Immersion

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Abstract

This paper analyzes immersion in audiovisual experiences by integrating psychological insights and technological innovations. It explores methodologies for measuring immersion, the impact of interactive environments, and technological advancements on immersive experiences. By identifying the common factors influencing immersion and highlighting research gaps, such as the need to define the phenomena and standardize measurement techniques, this paper aims to provide a better understanding of the relationship between immersive experiences and various audiovisual media.

1 Introduction

Immersion in audiovisual media profoundly affects the user experience in applications ranging from virtual reality (VR) to gaming and digital performances. This concept involves the user's deep engagement and the feeling of being absorbed in a digital environment, which is achieved through the seamless integration of psychological involvement and technological innovation.

This seminar paper provides a multidimensional review of the immersion phenomenon and examines its psychological underpinnings along with the technological mechanisms that foster such experiences. The current scholarly discourse often conflates related but distinct concepts such as immersion, envelopment, presence, transportation, and flow. Therefore, the paper proposes a refined framework for understanding these terms, offering clarity and direction for future research.

In addition, the paper evaluates different methodologies for measuring immersion, discussing their effectiveness and limitations within various interactive environments. Through this exploration, the paper advocates for a multidisciplinary approach to studying immersion, emphasizing the necessity of aligning technological advancements with psychological insights to fully realize immersive media's potential.

The ultimate goal is to provide a clearer understanding of how immersive technologies can be optimally designed and utilized to enhance user engagement and satisfaction in various audiovisual applications.

2 Review sections

2.1 Immersion defined

The term immersion in audiovisual experiences refers to both psychological engagement and sensory stimulation. The article "Defining Immersion: Literature Review and Implications for Research on Audiovisual Experiences" proposes the following adaptable definition of immersion based on the literature review:

"Immersion is a phenomenon experienced by an individual when they are in a state of deep mental involvement in which their cognitive processes (with or without sensory stimulation) cause a shift in their attentional state such that one may experience disassociation from the awareness of the physical world."

The concept of immersion can be divided into two paradigms: an individual's psychological state and the objective properties of the technology or system that facilitate the experience. Fig. 1 displays the three primary reasons which can lead to psychological immersion, either independently or in conjunction with other factors. These reasons include the subjective sense of being surrounded or experiencing multisensory stimulation, absorption in the narrative or the depiction of the narrative, and absorption when facing strategic and/or tactical challenges.

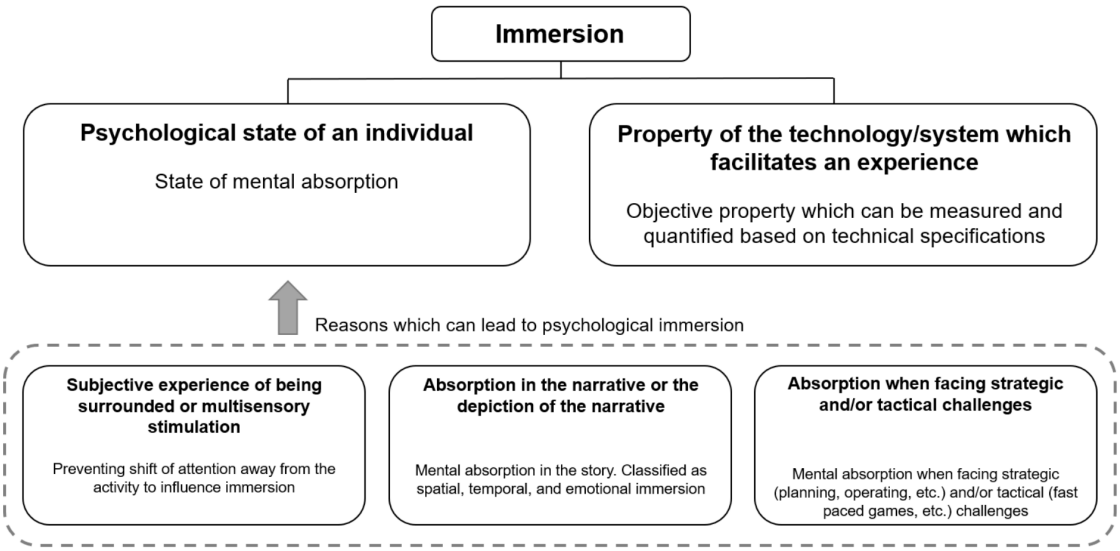

Figure 1: *Summary of the literature review presented in the article [1].*

Achieving immersion requires consideration of all sensory modalities, as well as factors that can either facilitate or disrupt immersion. These factors include the system (physical properties of the reproduction system and the content), narrative (content), environment (physical environment and contextual conditions), individual factors (affective states, mood, preference, skills, previous knowledge, expertise,

