison of employee workspace satisfaction across ABW office configurations

Analysis of the mean satisfaction scores revealed differences among the office types. Open Offices garnered the lowest mean satisfaction score of 2.61 (SD = 0.98), suggesting moderate dissatisfaction among participants. In contrast, Focus Rooms were more favorably perceived, with a mean score of 3.85 (SD = 0.86). This preference was even more pronounced in Quiet Offices, which achieved the highest mean satisfaction score of 4.05 (SD = 0.82), indicating that participants were most content in quieter workspaces. Statistical analysis using a paired samples t-test to compare satisfaction levels between Quiet Offices and Focus Rooms found no significant difference (M = 4.05, SD = 0.82 for Quiet Offices; M = 3.85, SD = 0.86 for Focus Rooms; t(77) = -1.05, p = 0.29), with a small effect size (mean difference = 0.2, 95% CI: -0.58 to 0.18, Cohen's d = 0.23). However, the satisfaction scores between Open Offices and Focus Rooms did differ significantly (M = 2.61, SD = 0.98 for Open Offices; M = 3.85, SD = 0.86 for Focus Rooms; t(77) = 5.91, p < .0001), with a large effect size (mean difference = 1.24, 95% CI: [0.82 to 1.65], Cohen’s d = -1.33). This significant difference highlights a preference for Focus Rooms over Open Offices.

5.3.2. Perceived Privacy Across ABW Environments

In this section the employees' perceptions of privacy while performing focus tasks in the three ABW workspaces were analyzed. Participants expressed their level of agreement with the statement, "This environment provides enough privacy to comfortably do individual heads-down work," using a 5-point Likert scale. Scores ranged from 1 ('Strongly Disagree') to 5 ('Strongly Agree'), to establish a 'Perceived Privacy Score' for each environment as seen in Figure 40. A higher score denotes a greater sense of privacy.

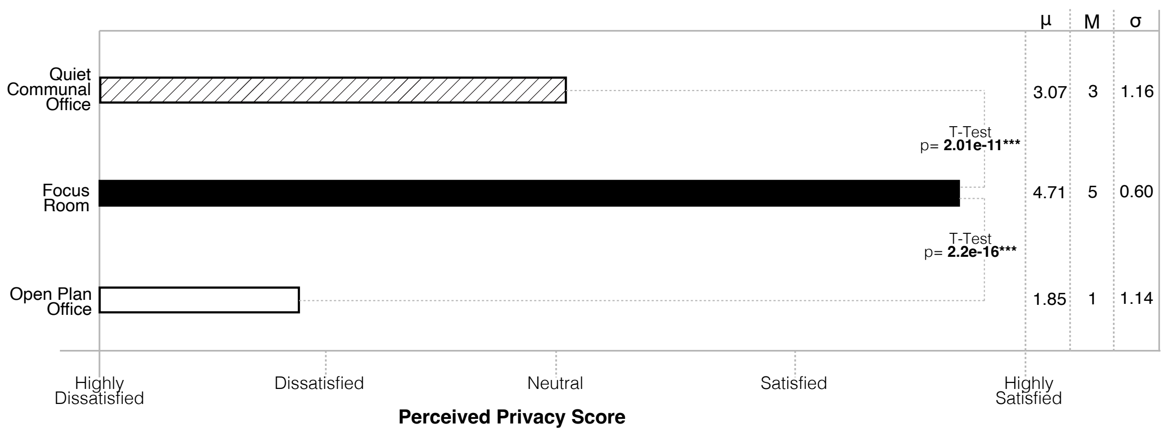

Figure 40. Employee privacy ratings for focused work in various ABW office configurations

Upon examining employees' perceived privacy, variations emerged across the three ABW environments. Open Offices recorded a mean privacy score of 1.85 (SD = 1.14), suggesting a lower perceived privacy level. Quiet Offices received a higher rating, with a mean score of 3.07 (SD = 1.16), reflecting moderate privacy. Focus Rooms were perceived as significantly more private, achieving the highest mean score of 4.71 (SD = 0.60). Statistical analysis highlighted this discrepancy. A paired samples t-test comparing Quiet Offices to Focus Rooms revealed a significant difference in privacy perceptions (M = 3.07, SD = 1.16 vs. M = 4.71, SD = 0.60; t(77) = 7.84, p = 2.01 e-11), with a large effect size (mean difference = 1.64, 95% CI: 1.23 to 2.06, Cohen's d = -1.76), suggesting that Focus Rooms are seen as substantially more private. When comparing Open Offices to Focus Rooms, the difference was even more pronounced (M = 1.85, SD = 1.14 for Open Offices; M = 4.71, SD = 0.60 for Focus Rooms; t(77) = 13.871, p = 2.2 e-16). The very large effect size (mean difference = 2.86, 95% CI: 2.45 to 3.28, Cohen's d = -3.12) indicates a strong preference for the privacy Focus Rooms offer. These findings highlight the impact of office layout on employees' sense of privacy during tasks that require focus and minimal distraction.

5.3.3 Perceived Compatibility for Focus Work in ABW Environments

In the study, employees assessed the compatibility of various ABW office types for focused work. This was quantified using a 5-point Likert scale where respondents indicated their agreement with the statement, "This environment is suitable for individual heads-down work." Scores ranged from 1 ('Strongly Disagree') to 5 ('Strongly Agree'), with each rising point reflecting a higher suitability level. The aggregated scores termed the 'Perceived Compatibility Score', gauges the compatibility of each environment for focused work as seen in Figure 41.

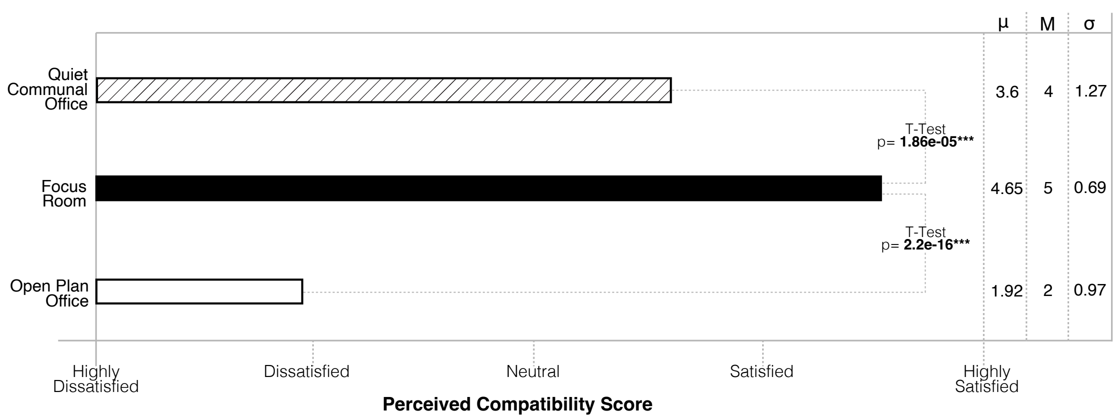

Figure 41. Assessment of focused work compatibility across different ABW office configurations

The assessment of ABW environments for focused work revealed distinct perceptions among employees. The mean 'perceived compatibility' scores varied: Open Offices had a mean score of 1.92 (SD = 0.97), suggesting they were less suited for focused tasks. Quiet Offices were rated better with a mean score of 3.6 (SD = 1.27), while Focus Rooms were considered the most suitable, achieving the highest mean score of 4.65 (SD = 0.69). Statistical analysis underscored these differences, a paired samples t-test showed a significant difference in the perceived compatibility for focused work between Quiet Offices and Focus Rooms (M = 3.6, SD = 1.27 for Quiet Offices; M = 4.65, SD = 0.69 for Focus Rooms; t(77) = 4.56, p = 1.86 e-5), with a large effect size (mean difference = 1.05, 95% CI: 0.59 to 1.51, Cohen’s d = -1.02). Moreover, when comparing Open Offices to Focus Rooms, the difference was even more pronounced (M = 1.92, SD = 0.97 for Open Offices; M = 4.65, SD = 0.69 for Focus Rooms; t(77) = 14.39, p = 2.2 e-16), with a very large effect size (mean difference = 2.73, 95% CI: 2.34 to 3.10, Cohen’s d = -3.21). This suggests that Focus Rooms are perceived as more conducive to focused work when compared to the other ABW environments studied.

5.4 Indoor Occupant Performance in ABW Environments

The study objectively measured cognitive performance by recording participants' completion times and error rates while engaging in the focused task (Stroop Test) within each ABW environment. Completion times were indicative of cognitive processing speed, while error rates reflected attentional capacity. Through these metrics, insights were gained into how different ABW settings could potentially influence these aspects of cognitive performance. The analysis provided an empirical basis for understanding the interaction between workspace design and cognitive performance, highlighting the impact of environmental characteristics on employees’ cognitive efficiency and accuracy.

5.4.1. Influence of Work Environments on Cognitive Processing Speed

Cognitive processing speed, a key indicator of cognitive performance, reflects an individual's ability to perceive, understand, process, and respond to information. This ability is critical for performance across various cognitive domains, including reading, learning, memory retention, and the efficiency of performing mental operations. Often, it is evaluated through tasks that necessitate rapid decision-making capabilities, like tasks that require visual scanning, attention to detail, and swift motor responses. Within the scope of this study, 41 participants' times to complete a specified focus task (Stroop Test) were meticulously recorded across three distinct ABW environments. The collected data was graphically interpreted through a box and whisker plot, intended to be showcased in Figure 42.

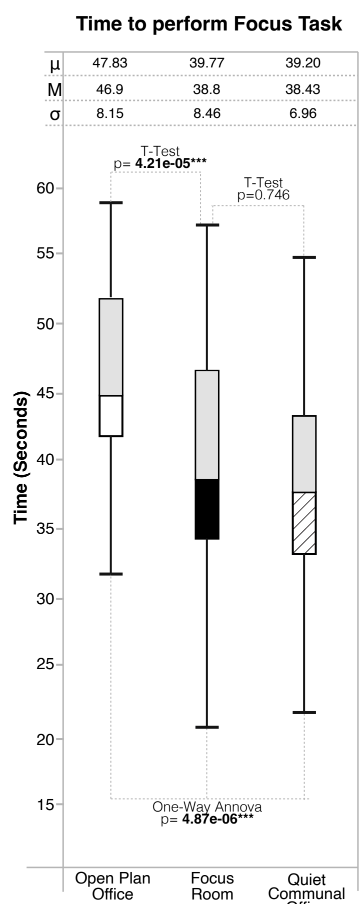

Figure 42. Influence of work environments on cognitive processing speed

The Focus Rooms, particularly designed for focus tasks requiring intense concentration and minimal external distractions, were one of the environments assessed. This setting is typically reserved for activities demanding deep cognitive processing such as analytical thinking, complex problem-solving, and extensive reading or writing; essentially, any work requiring undivided attention. Comparative performance analysis between the Open Offices, Quiet Offices, and the Focus Rooms was conducted to understand the efficacy of each environment in supporting focus tasks. This comparison aimed to illustrate the potential impact of environmental design on employee cognitive performance, particularly in spaces that are either specifically designed or not expressly intended for tasks requiring high levels of concentration. Upon analysis of the task completion times across different work environments, it was found that the environment influences the time efficiency of task performance. In a Quiet Office setting, participants exhibited the most rapid task completion, with a mean time of 39.20 seconds and a standard deviation of 6.96. This environment proved to be the most conducive to focused tasks, reflecting the fastest mean completion time among the tested settings. Contrastingly, the Focus Rooms yielded a slightly higher mean completion time of 39.77 seconds with a standard deviation of 8.46. While this mean time is marginally slower than that of the Quiet Office, it still signifies a high level of suitability for tasks that necessitate concentration, aligning closely with the completion times of the Quiet Office environment.

The Open Office environment, however, presented an increase in the mean completion time, recorded at 47.83 seconds with a standard deviation of 8.15. This indicates that tasks that require concentration may be adversely affected in such a setting, highlighting a potential challenge for maintaining focus. The comparative analysis of the Quiet Offices and Focus Rooms reveals that both environments are conducive to efficient task execution. Nonetheless, the greater standard deviation observed in the Focus Rooms suggests a broader range of individual performance outcomes. This variability may be indicative of a differential personal response to the work environment, possibly influenced by individual work style preferences or the degree of interaction within the space.

