

Multisensory Spatial Experience and Perceptual Engagement in Immersive Media Exhibitions

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Abstract

This study investigates the construction of sensory spatial experience within immersive media exhibitions with a focus on how multisensory design shapes audience perception and engagement. Using *Immersive Sea: Beyond the Surface* as a central case study, the study analyzes how visual, auditory, kinesthetic, and symbolic elements integrate to form complex sensory environments that transcend traditional exhibition formats. Theoretical frameworks like ecological perception theory, reception aesthetics, and presence theory inform the analysis to emphasize embodied perception and the dynamic interaction between technology, space, and the viewer. The findings demonstrate that sensory spatial experience is an active process of perceptual negotiation mediated by technological, cultural, and cognitive factors. By situating sensory space as both an artistic practice and a perceptual system, this study contributes to the growing discourse on embodied experience in digital media environments.

Keyword : Immersive Media, Sensory Spatial Experience, Embodied Perception, Digital Exhibition Design, Presence

1. Introduction

In modern society, space has transcended its purely physical dimensions to become a construct shaped by sensory, symbolic, and technological modalities. Within this expanded understanding of space, digital media technologies have emerged as tools that extend the boundaries of human perception and enable novel forms of sensory spatial experience [1]. This study focuses on sensory experiences constructed within virtual environments, with particular attention to spatial experiences created by virtual fish images situated within the immaterial yet fluid spatial structure of air bubbles in the work, *Immersive Sea: Beyond the Surface*. The exhibition presents a digitally constructed environment that stimulates the viewer's senses through the complex interplay of audiovisual elements such as underwater movement, light refraction, reverberating soundscapes, and interactive visual elements responsive to the viewer's gaze and motion.

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Received(May 2, 2025), Review Result(1st: May 22, 2025), Accepted(June 13, 2025), Published(June 30, 2025)



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These exhibition characteristics create a fitting framework for the study of sensory spatial experience, which is understood not solely as a function of physical space but as an emergent phenomenon shaped by the dynamic interplay of human perception, emotional response, and technological mediation. Accordingly, this study investigates how sensory spatial experience is constructed in digitally mediated virtual environments and examines how the symbolic and sensory attributes of virtual fish within air bubble structures affect the viewer's perceptual engagement.

Previous research on spatial experience has primarily focused on physical environments while emphasizing perceptual processes and the sense of place [2-4]. In contrast, relatively few studies have addressed technologically augmented sensory experiences in virtual space. Ecological perception theory, which underscores the direct interaction between organisms and their environments, offers a critical framework here by viewing perception as an active, embodied process shaped by environmental structures and movement. Based on this premise, this study assumes that sensory experiences in virtual environments are not merely subjective impressions but structured phenomena mediated by spatial and technological configurations. In parallel, reception aesthetics highlights the viewer's active role in constructing meaning, positioning interpretation as an essential component of the work itself [5]. This study thus analyzes the interplay between viewer perception and immersive spatial structure on the purpose of investigating the ontological status of virtual space from a sensory standpoint.

This study aims to articulate the concept of sensory realism in virtual spaces, grounded in multisensory experience, and to investigate its operational mechanisms and aesthetic implications through detailed analysis of a specific work. In doing so, it contributes to the broader discourse on the artistic and social expansion of sensory experience while offering practical insights for the design, experiential planning, and interaction strategies of digital exhibition spaces.

2. Theoretical Background of Sensory Spatial Experience

Sensory spatial experience refers to the comprehensive process through which individuals perceive and interpret space via their bodily senses, forming emotional responses and achieving immersion [6]. This process extends beyond mere visual perception while incorporating the complex interplay of auditory, tactile, and kinesthetic stimuli. Space is no longer understood simply as a physical background or structural arrangement but is redefined as a perceptual and interactive field constructed and imbued with meaning through sensory engagement.

