

Effects of Differences in Augmented Reality Rural Landscape Scene Configurations on Perceived Restorativeness

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Abstract

INTRODUCTION: Accelerated urbanization and increasingly fast-paced lifestyles have intensified mental health challenges. Although previous studies have demonstrated the effectiveness of Virtual Reality and Augmented Reality in promoting psychological well-being, most research has primarily focused on isolated, single-scene interventions, leaving the effects of scene organization in AR interaction design largely unexplored.

OBJECTIVES: This study aimed to investigate whether different Augmented Reality scene organization strategies differentially affect psychological regulation by comparing a static appreciation-based parallel architecture with a dynamic exploration-based vertical architecture.

METHODS: Grounded in Attention Restoration Theory and Environment-Behavior and Spatial Design principles, a comparative experiment was conducted under balanced design-content conditions. The designed static appreciative and dynamic exploratory rural healing scenes were imported into a mobile Augmented Reality development environment based on the Kivicube platform. The resulting scenes were exported via QR codes, allowing participants to access the standardized intervention platform using mobile phones or tablets. Participants experienced one of the two Augmented Reality scene organization modes, after which their attention restoration and sense of presence were evaluated.

RESULTS: The dynamic exploration-based vertical architecture significantly outperformed the static appreciation-based parallel architecture in terms of attention restoration and sense of presence, indicating that scene organization may play an important role in shaping psychological experiences within Augmented Reality environments.

CONCLUSION: These findings are consistent with the directional predictions for the psychological mechanisms proposed by Self-Determination Theory and Flow Theory, while offering practical guidance for the interaction design of Augmented Reality-based restorative environments.

Keywords: Augmented Reality (AR); Rural Landscape; Attention Restoration; Static Appreciative Scenario; Dynamic Exploratory Scenario; Gamification

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1. Introduction

Environmental elements are intrinsically linked to comprehensive human health, exerting both physiological and psychological effects. Beyond the influence of spatial air quality on physical health, mental and emotional well-being play an equally vital role [1]. However, with the accelerating pace of urban life and intensifying workplace stress, seeking

a temporary escape from reality has emerged as a key strategy for stress relief. Consequently, virtual restorative environments and their therapeutic effects have attracted increasing academic attention. Previous studies have indicated that virtual restorative environments typically incorporate virtual natural landscapes and biophilic designs.

When physical movement is constrained by time and distance, these therapeutic scenes demonstrate significant restorative efficacy across domains such as emotional intervention, cognitive training, and motor rehabilitation [2].

Currently, the global healthcare sector is leveraging digital technologies to drive a paradigm shift in psychological therapy. In its Global Strategy on Digital Health 2020–2025, the World Health Organization (WHO) explicitly positions digital health as a critical driver for achieving universal health coverage [3]. Although most studies focus on digitally driven therapeutic approaches from a pathological perspective, mainly encompassing modalities such as computerized cognitive behavioral therapy (CCBT), AI-powered chatbots, virtual reality exposure therapy (VRET), and biofeedback-based digital games. Research by Zeka et al. explored the efficacy of immersive technologies in treating various types of mental disorders [4]. As noted by Grimaldos et al., extensive controlled trials have assessed the effectiveness of virtual reality (VR) exposure therapy across different anxiety disorders [5].

For the general population experiencing daily work and life stress, the primary focus shifts from clinical cure to emotional health and mind-body regulation. Consequently, a growing body of research explores mental health interventions delivered via smart devices, such as smartphones, tablets, and wearables, integrated with virtual technologies like Augmented Reality (AR) and Virtual Reality (VR). Researchers have increasingly compared emotional responses and differences between AR and VR across distinct task scenarios from multiple perspectives. For instance, Deltcho Valtchanov et al. demonstrated that VR settings depicting natural environments significantly elevate positive emotions [6]. Through VR-assisted design, research confirms that integrating natural features and biophilic street furniture/amenities contributes to promoting positive emotional responses among urban street users [7]. Research by Kim et al. revealed that active participation in virtual reality (VR) experiences elevates mood more effectively than passive observation. Furthermore, through experimental comparisons of four distinct VR interaction modes, the study confirmed both the positive and negative effects of interaction frequency across different experiential conditions [8].

Although existing studies have demonstrated the positive effects of virtual reality (VR), augmented reality (AR), and related technologies on mental health through various approaches, and have identified the emotion regulation mechanisms underlying different application scenarios based on diverse research objectives, most have focused on isolated, scenario-specific contexts. From the perspective of interaction design, little attention has been paid to whether the design of relationships between different scenarios leads to differential effects on the construction of emotional values. To address this gap, the present study proposes two scene architectures: a static scene architecture and a dynamic scene architecture. A comparative experiment was conducted to examine the differences in their effects.