Statistical analysis using a paired samples t-test showed a significant time difference between the Open Offices and Focus Rooms ($t(77) = 4.34$, $p = 4.21e\text{-}5$), with a substantial effect size (Cohen's $d = -0.97$). This difference underscores the potential of the Focus Rooms for enhancing focused work, as the task completion times in Open Offices were notably slower on average, by approximately 8 seconds; an important margin in high-stakes work contexts. A one-way ANOVA reaffirmed the significant impact of the work environment on task completion times ($F(2, 118) = 22.96$, $p < .001$), solidifying the argument that environment type is crucial in cognitive task performance. Post hoc analyses further explained the specific differences between each environment, allowing us to reject the null hypothesis of no mean difference across the environments. The findings highlight the necessity for strategic workspace design, catering to the cognitive demands of workers and the tasks at hand.

5.4.2. Influence of Work Environment on Attentional Capacity

'Attentional Capacity' is a cognitive term that describes an individual's ability to process and maintain attention on a certain amount of information or number of tasks simultaneously. In this study, attentional capacity was evaluated by measuring the accuracy of participants' performances during a focus task. Unlike cognitive processing speed, which assesses how quickly a task is completed, attentional capacity is concerned with how accurately it is performed. For the 41 participants, the accuracy was determined by counting the errors made while undertaking the Stroop Test in three different ABW environments. The data on errors were then visually displayed using a box and whisker plot as seen in figure 43.

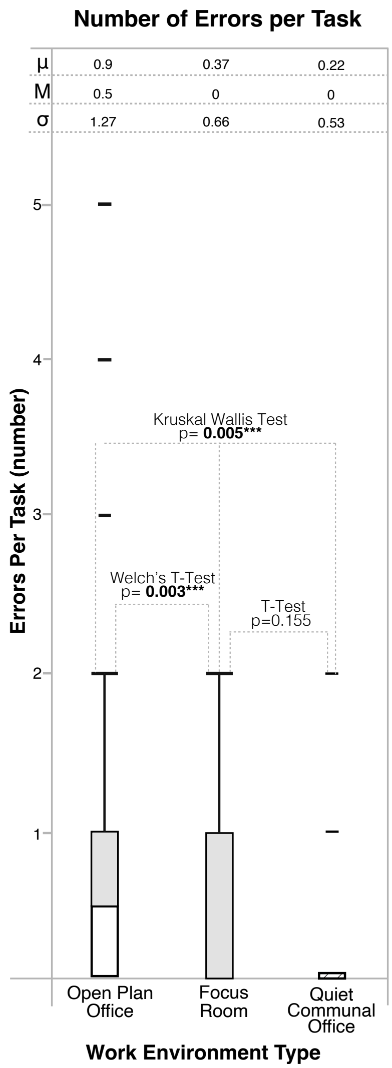

Figure 43. Influence of work environments on error rates

This analytical approach allowed for a comparative examination of attentional capacity between the Open Offices, Quiet Offices, and Focus Rooms; adding a layer of understanding to how different work environments may affect the precision with which focus tasks are completed. The study's exploration into 'Attentional Capacity'; led to findings regarding the precision of focus task performance within various work environments. This facet of cognitive performance was measured in conjunction with cognitive processing speed, offering a comprehensive perspective on participants' efficacy in executing the focus task. Errors made by participants during the execution of the Focus Task (Stroop Test) were meticulously recorded across three ABW environments, yielding the following results:

Participants in the Open Offices recorded the highest average error count, with a mean of 0.9 errors per task. The accompanying standard deviation of 1.27 highlighted a difference in performance levels among individuals, suggesting inconsistent task execution within this environment. Conversely, the Focus Rooms presented a marked improvement in performance, evidenced by a lower mean error count of 0.37 errors per task and a reduced standard deviation of 0.6. This indicates a more uniform level of performance among the participants. The Quiet Office was found to be the most favorable environment in terms of error frequency, with participants averaging the least number of errors at 0.22 per task and the smallest standard deviation of 0.53, denoting a consistent performance near the mean for each participant. These empirical observations reinforce the hypothesis that the office environment exerts a strong influence on the precision of task execution, corroborating established theories within the realms of attentional capacity and environmental psychology. The data suggest that quieter and less disruptive settings, such as Quiet Offices and Focus Rooms, are conducive to minimizing performance errors, thereby facilitating tasks that demand acute attention.

To address the non-normality and heteroscedasticity of the error rate data, a non-parametric Kruskal-Wallis chi-squared test was utilized to evaluate the medians of error rates across the environments. This test substantiated a statistically significant variance in error distributions among the different settings ($\chi^2(2) = 10.618$, $p = .004947$). Further analysis via Welch two-sample t-tests, which accommodate unequal variances, revealed a significant disparity in error rates between the Open Offices and the Focus Rooms ($t(52.07) = 3.087$, $p = 0.003$). This finding emphasizes a considerable effect size and a reduced probability of errors within the Focus Rooms. While the difference in error rates between the Focus Rooms and the Quiet Offices was not statistically significant (p-value of 0.26), the collective data firmly propose that the physical characteristics of the work environment exert a tangible effect on attentional capacity and task accuracy. These insights are critically important for the design and optimization of workspaces that enhance cognitive functionality.

5.5. Implications for Design and Practice:

This experiment explored the influence of office design on employee performance, particularly in tasks that require high levels of concentration. The study uncovered variances in cognitive performance and workspace satisfaction across different ABW environments. These findings extended our understanding of how the design of physical workspaces shaped cognitive and psychological outcomes for employees. The evidence gathered supported the prevailing scholarly view that office design had a considerable effect on employee productivity and cognitive capacity, as documented in the literature (Becker, Soucek, and G\" oritz 2022; M. Hansika and B. Amarathunga 2016; A. Hameed and S. Amjad 2009). Notably, environments such as Quiet Offices and Focus Rooms, which recorded high satisfaction and lower error rates, were in line with research underscoring the need for workspaces that facilitated both concentrated and collaborative work (Wineman 1982; Sultan, Jabeen, and Qureshi 2020). These preferences were in accordance with theories of attentional capacity and environmental psychology, which suggested that workspaces designed to minimize distractions could enable more focused work and decrease cognitive burden (Maher and von Hippel 2005; Roper and Juneja 2008). The distinct preference for quiet and focus-oriented workspaces indicated a potential enhancement of employee well-being and productivity. This was particularly pertinent in the evolution of the post-pandemic work environments, where there is a shift in employee expectations towards more flexibility and personal control over their workspaces.

5.5.1. Impacts of ABW Work Environments on Perception

The variability in performance within the same office types suggests that individual preferences play an important role in workspace suitability. This finding highlights the importance of offering a variety of workspaces within the ABW model to accommodate different work styles and tasks, thereby supporting a diverse workforce. The qualitative assessments of ABW environments, as per the findings from the given data, offer a nuanced perspective on the employee experience in relation to workspace satisfaction, perceived privacy, and perceived compatibility for focused work.

5.5.2. Impacts of ABW Work Environments on Workspace Satisfaction

Employee satisfaction with their work environment is a critical component of their overall experience and effectiveness at work. The insights from this study underscore a preference for workspaces that offer quietness and privacy for tasks that demand intense focus. Quiet Offices garnered the most favorable satisfaction scores, suggesting that spaces that harmonize the communal advantages of shared areas with the focus-enhancing qualities of a quieter ambiance align closely with employee preferences. This trend suggests that employee satisfaction is predominantly associated with the acoustic qualities of the environment rather than its size or the number of occupants. Both Quiet Offices and Focus Rooms, despite their differing layouts and capacities, share similar acoustic profiles ranging from 40 to 45 decibels without intelligible human speech and this commonality is reflected in comparable ratings for employee experience and cognitive performance. Conversely, Open Offices, characterized by an average noise level of 70 decibels and the presence of intelligible human conversation, produce a moderate level of employee dissatisfaction. This dissatisfaction suggests a pressing need to reassess such environments, considering their potential to distract or overstimulate, thereby impacting the effectiveness of employees engaged in concentration-intensive tasks.

5.5.3. Impacts of ABW Work Environments on Perceived Privacy

Privacy emerges as a crucial element in an employee's comfort and their capacity to perform tasks that require deep concentration. The study's findings indicate a clear preference for Focus Rooms, validating their efficiency in providing the privacy necessary for tasks that demand high levels of focus. This is in stark contrast to the low privacy ratings for Open Offices, which suggest that such layouts may be detrimental to performance on tasks where privacy is paramount. Quiet Offices represent a median solution, striking a balance between openness and seclusion. This suggests that perceived privacy within a workspace is a multifaceted construct, influenced not solely by the acoustic environment which appears to be a factor in workplace satisfaction, but also by a variety of elements including occupancy rates, office layout, the size of the office, and the overarching office design. This is corroborated by the substantial differences in Perceived Privacy Scores across the three ABW environments studied. Unlike the satisfaction scores, where Quiet Offices and Focus Rooms shared similar ratings possibly due to the comparable acoustic profiles, perceived privacy seems to be shaped by an amalgamation of different factors. These contribute collectively to the perception of privacy in each ABW environment, underscoring the complexity of designing workspaces that cater to the varied needs of employees.

5.5.4. Perceived Compatibility for Focused Work

The perceived compatibility of workspaces in supporting focused tasks is a critical aspect of ABW environments. It is this perceived compatibility that often guides employees in selecting a particular workspace out of the various options available, ensuring they choose an environment that best supports their need for concentration and efficiency in their tasks. In line with expectations, Focus Rooms were found the most conducive to concentration-intensive work. This preference can be attributed to their design, which intrinsically minimizes distractions, thereby fostering a conducive environment for focused tasks. Quiet Offices were perceived as superior to Open Offices yet did not quite match the compatibility of Focus Rooms for focus-intensive work. This indicates that Quiet Offices, despite their advantages over Open Offices, still have the potential for enhancement to better support tasks that require high concentration. Interestingly, despite the participants' perception of the Focus Rooms as the ideal setting for focus tasks, the objective measures of performance; including cognitive processing speed and attentional capacity suggested a different narrative. Contrary to expectations, Quiet Offices were marginally more effective in supporting focused work than Focus Rooms, as evidenced by the objective data on task efficiency and accuracy. This discrepancy highlights a divergence between employee perceptions of their work environment and their actual performance within it. Such a finding poses a critical reflection point on the ABW strategy, which largely depends on employees selecting work environments based on personal perception. It suggests that perceived compatibility may not always align with actual performance, an insight that could have implications for workplace design and strategy.

In summary of the influence of ABW environments on employee perceptions and experience; the findings have revealed that individual preferences influence the perception of workspace compatibility, emphasizing the need for diverse spaces within the ABW framework to support varied workstyles and tasks. Workspace satisfaction was notably higher in environments that offer quiet and privacy, essential for focus-intensive work, with Quiet Offices receiving the highest satisfaction scores due to their optimal balance of communal and quiet spaces. Interestingly, while Focus Rooms were perceived as the ideal for focused work, Quiet Offices outperformed them in objective measures of task performance, suggesting that employee perceptions of workspace compatibility might not always coincide with actual productivity. This discrepancy underscores the complexity of workspace design and the potential need to rethink ABW strategies that rely heavily on individual choice and perception.

5.5.5. Impacts of ABW Work Environments on Cognitive Performance

Experiment four rigorously assessed the impact of ABW environments on employee cognitive performance, with a particular emphasis on focus tasks that require high levels of concentration. The findings revealed that environments not specifically designed for focus work, such as Open Offices, considerably undermine employee efficiency. In such spaces, our data indicated a 20.87% decline in efficiency when compared to Focus Rooms designed for focus tasks, which could translate into a loss of potential and resources for employees and corporations, especially when considering the proportion of corporate budgets typically allocated to human resources. Furthermore, the accuracy of employees engaged in focused tasks was also compromised in these non-optimized settings, with error rates soaring by 143% relative to those in Focus Rooms'as seen in Figure 44. This not only has a negative impact on resources but also on employee well-being, satisfaction, and self-esteem.

