Full paper

International Journal of Real Estate Studies

INTREST

Virtual Reality for Residential Daylight Assessment: Enhancing Homebuyer Decision-Making and Purchase Intention

Athira Azmi*, Sarah Abdulkareem Salih, Annisa Ummihusna, Maszura Abd Ghafar

Department of Architecture, Faculty of Design and Architecture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

*Corresponding author's email: athira.azmi@upm.edu.my

Article history: Received: *31 March 2026* Received in revised form: *4 May 2026*
Accepted: *5 May 2026* Published online: *30 June 2026*
DOI: https://doi.org/10.11113/intrest.v20n1.480

Abstract

Daylight is a critical factor influencing mental well-being, impacting mood regulation, cognitive performance, and circadian rhythms, which are the key aspects that shape the desirability and liveability of residential environments. Conventional daylight assessments for real estate rely on physical models and in-person site visits to show units, which can be costly and time-consuming. With advancements in Virtual Reality (VR), daylight conditions can now be simulated in immersive, interactive environments, offering a cost-effective and ecologically valid method for assessing homebuyers' emotional responses. This study explores the role of VR-based daylight simulation in enhancing emotional well-being, drawing insights from environmental psychology, neuroarchitecture, and immersive technology. Grounded in Approach–Avoidance Theory, this research examines how variations in daylight brightness influence pleasure and satisfaction. A within-subjects experimental design was conducted with 50 participants experiencing two VR-simulated bedroom settings, one bright and one dark. Emotional responses were analyzed using Paired Samples *t*-tests and repeated measures ANOVA. Results showed significantly higher pleasure and satisfaction scores in the bright daylight condition ($p < 0.001$), confirming daylight's positive impact on emotions. Notably, satisfaction was more sensitive to lighting variations than pleasure, suggesting that satisfaction is directly influenced by environmental conditions, while pleasure remains more stable due to subjective preferences and contextual associations. These findings validate VR as a robust tool for daylight research, offering a controlled, immersive, and ecologically valid method for studying daylight's psychological and behavioral effects. The findings offer valuable insights for architects, developers, and real estate professionals, advocating for VR as a transformative tool in real estate design and marketing. By highlighting the relationship between daylight quality and emotional well-being, this study supports the creation of more liveable, resilient, and marketable urban residential spaces, aligning with the evolving priorities of sustainable real estate development.

Keywords: Virtual Reality, Daylight, Home Purchase Intention, Environmental Psychology, Approach-Avoidance Theory

■1.0 INTRODUCTION

The built environment plays a crucial role in shaping human health and well-being (St-Jean et al., 2022), with daylight being a fundamental factor influencing occupants' psychological and physiological state (Jung et al., 2024; Leung et al., 2024; Nagare et al., 2021; Qu et al., 2024). Various research has highlighted how exposure to natural light regulates circadian rhythms, enhances mood, and contributes to overall mental health (Ghaeili Ardabili et al., 2023; Jafarifiroozabadi et al., 2023; Kong et al., 2022; Nagare et al., 2021). Bedrooms, designed for relaxation and recovery, require well-planned daylighting strategies to enhance occupants' emotional and physiological well-being (Al-Qamadi, 2024; Canazei et al., 2022). However, while extensive research has explored the effects of natural light on human well-being, there remains a significant gap in studies utilizing digital visualization technologies, such as Virtual Reality (VR), for daylight research (Azmi et al., 2025).

VR enables immersive simulations that allow researchers to evaluate user response in a controlled and interactive environment, offering new possibilities for studying occupants' emotional state (Heydarian & Becerik-Gerber, 2017). This technology has been used in various studies concerning user needs, particularly regarding daylight comfort as VR can simulate lighting in the immersive virtual environment. However, existing research on daylight visual comfort using VR is heavily skewed toward office and commercial environments, leaving a critical gap in residential studies, particularly in bedrooms (Azmi et al., 2025). Furthermore, according to Azmi et al., (2025), most existing research that applies VR simulation for daylight impact on occupants' emotion, cognition, and physiology is conducted in European and North American contexts, limiting the applicability of findings to regions with different climatic conditions, such as Southeast Asia. Addressing these gaps would advance VR applications in daylight research, enhancing occupant-centric design strategies for improved well-being and sustainability.