Based on environmental psychology and health design theories, this study developed two experimental scenarios as comparative intervention conditions. The static condition

consisted of three independent therapeutic sensory interfaces arranged in a parallel structure. Participants could freely switch between interfaces, but no hierarchical progression or sequential relationship was embedded in the interaction design. In contrast, the dynamic condition adopted a hierarchical, progressive scene architecture comprising two core sensory interfaces, each containing multiple interactive layers. Through continuous interaction, participants were able to explore increasingly deeper levels of content, forming a progressive structure of interface–subinterface–deep content.

Although the dynamic condition contained fewer primary interfaces than the static condition, it incorporated a greater number of interaction layers, resulting in an information architecture characterized by greater vertical depth. To ensure experimental comparability, the total number of interfaces in the static condition and the overall hierarchical depth in the dynamic condition were balanced to achieve comparable design complexity and content weight. This design enabled a fair comparison between the two scene architectures while controlling for the overall amount of interaction content.

The study sought to examine whether, under equivalent design-content weighting, static and dynamic scene architectures produce significantly different emotional outcomes. Specifically, it investigated whether the underlying technological architecture of scene organization exerts a substantive influence on users' attention restoration.

2. Theoretical Framework and Research Methods

Systematically proposed by environmental psychologists Stephen Kaplan and Rachel Kaplan in the late 1980s, Attention Restoration Theory (ART) is one of the most influential theoretical frameworks in environmental psychology and health sciences. This theory posits that exposure to natural environments facilitates recovery from directed attention fatigue induced by prolonged cognitive load, inducing pleasure and subsequently restoring attention and other cognitive functions. Directed attention expended in daily work and study can be disengaged within soft, natural environments, thereby facilitating cognitive recovery [9]. A substantial body of empirical research has provided evidence supporting the positive effects of natural environments on attention restoration. Participants who viewed slides of natural landscapes exhibited greater gains in post-test positive affect compared to those who viewed slides of urban environments [10]. In evaluations of participants' experiences across natural, urban, or indoor relaxation settings, individuals in the natural environment condition demonstrated more positive feedback regarding dimensions such as "being away," "fascination," "coherence," and "compatibility." [11]. Furthermore, researchers found that students exposed to richer window views of nature performed significantly better on sustained attention tests than those with less exposure, demonstrating the impact of window nature views on students' attentional performance [12]. In comparative studies assessing the behavioral, emotional, and

cognitive performance of children with ADHD in woodland natural environments versus urban built environments, results indicated that woodland settings exerted more pronounced positive effects [13]. These studies collectively underscore the vital significance of natural environments for restoring and enhancing cognitive functions.

Regarding experiments in virtual environments, numerous studies have also confirmed the positive effects of virtual natural environments on psychological and emotional regulation. In a laboratory study using restorative environmental images, researchers presented two groups of participants with restorative and non-restorative images on a computer screen, with each image displayed for 15 seconds. The experimental results demonstrated that even brief exposure to virtual nature can effectively restore attention [14]. With the continuous maturation of digital technologies and virtual devices, research utilizing VR and AR for psychological intervention has emerged as a new research trend. A comparative experiment contrasting active exploration within an immersive virtual forest with viewing VR slides proved that computer-generated natural environments possess a restorative potential similar to that of photos and videos showcasing real nature [6]. In studies comparing virtual natural environments with virtual urban environments using 360° real-world VR recordings, natural environments consistently exhibited positive psychological effects [15]. However, challenges remain in this field; VR devices may induce motion sickness (cybersickness) due to their wearability, thereby imposing certain limitations on their application. Conversely, AR creates favorable conditions for adoption and usability because it can be experienced via smartphones and mobile devices, alongside relatively low development and usage costs. Currently, research in the AR domain predominantly focuses on post-use user experience, with only a few studies addressing the relationship between AR and environmental perception. For instance, studies have investigated the impact of AR museum experiences on attention restoration, stress reduction, and anxiety relief [16], as well as explored generating restorative experiences through environmental embedding and simulated physical controls to stimulate consumer behavior [17]. Compared with research in the VR domain, the application of AR in the field of attention restoration remains relatively sparse.