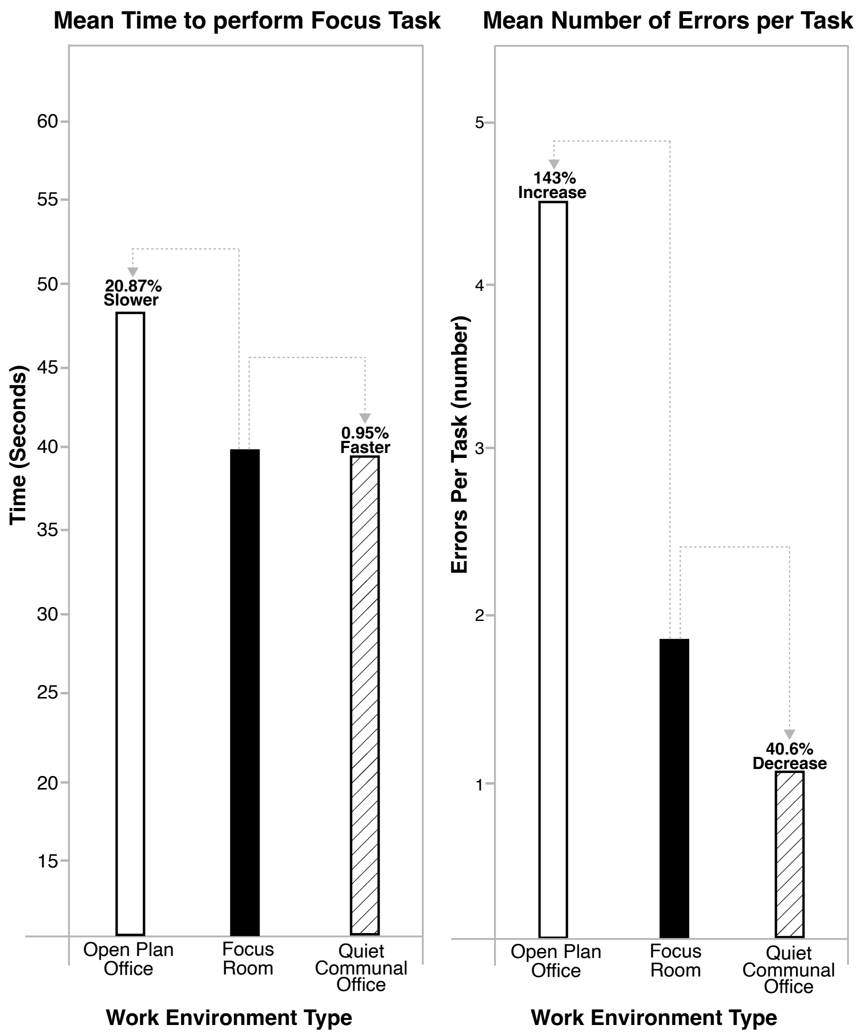

Figure 44. Employee performance on focus task across ABW office types

Interestingly, the study found that Quiet Offices could yield comparable performance outcomes for focused work than designated Focus Rooms. This phenomenon may be attributable to the acoustical similarities between the two, despite stark differences in other environmental factors such as office size, design, the number of occupants, and furniture arrangement. This suggests that acoustic conditions may play a pivotal role in facilitating concentrated work. These conclusions are supported by literature emphasizing the negative impact of disruptions and distractions commonly encountered in open workstations, reinforcing the need for well-thought-out design considerations in workplace environments.

5.5.6. Implications for Office Design

The findings indicate a shift in the paradigm of office design, particularly in the context of ABW configurations. Contrary to traditional assumptions, the findings suggest that Quiet Offices can be more effective than Focus Rooms' for concentrated work, offering both greater efficiency and accuracy. For corporations, this translates into a more economical and space-efficient solution to accommodate a given number of employees engaged in tasks requiring focus and concentration. Rather than allocating separate Focus Rooms, integrating Quiet Communal workstations into the design may yield better results. The study advocates for the categorization of an institution's tasks based on their work environment needs, thereby allowing for an ABW configuration that reflects the actual workload distribution of an organization. Adopting preset ratios in ABW design has proven to lead to suboptimal performance and employee experience, as our data indicates that employees are less efficient and more prone to errors when performing focused tasks in unsuitable environments, such as Open Offices. Furthermore, the mismatch between task requirements and the ABW environment may negatively impact employee experience in the office, leading to decreased satisfaction, discord with privacy needs, and overall dissatisfaction. These findings echo the existing literature, underscoring the importance of tailoring office designs to the varied types of work performed within an organization.

5.6. Summary of Findings:

This study investigated the impacts of ABW environments on employee cognitive performance and employee experience. Employing a laboratory-based experimental design with virtual reality (VR) technology. This study evaluated the role of environmental design in employee cognitive performance and experience and produced findings that add to the ongoing discourse on office design and its effect on employee productivity. As we navigate the ever-changing landscape of work, which demands increasingly adaptable and supportive work environments, the findings emphasize the need for spaces that can cater to the diverse requirements of a dynamic workforce. The ABW model emerges as an effective paradigm, offering versatility and flexibility to meet these evolving needs.

The findings show that the physical characteristics of a workspace influence cognitive performance, particularly in tasks requiring focused attention. This aligns with theories of attentional capacity and environmental psychology, suggesting that quieter and less disruptive environments, such as Quiet Offices and Focus Rooms, enhance employees' ability to perform tasks with greater accuracy and efficiency. Furthermore, the research highlights the importance of workspace design in relation to employee satisfaction. Qualitative data from participant feedback reveal a preference for work environments that offer privacy and minimize distractions. Quiet Offices received the highest satisfaction ratings, implying that employees value a balance between a collaborative atmosphere and the ability to work uninterrupted.

Statistical analyses confirmed significant differences in error rates and task completion times across various ABW environments. Notably, when focus tasks are performed in environments that are not conducive to such work, such as open-plan offices, our study observed a considerable decline in efficiency; specifically, a drop of 20.87%. Furthermore, the likelihood of errors increased by up to 143% compared to performance in Focus Rooms. This stark contrast underlines the need for office designs that balance communal interaction with individual privacy, essential for tasks requiring high levels of concentration. These differences underscore the tangible impacts that office design can have on both the attentional capacity and cognitive processing speed of employees. The study's outcomes suggest that incorporating diverse workspace types within an office layout can cater to the multifaceted needs of employees, ultimately enhancing overall productivity and satisfaction.

The convergence of qualitative and quantitative data from this research provides an understanding of how ABW environments can be optimized. It highlights the necessity for a nuanced approach to office design that considers not only the functional requirements of the workforce but also the cognitive and psychological well-being of employees. This study reveals a clear relationship between employees' perceptions of an environment's compatibility for focused work and their actual performance, thereby validating the ABW strategy that empowers individuals to select spaces based on task requirements. However, barriers such as employee reluctance to switch workspaces and a shortage of certain types of ABW environments may lead to suboptimal space usage. It is therefore critical not only to educate employees on the optimal use of ABW spaces but also to ensure a sufficient variety of environments to support a wide range of tasks. Maintaining dynamic ABW ratios and adopting a modular design approach enables swift and effective adaptations to changes in task demands. This underscores the importance of regularly reassessing the design of the Physical Work Environment (PWE) to align with the magnitude of tasks and the availability of supportive environments.

The insights derived from this study contribute to the growing body of knowledge advocating for strategic office space design. These insights reinforce the necessity of cultivating adaptable, supportive work environments that align with the multifaceted needs of today's workforce. Embracing the foundational principles of diversity and adaptability inherent in the ABW model appears to be a promising step toward achieving these goals in the ever-evolving nature of work. In conclusion, this study serves as a call to action for organizations and designers to reevaluate and innovate ABW environments. By fostering workspaces that are attuned to the varied tasks and preferences of employees, organizations may enhance cognitive performance, job satisfaction, and overall workplace efficacy. As the corporate world continues to evolve, especially in the wake of changing work models post-pandemic, such insights will be helpful in shaping the future of workspaces that are both productive and psychologically rewarding for the workforce.

CHAPTER 6

SUMMARY OF FINDINGS AND FUTURE RESEARCH

6.1. Summary of Findings

This dissertation presents a series of in-depth studies that systematically examine the impacts of various environmental, contextual, and design factors on indoor occupant perception, environmental adaptation, and performance ranging from the micro-level of window shading preferences to the macro-level considerations of office layouts on perception and performance. Initially, the study delves into the subtleties of window shading conditions, exploring how they are influenced by sky conditions and space functions. It becomes evident that preferences are not singular; they adapt to the purpose of the room, with a notable inclination towards half-closed shading conditions. This inclination suggests a universal human desire to strike a balance between privacy and connectivity with the natural world.

The next experiment built on the findings of the first experiment by extending the investigation into the realm of traditional architectural elements, like patterned solar screens, and revealed their capacity to shape perceptions of privacy and views. Patterns such as Mashrabiyas not only carry cultural resonance but also interact with both urban and forest views to affect occupant satisfaction differently. The nuanced understanding of how screen patterns can either obstruct or enhance views, while also providing a sense of privacy, emerges as a critical design consideration.

Advancing further, this dissertation explored the contemporary office landscape transformed by the pandemic. Virtual reality simulations were used to gain a window into the efficiency of different Activity-Based Working (ABW) environments in supporting indoor occupant's performance on focus tasks. The contrast in cognitive performance and satisfaction levels between Open Offices and Focus Rooms offers a compelling argument for a design approach that respects the need for both interaction and seclusion within the professional domain.

The cumulative findings of this dissertation underline a salient point: environmental factors, contextual factors, and the design of the built environment together are essential determinants of occupant perception and performance. Each element, from the transparency of a window to the acoustic properties of an office, either contributes to or detracts from the overall functionality and experiential quality of a space. The critical balance between privacy and exposure, silence and communication, nature and architecture, is where the optimal design for human performance and satisfaction lies.

The implications of this research for architectural and interior design practices are numerous. It calls for a design philosophy that prioritizes the psychological and physiological experiences of individuals within indoor spaces. A responsive, human-centered approach must be at the heart of design decisions to craft spaces that are not just environmentally sustainable and aesthetically appealing but also conducive to the health, satisfaction, and productivity of occupants. Looking forward, the field stands at a promising crossroads, where the integration of traditional design wisdom with innovative technological approaches to holistic design. This dissertation's findings serve as a springboard for future research opportunities, particularly in the evaluation of long-term impacts of design interventions and the potential of emergent technologies to refine our understanding of environmental design psychology.

6.2. Limitations of the Research

The experiments detailed in this dissertation have been instrumental in illuminating various facets of the human-built environment relationship, providing invaluable insights into how design choices impact indoor occupant perception, performance, and satisfaction. However, it's essential to recognize that each experiment has its own set of limitations.

Experiment 1

In Experiment 1, static images were used instead of the 2D navigable interactive images employed in Experiments 2 and 3. Eight images were shown simultaneously, limiting participants' ability to focus on individual images and affecting their capacity to visualize themselves in the space. Although this may have had a limited effect on the results, as the primary objective was to understand preferences for window shading conditions in relation to contextual and environmental factors, it is still a noteworthy limitation. Additionally, the study showed each scene at a specific point in time, which does not account for the dynamic nature of environmental factors such as sky conditions and daylight patterns. This can influence shading preferences, as occupants might prefer different shading conditions at varying sun angles. The virtual environments aimed to be realistic rather than photorealistic, and light measurements were not quantified since the study did not focus on lighting conditions or visual comfort. The scenes were presented from a single viewpoint, limiting the comparison to a more static perception rather than a dynamic, real-world experience. With only 30 participants, mostly affiliated with the University of Oregon, the sample size and demographic further limit the generalizability of the findings.

Experiments 2 and 3

Experiments 2 and 3 addressed the static nature of the images in Experiment 1 by using 2D navigable images, allowing participants to explore by panning and zooming, thus providing various perspectives and angles. Participants were shown one image at a time, enhancing focus and the ability to visualize themselves in the space. Despite these improvements, the views in Experiment 2, which represented contrasting forest and urban scenes, were not high-quality views based on extensive view quality studies but were representative of different scene types. Although the ratio of foreground, background, sky, and objects was attempted to be consistent, it was not quantified. Furthermore, the urban view included people to suggest potential privacy intrusions, unlike the forest view. While navigable and interactive, the external environmental factors like daylight and sky conditions remained constant, which differs significantly from real-world environments. The sample size was increased to 150 participants, strengthening the findings, but the variability in device screen size and quality for the surveys could impact the results. Participants were allowed to explore the scenes at their own pace, resulting in varying exposure times, which could affect the study outcomes.