Thus, this paper posits the need for further exploration of VR-based daylight simulations to deepen our understanding of how lighting influences human emotions and behavior within an immersive environment. In this research, Approach-Avoidance Theory was employed to provide a valuable framework for understanding how individuals respond to their surroundings (Khaleghimoghaddam, 2024). The theory suggests that people instinctively approach environments that induce positive emotions, such as pleasure and satisfaction, while avoiding those that evoke discomfort or psychological distress. While previous studies have demonstrated the psychological benefits of daylight exposure, there is a need for empirical research that links daylight visual comfort to emotional and behavioral responses in a controlled experimental setting particularly in residential context (Azmi et al., 2025).

■2.0 LITERATURE REVIEW

2.1 Neuroaesthetics of The Built Environment

The field of architecture has evolved to incorporate interdisciplinary studies to better understand human-environment interactions, particularly the neuroscience of perception, cognition, and emotional responses to the built environment (Lee et al., 2022). Humans spend over 90% of their time in built environments, yet the psychological and neural effects of architecture remain underexplored. Recent advancements in the neuroscience of architecture, framed within the aesthetic triad model (Chatterjee & Vartanian, 2016), suggest that architectural experiences arise from the interaction of three neural systems: sensory-motor processing (bottom-up perception of physical features), knowledge-meaning processing (top-down influences shaped by cultural and personal context), and emotion-valuation (integrating sensory and cognitive inputs to generate emotional responses), collectively shaping human-building interactions (Chatterjee et al., 2021).

One example of the study in neuroaesthetics of the built environment show that curvilinear building interiors are perceived as more beautiful and pleasing than rectilinear spaces, with increased activation in the anterior cingulate cortex, a brain region linked to reward processing (Coburn et al., 2017). Their research also revealed that enclosed spaces can induce fear and stress, as seen in experiments where participants in windowless virtual rooms exhibited higher stress hormone levels, likely due to amygdala-driven stress responses, suggesting that architectural design directly influences emotional and physiological well-being (Coburn et al., 2017). However, most neuroaesthetics research rely on 2D images and are non-immersive, hence, advancements in VR may provide a more accurate representation of how individuals perceive and interact with built environments as it allows for simulation and replication of buildings experimentally (Coburn et al., 2017).

2.2 Impact of Daylight on Building Occupants' Emotional Well-Being

Daylight exposure is well-documented to influence mental health by regulating sleep patterns, reducing stress, and improving mood. Studies have shown that insufficient daylight can lead to conditions such as seasonal affective disorder (SAD) and other mood-related disorders. In architectural design, daylighting strategies are often evaluated based on physical parameters such as illuminance levels and glare indices. However, an emerging body of research highlights the importance of subjective experience, where emotional responses to daylight contribute to an occupant's overall wellbeing. VR has been increasingly used in environmental psychology to assess spatial perception and emotional reactions in built environments.

In the context of residential architecture, the impact of daylight on emotional well-being has been widely recognized. The presence of natural light in a space has been found to enhance positive emotional responses, reduce stress, and improve cognitive function (Mehrabian & Russell, 1974). Several studies have shown that daylight influences circadian rhythms, which, in turn, regulate mood and overall mental health. Spaces that allow for greater daylight penetration tend to foster positive emotional states, thereby promoting an approach tendency towards such environments (Zhang et al., 2022). Conversely, poorly lit or dim environments have been associated with negative affect, avoidance behaviors, and even symptoms of depression (Mehrabian & Russell, 1974). These findings underscore the importance of daylight access in architectural design, particularly in spaces meant for rest and recovery, such as bedrooms.