Although previous studies have demonstrated the effectiveness of VR and AR in promoting psychological well-being, they have primarily focused on isolated single-scene interventions, leaving the effects of scene organization in AR interaction design largely unexplored. Related AR design research has also explored participatory approaches to advancing sustainability, illustrating the broader potential of AR as a medium for user-engaged design practices [18]. Drawing upon Attention Restoration Theory and environmental design theory [19], this study investigates how AR scenario architecture fundamentally impacts restorative perception. Using sites with comparable natural landscape elements as cases, we established two distinct setups: a static scenario set in a natural village that provides therapeutic environmental exposure via visual-based multisensory

simulation, and a dynamic scenario situated along a village water system featuring an exploratory, plant-focused AR application. The latter integrates gamification principles and operant conditioning to establish a progressive task hierarchy with real-time feedback.

Both scenario configurations were digitally deployed using the Kivcube mobile augmented reality development platform. Participants accessed the standardized intervention platform by scanning an experimental QR code and completed the scenario experience under a controlled exposure duration of 3 to 5 minutes.

To assess participants' restorative perceptions and spatial presence, data collection drew upon the Perceived Restorativeness Scale (PRS; Hartig et al., 1997; Chinese revision by Li et al., 2024) [20-21] and the Igroup Presence Questionnaire (IPQ) [22]. To accommodate immediate post-AR measurement, targeted items spanning the core dimensions of both constructs were extracted from the original instruments and rated on a 5-point Likert scale. Statistical analyses were performed in SPSS, employing Independent-samples t-tests to evaluate inter-group dimensional differences at a significance threshold of $\alpha = 0.05$. Since multiple comparisons were performed, the Bonferroni method was used to correct for the multiple comparisons, and the significance level was adjusted to $\alpha = 0.025$.

3. Scenario Design and Development

3.1 Interaction Design for the Static Rural Healing Scenario

The static scenario group primarily comprises three specially designed rural therapeutic scenes. The design site was selected from a natural landscape village oriented around wellness and restorative rural planning. In the preliminary phase of scene design, the defining characteristics of healing spaces were thoroughly investigated. In environmental psychology and healthcare design, the core concern of therapeutic spaces often centers on how spatial environments facilitate users' psychological recovery and physiological relaxation through sensory pathways. Based on the analysis of restorative spatial attributes, sensory experiences encompassing vision, audition, olfaction, and somatosensation can elicit distinct therapeutic effects. According to color psychology, color significantly influences individuals' emotional states, with different hues evoking varied affective responses. Jonauskaitė and Mohr synthesized the mapping between colors and emotions, revealing that red, yellow, and highly saturated colors correlate with high arousal. However, because red conveys a dominant sense of power [23], yellow is more appropriate for restorative contexts, which favor non-hierarchical, power-free structures that induce relaxation.

Consequently, the golden-yellow color scheme derived from natural paddy fields was adopted for the therapeutic spatial interface. Although comfortable and open, highly

uniform landscape settings risk inducing monotony and visual fatigue. In alignment with Optimal Arousal Theory, human emotional pleasure and interest are positively correlated with spatial novelty; excessively simple environmental stimuli can lead to negative affective states as novelty wears off [24]. By establishing visual focal points through suitably proportioned art installations, an optimal level of visual stimulation can be introduced to mobilize emotions, ultimately fostering enhanced restorative effects. Therefore, in the interface design for the static scenario group, the researchers integrated the local rural paddy field environment by utilizing the organic form of paddy-field art to establish a visual focal point within the expansive landscape. Unadorned straw sculptures, crafted without additional materials or artificial embellishments, created a sense of fluid rhythm as they swayed in the wind, evoking sensory pleasure and serving as the foundation for subsequent AR development. (see Figure 1).



Figure 1. Static Group Scenario 1: Swaying Wheat Fields

Interface 2 was developed in alignment with biophilic design principles [25], drawing on empirical evidence supporting the mental health benefits of biophilic settings [26]. The spatial orientation transitions from the aerial overview in Interface 1 to a human eye-level view, thereby strengthening virtual biophilic immersion. A multi-sensory experience is crafted where the tangible proximity of wheat and auditory wind cues evoke perceived natural fragrances. Low-slung netting seats crafted from sustainable hemp rope are elevated above the

crop layer, a structural choice engineered to prevent interference with both plant development and agricultural irrigation systems. (see Figure 2)