goals, motivation, etc.), and the interaction between the individual and the experience (significance of the content to the individual, acceptance of the task, alignment of goal and motivation). These factors are similar to those that affect the quality of experience (QoE). However, it's important to note that an experience must elicit immersion to qualify as an immersive experience, while QoE can theoretically be assessed for any experience. Thus, it's not enough to examine only the stimulus or the system, as they're not immersive independently of the human subject. Concepts of *immersive potential* and *immersive tendency* clarify this.

Immersive potential refers to a system or content's ability to create immersion. It remains constant for a given content presented by an unchanging system and depends on its ability to elicit immersion. Any changes to a system must lead to a noticeable perceptual change to alter its immersive potential. Additionally, immersion depends on an individual's immersive tendency, which determines their inclination to experience immersion. This tendency can be determined through questionnaires. [1]

2.2 Ambiguity and misuse

Envelopment

In the context of spatial audio, the terms *immersion* and *envelopment* are often used interchangeably, causing confusion among professionals. This confusion is particularly prevalent in research and practical audio applications. Envelopment is a concept that has been widely studied in concert hall acoustics and has expanded significantly with the growth of spatial audio. It is divided into two types: *environmental envelopment*, also known as listener envelopment (LEV), which is the sensation of being surrounded by a reverberant sound field, and *source-related envelopment*, which involves being surrounded by direct sound sources.

Envelopment refers to the perceptual aspect of being surrounded by sound and primarily depends on the physical sound field. In contrast, immersion is a cognitive experience that involves a deep mental engagement that can lead to disassociation from the physical world. It is important to accurately differentiate between these two terms, as envelopment does not necessarily result in immersion. For instance, a monophonic reproduction of one's favorite music may deliver an immersive experience due to emotional and cognitive engagement, even though it may not be enveloping. Conversely, listening to a binaural recording of restaurant ambiance through headphones might be enveloping but not necessarily immersive due to a lack of engaging narrative or context.

The misuse of the term immersion to describe any high-quality audio system, regardless of its ability to engage listeners psychologically, dilutes its significance. Envelopment often gets mistaken for immersion in marketing and technical descriptions, misleading users about the capabilities of a system. To maintain the integrity of spatial audio studies and applications, professionals must differentiate between these terms accurately. [1,2]

Presence, transportation, and flow

The discourse on immersive experiences is further complicated by terms like *presence*, *transportation*, and *flow*. These terms have unique meanings and implications, but they are often confused or used interchangeably with immersion. It's important to understand these terms in relation to each other and to immersion for precise communication and effective study design in the field of audiovisual experiences.

Presence is the psychological sense of being in a virtual environment, often linked to virtual reality research. It describes the experience of feeling situated in a place different from one's physical location, primarily mediated by technological systems. Presence is about the sensory deception that tricks the mind into believing it is somewhere else. This sense of 'being there' differs from immersion, which encompasses the sensory input and the individual's psychological engagement with the environment. Presence can occur without deep engagement or emotional involvement, which are hallmarks of immersion.

Transportation is frequently used in the study of narrative and media consumption. It describes the mental state of being transported into the narrative world, resulting in a temporary departure from one's physical environment. This concept closely aligns with narrative immersion but is specific to the context of engaging with stories, whether through reading, viewing, or listening. Transportation involves a deep mental involvement and emotional connection with the narrative, making it a subset of the broader concept of immersion focused explicitly on the content of the narrative rather than the medium through which it is delivered.

Flow is a concept that describes a state of intense focus and complete engagement in activities that provide a balance between the challenge presented and the individual's skill level. Flow is characterized by a loss of self-consciousness and a distorted sense of time due to deep concentration. Although flow and immersion share similarities, especially in their ability to engross individuals thoroughly, flow is distinct in its requirement for active participation and challenge, which are unnecessary for immersion. Immersion can occur in passive experiences, such as watching a film or listening to music, where the engagement does not depend on user input or skill utilization.