VR-based simulation allows researchers to control variables such as brightness, spatial configuration, and window placement, enabling the study of their impact on emotional responses in a controlled yet immersive setting (Kuhl & Koole, 2008). Studies employing VR-based experimental setups have demonstrated that users' physiological and psychological responses to simulated environments closely mirror those experienced in real-world settings (Khaleghimoghaddam, 2024). The ability to manipulate lighting conditions in VR provides valuable insights into how different daylight settings influence user preferences and behaviors, thereby informing daylighting strategies for improved occupant well-being.

From a neuroscientific perspective, VR-based studies have been instrumental in advancing our understanding of approach-avoidance behaviors in architectural settings. Research has indicated that immersive VR environments activate similar neural pathways involved in real-world spatial perception and emotional processing (Khaleghimoghaddam, 2024). For instance, studies have found that exposure to virtual spaces with high daylight availability activates brain regions associated with pleasure and relaxation, whereas dark or enclosed virtual spaces trigger avoidance responses and heightened stress markers (Zhang et al., 2022). Such findings validate VR as a reliable tool for evaluating architectural features and their psychological impact, reinforcing its potential for pre-construction daylight comfort assessments.

By leveraging VR technology, architects and researchers can predict user responses to different daylight scenarios, ensuring that spaces are designed to maximize mental health benefits and positive emotional engagement. As the field of architectural neuroscience continues to evolve, interdisciplinary studies combining psychology, architecture, and immersive technology will play a crucial role in optimizing built environments for human well-being.

2.3 Approach-Avoidance Theory

The Approach-Avoidance Theory has been extensively used to explain human interactions with the built environment, particularly in how individuals respond to architectural spaces. The theory postulates that individuals tend to approach environments that induce positive emotions and avoid those that elicit negative emotions (Khaleghimoghaddam, 2024). The neurological underpinnings of this behavior have been supported by studies using functional magnetic resonance imaging (fMRI), demonstrating that specific brain regions, such as the anterior midcingulate cortex and amygdala, are activated in response to enclosed or unpleasant spaces, leading to avoidance behaviors (Khaleghimoghaddam, 2024). In contrast, spacious and well-lit environments tend to evoke approach responses, reinforcing the importance of environmental factors in shaping user behavior. This connection between emotional processing and spatial perception has significant implications for architectural design, particularly in residential settings where emotional well-being is a crucial factor.

Jelić et al., (2016) explores the enactive approach to architectural experience, emphasizing the dynamic interaction between the human body, cognition, and built environments. They highlight how affordances—action possibilities within a space—shape human perception, emotion, and behavior through sensorimotor and neurophysiological responses. Drawing from neuroscience, psychology, and phenomenology, the study suggests that well-designed spaces enhance positive emotions and engagement, while poorly designed environments may induce stress or avoidance behaviors. The paper also advocates VR as a research tool, enabling controlled investigations into how spatial qualities affect emotional and cognitive states. Ultimately, it calls for a human-centered, neuroscientific approach to architectural design, ensuring that spaces promote mental well-being and positive engagement.

This study underscores the critical role of daylight in shaping emotional responses and approach-avoidance behaviors in residential spaces, particularly bedrooms. By integrating VR-based simulations with Approach-Avoidance Theory, this research provides a controlled, immersive environment for evaluating how different daylight conditions influence occupants' psychological well-being.

■3.0 RESEARCH METHODOLOGY

This study conducted an experiment to assess the effect of different daylight conditions in immersive virtual environments on participants' pleasure and satisfaction emotion. A within-subjects experiment design was employed following procedures by previous study (Azmi et al., 2022) as illustrated in Figure 1.