Figure 2. Static Group Scenario 2: Fragrance of Rice and Wheat Fields

Interface 3 operates at a micro-spatial scale, invoking a forest tea-room metaphor to induce relaxation and perceived safety in a semi-open space. Grounded in Prospect-Refuge Theory, which highlights how spatial configuration, light, and landscape shape security and affect [27]. Interface 3 utilizes dense bamboo thickets to form a semi-enclosed, tranquil refuge. Constructed from locally sourced bamboo, the tea pavilion lowers costs while promoting sustainable design. To compensate for natural daylight attenuation caused by the dense canopy, auxiliary lighting is strategically integrated. Recognizing that lighting parameters like luminance and color temperature dictate psychological states, with low illuminance and warm color temperatures empirically linked to calm, positive affect [28], the tea-room incorporates low-lux, orange floodlighting to amplify emotional engagement. (see Figure 3)



Figure 3. Static Group Scenario 3: Bamboo Forest Tea House

3.2 Interaction Design for the Dynamic Rural Healing Scenario

Distinct from static rural healing scenarios, dynamic scenarios are primarily characterized by deeper interaction hierarchies and scalable engagement pathways. This framework adopts a systematic workflow for touring digital vernacular healing landscapes, which encompasses five progressive modules: standardized operational guidelines, AR node recognition, landscape knowledge cards, task point collection, and symbolic point redemption within the AR system for task completion.

Upon scanning an experimental QR code to access the digital intervention platform, participants review the operational guidelines and proceed to an interactive map interface that visualizes the spatial layout and node distribution of the ancient village's cultural landscape. Participants can autonomously select any landscape node to trigger a multimodal information display: an initial click activates plant species identification alongside ecological insights, whereas a second click loads real-scene imagery of the location. A dynamic progress indicator at the interface bottom shifts from green to red once all nodes are activated, marking the completion of the intervention. Grounded in Attention Restoration Theory (ART) and positive psychology's flow framework, this intervention process fosters psychological restoration through the synergistic

effects of immersive landscape appreciation and pro-environmental engagement.

Through the mapped integration of real-scene spatial data and digital landscape cards, the system converts traditional vernacular landscapes into an interactive digital tourism framework. By facilitating off-site virtual exploration, it significantly elevates users' spatial presence and immersive interaction. (see Figure 4 and 5)



Figure 4. Dynamic Exploratory Vertical Scenario 1

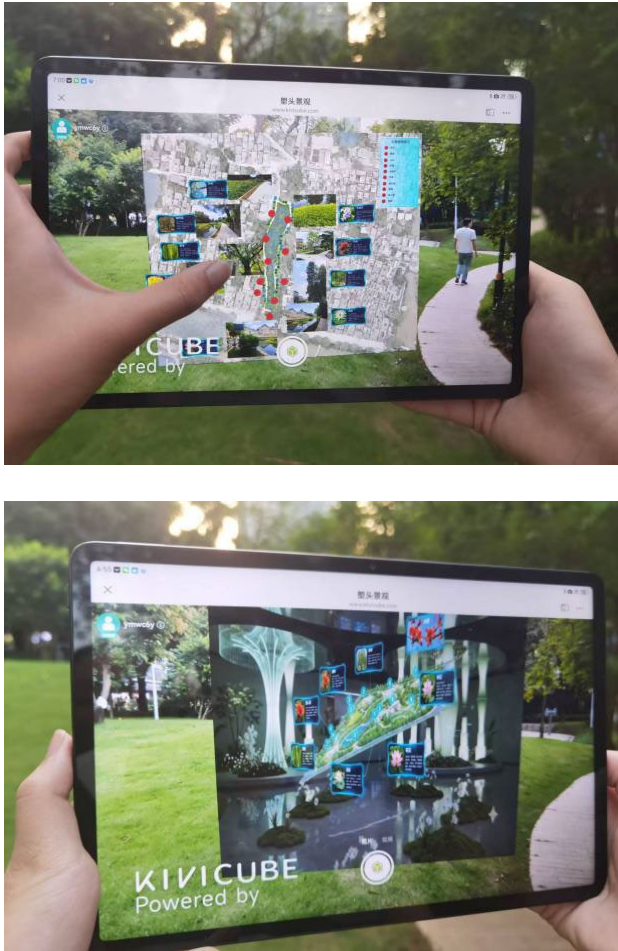


Figure 5. Dynamic Exploratory Vertical Scenario 2

4. Experimental Procedure

The previously designed static appreciation and dynamic exploration rural healing scenarios were imported into a mobile AR development environment powered by the Kivicube platform. The resulting scenarios were exported as QR codes, enabling participants to access the standardized intervention platform via smartphones or tablets for AR-based scene immersion and interactive visual exploration. The two QR codes are randomly assigned to the two groups. Ethical approval was obtained from the ethics committee of the authors' affiliated university prior to the commencement of the experimental procedures (NO.ZK202621105). A total of 73 participants were recruited. To refine the instrument, initial responses from eight participants served as a pilot test to resolve design flaws, after which the revised questionnaire was administered to 65 participants. Eight invalid responses, flagged for excessively brief completion times, extreme scoring, or contradictory data, were screened out. Consequently, 57 valid questionnaires were retained ($n = 57$; 27 males, 30 females). All participants gave informed consent. Given that participant recruitment occurred continuously during the study period and the final sample size could not be determined in advance, participants were