Understanding the nuances among presence, transportation, and flow is required, as each term offers a unique perspective on user experience. Further, it's crucial to use them accurately to prevent conceptual overlap that can cloud research findings and theoretical discussions. Precise understanding and communication of these terms will facilitate the meticulous design of studies and technologies aimed at fostering these distinct psychological states. This precision is particularly crucial in advancing research and developing technologies that strive to enhance not only the sense of presence or transportation but also true immersion in audiovisual experiences. [1]

2.3 Methods for measuring immersion

Measuring immersion in audiovisual research presents challenges due to the absence of a standardized definition, the multifaceted nature of the phenomenon and limited knowledge about its characteristics and factors. Additionally, there are difficulties in ensuring assessors' immersion, and immersion itself is fragile. This article discusses various methods for evaluating immersion, including objective physiological measures and subjective self-report techniques.

Physiological measures

Physiological responses can provide objective measures to evaluate the level of immersion experienced by viewers. One method to measure immersion involves the use of electroencephalograms (EEGs), which can monitor changes in brain activity patterns that signify immersive states. Another method is to monitor heart rate variability and electrodermal activity, which are valuable indicators of emotional arousal and cognitive engagement with immersive content. These methods allow researchers to determine the depth of immersion by observing biological responses that viewers may not be aware of.

Questionnaires

Assessing the level of immersion experienced by participants is usually done by asking post-experience questions and receiving verbal feedback. These assessments are typically done through questionnaires that feature scaled questions in various aspects of immersion, such as spatial presence, narrative engagement, and emotional involvement. However, these dimensions can vary between questionnaires, which are often specific to certain contexts, such as video games, virtual reality, audiovisual media, and books.

To address the challenge of measuring immersion across different media formats, Lessiter et al. developed the Independent Television Commission Sense of Presence Inventory (ITC-SOPI). This questionnaire measure is designed to determine presence, independent of media system and content properties. It is based on existing self-report measures and previous research.

A recent study was conducted with more than 600 participants across various interactive and non-interactive media to understand the sense of presence in virtual environments. The sense of presence refers to the feeling of being present in a virtual world. The study used the ITC-SOPI survey, which contained sixty-three items tapping possible manifestations of different content areas deemed relevant to presence based on theoretical and empirical papers. The areas included sense of space, involvement, attention, distraction, control and manipulation (autonomy), realness,

naturalness, perception of time, awareness of behavioral responses, a sense of social interaction, personal relevance, arousal, and negative effects. The data was analyzed using principal axis factoring.

Factor analysis was applied to identify and quantify how much of the total variability in survey responses could be attributed to different underlying factors, each representing a different aspect of the phenomenon being studied. The analysis revealed four distinct factors that contribute to the sense of presence in virtual environments:

- **Sense of Physical Space**: This factor accounted for 14.2% of the variance and was characterized by items that measure the user's sense of being physically present in the virtual environment.
- **Engagement**: This factor explained 11.1% of the variance and focused on the user's psychological involvement and enjoyment of the media experience.
- **Ecological Validity**: Contributing 7.6% to the variance, this factor pertains to how natural and believable the user found the virtual environment.
- **Negative Effects**: This factor accounted for 5.4% of the variance and included items related to adverse effects experienced by the user, such as dizziness or nausea.

Together, these factors explained 38.3% of the total variance, highlighting the multidimensional nature of the sense of presence in different types of media. The results suggest that while the ITC-SOPI survey offers reliable measures of presence, the diversity in contributing factors underscores the complexity of measuring such a subjective experience. [3]

Quantifying auditory factors

The article "Quantifying Factors of Auditory Immersion in Virtual Reality" explores the perceived importance of auditory elements in creating immersive VR experiences by audio professionals and consumers. The study investigates various auditory factors that are believed to impact the perception of immersion in VR. Surveys were used to quantify these effects, and 82 audio professionals and consumers were asked to participate. Prior to the main survey, the participants were asked some questions to help categorize them, including content type for contextualization of the remainder of the survey (games, music, film, and soundscapes). The survey rated factors such as vertical and horizontal listener envelopment, localization accuracy, apparent source width, externalization, and clarity.

The study showed that while all auditory factors were considered necessary for immersion and similar across the categories, horizontal sound perception was generally considered more critical than vertical sound perception, as shown in Fig. 2.