The theoretical foundation for sensory spatial experience is rooted in ecological perception theory,

which emphasizes direct interaction between humans and their environment. Perception is not seen as the passive reception of external stimuli but rather as an active exploration mediated by the organism's engagement with environmental structures. This perspective provides a useful analytical framework for interpreting sensory interaction within virtual environments. A core concept within this framework is affordance which refers to the action possibilities offered by objects or environments. In digital media environments, affordances function in virtual form, guiding users' sensory engagement based on bodily conditions, environmental cues, and interpretive actions [7]. Digital affordances, which respond to viewers' gaze, movement, and interpretation, play a crucial role in constructing sensory immersion and fostering a sense of presence.

Reception aesthetics offers additional insight into the interpretive structure of sensory space [8]. According to this perspective, the meaning of an artwork is not fixed but co-constructed by the viewer's interpretation and response. This is particularly applicable to interactive media exhibitions, where visual, auditory, and spatial elements are dynamically reconfigured based on the viewer's participation. The viewer, therefore, functions not as a passive observer but as an active agent who co-constructs the sensory space through interaction. In such processes, media, body, and perception interact to generate sensory space. Virtual environments can intentionally orchestrate these interactions to create supersensory scenes that exceed the boundaries of physical experience, thereby pioneering new territories in sensory spatial design.

The concept of presence is also highly relevant in the context of sensory spatial experience within media environments. Presence refers to the psychological state in which users feel a sense of 'being there' within a mediated space, perceiving it with a degree of authenticity akin to physical reality [9]. In this study, elements such as the swimming motion of virtual fish, spatial reverberations, and visual-auditory coherence induce perceptual consistency, fostering immersion and presence. This condition is directly related to the formation of sensory realism.

Sensory realism emerges when sensory data are presented with natural coherence and consistency. The organically animated fish, light refraction, and reverberant sounds simulate or reconstruct physical phenomena while enhancing perceptual credibility and enabling users to perceive virtual space as real. In turn, viewers experience immersive engagement accompanied by emotional resonance and cognitive-affective responses. Multisensory space theory challenges conventional sensory hierarchies and calls for an aesthetic reevaluation of non-visual senses such as hearing, touch, and even smell. Contemporary media spaces integrate diverse sensory modalities to stimulate users' sensory imagination and deepen immersion [10].

[Table 1] summarizes the theoretical frameworks employed in this study.

[Table 1] Theoretical Frameworks for Sensory Spatial Experience

Theory	Key Concept	Application
Ecological perception theory	Perception as active interaction with the environment	Explains sensory engagement in virtual spaces
Affordance theory	Environmental features suggest possible actions	Guides user interaction with digital elements
Reception aesthetics	Meaning co-constructed by viewer interpretation	Frames viewer as active co-creator of space
Presence theory	Psychological sense of being there in mediated space	Explains immersive realism of virtual space
Sensory Realism	Coherence and naturalness of multisensory data	Supports credible perception of virtual environment
Multisensory space Theory	Integration of multiple senses beyond visual dominance	Enables holistic sensory immersion

The ontological status of virtual space is reconsidered through the lens of sensory experience. Digital environments can attain an existential weight comparable to physical reality, effectively subverting the boundary between real and virtual through sensory mediation [10]. In this study, virtual fish and air bubble structures offer heterogeneous sensory experiences that, while distinct from physical reality, foster embodied experiences in which the viewer emerges as a newly constituted sensory subject. Ultimately, sensory spatial experience is a complex structure generated through bodily perception, technological mediation, and participatory interpretation. It can be understood not merely as the passive reception of stimuli but as an active process wherein the perceiving subject co-constructs the spatial experience. In this regard, this study seeks to analyze how the exhibition work stimulates viewers' sensory systems and facilitates spatial immersion.