allocated to the static and dynamic scenario groups using a partially randomized procedure. Participants selected QR codes corresponding to the two scenarios, and when unequal group sizes emerged during recruitment, the remaining QR codes were randomly distributed to maintain a relatively balanced allocation. The final valid sample consisted of 30 participants in the static scenario group and 27 participants in the dynamic scenario group. Intervention exposure was standardized at 3~5 minutes per participant, a duration informed by moderate intervention windows in existing VR/AR literature to reliably trigger attention restoration without causing cognitive fatigue. Following a brief post-experience relaxation period, participants completed the survey. Data collection was anonymous and captured demographic variables, perceived restorativeness, and spatial presence. Construct measurements utilized a 5-point Likert scale. Reliability analysis across 57 valid samples yielded an overall Cronbach's alpha of 0.900 ($\alpha = 0.808$ for restorative perception; $\alpha = 0.859$ for presence). All subscales and the full instrument exceeded $\alpha = 0.800$, confirming robust internal consistency and measurement reliability. Construct validity was verified via the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity: the KMO statistic reached 0.876, and Bartlett's test yielded an approximate $\chi^2 = 277.154$ ($df = 45$, $p < 0.001$). Meeting the thresholds of $KMO > 0.8$ and $p < 0.05$, the data met the required criteria for factor analysis.

5. Experimental Results

Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to examine the factor structure of the retained items. Independent samples t-tests were then performed to evaluate between-group differences in perceived restorativeness and spatial presence across the two experimental conditions.

An exploratory factor analysis (EFA) was first conducted on the 10 retained items using principal component extraction with oblique rotation. The analysis yielded a two-factor structure, accounting for 64.35% of the total variance.

A confirmatory factor analysis (CFA) was subsequently conducted to examine the proposed two-factor structure. The standardized factor loadings ranged from 0.581 to 0.849. The two-factor model demonstrated an acceptable overall fit ($\chi^2/df = 1.291$, CFI = 0.961, TLI = 0.949, IFI = 0.963, RMSEA = 0.072). Moreover, the two-factor model fitted the data significantly better than the one-factor model ($\Delta \chi^2 = 7.90$, $\Delta df = 1$, $p = 0.005$; $\Delta CFI = 0.027$).

The results of the independent samples t-test are presented below.

- Scenario type significantly impacted the dimension of spatial presence. There were 30 valid samples in the static appreciation group and 27 in the dynamic exploration group. An independent-samples t-test was conducted to compare spatial presence between the two conditions. Levene's test indicated that the assumption

of equal variances was satisfied ($F = 0.686, p = 0.411$). After Bonferroni correction for the two independent comparisons, the significance level was adjusted to $\alpha = 0.025$ ($0.05/2$). Participants in the dynamic exploration condition reported significantly higher spatial presence scores than those in the static appreciation condition, $t(55) = -2.513, p = 0.015 < 0.025$, mean difference = -0.451 , 95% CI $[-0.811, -0.091]$, Cohen's $d = -0.667$. This demonstrates that dynamic exploration fosters a stronger sense of immersive presence. The vertical, exploratory structure of the environment increased user engagement, thereby driving exploratory motivation and inducing deeper immersion.

- Similarly, perceived restorativeness was significantly higher in the dynamic exploration group than in the static appreciation group. Levene's test indicated that the assumption of equal variances was satisfied ($F = 0.005, p = 0.943$). Participants in the dynamic exploration condition reported significantly higher perceived restorativeness than those in the static appreciation condition, $t(55) = -2.707, p = 0.009 < 0.025$, mean difference = -0.457 , 95% CI $[-0.795, -0.119]$, Cohen's $d = -0.718$. This indicates a greater capacity of dynamic environments to facilitate psychological recovery. The hierarchical structure stimulates participants' exploratory tendencies, while the progressive presentation of new content, resembling a gamified progression, attenuates their perception of the passage of time, thereby fostering a sense of enjoyment through relaxed and engaging interaction. (see Table 1)

Table 1. Independent samples t-test results for study variables across scenario types (N = 57)