Q1: Vertical Listener Envelopment by Reverberation
Q2: Vertical Listener Envelopment by Sound Objects
Q3: Horizontal Listener Envelopment by Reverberation
Q4: Horizontal Listener Envelopment by Sound Objects
Q5: Vertical Localisation Accuracy
Q6: Horizontal Localisation Accuracy
Q7: Distance Localisation
Q8: Apparent Source Width
Q9: Externalisation
Q10: Clarity

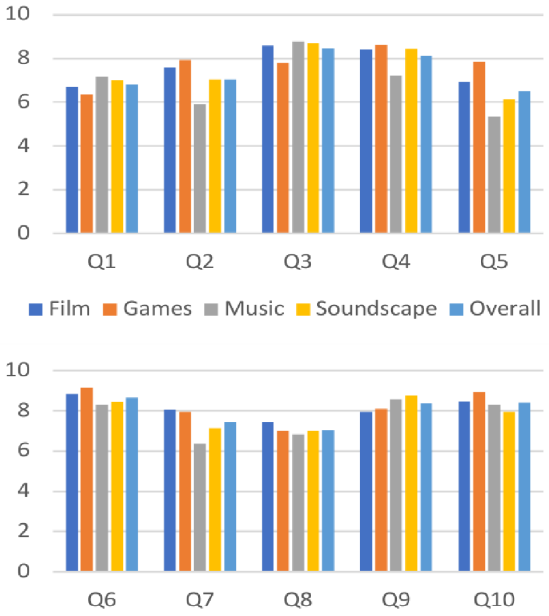

Figure 2: *The identified perceptual auditory factors and mean scores [4].*

Although the study provides an opportunity to gather opinions from non-naive subjects to compare with formal literature, the results reflect their interpretation of the phenomenon of immersion rather than identifying parameters of auditory perception that actually impact immersion. [4]

2.4 Interactive environments

Audio augmented reality

The research paper titled "Interactive Audio Augmented Reality in Participatory Performance" explores the utilization of AAR to shape the content of a participatory performance through human-computer and human-human interactions. It takes inspiration from multiplayer audio-only games and interactive storytelling elements and investigates AAR's potential to enhance the performance's overall experience. The study collected user engagement and presence data through questionnaires, observation, and group discussions.

The AR audio system used in this project was based on Bose Frames Audio Sunglasses, which feature acoustic transparency, headtracking, and user interaction options such as nodding, shaking the head, and tapping the frames. The system was developed using Unity for iOS phones, and a multiplayer experience was created over a local network connecting all players via a router.

The user experience design focused on integrating storytelling elements within an audio-augmented reality framework. Participants were given roles and instructions

that encouraged them to interact with the narrative and each other, using the audio environment to navigate and influence the story's progression.

Based on the study findings, the integration of 3D audio along with simple gesture interactions proved to be effective in engaging the participants and enhancing their sense of immersion. Among the different features of the experience, the social aspect was the most well-received. Despite being unfamiliar to one another, the participants were able to communicate using both verbal and non-verbal cues, which helped them to complete tasks and navigate through information that was not evenly distributed. [5]

Mixed reality

The "Interactive Storytelling in a Mixed Reality Environment" study explores the opportunities and challenges of integrating interactivity within mixed reality (MR) narratives. The research focuses on the "Eat Me, Drink Me" stage of the ALICE project and provides a compelling example of how physical and digital realms can be blended to enhance immersion in storytelling.

In this installation, participants interact with a physical environment augmented with digital elements. Their actions directly influence the unfolding narrative, and the design employs a variety of sensory feedback mechanisms such as visual, auditory, and tactile responses that dynamically react to user interactions. For instance, consuming items labeled "Eat Me" or "Drink Me" causes the virtual room to resize, simulating Alice's growth or shrinkage as per the original tale.

The study examines the impact of three different interaction modes on user experience: interactive environment (IE), non-interactive environment (NIE), and non-interactive with minimum stimuli (NIMS). The non-interactive variants consist of pre-programmed scenarios of the narrative played without considering the user's behavior. Despite the expectation that the interactive environment would produce significantly higher presence factors than the other two, the results indicate that the interaction types did not influence the feelings of presence and satisfaction from the experience. It is assumed that the strongly immersive environment of the installation contributes to high feelings of presence even when the environment is not responsive to the user's actions. However, participants in the non-interactive environment more frequently exhibited confusion and frustration than those in the interactive environment who expressed satisfaction every time they discovered an interaction asset. [6]

Theatre performance

The article "Devising Interactive Theatre: Trajectories of Production with Complex Bespoke Technologies" examines the use of interactive technologies in live theatre performances. Interactive theatre is an innovative form of performing arts that combines technology with live performance to create immersive experiences for both performers and audiences. The use of advanced audiovisual systems, sensors, and real-time data processing allows performers to interact with both the digital and physical elements of the stage in ways that were not possible before. These technologies are embedded with scripts in the form of computer code and possess design attributes that enable and restrict certain activities. This integration demands a high degree of adaptability and immersion from the performers, as they must navigate and respond to dynamic content that influences their performance in real-time.