Experiment 4

Experiment 4 aimed to address the limitations of the previous experiments by using immersive virtual architectural scenes to study the impact of office environment design on occupant experience and performance. This experiment employed virtual reality (VR) technology, using a VR HMD for all participants to ensure consistent resolution and external factors. Although the time spent in each environment varied slightly among participants due to task completion and questionnaire response times, this variation likely had minimal impact on the results.

Despite these efforts, several limitations remain. The VR method may not fully encapsulate the complexity of real-world office settings. The study by (Abboushi et al. 2019)showed that perception of the indoor environment variables can shift based on the medium of viewing particularly between the real world and screens. However, studies show that virtual VR HMD's can increase interactivity with the virtual environment and promote the participant's perception of presence within the virtual environment (de Kort et al. 2003; Kuliga et al. 2015) that are perceived differently when projected on walls compared to being viewed on screens. However, The limited sample size and the homogeneous nature of participants, all from the same corporate organization, may constrain the broader applicability of the findings. Privacy policies restricted demographic data collection, preventing further analysis of age, gender, etc. The study's reliance on VR means it lacks validation from real-world testing, necessitating future studies in actual environments to test generalizability. Expanding the sample size to include individuals from different organizations, industries, geographic locations, and cultural backgrounds is also essential to enhance the robustness and applicability of the findings.

The testing time for the focus task was limited to within 2 minutes. Although the STROOP test has been validated to quantify cognitive performance, actual focus tasks in real-world environments may vary, with people switching between tasks according to their preferences and behavior. Additionally, since the focus task was so short, the participants' performance in the different office environments may differ based on the duration they spend there.

Furthermore, the investigation focused on assessing the overall influence of office environments on experience and performance without isolating specific variables. This approach means that variables varied significantly from one environment to another, with some office environments having access to outdoor views through windows and others not having such views. Although the weight of the VR headset might have influenced performance outcomes, this potential variable was controlled by ensuring that all time-based comparisons were made within subjects rather than between them, maintaining consistency in the impact of headset weight across the three ABW environments examined.

By acknowledging these limitations and suggesting avenues for future research, this dissertation contributes to the ongoing discourse on the intricate relationship between the built environment and human experience.

6.3. Future Research Directions

The main goal of this dissertation was to expand on the existing knowledge on the human-built environment relationship with an attempt to inform future design of built spaces to enhance human health, experience, performance, satisfaction, and well-being. The investigation into indoor environmental variables has laid a groundwork that future studies can build upon. The diversity of these elements and their compound effects on occupant perception, performance, and experience necessitates a multifaceted approach to research.

Future studies should employ a broader spectrum of metrics, using objective task performance tests and subjective feedback to capture a comprehensive understanding of these environmental impacts. Furthermore, the advancement of technology presents the opportunity to leverage virtual reality (VR) and immersive environments as sustainable and scalable platforms for architectural research. This could allow for controlled, repeatable studies examining nuanced variables within built environments without the constraints of physical space modifications.

The findings of this dissertation highlight the need to further explore the longitudinal effects of Activity-Based Working (ABW) environments on employee performance and well-being. There is a call to extend research to specific design features, such as natural lighting and ambient noise, and their cognitive impact. In the evolving landscape of work, especially post-COVID-19, the ABW model's integration of remote and in-office work paradigms warrants investigation to uncover insights into the future dynamics of workplace design. An expansion beyond the current study's scope—limited to specific types of ABW spaces and typical occupancy scenarios can offer a more comprehensive understanding. Including variations in occupancy and studying spaces designed for social interaction and collaboration will provide insights into the full spectrum of the ABW model's effectiveness.

While this study has provided subjective and objective measures of focused task performance within ABW environments, it has not encompassed physiological responses. Future research should incorporate biometric measures, such as Electrodermal Activity (EDA), Heart Rate Variability (HRV), and Eye Tracking, for a more holistic view of the physiological impacts of these environments on stress and arousal levels. These objective measures, when linked with subjective perceptions of privacy, access to views, and window shading preferences, can illuminate the complexities of human-environment interaction as depicted in Figure 45.

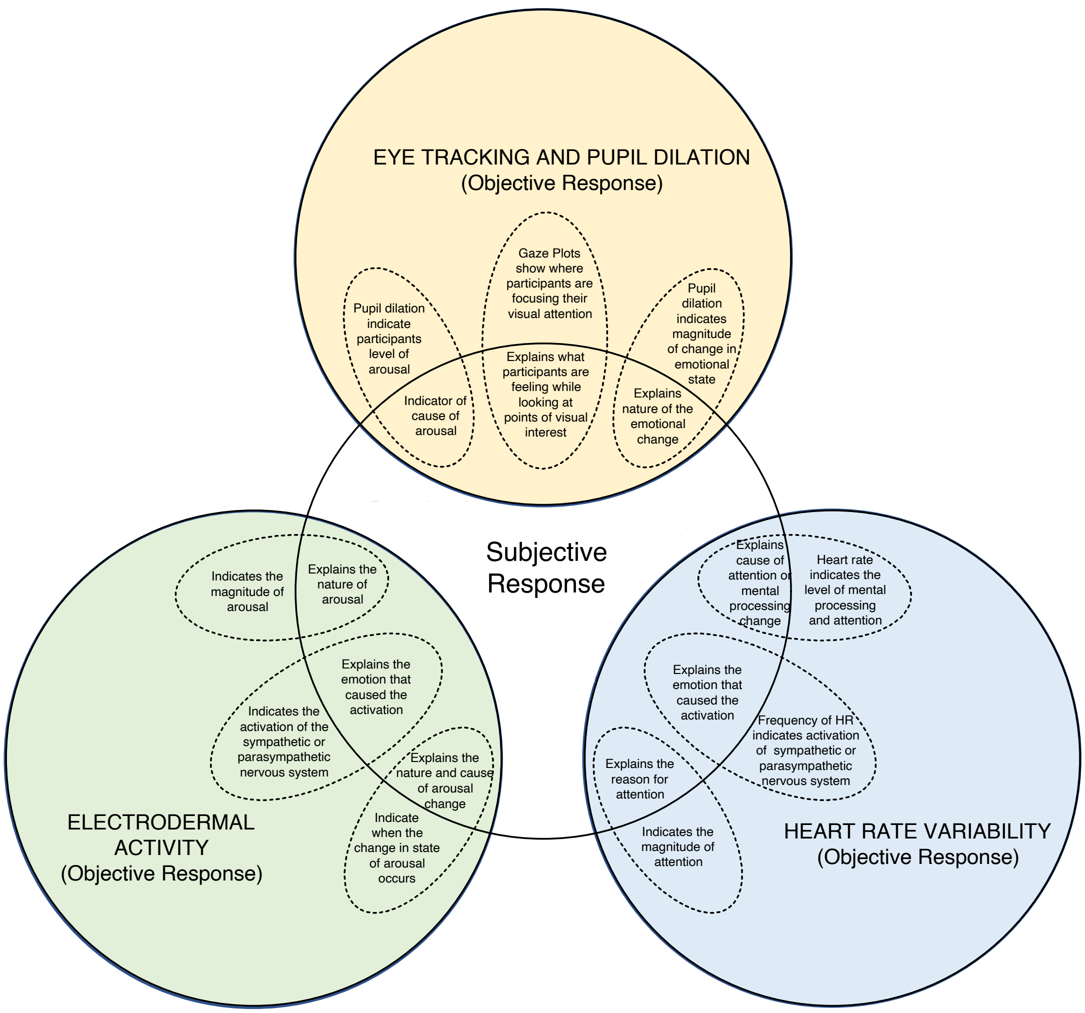

Figure 45. Triangulation Approach: Integrating biofeedback data, and task performance with subjective responses

The triangulation method, integrating subjective and objective measures along with eye tracking, has proven beneficial in associating participant experiences with specific visual interests within the virtual environment. This method also serves as a check against data irregularities, allowing for the cross-verification of results across different measures. Inconsistencies, whether due to instrument error or discrepancies between subjective and objective data, prompt a reevaluation of research methods and tools, ensuring the reliability and validity of findings.

In conclusion, the future direction of research should continue to emphasize the symbiotic relationship between occupants and their environments, striving for a holistic, interdisciplinary approach that combines technological advancements with human-centric design principles. The aim is to foster built environments that are not only functional but also conducive to the psychological and physiological health of their users.

REFERENCES

Ohrn, Maria, Viktoria Wahlstrom, Mette S. Harder, Maria Nordin, Anita Pettersson-Str\" omb\" ack, Christina Bodin Danielsson, David Olsson, Martin Andersson, and Lisbeth Slunga J arvholm. 2021. "Productivity, Satisfaction, Work Environment and Health after Relocation to an Activity-Based Flex Office—The Active Office Design Study." *International Journal of Environmental Research and Public Health* 18 (14): 7640.

A. Hameed and S. Amjad. 2009. "IMPACT OF OFFICE DESIGN ON EMPLOYEES PRODUCTIVITY: A CASE STUDY OF BANKING ORGANIZATIONS OF ABBOTTABAD, PAKISTAN."

Abboushi, Belal, Ihab Elzeyadi, Richard Taylor, and Margaret Sereno. 2019. "Fractals in Architecture: The Visual Interest, Preference, and Mood Response to Projected Fractal Light Patterns in Interior Spaces." *Journal of Environmental Psychology* 61 (February):57–70. https://doi.org/10.1016/j.jenvp.2018.12.005.

Abboushi, Belal, Ihab Elzeyadi, Kevin Van Den Wymelenberg, Richard Taylor, Margaret Sereno, and Grant Jacobsen. 2021. "Assessing the Visual Comfort, Visual Interest of Sunlight Patterns, and View Quality under Different Window Conditions in an Open-Plan Office." *LEUKOS* 17 (4): 321–37. https://doi.org/10.1080/15502724.2020.1785309.

Abd-Alhamid, Fedaa, Michael Kent, Christopher Bennett, John Calautit, and Yupeng Wu. 2019. "Developing an Innovative Method for Visual Perception Evaluation in a Physical-Based Virtual Environment." *Building and Environment* 162 (September):106278. https://doi.org/10.1016/j.buildenv.2019.106278.

Alelwani, Raed, Muhammad Waseem Ahmad, and Yacine Rezgui. 2020. "Public Perception of Vernacular Architecture in the Arabian Peninsula: The Case of Rawshan." *Buildings* 10 (9): 151.

Alkhalili, Noor, Ted Kesik, William O'Brien, and Terri Peters. 2018. "Developing and Testing Visual Privacy Metrics." *International Building Physics Conference*, September. https://surface.syr.edu/ibpc/2018/HF4/2.

Altman, Irwin. 1975. "The Environment and Social Behavior: Privacy, Personal Space, Territory, and Crowding."

Amato, M P, E Portaccio, B Goretti, V Zipoli, L Ricchiuti, M F De Caro, F Patti, R Vecchio, S Sorbi, and M Trojano. 2006. "The Rao's Brief Repeatable Battery and Stroop Test: Normative Values with Age, Education and Gender Corrections in an Italian Population." *Multiple Sclerosis Journal* 12 (6): 787–93.

Andargie, Maedot S., and Elie Azar. 2019. "An Applied Framework to Evaluate the Impact of Indoor Office Environme Ntal Factors on Occupants' Comfort and Working Conditions."

Sustainable Cities and Society 46 (April):101447. https://doi.org/10.1016/j.scs.2019.101447.

Aries, Myriam B. C., Jennifer A. Veitch, and Guy. R. Newsham. 2010. "Windows, View, and Office Characteristics Predict Physical and Psychological Discomfort." *Journal of Environmental Psychology* 30 (4): 533–41. https://doi.org/10.1016/j.jenvp.2009.12.004.

Babaei, Mohammadreza, Hosein Soltanzadeh, and S Yahya Islami. 2013. "A Study of the Lighting Behaviour of Moshabak in Kashan's Houses with Emphasis on the Notion of Transparency." *Architectural Science Review* 56 (2): 152–67.