	Scenario Type ($M \pm SD$)		t	p
	Static Group ($n=30$)	Dynamic Group ($n=27$)		
Perceived Restorativeness	3.380±0.613	3.837±0.661	-2.707	0.009
Spatial Presence	3.327±0.618	3.778±0.737	-2.513	0.015

P-values are unadjusted. Statistical significance was assessed using a Bonferroni-adjusted significance threshold of $\alpha = 0.025$ ($0.05/2$)

6. Discussion

The dynamic exploratory vertical scene architecture demonstrated significantly greater effects on psychological support, specifically in terms of attention restoration and sense of presence, than the static appreciative parallel scene architecture. Rather than being solely attributed to differences

in content presentation, the observed advantages of the dynamic group may be related to its interaction design, which encouraged users' autonomous exploration motivation. This finding is consistent with the predictions of Self-Determination Theory (SDT), which posits that supporting autonomy fosters intrinsic motivation and promotes psychological well-being [29]. Furthermore, the dynamic exploratory design may offer advantages in facilitating user flow experiences. These experimental findings are consistent with the direction hypothesized by Flow Theory, which suggests that an optimal balance between an individual's skill level and task challenge induces a state of heightened focus and self-forgetfulness [30]. The immersive experience observed in the dynamic group may be associated with optimized interactive feedback and the pacing of contextual narratives. Through a gamified exploratory process, participants may have experienced emotional relaxation, thereby contributing to perceived emotional support and restorative outcomes.

Based on the aforementioned research findings, three key design considerations are proposed for the development of AR applications in rural therapeutic landscapes.

- **Interaction Mechanism.** AR design content could transition from passive observation to an active-exploration-oriented vertical architecture, underpinned by a rationally constructed narrative framework with clarified hierarchical structures. Through in-depth exploration and interaction, flow experiences can be triggered, thereby satisfying the psychological needs for competence and autonomy as posited by Self-Determination Theory (SDT). This process enables users to achieve high levels of immersion and facilitates the restoration of directed attention.
- **Biophilic Content Construction.** The biophilic construction of landscape content via AR contributes to emotional regulation. By modulating viewpoints across the foreground, middle ground, and background, alongside seamless scene transitions, users' sense of presence can be substantially enhanced, allowing them to perceive the authentic existence of the environment. This approach mitigates the psychological burden induced by the uncertainty of non-sequential scenes. Furthermore, the combined application of open and enclosed spatial configurations strengthens the sense of refuge, fostering feelings of security and being contained, thereby enhancing the efficacy of psychological restoration.

Multisensory Synergistic Design. By integrating dynamic visual stimuli with ambient acoustic elements, an environmental soundscape effect can be created, incorporating natural acoustic cues such as wind rustling, insect chirping, and avian vocalizations into the design. Combined with the principles of color psychology, a warm, serene, and pleasant atmosphere can be cultivated, enabling multisensory synergy to promote immersive restorative experiences.

Although this study proposes active exploration, biophilic content, and multisensory integration as potential design strategies for AR-based healing landscapes, their application should consider variations in contextual characteristics and related factors. Interactive exploration approaches should be adapted according to users' physical abilities, technological familiarity, and cognitive demands. The selection of biophilic elements and narrative content should be aligned with regional ecological characteristics and cultural contexts. The transferability of these design principles to different regions, age groups, and non-rural environments depends on appropriate contextual adaptation.

The design of augmented reality (AR)-based environments may provide a scalable and cost-effective approach to supporting psychological well-being, with potential relevance to health economics. By integrating carefully designed, low-cost interventions into immersive AR experiences, such environments may enhance psychological resilience and foster a stronger sense of perceived restorativeness. From a health economics perspective, the scalability and relatively low resource requirements of AR-based interventions suggest their potential as a resource-efficient approach to health promotion. The exploratory findings suggest that the deliberate integration of content, modes of interaction, and experiential architecture highly enhance psychological impact. Therefore, future research should move beyond the technological capabilities of AR to systematically investigate how the fine-grained design of content and experiential structures can be optimized to further enhance perceived restorativeness and well-being.