3. Analysis of the components of sensory space experience

3.1. Multisensory Design Components

Sensory spatial experience extends beyond the visual appreciation of physical environments but it is constructed through the integrated operation of multiple senses-visual, auditory, tactile, and kinesthetic-that together elicit perception, emotional responses, and immersion. Rather than unfolding in a linear or passive manner, sensory spatial experience emerges as a complex and multilayered phenomenon

shaped by dynamic interaction.

As shown in [Fig. 1], this study analyzes the exhibition work, Immersive Oceans: Beyond the Surface, to explore how visual, auditory, kinesthetic, spatial-symbolic, and interpretive elements collectively contribute to the construction of sensory immersion. At the core of the exhibition are the virtual fish, generated through 3D modeling, video projection, and a spatial projection structure. Their fluid, nonlinear, and algorithmically varied swimming patterns simulate organic movement in order to offer biologically resonant visual stimuli that activate dynamic perceptual engagement.



[Fig. 1] Immersive Oceans: Beyond the Surface, Suncheon National University, South Korea, January 20-24, 2025

Complementing this visual design, the manipulation of lighting through controlled refraction, reflection, and transparency constructs a surreal underwater ambiance that enhances the illusion of spatial depth and fluidity. The auditory environment contributes further by blurring boundaries between real and virtual spaces. Sounds of swimming fish, underwater reverberations, and subtle air bubble pops coalesce into a soundscape that anchors the viewer within the virtual space. These auditory elements, spatially distributed and synchronized with visual cues, heighten the sense of realism and presence while personalizing the experience through positional variation.

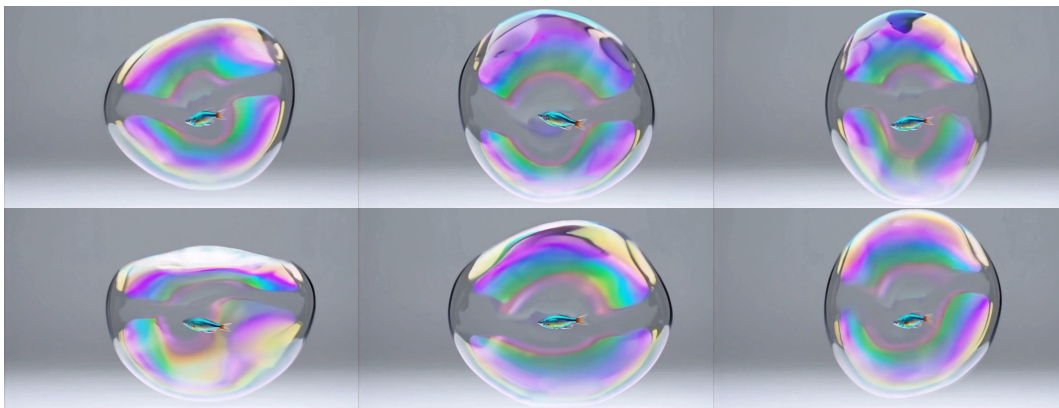
The kinesthetic dimension plays an equally critical role. Viewers are encouraged to move freely within the space while adjusting their vantage points according to personal interpretation. This bodily engagement activates spatial exploration and fosters nonverbal interaction between the viewer and virtual

elements. The modulation of distance, depth, and spatial layering supports dynamic kinesthetic sensations and allows viewers to continuously reconstruct their perceptual experience.

3.2. Symbolic Structure and Experiential Dynamics

Beyond its multisensory integration, the exhibition employs symbolic structures that shape viewers' interpretive engagement. The bubble-like spatial forms serve not only as visual anchors but as central symbolic devices. These structures embody dualities-enclosure and permeability, containment and flow-functioning as perceptual thresholds that blur distinctions between inside and outside, reality and virtuality. Although physically inaccessible, the bubbles act as transparent interfaces that mediate the viewer's gaze into enclosed virtual environments, cultivating both spatial tension and psychological immersion.