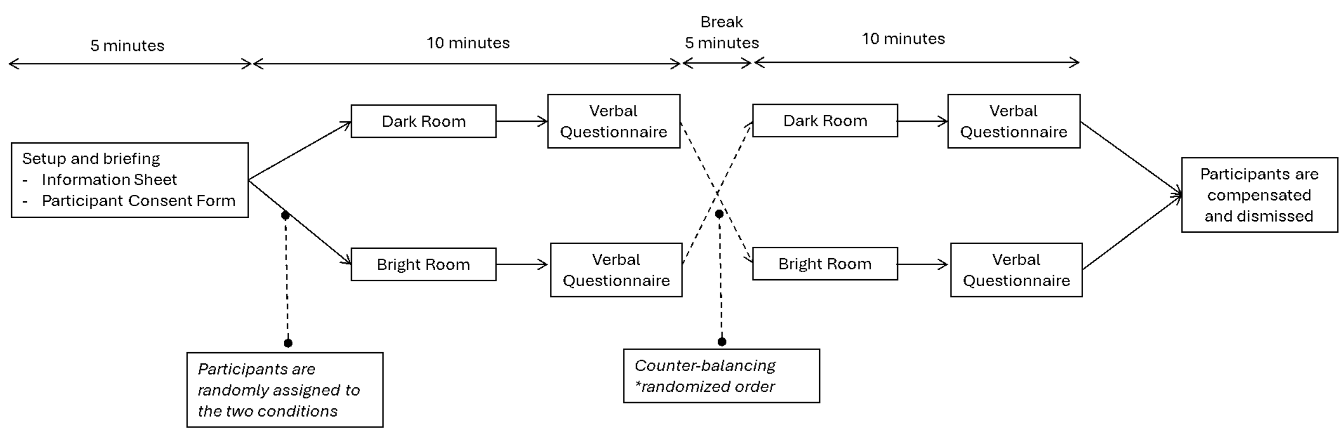

Figure 1 Experiment design
(Source: Authors own work)

For this experiment, 50 participants were selected using purposive sampling method to select participants that meet the inclusion criteria – over the age of 18 years, and do not have vision problems such as color blindness. This is to prevent any bias in visual perception that could affect the accuracy of participants' responses to daylight conditions, ensuring that the findings reflect genuine emotional and behavioral reactions rather than limitations in visual processing. The study has been approved by Universiti Putra Malaysia Ethics Committee for Research Involving Human Subjects (Approval No. JKEUPM-2024-897).

This experiment utilized immersive virtual environments viewed in VR equipment – HTC Vive, to simulate two distinct bedroom design with different daylight conditions – dark and bright, in a standardized 3D-rendered apartment bedroom. The 3D models were created in SketchUp Pro and rendered with Enscape. Figure 2 shows the bedroom Type 1, with the window facing the east direction. Figure 3 depicts the bedroom Type 2 with the window facing west direction. The brightness of the room in the simulation was affected by the sun location at 1.30pm, where bedroom Type 2 receives more direct sunlight compared to bedroom Type 1.

Figure 2 VR simulation of the Bedroom Type 1
(Source: Authors own work)

Figure 3 VR simulation of the Bedroom Type 2
(Source: Authors own work)

The verbal questionnaire used in this study consisted of nine questions on a 10-point Likert scale, designed to evaluate participants' perceptions of brightness, pleasantness, satisfaction, and room usage preference. These questionnaire items were adapted from validated measures in previous daylight perception and visual comfort studies, including Moscoso et al. (2021, 2022), Kong et al. (2022), Chamilothori et al. (2022a, 2022b), and Mirdamadi et al. (2023). By incorporating established assessment tools, the study ensured comparability with prior research while maintaining reliability in measuring participants' subjective experiences of daylight within the VR-simulated environment.

■4.0 RESULTS

4.1 Descriptive Statistics

Descriptive statistics were computed for Pleasure and Satisfaction scores in both Bright and Dark room conditions. The mean Satisfaction score in the Bright room was 8.43 (SD = 0.96), which was notably higher than in the Dark room (M = 4.90, SD = 1.71). Similarly, the mean Pleasure score was higher in the Bright room (M = 8.02, SD = 1.10) compared to the Dark room (M = 5.05, SD = 1.75). The range of Satisfaction scores varied from 1 to 9 in the Dark room, whereas in the Bright room, scores ranged from 6 to 10. For Pleasure scores, participants rated between 1 and 10 in the Dark room, while in the Bright room, ratings ranged from 5 to 10.