Despite the practical implications of these design recommendations, several limitations should be considered when interpreting the findings. Participant recruitment was constrained by some individuals' cautious attitudes toward AR technology. The sample was predominantly composed of individuals aged 30–60 years, with limited representation of individuals younger than 30 or older than 60. Accordingly, the findings should be interpreted primarily as exploratory and require further validation in larger and more diverse samples. Second, similar to previous studies on immersion and presence, this research relied primarily on subjective self-report data. Although the abbreviated measures showed preliminary evidence supporting their factor structures, they should be considered exploratory measures requiring further psychometric examination. Third, the study employed a post-test-only design, with group allocation following a partially randomized allocation procedure that combined participant-selected QR codes with random assignment of the remaining codes. This design precluded the assessment of within-participant changes over time and could not fully exclude potential pre-existing differences between groups, thereby limiting causal inference. Fourth, no non-AR control condition was included. Therefore, although this study focused on comparing different AR-based scenario designs, the extent to which the observed effects are specific to AR-supported experiences requires further investigation. Fifth, although efforts were made to maintain comparable content across scenario conditions, the content volume was not fully quantitatively controlled, and future studies should further

examine the extent to which content-related factors may contribute to the observed effects. Despite these limitations, this study provides valuable implications for design practice and future research. Future studies should employ rigorous randomization procedures, incorporate baseline measurements and non-AR control conditions in larger and more diverse samples, balance content across experimental conditions, and integrate objective physiological and behavioral measures, such as heart rate variability (HRV) and galvanic skin response (GSR), using longitudinal designs to examine the long-term effects of AR interventions.

7. Conclusion

In this study, rural healing landscapes were designed based on color psychology theory, biophilic design theory, and prospect-refugium theory, while the scenario operational mode architecture was established using flow theory. Digital deployment was realized using the Kivcube mobile augmented reality (AR) development platform, which developed two scenarios with balanced content weights: a static parallel structure scenario and a dynamic exploratory vertical scenario. Experimental data were collected from participants using scale-based questionnaires. The experimental results indicated that the dynamic exploratory vertical scenario architecture was highly likely to exert a greater impact on psychological support, specifically in terms of attention restoration and sense of presence, than the static appreciative parallel architecture mode. These findings are consistent with directional predictions for the psychological mechanisms proposed by Self-Determination Theory and Flow Theory, providing design evidence for the design and development of augmented reality scenarios in terms of interaction mechanisms, biophilic content construction, and multisensory integration.

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References

- [1] Engineer A, Gualano RJ, Crocker RL, Smith JL, Maizes V, Weil A, et al. An integrative health framework for wellbeing in the built environment. *Build Environ.* 2021 11;205:108253. <https://doi.org/10.1016/j.buildenv.2021.108253>