From the audience's perspective, interactive elements transform the viewing experience by breaking the 'fourth wall' and inviting spectators into the narrative. Technologies such as AR, spatial audio, and motion tracking expand the physical boundaries of the stage, creating a more enveloping and engaging environment. Audience members may influence or alter the narrative flow through their responses and interactions, which are integrated into the performance in real time, making each show a unique encounter. This level of engagement can enhance the immersive quality of the experience, making audience members feel like active participants in the narrative unfolding before them.

The integration of interactive technologies in theatre challenges traditional paradigms of performance and viewing, requiring both performers and audiences to engage with the narrative and each other in novel ways. Future research should continue to explore how these technologies affect the psychological and emotional engagement of both performers and audiences, seeking to optimize the balance between technology use and narrative integrity. By documenting and analyzing these innovative productions, valuable insights can be gained into the effective design and implementation of technology in live theatre, enhancing both the performative and spectatorial aspects of immersive theatre experiences. [7]

Video games

Video games offer an immersive experience by combining auditory, visual, and interactive elements. This section discusses the concepts of flow and immersion in gaming, and how they contribute to the deep engagement and satisfaction that players derive from video games. The article "Flow and Immersion in Video Games: The Aftermath of a Conceptual Challenge" evaluates these constructs and suggests that they may not be as distinct as previously thought.

The research shows that flow and immersion represent a continuum of engagement, rather than discrete states. Flow is defined as the optimal state where challenges

match a player's skill level, while immersion is described as deep mental involvement. However, both contribute to the immersive experience of video games, characterized by a loss of self-awareness, altered perception of time, and heightened focus and enjoyment.

To optimize both flow and immersion, game designers need to create environments that dynamically adjust challenges to match player skills while maintaining narrative and interactive richness. This is a complex task that involves understanding the relation between player capabilities and game demands, which enhances the immediate gaming experience and supports sustained engagement and satisfaction.

Future research could explore the neural correlates and psychological impacts of flow and immersion, further refining our understanding of how video games captivate and hold players' attention. This research could push the boundaries of immersive technology in general. [8]

3 Discussion

The seminar explored the concept of immersion in audiovisual experiences. It was found that an interdisciplinary approach is necessary, which integrates psychological insights, technological innovations, and interaction design. The nuances between immersion, envelopment, presence, transportation, and flow were examined, and it became clear that each contributes uniquely to the overarching experience of immersion but is frequently misunderstood or conflated with the others. Hence the critical need for clarity in the terminology used within the immersive technology field. Misuse of terms such as immersion and envelopment, especially in marketing, can lead to misconceptions about the capabilities of audiovisual systems. Advocating for standardized definitions that reflect the interplay between technology and user experience is essential for advancing the field.

The discussion highlighted that immersion is not solely a byproduct of technological environments such as virtual reality or advanced audio systems; it fundamentally hinges on the user's psychological engagement and emotional involvement. Therefore, an interdisciplinary strategy that combines principles from psychology, technology, and media studies is needed to design immersive experiences effectively. Technological advancements can create conditions conducive to immersion, but they must be purposefully aligned with psychological objectives to truly captivate the user. Technologies that focus merely on sensory inputs without facilitating cognitive and emotional engagement may fall short of achieving genuine immersion. Therefore, the design and development of immersive technologies should consider how these tools interact with human sensory and cognitive systems to elicit deep engagement.

Measuring immersion is a challenging task due to its subjective nature and individual differences in experiences. It becomes even more complex when we consider the vast variety of audiovisual media we have today. Although physiological measures

and subjective questionnaires provide valuable insights, there is a need for more standardized and robust methods that can bridge objective data and subjective experiences across diverse use cases.

In order to better understand the impact of sensory input and narrative elements on immersive experiences, future research should examine these factors in greater depth. To enhance both the perceptual and psychological dimensions of immersion, there is a need for ongoing technological innovation, as well as for the development of comprehensive models and measurement tools that can evaluate and enhance immersion in complex audiovisual environments. In order to achieve these goals, it is essential to collaborate systematically across different disciplines.

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