These findings suggest that participants generally reported higher levels of Pleasure and Satisfaction in the Bright room condition compared to the Dark room condition, with lower variability in responses in the Bright environment. Skewness and kurtosis values were examined to assess the normality of the paired differences. The skewness values for the data fell within the acceptable range of ±2. The kurtosis values were also within an acceptable range, suggesting that the assumption of normality was approximately met. The results are summarized in Table 1.

Table 1 Descriptive Statistics

Emotion	N	Minimum	Maximum	Mean	Std. Deviation
Sat_Dark	50	1	9	4.90	1.707
Sat_Bright	50	6	10	8.43	.957
Ple_Dark	50	1	10	5.05	1.754
Ple_Bright	50	5	10	8.02	1.100

4.2 Paired sample *t*-test results

A paired samples t-test was conducted using SPSS to examine whether the differences in scores between the dark and bright conditions in the virtual environment were statistically significant. For Satisfaction emotion, the difference between bedroom Type 1 and bedroom Type 2 was significant, t (49) = -14.99, p < 0.001, indicating a substantial increase in Satisfaction scores under bright conditions in VR. For Pleasure emotion, the difference between bedroom Type 1 and bedroom Type 2 was also significant, t (49) = -11.23, p < 0.001, suggesting that brightness of the bedroom simulated in VR had a notable impact on Pleasure emotion scores. The effect sizes, calculated using Cohen's d, were -2.12 for Satisfaction and -1.59 for Pleasure, indicating a large effect of brightness on both measures. Table 2 summarizes the paired samples correlation results while Table 3 summarizes the results of the paired samples t-test.

Table 2 Paired Samples Correlation Results

Emotion	N	Correlation	Significance	
			One-Sided p	Two-Sided p
Sat_Dark & Sat_Bright	50	.324	.011	.022
Ple_Dark & Ple_Bright	50	.204	.078	.155

Table 3 Paired Samples *t*-test Results

Emotion	Mean	Std. Deviation	t	Effect size (Cohen's d)	p-value
Sat_Dark & Sat_Bright	-3.530	1.664	-14.992	-2.120	<.001
Ple_Dark & Ple_Bright	-2.970	-14.99	-11.227	-1.588	<.001

Overall, the results demonstrate that the brightness of the bedroom, as simulated in VR, significantly influences both Satisfaction and Pleasure emotion scores, with higher values observed under bright conditions. The strong effect sizes further validate the substantial psychological impact of lighting conditions on emotional responses. These findings align with previous studies that have examined the influence of room daylighting on satisfaction and pleasure in real-world physical environments (Jamrozik et al., 2019; Woo et al., 2021), suggesting that VR simulations can effectively replicate similar emotional and behavioral responses to daylight variations. By providing a controlled and immersive research setting, VR offers a valuable tool for studying the nuanced effects of daylight access on mental health and well-being, enabling researchers to develop evidence-based lighting strategies for optimizing indoor environments.

4.3 Repeated Measures ANOVA test

A repeated measures ANOVA was conducted to examine the effects of room condition (Type 1- dark vs. Type 2- bright) and emotion (Satisfaction vs. Pleasure) on participants' responses. The analysis aimed to determine whether room lighting conditions significantly influenced the reported levels of Pleasure and Satisfaction and whether the impact of brightness varied depending on the type of emotion being assessed.

The results indicated that the main effect of room brightness was not statistically significant, $F(1, 49) = 3.021$, $p = .088$, $\eta^2 = .058$, suggesting that there was no substantial difference in participant responses between the dark and bright room conditions. In contrast, the main effect of emotion was highly significant, $F(1, 49) = 182.321$, $p < .001$, $\eta^2 = .788$, indicating a strong influence of emotional state on participant responses. Additionally, the interaction effect between room brightness and emotion was statistically significant, F(1, 49) =

16.410, $p < .001$, $\eta^2 = .251$, suggesting that the impact of room condition varied depending on the emotional dimension being assessed. The result is summarized in Table 4.