Babapour, Maral. 2019. "From Fading Novelty Effects to Emergent Appreciation of Activity-Based Flexible Offices: Comparing the Individual, Organisational and Spatial Adaptations in Two Case Organisations." *Applied Ergonomics* 81 (November):102877.

Banbury, SP, and DC Berry. 2005. "Office Noise and Employee Concentration: Identifying Causes of Disruption and Potential Improvements." *Ergonomics* 48 (1): 25–37.

Baras, Karolina, and Adriano Moreira. 2011. "Groups and Frequent Visitors Shaping the Space Dynamics." In *Smart Spaces and Next Generation Wired/Wireless Networking*, 111–22. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-22875-9_10.

Barlow, Stuart, and Dusan Fiala. 2007. "Occupant Comfort in UK Offices—How Adaptive Comfort Theories Might Influence Future Low Energy Office Refurbishment Strategies." *Energy and Buildings*, Comfort and Energy Use in Buildings - Getting Them Right, 39 (7): 837–46. https://doi.org/10.1016/j.enbuild.2007.02.002.

Batool, A, P Rutherford, P McGraw, T Ledgeway, and S Altomonte. 2020. "View Preference in Urban Environments." *Lighting Research & Technology* 53 (7): 613–36. https://doi.org/10.1177/1477153520981572.

Bauer, I. 1994. "Patients' Privacy. Developments in Nursing and Health Care." *Avebury. Brookfield*.

Becker, Cathrin, Roman Soucek, and Anja S. G\" oritz. 2022. "Activity-Based Working: How the Use of Available Workplace Options Increases Perceived Autonomy in the Workplace." *Work* 73 (4): 1325–36.

Bennet, Isis, William O'Brien, and H Burak Gunay. 2014. "Effect of Window Blind Use in Residential Buildings: Observation and Simulation Study." *Proceedings of eSIM2014, Ottawa, Canada* 89.

Berry, Michael A. 1991. "Indoor Air Quality: Assessing Health Impacts and Risks." *Toxicology and Industrial Health* 7 (5–6): 179–86. https://doi.org/10.1177/074823379100700520.

Boubekri, Mohamed, Robert B. Hull, and Lester L. Boyer. 1991. "Impact of Window Size and Sunlight Penetration on Office Workers' Mood and Satisfaction: A Novel Way of Assessing Sunlight." *Environment and Behavior* 23 (4): 474–93. https://doi.org/10.1177/0013916591234004.

Boubekri, Mohamed, Jaewook Lee, Piers MacNaughton, May Woo, Lauren Schuyler, Brandon Tinianov, and Usha Satish. 2020. "The Impact of Optimized Daylight and Views on the Sleep Duration and C Ognitive Performance of Office Workers." *International Journal of Environmental Research and Public Health* 17 (9): 3219. https://doi.org/10.3390/ijerph17093219.

Bower, Isabella, Richard Tucker, and Peter G. Enticott. 2019. "Impact of Built Environment Design on Emotion Measured via Neurophysio Logical Correlates and Subjective Indicators: A Systematic Review." *Journal of Environmental Psychology* 66 (December):101344. https://doi.org/10.1016/j.jenvp.2019.101344.

Braçe, Olta, Marco Garrido-Cumbrera, Ronan Foley, José Correa-Fernández, Gina Suárez-Cáceres, and Raffaele Lafortezza. 2020. "Is a View of Green Spaces from Home Associated with a Lower Risk of An Xiety and Depression?" *International Journal of Environmental Research and Public Health* 17 (19): 7014. https://doi.org/10.3390/ijerph17197014.

Bridger, Robert S., and Kate Brasher. 2011. "Cognitive Task Demands, Self-Control Demands and the Mental Well-Being of Office Workers." *Ergonomics* 54 (9): 830–39.

Brink, Henk W., Marcel G. L. C. Loomans, Mark P. Mobach, and Helianthe S. M. Kort. 2022. "A Systematic Approach to Quantify the Influence of Indoor Environmenta l Parameters on Students' Perceptions, Responses, and Short-term Acade Mic Performance." *Indoor Air* 32 (10). https://doi.org/10.1111/ina.13116.

Buchecker, Matthias, and Barbara Degenhardt. 2015. "The Effects of Urban Inhabitants' Nearby Outdoor Recreation on Their w Ell-Being and Their Psychological Resilience." *Journal of Outdoor Recreation and Tourism* 10 (July):55–62. https://doi.org/10.1016/j.jort.2015.06.007.

Burgoon, Judee K. 1982. "Privacy and Communication." *Annals of the International Communication Association* 6 (1): 206–49.

C^ ot\' e, St\' ephane, and Christopher T. H. Miners. 2006. "Emotional Intelligence, Cognitive Intelligence, and Job Performance." *Administrative Science Quarterly* 51 (1): 1–28.

"C A R A + Co. Studio on Instagram: 'I Love a Good Breezeway // a Renovation of an Engineering Office in São Paulo by @estudio_piloti . #renovation #bespoke #interiors #liveinspired #architecture #braziliandesign #sãopaulo #brick.'" 2024. Instagram. February 20, 2024. https://www.instagram.com/p/C3kuD4ELrcB/.

Candido, Christhina, Leena Thomas, Shamila Haddad, Fan Zhang, Martin Mackey, and Wei Ye. 2018. “Designing Activity-Based Workspaces: Satisfaction, Productivity and Physical Activity.” *Building Research & Information* 47 (3): 275–89.

Carlos, Vera Silva, and Ricardo Gouveia Rodrigues. 2015. “Development and Validation of a Self-Reported Measure of Job Performance.” *Social Indicators Research* 126 (1): 279–307.

Cauwerts, Coralie. 2013. “Influence of Presentation Modes on Visual Perceptions of Daylit Spaces.” *Université Catholique de Louvain (UCL), Louvain-La-Neuve, Belgium*.

Celia Henry Arnaud. 2019. “What’s in the Air in Our Homes?” *C&EN Global Enterprise* 97 (46): 34–40. https://doi.org/10.1021/cen-09746-cover.

Chamilothori, Kynthia. 2019. “Perceptual Effects of Daylight Patterns in Architecture.” EPFL.

Chamilothori, Kynthia, Giorgia Chinazzo, J. Rodrigues, E. S. Dan-Glauser, Jan Wienold, and Marilyne Andersen. 2019. “Subjective and Physiological Responses to Façade and Sunlight Pattern Geometry in Virtual Reality.” *Building and Environment* 150:144–55.

Chamilothori, Kynthia, Jan Wienold, and Marilyne Andersen. 2019a. “Adequacy of Immersive Virtual Reality for the Perception of Daylit Spaces: Comparison of Real and Virtual Environments.” *Leukos* 15 (2–3): 203–26.

———. 2019b. “Adequacy of Immersive Virtual Reality for the Perception of Daylit Spaces: Comparison of Real and Virtual Environments.” *LEUKOS* 15 (2–3): 203–26. https://doi.org/10.1080/15502724.2017.1404918.

Chauvel, P, JB Collins, R Dogniaux, and J Longmore. 1982. “Glare from Windows: Current Views of the Problem.” *Lighting Research & Technology* 14 (1): 31–46.

Chen, Y, Z Cui, and L Hao. 2019. “Virtual Reality in Lighting Research: Comparing Physical and Virtual Lighting Environments.” *Lighting Research & Technology* 51 (6): 820–37. https://doi.org/10.1177/1477153518825387.

Chessa, Manuela, Guido Maiello, Alessia Borsari, and Peter J. Bex. 2019. “The Perceptual Quality of the Oculus Rift for Immersive Virtual Reality.” *Human–Computer Interaction* 34 (1): 51–82. https://doi.org/10.1080/07370024.2016.1243478.

Cheung, Millissa F. Y., and Iris D. Zhang. 2020. “The Triggering Effect of Office Design on Employee Creative Performance: An Exploratory Investigation Based on Duffy’s Conceptualization.” *Asia Pacific Journal of Management* 38 (4): 1283–1304.

Chi, Doris A, David Moreno, and Jaime Navarro. 2017. “Design Optimisation of Perforated Solar Façades in Order to Balance Daylighting with Thermal Performance.” *Building and Environment* 125:383–400.

Cho, Sung Heui, and Tae Kyung Lee. 2011. "A Study on Building Sustainable Communities in High-Rise and High-Density Apartments – Focused on Living Program." *Building and Environment* 46 (7): 1428–35. https://doi.org/10.1016/j.buildenv.2011.01.004.

Cho, Sung Heui, Tae Kyung Lee, and Jeong Tai Kim. 2011. "Residents' Satisfaction of Indoor Environmental Quality in Their Old Apartment Homes." *Indoor and Built Environment* 20 (1): 16–25. https://doi.org/10.1177/1420326X10392010.

"Collaborative & Social Space Design After COVID-19." 2020. Steelcase. June 3, 2020. https://www.steelcase.com/research/articles/topics/post-covid-workplace/better-together-future-shared-spaces-office/.

Collins, Belinda Lowenhaupt. 1975. *Windows and People: A Literature Survey: Psychological Reaction to Environments with and without Windows*. Vol. 70. US Department of Commerce, National Bureau of Standards.

Commission Internationale de l'Eclairage. 2004. *Cie 158-2004: Ocular Lighting Effects on Human Physiology and Behavior*. Commission Internationale de l'Eclairage.

Dazkir, Sibel S., and Marilyn A. Read. 2011. "Furniture Forms and Their Influence on Our Emotional Responses Toward Interior Environments." *Environment and Behavior* 44 (5): 722–32. https://doi.org/10.1177/0013916511402063.

DeLucia, P. R. 2008. "Critical Roles for Distance, Task, and Motion in Space Perception: Ini Tial Conceptual Framework and Practical Implications." *Human Factors: The Journal of the Human Factors and Ergonomics Society* 50 (5): 811–20. https://doi.org/10.1518/001872008x312297.

Diemer, Julia, Georg W Alpers, Henrik M Peperkorn, Youssef Shiban, and Andreas Mühlberger. 2015. "The Impact of Perception and Presence on Emotional Reactions: A Review of Research in Virtual Reality." *Frontiers in Psychology* 6:26.

Doyal, Len. 1997. "Human Need and the Right of Patients to Privacy." *Journal of Contemporary Health Law and Policy* 14 (1): 1–22.

Dreyer, Bianca C., Simon Coulombe, Stephanie Whitney, Manuel Riemer, and Delphine Labbé. 2018. "Beyond Exposure to Outdoor Nature: Exploration of the Benefits of a Gr Een Building's Indoor Environment on Wellbeing." *Frontiers in Psychology* 9 (August). https://doi.org/10.3389/fpsyg.2018.01583.

Drucker-Colín, René. 1995. "The Function of Sleep Is to Regulate Brain Excitability in Order to Satisfy the Requirements Imposed by Waking." *Behavioural Brain Research* 69 (1–2): 117–24.

Eilers, Mark, John Reed, and TecMRKT Works. 1996. "Behavioral Aspects of Lighting and Occupancy Sensors in Private Offices: A Case Study of a University Office Building." In *Summer Study on Energy Efficiency in Buildings*.

Elzeyadi, Ihab. 2017. "The Impacts of Dynamic Façade Shading Typologies on Building Energy Performance and Occupant's Multi-Comfort." *Architectural Science Review* 60 (4): 316–24.

Erdodi, Laszlo A., Sanya Sagar, Kristian Seke, Brandon G. Zuccato, Eben S. Schwartz, and Robert M. Roth. 2018. "The Stroop Test as a Measure of Performance Validity in Adults Clinically Referred for Neuropsychological Assessment." *Psychological Assessment* 30 (6): 755–66.

Eva-Christina Edinger. 2014. "Examining Space Perceptions. Combining Visual and Verbal Data with Rea Ctive and Non-Reactive Methods in Studies of the Elderly and Library U Sers."

Falschlunger, Lisa, Horst Treiblmaier, Othmar Lehner, and Elisabeth Grabmann. 2015. "Cognitive Differences and Their Impact on Information Perception: An E Mpirical Study Combining Survey and Eye Tracking Data." In *Information Systems and Neuroscience*, 137–44. Springer International Publishing. https://doi.org/10.1007/978-3-319-18702-0_18.