Through real-time reconfiguration of sensory inputs responding to viewers' movement and interpretation, the exhibition produces individualized and affectively resonant experiences. The simultaneity of audiovisual data and its dynamic adaptation to spatial variables imbue the environment with temporal and nonlinear qualities, framing sensory space as a living, responsive system rather than a static setting.



[Fig. 2] The organic motion of the virtual fish

Crucially, the exhibition's immersive quality does not stem merely from an accumulation of multimodal stimuli but from the intentional coherence and interactivity among its components. As shown in [Fig. 2], the organic motion of the virtual fish is not a literal simulation but an expressive abstraction of biological movement that evokes emotional resonance through memory, imagination, and introspection.

The spatial layout further guides experiential flow. A darkened periphery and centrally illuminated zone choreograph the viewer's navigation toward the bubble structures in order to transform physical movement into a perceptual journey. This open-ended, nonlinear narrative structure allows viewers to actively reconstruct sensory meaning, generating a layered experiential space where perception, meaning, temporality, and spatiality are intricately interwoven.

Ultimately, *Immersive Oceans: Beyond the Surface* presents a comprehensive model of sensory spatial experience. It integrates audiovisual stimulation, kinesthetic engagement, symbolic spatial metaphors, and viewer interpretation into an embodied, dynamic perceptual field. Digital technology here functions not merely as a representational tool but as an agent that reconfigures sensory modalities, deconstructs spatial logic, and facilitates existential encounters. Through this integration, the exhibition exemplifies how sensory-centered artistic practices may redefine the boundaries of digital exhibition environments and emphasizes that immersive design requires both technical sophistication and conceptual intentionality.

[Table 2] Sensory Components in the Exhibition Content of *Immersive Oceans: Beyond the Surface*

Components	Sensory stimulation method	Spatial experiential characteristics	Aesthetic/artistic effect
Virtual fish image	Visual focus, sense of movement	Formation of realism through organic movement	Biological sensory stimulation, visual immersion
Air bubble	Visual, Spatial Metaphors	Dual spatial perception of boundaries and internality, transparency and closure	Constructing surreal spaces, conveying symbolic narratives
Lighting effects	Spatial distortion caused by reflection	Adjusting the depth of space and inducing sensory rhythms based on color flow	Emotional visual effects, enhanced emotional immersion
Sound configuration	Sound reverberation	Differentiating auditory experiences according to visitor movement	Giving direction to space, enhancing immersion, promoting sensory integration
Audience interaction	Visual, auditory, and kinesthetic feedback	Composition of visual and sound responses based on audience interpretation	Inducing sensory subjectification and participatory immersion experiences
Space flow and lighting	Kinesthetic sense, Eye guidance	Intentional directional movement guidance, blurring of surrounding awareness	Creating spatial tension, controlling the point of immersion

[Table 2] presents a structured analysis of the components constituting the sensory spatial experience in the exhibition. It categorizes key elements along three analytical axes including methods of sensory stimulation, spatial experiential characteristics, and aesthetic effects. This framework enables a systematic understanding of how individual components contribute to perceptual immersion and highlights the

interplay between technology, perception, and affect within the context of the exhibition.

This spatial choreography transforms physical navigation into a perceptual journey and allows for a progressive transition of sensory states. Importantly, the immersive quality of the exhibition does not derive from the mere aggregation of multimodal stimuli. Instead, it emerges from the coherence and interactivity of the components-visual forms, auditory elements, spatial symbolism, and bodily participation. These elements converge to form an interconnected perceptual ecosystem wherein boundaries between stimulus and response, representation and reality, dissolve. The exhibition space becomes a field of experiential density, redefining conventional paradigms of exhibition viewing and elevating sensory spatial experience from technological spectacle to artistic practice. By integrating symbolic, affective, and sensory elements, the exhibition exemplifies how digital media can function not only as representational tools but also as mediators of existential experience.