Table 4 Tests of Within-Subjects Effects (ANOVA)

Source	Sum of Squares	df	Mean Squares	F	p-value	Partial η²
Room	0.980	1	0.980	3.021	0.088	0.058
Emotion	528.125	1	528.125	182.321	<.001	0.788
Room × Emotion	3.920	1	3.920	16.410	<.001	0.251
Error (Room)	15.895	49	0.324			
Error (Emotion)	141.937	49	2.897			
Error (Room × Emotion)	11.705	49	0.239			

Pairwise comparisons using Bonferroni adjustment further clarified these effects. The mean scores for satisfaction in the dark and bright rooms were M = 4.90, SD = 1.707 and M = 8.43, SD = .957, respectively. Similarly, for pleasure, the mean scores were M = 5.05, SD = 1.754 in the dark room and M = 8.02, SD = 1.100 in the bright room. The comparison between dark and bright conditions within the same emotional state did not reach significance (p = .088), but comparisons between satisfaction and pleasure conditions were statistically significant, $p < .001$. The Bonferroni-adjusted mean difference for Emotion was -3.250 ($p < .001$, 95% CI: -3.734, -2.766), confirming that pleasure scores were significantly higher than satisfaction scores across conditions. Table 5 show the pairwise comparison results.

Table 5 Pairwise Comparisons

Comparison	Mean Difference (I-J)	Std. Error	p-value	95% CI (Lower)	95% CI (Upper)
Dark Room vs. Bright Room	0.140	0.081	0.088	-0.022	0.302
Satisfaction vs. Pleasure	-3.250	0.241	<.001	-3.734	-2.766

Table 6 shows the interaction effect was evident in the Room × Emotion pairwise comparisons. For satisfaction, the mean score increased from 4.905 in the dark room to 8.435 in the bright room. Similarly, for pleasure, the mean score increased from 5.045 in the dark room to 8.015 in the bright room. The significant interaction suggests that emotional responses to room conditions were stronger for satisfaction than for pleasure, reinforcing the idea that lighting conditions differentially impact emotional states.

Table 6 Interaction Pairwise Comparisons (Room × Emotion)

Room	Emotion	Mean	Std. Error	95% CI (Lower)	95% CI (Upper)
Dark	**Satisfaction**	4.905	0.241	4.420	5.390
Bright	**Satisfaction**	8.435	0.135	8.163	8.707
Dark	**Pleasure**	5.045	0.248	4.547	5.543
Bright	**Pleasure**	8.015	0.156	7.702	8.328

Overall, these findings indicate that while room conditions alone did not significantly influence participants' responses, the emotional state played a significant role. The interaction effect suggests that satisfaction ratings were more sensitive to changes in room lighting compared to pleasure ratings.

■5.0 DISCUSSION

The significant improvements in pleasure and satisfaction emotions under VR-simulated brighter daylight conditions observed in this study reinforce a growing body of evidence linking daylight exposure to positive emotional well-being. Consistent with our findings, past research has repeatedly shown that increased natural light yields notable benefits for mood and contentment (Landvreugd et al., 2024). The results align with field studies in real buildings, for example Woo et al. (Woo et al., 2021) reported office workers with enhanced daylight access were eight times more likely to report satisfaction with their lighting and showed significantly higher positive affect compared to dim-lit conditions. These consistencies suggest that the uplifting impact of daylight on emotions in our VR-simulated bedroom is not only statistically significant but also in line with established trends in daylight research. Our findings also align with the Approach–Avoidance Theory and neuroscience research on architecture that the bright, daylight-filled room generated significantly higher pleasure, a positive emotional state that naturally encourages approach motivation. Participants in the bright condition not only reported more enjoyment and satisfaction but likely felt more inclined to spend time in that room or found it inviting on a subconscious level. In contrast, the dimly lit room, which yielded lower pleasure scores, can be seen as eliciting a comparatively negative or less stimulating affective state – one that might prompt avoidance tendencies (Khaleghimoghaddam, 2024).

The interaction effect observed in this study suggests that satisfaction ratings were more sensitive to changes in room lighting compared to pleasure ratings, indicating that participants' overall contentment with the space was more directly influenced by brightness levels than their emotional enjoyment. This distinction is important as it highlights how satisfaction, which often reflects cognitive evaluations and expectations about an environment, is more susceptible to variations in daylight conditions, whereas pleasure, a more immediate and affect-driven response, may be influenced by other environmental or personal factors beyond just brightness.