- [2] Hao SM, Wang C, Hou R, Zhang YS. Research progress in virtual healing environments and healing benefits thereof. *Landscape Archit.* 2022;29(8):79-85. DOI: 10.14085/j.fjyl.2022.08.0079.07
- [3] World Health Organization. Global strategy on digital health 2020-2025. Geneva: World Health Organization; 2021. <https://iris.who.int/handle/10665/344249>.
- [4] Zeka F, Clemmensen L, Valmaggia L, Veling W, Hjorthøj C, Glenthøj LB. The effectiveness of immersive virtual reality-based treatment for mental disorders: a systematic review with meta-analysis. *Acta Psychiatr Scand.* 2025;151(3):210-230. <https://doi.org/10.1111/acps.13777>
- [5] Grimaldos J, Fernández-Buendía S, Bretón-López J, Miguel C, Cuijpers P, Quero S. Augmented reality exposure treatments in anxiety and related disorders: a systematic review. *Internet Interv.* 2025;39:100812. <https://doi.org/10.1016/j.invent.2025.100812>
- [6] Valtchanov D, Barton KR, Ellard C. Restorative effects of virtual nature settings. *Cyberpsychol Behav Soc Netw.* 2010;13(5):503-512. <https://doi.org/10.1089/cyber.2009.0308>
- [7] Zhang Z, Xu LQ. Creating emotions in virtual reality: an evidence-based exploration of micro-renewal designs for healing and vitality streets. *Landscape Archit.* 2024;31(4):53-60. <https://doi.org/10.3724/j.fjyl.202401250060>
- [8] Kim I, Azimi E, Kazanzides P, Huang CM. Active engagement with virtual reality reduces stress and increases positive emotions. In: 2023 IEEE International Symposium on Mixed and Augmented Reality (ISMAR). IEEE; 2023. p. 523-532. <https://doi.org/10.1109/ISMAR59233.2023.00067>
- [9] Kaplan S, Kaplan R. The experience of nature: a psychological perspective. Cambridge: Cambridge University Press; 1989.
- [10] Ulrich RS. Visual landscapes and psychological well-being. *Landscape Res.* 1979;4(1):17-23. <https://doi.org/10.1080/01426397908705892>
- [11] Hartig T, Mang M, Evans GW. Restorative effects of natural environment experiences. *Environ Behav.* 1991;23(1):3-26. <https://doi.org/10.1177/0013916591231001>
- [12] Tennessen CM, Cimprich B. Views to nature: effects on attention. *J Environ Psychol.* 1995;15(1):77-85. [https://doi.org/10.1016/0272-4944\(95\)90016-0](https://doi.org/10.1016/0272-4944(95)90016-0)
- [13] van den Berg AE, van den Berg CG. A comparison of children with ADHD in a natural and built setting. *Child Care Health Dev.* 2011;37(3):430-439. <https://doi.org/10.1111/j.1365-2214.2010.01172.x>
- [14] Berto R. Exposure to restorative environments helps restore attentional capacity. *J Environ Psychol.* 2005;25(3):249-259. <https://doi.org/10.1016/j.jenvp.2005.07.001>
- [15] Yu CP, Lee HY, Luo XY. The effect of virtual reality forest and urban environments on physiological and psychological responses. *Urban For Urban Green.* 2018;35:106-114. <https://doi.org/10.1016/j.ufug.2018.08.013>
- [16] Shen J, Yin M, Wang W, Hua M, Choi Y, Garaj V, et al. Dwells in museum: the restorative potential of augmented reality. *Telemat Inform Rep.* 2024;14:100136. <https://doi.org/10.1016/j.teler.2024.100136>
- [17] Huang TL. Restorative experiences and online tourists' willingness to pay a price premium in an augmented reality environment. *J Retail Consum Serv.* 2021;58:102256. <https://doi.org/10.1016/j.jretconser.2020.102256>
- [18] Feng Z, Cao X. Practices of Eco-Symbiotic Design: Advancing Fashion Sustainability through Participatory Augmented Reality (AR) Design. *Fashion Technology.* 2025 Jan 25;1(1):47-53.
- [19] Giuliani MV, Scopelliti M. Empirical research in environmental psychology: past, present, and future. *J Environ Psychol.* 2009;29(3):375-386. <https://doi.org/10.1016/j.jenvp.2008.11.008>
- [20] Hartig T, Korpela K, Evans GW, Gärling T. A measure of restorative quality in environments. *Scand Hous Plan Res.* 1997;14(4):175-194. <https://doi.org/10.1080/02815739708730435>
- [21] Li YH, Du XY, Wu JP. Revision of the Chinese version of the Perceived Restorativeness Scale. *China J Health Psychol.* 2024;32(12):1883-1889. DOI: 10.13342/j.cnki.cjhp.2024.12.025
- [22] Schubert T, Friedmann F, Regenbrecht H. The experience of presence: factor analytic insights. *Presence Teleoper Virtual Environ.* 2001;10(3):266-281. <https://doi.org/10.1162/105474601300343603>
- [23] Jonauskaitė D, Mohr C. Do we feel colours? A systematic review of 128 years of psychological research linking colours and emotions. *Psychon Bull Rev.* 2025;32(4):1457-1486. <https://doi.org/10.3758/s13423-024-02615-z>
- [24] Berlyne DE. Novelty, complexity, and hedonic value. *Percept Psychophys.* 1970;8(5):279-286. <https://doi.org/10.3758/BF03212593>
- [25] Ryan CO, Browning WD. Biophilic design. In: Loftness V, editor. *Sustainable built environments*. New York (NY): Springer; 2020. p. 1-28. https://doi.org/10.1007/978-1-0716-0684-1_1034
- [26] Hou Y, Zhang S. Long-term effects of urban biophilic art environments on depression and anxiety symptoms: a longitudinal intervention study. *BMC Psychol.* 2026;14(1):500. <https://doi.org/10.1186/s40359-026-04262-6>
- [27] Dosen A, Ostwald M. Prospect and refuge theory: constructing a critical definition for architecture and design. *Int J Des Soc.* 2013;6(1):9-23. <https://doi.org/10.18848/2325-1328/CGP/v06i01/38559>
- [28] Baron RA, Rea MS, Daniels SG. Effects of indoor lighting (illuminance and spectral distribution) on the performance of cognitive tasks and interpersonal behaviors: the potential mediating role of positive affect. *Motiv Emot.* 1992;16(1):1-33. <https://doi.org/10.1007/BF00996485>
- [29] Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol.* 2000;55(1):68-78. <https://doi.org/10.1037/0003-066X.55.1.68>
- [30] Csikszentmihalyi M. *Flow: the psychology of optimal experience*. New York (NY): Harper & Row; 1990.