Farley, Kelly MJ, and Jennifer Ann Veitch. 2001. *A Room with a View: A Review of the Effects of Windows on Work and Well-Being*. Institute for Research in Construction, National Research Council Canada.

Fikfak, Alenka, Martina Zbašnik-Senegačnik, and Samo Drobne. 2022. "Greenery as an Element of Imageability in Window Views." *Land* 11 (12): 2157. https://doi.org/10.3390/land11122157.

Fincke, Isabelle, Amy Hieb, Volker Harth, and Stefanie Mache. 2020. "Activity-Based Working: Qualitative Analysis of Working Conditions and Health-Related Outcomes." *Work* 67 (3): 625–39.

Finnegan, Mary C., and Linda Zener Solomon. 1981. "Work Attitudes in Windowed vs. Windowless Environments." *The Journal of Social Psychology* 115 (2): 291–92. https://doi.org/10.1080/00224545.1981.9711674.

Forth, John, and Robert McNabb. 2008. "Workplace Performance: A Comparison of Subjective and Objective Measures in the 2004 Workplace Employment Relations Survey." *Industrial Relations Journal* 39 (2): 104–23.

Foster, Michelle, and Tadj Oreszczyn. 2001a. "Occupant Control of Passive Systems: The Use of Venetian Blinds." *Building and Environment* 36 (2): 149–55. https://doi.org/10.1016/s0360-1323(99)00074-8.

———. 2001b. “Occupant Control of Passive Systems: The Use of Venetian Blinds.” *Building and Environment* 36 (2): 149–55.

G. Ditchburn. 2014. “The Rise and Fall of the Hot Desk: Say Hello to Activity-Based Working.”

G. Franz. 2006. “Space, Color, and Perceived Qualities of Indoor Environments.”

Graf, Peter, Bob Uttl, and Holly Tuokko. 1995. “Color- and Picture-Word Stroop Tests: Performance Changes in Old Age.” *Journal of Clinical and Experimental Neuropsychology* 17 (3): 390–415.

Grobman, Yasha Jacob, Isaac Guedi Capeluto, and Guy Austern. 2017. “External Shading in Buildings: Comparative Analysis of Daylighting Performance in Static and Kinetic Operation Scenarios.” *Architectural Science Review* 60 (2): 126–36.

Gunay, H Burak, William O’Brien, Ian Beausoleil-Morrison, and Sara Gilani. 2017. “Development and Implementation of an Adaptive Lighting and Blinds Control Algorithm.” *Building and Environment* 113:185–99.

Gustafson, Roland, and Håkan K\" allm\' en. 1990. “Effects of Alcohol on Cognitive Performance Measured with Stroop’s Color Word Test.” *Perceptual and Motor Skills* 71 (1): 99–105.

Gwizdka, Jacek. 2010. “Using Stroop Task to Assess Cognitive Load.” In *Proceedings of the 28th Annual European Conference on Cognitive Ergonomics*. ACM.

H. Salonen, M. Lahtinen, S. Lappalainen, L. Knibbs, L. Morawska, and K. Reijula. 2014. “The Impact of Windows, Daylight and Views of Nature on Health and Well Being in Healthcare Facilities.”

Hadavi, Sara. 2017. “Direct and Indirect Effects of the Physical Aspects of the Environment on Mental Well-Being.” *Environment and Behavior* 49 (10): 1071–1104. https://doi.org/10.1177/0013916516679876.

Hadavi, Sara, Rachel Kaplan, and MaryCarol R. Hunter. 2017. “How Does Perception of Nearby Nature Affect Multiple Aspects of Neighb Ourhood Satisfaction and Use Patterns?” *Landscape Research* 43 (3): 360–79. https://doi.org/10.1080/01426397.2017.1314453.

Haldi, Frédéric, and Darren Robinson. 2009. “Interactions with Window Openings by Office Occupants.” *Building and Environment* 44 (12): 2378–95.

Halim Kazan and Sefer Gumus. 2013. “Measurement of Employees’ Performance: A State Bank Application.”

Han, Heesup, Hyoungeun Moon, and Sunghyup Sean Hyun. 2019. “Indoor and Outdoor Physical Surroundings and Guests’ Emotional Well-Be Ing.” *International Journal of*

Contemporary Hospitality Management 31 (7): 2759–75. https://doi.org/10.1108/ijchm-10-2018-0852.

Hänninen, Otto, and Patrick Goodman. 2019. "Outdoor Air as a Source of Indoor Pollution." In *Indoor Air Pollution*, 35–65. The Royal Society of Chemistry. https://doi.org/10.1039/9781788016179-00035.

Hedge, Alan. 1982. "The Open-Plan Office." *Environment and Behavior* 14 (5): 519–42.

Heerwagen, JH, and DR Heerwagen. 1986. "Lighting and Psychological Comfort." *Lighting Design and Application* 16 (4): 47–51.

Heikkinen, Anna-Leena, Tuomo H\" anninen, Pekka Kuikka, Ritva Akila, Aslak Savolainen, Teppo Valtonen, Adil Umer, et al. 2021. "The Cognitive Function at Work Questionnaire (CFWQ): A New Scale for Measuring Cognitive Complaints in Occupational Population." *Applied Neuropsychology: Adult* 30 (6): 649–60.

Hendrick, Clyde, Osyp Martyniuk, Terry J Spencer, and John E Flynn. 1977. "Procedures for Investigating the Effect of Light on Impression: Simulation of a Real Space by Slides." *Environment and Behavior* 9 (4): 491–510.

Herkel, Sebastian, Ulla Knapp, and Jens Pfafferott. 2008. "Towards a Model of User Behaviour Regarding the Manual Control of Windows in Office Buildings." *Building and Environment* 43 (4): 588–600.

Heydarian, Arsalan, Joao P. Carneiro, David Gerber, Burcin Becerik-Gerber, Timothy Hayes, and Wendy Wood. 2015. "Immersive Virtual Environments versus Physical Built Environments: A Benchmarking Study for Building Design and User-Built Environment Explorations." *Automation in Construction* 54 (June):116–26. https://doi.org/10.1016/j.autcon.2015.03.020.

Heydarian, Arsalan, Evangelos Pantazis, Joao P. Carneiro, David Gerber, and Burcin Becerik-Gerber. 2015. "Towards Understanding End-User Lighting Preferences in Office Spaces by Using Immersive Virtual Environments," June, 475–82. https://doi.org/10.1061/9780784479247.059.

Higuera-Trujillo, Juan Luis, Juan López-Tarruella Maldonado, and Carmen Llinares Millán. 2017. "Psychological and Physiological Human Responses to Simulated and Real Environments: A Comparison between Photographs, 360° Panoramas, and Virtual Reality." *Applied Ergonomics* 65 (November):398–409. https://doi.org/10.1016/j.apergo.2017.05.006.

Hobbs, Lee. n.d. "Your Workplace of the Future." Leesman. Accessed December 17, 2021. https://www.leesmanindex.com/your-workplace-of-the-future/.

Hodzic, Sabina, Bettina Kubicek, Lars Uhlig, and Christian Korunka. 2020. "Activity-Based Flexible Offices: Effects on Work-Related Outcomes in a Longitudinal Study." *Ergonomics* 64 (4): 455–73.

Hoendervanger, Jan Gerard, Iris De Been, Nico W. Van Yperen, Mark P. Mobach, and Casper J. Albers. 2016. "Flexibility in Use: Switching Behaviour and Satisfaction in Activity-Based Work Environments." *Journal of Corporate Real Estate* 18 (1): 48–62. https://doi.org/10.1108/JCRE-10-2015-0033.

I. Balážová, G. Clausen, and D. Wyon. 2007. "The in Fluence of Exposure to Multiple Indoor Environmental Parameters on Human Perception, Performance and Motivation."

Inkarojrit, Vorpat. 2005a. "Balancing Comfort: Occupants' Control of Window Blinds in Private Offices."

———. 2005b. "Balancing Comfort: Occupants' Control of Window Blinds in Private Offices," October. https://escholarship.org/uc/item/3rd2f2bg.

Inoue, T., T. Kawase, T. Ibamoto, S. Takakusa, and Y. Matsuo. 1988. "The Development of an Optimal Control System for Window Shading Devices Based on Investigations in Office Buildings." *ASHRAE Transactions* 94:1034–49.

Ipsen, Christine, Kathrin Kirchner, and John Hansen. 2020a. *EXPERIENCES OF WORKING FROM HOME IN TIMES OF COVID-19 International Survey Conducted the First Months of the National Lockdowns*. https://doi.org/10.11581/dtu:00000085.

———. 2020b. *EXPERIENCES OF WORKING FROM HOME IN TIMES OF COVID-19 International Survey Conducted the First Months of the National Lockdowns*. https://doi.org/10.11581/dtu:00000085.

J. Hanze. 2015. "Tool Development for Measuring and Optimizing Workplace Utilization in Activity-Based Work Environments."

James, Olivia, Paul Delfabbro, and Daniel L. King. 2021. "A Comparison of Psychological and Work Outcomes in Open-Plan and Cellular Office Designs: A Systematic Review." *SAGE Open* 11 (1): 215824402098886.

Jamrozik, Anja, Nicholas Clements, Syed Shabih Hasan, Jie Zhao, Rongpeng Zhang, Carolina Campanella, Vivian Loftness, et al. 2019. "Access to Daylight and View in an Office Improves Cognitive Performanc e and Satisfaction and Reduces Eyestrain: A Controlled Crossover Study." *Building and Environment* 165 (November):106379. https://doi.org/10.1016/j.buildenv.2019.106379.

Jun, Esther, Steven Landry, and Gavriel Salvendy. 2013. "Exploring the Cognitive Costs and Benefits of Using Multiple-View Visu Alisations." *Behaviour & Information Technology* 32 (8): 824–35. https://doi.org/10.1080/0144929x.2011.630420.

Kalyani Wankhede and Amit Wahurwagh. 2017. "The Sensory Experience and Perception of Urban Spaces."

Kamarulzaman, N., A.A. Saleh, S.Z. Hashim, H. Hashim, and A.A. Abdul-Ghani. 2011. "An Overview of the Influence of Physical Office Environments Towards Employee." *Procedia Engineering* 20:262–68.

Kaplan, Rachel. 2001. "The Nature of the View from Home." *Environment and Behavior* 33 (4): 507–42. https://doi.org/10.1177/00139160121973115.

Karst, Kenneth L. 1967. "Privacy and Freedom Book Reviews." *Cornell Law Review* 53 (4): 744–46.

Kelley, Scott T, and Jack A Gilbert. 2013a. "Studying the Microbiology of the Indoor Environment." *Genome Biology* 14 (2): 202. https://doi.org/10.1186/gb-2013-14-2-202.

———. 2013b. "Studying the Microbiology of the Indoor Environment." *Genome Biology* 14 (2): 202. https://doi.org/10.1186/gb-2013-14-2-202.

Kennedy, Rosemary, and Laurie Buys. 2015. "The Impact of Private and Shared Open Space on Liveability in Subtropical Apartment Buildings." In *Global Interchanges: Resurgence of the Skyscraper City (Proceedings of the CTBUT 2015 International Conference)*, edited by A. Wood and D. Malott, 318–23. United States of America: The Council on Tall Buildings and Urban Habitat (CTBUT). http://global.ctbuh.org/resources/papers/download/2476-the-impact-of-private-and-shared-open-space-on-liveability-in-subtropical-apartment-buildings.pdf.

Kenzari, Bechir, and Yasser Elsheshtawy. 2003. "The Ambiguous Veil: On Transparency, the Mashrabiy'ya, and Architecture." *Journal of Architectural Education* 56 (4): 17–25.

Kim, Amy, Shuoqi Wang, Ji-Eun Kim, and Dorothy Reed. 2019. "Indoor/Outdoor Environmental Parameters and Window-Opening Behavior: A Structural Equation Modeling Analysis." *Buildings* 9 (4): 94. https://doi.org/10.3390/buildings9040094.

Kim, Junhee, Kim Nimon, Ji Hoon Song, and Drea Zigarmi. 2015. "Toward Employee Work Passion and Performance: A Validation of the Work Cognition Inventory in Korea." *Human Resource Development International* 18 (2): 169–90.