4. Discussion

The findings of this study demonstrate that sensory spatial experience in immersive media exhibitions is not merely the result of technological implementation but rather a complex and dynamic interplay among sensory integration, symbolic mediation, and embodied interpretation. The exhibition *Immersive Oceans: Beyond the Surface* serves as a model through which these multidimensional processes are illuminated.

First, the analysis underscores the importance of multisensory synchronization in generating immersive engagement. The coordinated operation of visual, auditory, kinesthetic, and spatial-symbolic elements fosters perceptual coherence and allows viewers to experience virtual environments as temporally fluid and spatially embodied realities. This integrated approach validates the theoretical propositions of ecological perception theory, which frames perception as an active and continuous engagement with the environment.

Second, the exhibition's use of symbolic spatial structures, particularly the air bubble motif, highlights the interpretive dimension of sensory space. The bubble operates simultaneously as a visual anchor and a perceptual threshold while suspending the viewer between interior and exterior, real and virtual domains. This duality aligns with reception aesthetics and emphasizes the viewer's role in constructing meaning through interaction and interpretation.

Third, the findings demonstrate how presence and sensory realism are achieved not through the sheer volume of sensory input but through the natural coherence of sensory data. The exhibition's careful

design of organic movement, sound reverberation, and light refraction fosters a credible and emotionally resonant sensory environment, supporting the viewer's psychological sense of being there.

Beyond theoretical insights, this study offers practical implications for designers, curators, and media artists involved in the creation of immersive exhibition spaces. The deliberate orchestration of multisensory elements can serve as a strategic design principle for the construction of emotionally engaging and participatory environments. Furthermore, the symbolic layering of space may be utilized to deepen the conceptual and affective dimensions of audience experience.

Importantly, the framework developed in this study holds relevance for emerging applications within metaverse environments, and digital twin systems, where embodied sensory design is becoming increasingly central. As immersive technologies evolve, the careful integration of embodied perception, symbolic spatial devices, and user-driven interpretation will be essential for constructing meaningful and credible digital spaces.

5. Conclusion

This study analyzed the exhibition *Immersive Sea: Beyond the Surface* with focus on the construction and perception of sensory spatial experiences within virtual environments mediated by digital content. The exhibition, structured around the symbolic spatial device of air bubbles and centered on digital fish as dynamic visual objects, integrated audiovisual, kinesthetic, and interpretive elements to provide a multisensory immersive experience. The findings demonstrate that sensory spatial experience transcends the passive reception of audiovisual stimuli, instead constituting a holistic perceptual process wherein space, technology, the body, and sensory modalities are interwoven into an interactive experiential field.

By employing theoretical frameworks such as ecological perception theory, reception aesthetics, and presence theory, this study offers a theoretical shift from understanding exhibitions as sites of visual image consumption to recognizing them as perceptual environments. This reframing provides a conceptual foundation for practical applications in fields such as sensory-based media space design, experiential interface development, and emotionally immersive content creation.

Nonetheless, the study is grounded in a single case analysis, which limits the generalizability of its conclusions. It does not quantitatively measure the influence of individual viewer variables such as sensory preferences, cultural backgrounds, and physical conditions on spatial perception and immersion. In this regard, future research can be done through comparative studies across multiple exhibition contexts by incorporating both qualitative methodologies and quantitative user data analysis. The concept

of sensory spatial experience developed in this study can also be extended beyond the domain of media art exhibitions to other immersive media environments, including virtual reality (VR), augmented reality (AR), and mixed reality (MR) [11][12]. When integrated with metaverse-based sensory design, digital twin simulations, and emotion-driven interface research, the principles outlined here may contribute to the technological and artistic evolution of sensory-centered content. Ultimately, this study underscores the capacity of space to operate not merely as a physical backdrop but as a medium for sensory narrative construction, enabled through the convergence of digital technology and embodied perception. By interpreting the structure of sensory space as realized in exhibition content and articulating its artistic and experiential implications, the study contributes to the theoretical advancement and practical application of sensory-centric media content studies.

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