One possible explanation for this heightened sensitivity in Satisfaction scores is that Satisfaction is linked to perceptions of functional adequacy and comfort in a space, which are strongly tied to daylighting quality. Brighter conditions in the VR simulation may have led participants to perceive the space as more comfortable, visually appealing, and practical for activities, thereby elevating their satisfaction levels. Conversely, the dimly lit condition might have been perceived as less inviting or even inadequate for a bedroom environment, leading to a more pronounced drop in satisfaction. This makes Satisfaction an essential metric in assessing architectural environments.

On the other hand, Pleasure ratings, while also positively influenced by daylight, showed a comparatively smaller difference between bright and dark conditions, suggesting that pleasure is a more stable emotional response that does not fluctuate as drastically with changes in lighting. This could be attributed to the fact that Pleasure is shaped not only by environmental factors such as brightness but also by personal preferences, prior experiences, and contextual associations with different lighting conditions. For instance, some participants may still find dimly lit environments pleasurable due to their association with relaxation or coziness, even if their overall satisfaction with the space is reduced due to perceived lack of functionality.

Environmental psychology research emphasizes the perception of how lighting feels depends not only on the light level itself, but on personal preferences, past experiences, and context. The findings of this research corroborate with the other studies that objective brightness alone isn't a perfect predictor of mood – what matters is whether the lighting is judged appropriate or comfortable by the individual. A cross-cultural field study by Küller et al. (2006) found that office workers' overall mood was lowest when they perceived their workspace lighting as "much too dark," rose to its highest when lighting felt "just right," and fell again if it was "too bright" (Küller et al., 2006). Satisfaction is more immediately tied to environmental conditions, and is more dynamic and responsive to environmental changes, particularly in lighting conditions. On the other hand, pleasure may be less volatile and more influenced by subjective interpretation rather than direct environmental stimulus alone.

■6.0 CONCLUSION

This study reinforces the novelty and significance of VR as an advanced tool for simulating daylight in psychological and research in architecture design and real estate. By demonstrating that VR can effectively replicate real-world daylight experiences, this study highlights VR's potential to offer reliable, repeatable, and controlled experiments that is more cost and time-saving. Our findings reveal that participants exposed to VR-simulated bright daylight environments reported significantly higher pleasure and satisfaction scores compared to dimly lit environments, confirming the positive emotional impact of increased daylight. These outcomes mirror responses observed in physical settings, validating VR's effectiveness in assessing emotional and behavioral reactions to environmental lighting conditions.

The integration of VR simulation into daylight assessment contributes to advancements in neuroarchitecture, environmental psychology, and human-centric design, promoting mental health and well-being for building occupants. In the field of real estate and urban development, these insights are critical for designing liveable, resilient, and emotionally supportive residential environments—key priorities in navigating growth and ensuring investment viability in urbanising markets.

Moreover, this research positions VR as a transformative tool for architects, developers, and real estate professionals, offering a cost-effective and innovative method for optimizing indoor environments. By incorporating VR-based daylight assessment into home-buying and property development processes, the industry can better address consumer demands for comfort and well-being, enhance marketing strategies, and support sustainable and smart urban design initiatives. This aligns with the broader goals of creating community-centric, inclusive, and technologically integrated living spaces, thereby fostering harmonious real estate evolution.

Future research should continue to leverage VR's capabilities to investigate mental well-being across diverse spatial and cultural contexts. Incorporating physiological and neurological measures, such as heart rate variability, stress biomarkers, or EEG data, into VR daylight experiments could provide a more comprehensive understanding of how built environments impact health and emotional resilience. Such interdisciplinary exploration would advance the emerging field of neuroarchitecture and support innovative, sustainable, and culturally sensitive urban development, in line with the evolving needs of rapidly growing cities.

Acknowledgement

This study was funded by Geran Putra IPM from Universiti Putra Malaysia (GP-IPM/2023/9772700).

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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