Kort, YAW de, WA IJsselsteijn, J Kooijmans, and Y Schuurmans. 2003. "Virtual Environments as a Research Tool for Environmental Psychology: A Study of the Comparability of Real and Virtual Environments." *Presence: Teleoperators Virtual Environ* 12:360–73.

Kuliga, S. F., T. Thrash, R. C. Dalton, and C. Hölscher. 2015. "Virtual Reality as an Empirical Research Tool — Exploring User Experience in a Real Building and a Corresponding

Virtual Model." *Computers, Environment and Urban Systems* 54 (November):363–75. https://doi.org/10.1016/j.compenvurbsys.2015.09.006.

Kuş, Büşra. 2019. "A Comparative Study on Spatial Perception in Real and Virtual Office Environments under Different Lighting Conditions." Thesis, Bilkent University. http://repository.bilkent.edu.tr/handle/11693/48388.

Laouadi, A. 2010. "Guidelines for Effective Residential Solar Shading Devices," March. https://www.osti.gov/etdeweb/biblio/21350713.

Leather, Phil, Mike Pyrgas, Di Beale, and Claire Lawrence. 1998. "Windows in the Workplace: Sunlight, View, and Occupational Stress." *Environment and Behavior* 30 (6): 739–62.

Lee, E. S., D. L. DiBartolomeo, and S. E. Selkowitz. 1998. "Thermal and Daylighting Performance of an Automated Venetian Blind and Lighting System in a Full-Scale Private Office." *Energy and Buildings* 29 (1): 47–63. https://doi.org/10.1016/S0378-7788(98)00035-8.

Lee, Jaehyuk, Haeseong Je, and Jeongsoo Byun. 2011. "Well-Being Index of Super Tall Residential Buildings in Korea." *Building and Environment* 46 (5): 1184–94. https://doi.org/10.1016/j.buildenv.2010.12.010.

Lee, So Young, and Jay L. Brand. 2005. "Effects of Control over Office Workspace on Perceptions of the Work Environment and Work Outcomes." *Journal of Environmental Psychology* 25 (3): 323–33.

Lee, Young S., and Denise A. Guerin. 2009. "Indoor Environmental Quality Related to Occupant Satisfaction and Perf Ormance in LEED-Certified Buildings." *Indoor and Built Environment* 18 (4): 293–300. https://doi.org/10.1177/1420326x09105455.

Leino-Kilpi, H., M. Välimäki, T. Dassen, M. Gasull, C. Lemonidou, A. Scott, and M. Arndt. 2001. "Privacy: A Review of the Literature." *International Journal of Nursing Studies* 38 (6): 663–71. https://doi.org/10.1016/S0020-7489(00)00111-5.

Linda Rolfö. 2018. "Activity-Based Flexible Office Work Environments : Design and Implementation Processes and Outcomes."

Lindsay, C., and P. J. Littlefair. 1992. "Occupant Use of Venetian Blinds in Offices." *Building Research Establishment*.

Lindsay, CRT. 1989. "The Use of Adjustable Shading Devices: An Experimental Methodology." In .

Littlefair, Paul. 2018. *Solar Shading of Buildings*. Second edition. BRE Report 364. Bracknell: IHS Markit.

Liu, Qiang, Zheng Huang, Zhijiang Li, Michael R. Pointer, Geng Zhang, Zhen Liu, Hanwen Gong, and Zhen Hou. 2020. “A Field Study of the Impact of Indoor Lighting on Visual Perception an d Cognitive Performance in Classroom.” *Applied Sciences* 10 (21): 7436. https://doi.org/10.3390/app10217436.

M. Hansika and B. Amarathunga. 2016. “Impact of Office Design on Employees’ Performance; A Case Study of Banking Organizations of Western Province in Sri Lanka.”

Mahdavi, Ardeshir, and Claus Pröglhöf. 2008. “169: Observation-Based Models of User Control Actions in Buildings.” In *Proc. PLEA*. Citeseer.

Maher, Alena, and Courtney von Hippel. 2005. “Individual Differences in Employee Reactions to Open-Plan Offices.” *Journal of Environmental Psychology* 25 (2): 219–29.

Maniccia, Dorene, Burr Rutledge, Mark S Rea, and Wayne Morrow. 1999. “Occupant Use of Manual Lighting Controls in Private Offices.” *Journal of the Illuminating Engineering Society* 28 (2): 42–56.

Marín-Restrepo, Laura, Maureen Trebilcock, and Mark Gillott. 2020. “Occupant Action Patterns Regarding Spatial and Human Factors in Office Environments.” *Energy and Buildings* 214 (May):109889. https://doi.org/10.1016/j.enbuild.2020.109889.

Markus, Thomas A. 1967. “The Function of Windows—A Reappraisal.” *Building Science* 2 (2): 97–121.

Marselle, Melissa, Katherine Irvine, Altea Lorenzo-Arribas, and Sara Warber. 2014. “Moving beyond Green: Exploring the Relationship of Environment Type an d Indicators of Perceived Environmental Quality on Emotional Well-Bein g Following Group Walks.” *International Journal of Environmental Research and Public Health* 12 (1): 106–30. https://doi.org/10.3390/ijerph120100106.

McLaurin, Janet Pogue. n.d. “5 Trends Driving the New Post-Pandemic Workplace.” Gensler. Accessed December 27, 2021. https://www.gensler.com/blog/5-trends-driving-the-new-post-pandemic-workplace.

Mewomo, Modupe Cecilia, James Olaonipekun Toyin, Comfort Olubukola Iyiola, and Olusola Raphael Aluko. 2023. “Synthesis of Critical Factors Influencing Indoor Environmental Quality and Their Impacts on Building Occupants Health and Productivity.” *Journal of Engineering, Design and Technology* 21 (2): 619–34. https://doi.org/10.1108/jedt-10-2021-0595.

Miller, Steven L., Suhas Chelian, Will McBurnett, Winnie Tsou, and Amy A. Kruse. 2019a. “An Investigation of Computer-Based Brain Training on the Cognitive and EEG Performance of Employees.” In *2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. IEEE.

———. 2019b. “An Investigation of Computer-Based Brain Training on the Cognitive and EEG Performance of Employees.” In *2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. IEEE.

Min, Yoon-Ki. 2014. “The Effect of Indoor Thermal Comfort on Visual Search Task Performance s in a Personal Learning Environment.” *Psychology and Behavioral Sciences* 3 (6): 185. https://doi.org/10.11648/j.pbs.20140306.11.

MLA, Joyce W. Tang, and PhD Robert D. Brown MLA. 2006. “The Effect of Viewing a Landscape on Physiological Health of Elderly Women.” *Journal of Housing For the Elderly* 19 (3–4): 187–202. https://doi.org/10.1300/J081v19n03_10.

“Mountain View.” n.d. SGA. Accessed May 15, 2024. https://www.sgaltd.co.nz/residential/mountain-view.

Murdoch, Michael J., Mariska G. M. Stokkermans, and Marc Lambooij. 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.

N. Emami, A. Khodadadi, and P. V. Buelow. 2014. “Design of a Shading Screen Inspired by Persian Geometric Patterns: An Integrated Structural and Daylighting Performance Evaluation.”

Newsham, G. R. 1994. “Manual Control of Window Blinds and Electric Lighting: Implications for Comfort and Energy Consumption.” *Indoor Environment* 3 (3): 135–44.

Nicky Mosselman, A. Gosselink, and M. Beijer. 2010. “Long-Term Effects of Activity Based Working.”

Nobuyoshi, J. 1993. “Focused Communication Tasks and Second Language Acquisition.” *ELT Journal* 47 (3): 203–10.

Obeidat, Saif Mohammed, and Islam Mohammed Obeidat. 2022. “Indoor Environmental Quality in Sustainable Interior Design and It Is Impact on Individual’s Behavior in Residential Environment.” In *2022 ASU International Conference in Emerging Technologies for Sustain Ability and Intelligent Systems (ICETSIS)*. IEEE. https://doi.org/10.1109/icetsis55481.2022.9888881.

O’Brien, William, Konstantinos Kapsis, and Andreas K Athienitis. 2013. “Manually-Operated Window Shade Patterns in Office Buildings: A Critical Review.” *Building and Environment* 60:319–38.

Okoli, Ifeanyi Emmanuel Nuel, Evelyn Ayamba Bassey Ewah, and Christian Uchenna Chukwu. 2023. “Accelerating Employee Performance through Management by Objectives: Evidence from Manufacturing Firms.” *European Journal of Business and Management Research* 8 (4): 216–22.

Ornstein, Suzyn. 1989. “The Hidden Influences of Office Design.” *Academy of Management Perspectives* 3 (2): 144–47.

Osimani, A, A Alon, A Berger, and J M Abarbanel. 1997. “Use of the Stroop Phenomenon as a Diagnostic Tool for Malingering.” *Journal of Neurology, Neurosurgery & Psychiatry* 62 (6): 617–21.

Oyg\" ur, Işıl, Ebru Erg\" oz Karahan, and \" Ozg\" ur G\" oçer. 2022. “Hybrid Workplace: Activity–Based Office Design in a Post–Pandemic Era.” *Journal of Interior Design* 47 (3): 3–10.

P. James, M. Jentsch, and A. Bahaj. 2006. “Window Opening and Blind Usage Patterns in a Naturally Ventilated Offi Ce Building: To What Extent Does User Behaviour Compromise Potential b Uilding Performance?”

“Perceived Openness-Enclosure of Architectural Space.” 1974. *Environment and Behavior* 6 (1): 37–52. https://doi.org/10.1177/001391657400600102.

Phillips, David R., Oi-ling Siu, Anthony G. O. Yeh, and Kevin H. C. Cheng. 2005. “The Impacts of Dwelling Conditions on Older Persons’ Psychological Well-Being in Hong Kong: The Mediating Role of Residential Satisfaction.” *Social Science & Medicine*, Burning Issues - Selected papers from the 10th International Symposium in Medical Geography, Manchester 2003, 60 (12): 2785–97. https://doi.org/10.1016/j.socscimed.2004.11.027.

Pradhan, Rabindra Kumar, and Lalatendu Kesari Jena. 2016. “Employee Performance at Workplace: Conceptual Model and Empirical Validation.” *Business Perspectives and Research* 5 (1): 69–85.

R. Islam and Shuib bin Mohd Rasad. 2006. “Employee Performance Evaluation by the AHP: A Case Study.”

Ramos-Villagrasa, Pedro J., Juan R. Barrada, Elena Fern\' andez-del-R\' io, and Linda Koopmans. 2019. “Assessing Job Performance Using Brief Self-Report Scales: The Case of the Individual Work Performance Questionnaire.” *Revista de Psicolog\' Ia Del Trabajo y de Las Organizaciones* 35 (3): 195–205.

Rea, M. S. 1984. “Window Blind Occlusion: A Pilot Study.” *Building and Environment* 19 (2): 133–37. https://doi.org/10.1016/0360-1323(84)90038-6.

Reinhart, Christoph F., and Karsten Voss. 2003a. “Monitoring Manual Control of Electric Lighting and Blinds.” *Lighting Research & Technology* 35 (3): 243–58.

Reinhart, Christoph F, and Karsten Voss. 2003b. “Monitoring Manual Control of Electric Lighting and Blinds.” *Lighting Research & Technology* 35 (3): 243–58.

“Returning to Work - May 31, 2021.” 2021. Leger. May 31, 2021. https://leger360.com/surveys/legers-north-american-tracker-may-31-2021/.

Rezaian, Elnaz, Kasra Amini, Soha Matoor, Sina A. Milani, and Rima Fayaz. 2014. “Design and Geometrical Optimization of the Veranda Roof Pattern with t He Target of Visual Comfort in Shāremān as One of the Solar Decathlon China 2013 Houses.” *Building Simulation* 8 (3): 323–36. https://doi.org/10.1007/s12273-014-0209-0.

Rivas, Ioar, Julia C. Fussell, Frank J. Kelly, and Xavier Querol. 2019. “Indoor Sources of Air Pollutants.” In *Indoor Air Pollution*, 1–34. The Royal Society of Chemistry. https://doi.org/10.1039/9781788016179-00001.

Rockcastle, S, M Danell, E Calabrese, G Sollom-Brotherton, A Mahic, K Van Den Wymelenberg, and R Davis. 2021. “Comparing Perceptions of a Dimmable LED Lighting System between a Real Space and a Virtual Reality Display.” *Lighting Research & Technology*, February, 1477153521990039. https://doi.org/10.1177/1477153521990039.

Rodriguez, Francisca, Veronica Garcia-Hansen, Alicia Allan, and Gillian Isoardi. 2021. “Subjective Responses toward Daylight Changes in Window Views: Assessin g Dynamic Environmental Attributes in an Immersive Experiment.” *Building and Environment* 195 (May):107720. https://doi.org/10.1016/j.buildenv.2021.107720.

Roelofsen, Paul. 2002. “The Impact of Office Environments on Employee Performance: The Design of the Workplace as a Strategy for Productivity Enhancement.” *Journal of Facilities Management* 1 (3): 247–64.

Roper, Kathy O., and Parminder Juneja. 2008. “Distractions in the Workplace Revisited.” *Journal of Facilities Management* 6 (2): 91–109.

Ropo, Arja, and Ritva Höykinpuro. 2017. “Narrating Organizational Spaces.” *Journal of Organizational Change Management* 30 (3): 357–66. https://doi.org/10.1108/jocm-10-2016-0208.

Rosenthal, Norman, DA Sack, C Carpenter, Barbara Parry, Wallace Mendelson, and TA Wehr. 1985. “Antidpressant Effects of Light in Seasonal Affective Disorder.” *The American Journal of Psychiatry* 142 (March):163–70. https://doi.org/10.1176/ajp.142.2.163.

Rubin, Arthur I, Belinda Lowenhaupt Collins, and Robert L Tibbott. 1978. *Window Blinds as a Potential Energy Saver: A Case Study*. US Department of Commerce, National Bureau of Standards.

Saad, Lydia, and Adam Hickman. 2021. “Majority of US Workers Continue to Punch in Virtually.” *Gallup, Available at: Https://News. Gallup. Com/Poll/329501/Majority-Workers-Continue-Punch-Virtually. Aspx*.

Sailer, Kerstin, Petros Koutsolampros, and Rosica Pachilova. 2021. “Differential Perceptions of Teamwork, Focused Work and Perceived Productivity as an Effect of Desk Characteristics within a Workplace Layout.” Edited by Wenjia Zhang. *PLOS ONE* 16 (4): e0250058.

Salonen, Heidi, Marjaana Lahtinen, Sanna Lappalainen, Nina Nevala, Luke D. Knibbs, Lidia Morawska, and Kari Reijula. 2013. “Physical Characteristics of the Indoor Environment That Affect Health and Wellbeing in Healthcare Facilities: A Review.” *Intelligent Buildings International* 5 (1): 3–25. https://doi.org/10.1080/17508975.2013.764838.

Sanati, Leyla, and Michael Utzinger. 2013. “The Effect of Window Shading Design on Occupant Use of Blinds and Elec Tric Lighting.” *Building and Environment* 64 (June):67–76. https://doi.org/10.1016/j.buildenv.2013.02.013.

Saraga, Dikaia E. 2020. “Special Issue on Indoor Air Quality.” *Applied Sciences* 10 (4): 1501. https://doi.org/10.3390/app10041501.

Satumane, Anupam, and Siobhan Rockcastle. n.d. “The Impact of Space Function and Window View on Perceived Indoor Environmental Quality and Privacy.”

Schuster, E. A. 1976. “Privacy and the Hospitalization Experience.” *Communicating Nursing Research* 7 (January):153–71.

Schuster, Eleanor A. 1976. “Privacy, the Patient and Hospitalization.” *Social Science & Medicine (1967)* 10 (5): 245–48. https://doi.org/10.1016/0037-7856(76)90007-X.

Shan, Xin, Anastasia Nissa Melina, and En-Hua Yang. 2018. “Impact of Indoor Environmental Quality on Students’ Wellbeing and Perf Ormance in Educational Building through Life Cycle Costing Perspective.” *Journal of Cleaner Production* 204 (December):298–309. https://doi.org/10.1016/j.jclepro.2018.09.002.

Sherif, Ahmed, Hanan Sabry, and Tarek Rakha. 2012. “External Perforated Solar Screens for Daylighting in Residential Deser t Buildings: Identification of Minimum Perforation Percentages.” *Solar Energy* 86 (6): 1929–40. https://doi.org/10.1016/j.solener.2012.02.029.

Shi, Yongxiang, Jialin Wu, Li Lan, and Zhiwei Lian. 2023. “Interactive Effects of Indoor Environmental Factors on Work Performanc e.” *Ergonomics*, August, 1–16. https://doi.org/10.1080/00140139.2023.2243407.

Slater, A. I. 1987. “Lighting Controls: An Essential Element of Energy-Efficient Lighting,” January. https://www.osti.gov/etdeweb/biblio/6204118.

Steemers, Koen, and Geun Young Yun. 2009. “Household Energy Consumption: A Study of the Role of Occupants.” *Building Research & Information* 37 (5–6): 625–37. https://doi.org/10.1080/09613210903186661.

Sultan, Muhammad Faisal, Mehwish Jabeen, and Ali Raza Qureshi. 2020. "Estimating The Resultant of Office Design of Employee Performance: Evidence from Employees From NADRA." *Academic Journal of Social Sciences (AJSS)* 4 (1): 60–84.

Sundstrom, Eric, Mary Graehl Sundstrom, and Sundstrom Eric. 1986. *Work Places: The Psychology of the Physical Environment in Offices and Factories*. CUP Archive.

Sutter, Yannick, Dominique Dumortier, and Marc Fontoynont. 2006. "The Use of Shading Systems in VDU Task Offices: A Pilot Study." *Energy and Buildings* 38 (7): 780–89.

Talbot, Janet Frey, and Rachel Kaplan. 1991. "The Benefits of Nearby Nature for Elderly Apartment Residents." *The International Journal of Aging and Human Development* 33 (2): 119–30. https://doi.org/10.2190/XK9Q-3MDL-XYW9-9QL3.

Tiwari, Richa, Mukesh Pandey, and Anupama Sharma. 2010. "An Approach to Human Adaptability towards Its Built Environment: A Rev Iew." *Energy and Power Engineering* 02 (02): 90–94. https://doi.org/10.4236/epe.2010.22013.

Torresin, S., G. Pernigotto, F. Cappelletti, and A. Gasparella. 2018. "Combined Effects of Environmental Factors on Human Perception and Obje Ctive Performance: A Review of Experimental Laboratory Works." *Indoor Air* 28 (4): 525–38. https://doi.org/10.1111/ina.12457.

Tregenza, Peter, and Michael Wilson. 2013. *Daylighting: Architecture and Lighting Design*. Routledge.

Tuaycharoen, N, and PR Tregenza. 2007. "View and Discomfort Glare from Windows." *Lighting Research & Technology* 39 (2): 185–200.

Tuszyńska-Bogucka, Wioletta, Bartłomiej Kwiatkowski, Magdalena Chmielewska, Mariusz Dzieńkowski, Wojciech Kocki, Jarosław Pełka, Natalia Przesmycka, Jacek Bogucki, and Dariusz Galkowski. 2020. "The Effects of Interior Design on Wellness – Eye Tracking Analysis i n Determining Emotional Experience of Architectural Space. A Survey on a Group of Volunteers from the Lublin Region, Eastern Poland." *Annals of Agricultural and Environmental Medicine* 27 (1): 113–22. https://doi.org/10.26444/aaem/106233.

Ulfa Auliyah, and M. Nawawiy Loebis. 2019. "Study of User Perception of A Room (Case Study: Architecture Building)." *International Journal of Architecture and Urbanism* 3 (3): 334–41. https://doi.org/10.32734/ijau.v3i3.3749.

Ulrich, R. S. 1984. "View through a Window May Influence Recovery from Surgery." *Science* 224 (4647): 420–21. https://doi.org/10.1126/science.6143402.

Ulrich, Roger S. 1979. "Visual Landscapes and Psychological Well-being." *Landscape Research* 4 (1): 17–23. https://doi.org/10.1080/01426397908705892.

———. 1981. “Natural Versus Urban Scenes: Some Psychophysiological Effects.” *Environment and Behavior* 13 (5): 523–56. https://doi.org/10.1177/0013916581135001.

Ulrich, Roger S, and RF Simons. 1986. “Recovery from Stress during Exposure to Everyday Outdoor Environments.” In , 17:115–22.

Ulrich, Roger S., Robert F. Simons, Barbara D. Losito, Evelyn Fiorito, Mark A. Miles, and Michael Zelson. 1991. “Stress Recovery during Exposure to Natural and Urban Environments.” *Journal of Environmental Psychology* 11 (3): 201–30. https://doi.org/10.1016/S0272-4944(05)80184-7.

“University of Aberdeen New Library / Schmidt Hammer Lassen Architects | ArchDaily.” n.d. Accessed May 15, 2024. https://www.archdaily.com/276161/university-of-aberdeen-new-library-schmidt-hammer-lassen-architects.

Van der Elst, Wim, Martin P. J. Van Boxtel, Gerard J. P. Van Breukelen, and Jelle Jolles. 2006. “The Stroop Color-Word Test.” *Assessment* 13 (1): 62–79.

Veitch, J. A., K. M. J. Farley, Kelly M. J. Farley, Jennifer A. Veitch, and Jennifer A. Veitch. 2001. *A Room with a View: A Review of the Effects of Windows on Work and Well-Being*.

Veitch, J. A., S. Mancini, A. D. Galasiu, and A. Laouadi. 2009. “Survey on Canadian Households’ Control of Interior Climate. Report B-3243.2.” *NRC Institute for Research in Construction*, 1–85.

Veitch, Jennifer A. 2001. “Lighting Quality Contributions from Biopsychological Processes.” *Journal of the Illuminating Engineering Society* 30 (1): 3–16. https://doi.org/10.1080/00994480.2001.10748329.

Voordt, Theo J.M. van der. 2004. “Productivity and Employee Satisfaction in Flexible Workplaces.” *Journal of Corporate Real Estate* 6 (2): 133–48.

Waite-Chuah, Sheila. 2012. “Living in the Comfort Zone: At What Cost?” *Sustainability* 5 (6): 386–90. https://doi.org/10.1089/SUS.2012.9909.

Wineman, Jean D. 1982. “Office Design and Evaluation.” *Environment and Behavior* 14 (3): 271–98.

Wohlers, Christina, and Guido Hertel. 2016. “Choosing Where to Work at Work – towards a Theoretical Model of Benefits and Risks of Activity-Based Flexible Offices.” *Ergonomics* 60 (4): 467–86.

Yang, Junjing, Mattheos Santamouris, and Siew Eang Lee. 2016. “Review of Occupancy Sensing Systems and Occupancy Modeling Methodologies for the Application in Institutional Buildings.” *Energy and Buildings* 121 (June):344–49. https://doi.org/10.1016/j.enbuild.2015.12.019.

Yildirim, Kemal, Aysu Akalin-Baskaya, and Mine Celebi. 2007. "The Effects of Window Proximity, Partition Height, and Gender on Perceptions of Open-Plan Offices." *Journal of Environmental Psychology* 27 (2): 154–65.

Yongli Ren, Martin Tomko, Kevin Ong, Y. Bai, and M. Sanderson. 2014. "The Influence of Indoor Spatial Context on User Information Behaviours."

Yun, Geun Young, Hwa Young Shin, and Jeong Tai Kim. 2010. "Monitoring and Evaluation of a Light-Pipe System Used in Korea." *Indoor and Built Environment* 19 (1): 129–36. https://doi.org/10.1177/1420326X09358007.

Zhang, Xi, Zhiwei Lian, and Qingfeng Ding. 2016. "Investigation Variance in Human Psychological Responses to Wooden Indo or Environments." *Building and Environment* 109 (November):58–67. https://doi.org/10.1016/j.buildenv.2016.09.014.

Zhang, Yufan, and Peter Barrett. 2012. "Factors Influencing the Occupants' Window Opening Behaviour in a Naturally Ventilated Office Building." *Building and Environment* 50:125–34.