Guiding Attention in a Virtual Reality Theater - A case study of the Virtual Reality Performance Symmetry

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Figure 1: The actors performing in Virtual Reality.

ABSTRACT

With comparatively new technologies such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and Spatial Computing, the range of interaction possibilities for theatrical performances is expanding considerably. While classical user interfaces are based on predefined visual compositions, VR applications can create highly dynamic scenarios in which the impact of established attention-guiding techniques has an uncertain effect on the user. Users often have a great deal of freedom of movement, which can make established attention-guiding approaches less effective. This study examines the challenges and solutions associated with *attention-guiding* in VR environments, particularly in the context of digital theater productions. The study focuses on the development and implementation of attention-guiding techniques for the VR performance *Symmetry*. Combining expert interviews, systematic research, and practical implementation, this research aims to identify non-intrusive and intuitive methods to effectively guide users' attention. The results highlight the importance of visual cues, color saturation, and salience modulation to enhance user engagement and immersion while addressing the challenges posed by emerging technologies in the theatrical space.

CCS CONCEPTS

• **Human-centered computing → Interaction design**; **Collaborative and social computing**; • **Applied computing → Media arts**.

KEYWORDS

Theater, Digital Theater, Virtual Production, Virtual Reality, Metaverse

1 Introduction

Technical artists in digital theater productions have often experienced that viewers, whether participants or observers, are so distracted by the novelty of the technology or the technologically augmented objects themselves that they tend to miss essential plot elements or central messages from the actors and the story. This distraction emphasizes the need to develop methods that focus the user's attention without taking it away from the important content or being too restrictive and limiting.[12, 16] Combining this practical experience with my personal background in theater arts and video game development provides an opportunity to further develop established attention techniques and apply them specifically to the needs of VR environments, not just for theatrical purposes but commercial purposes as well. Furthermore, research on attention-guiding techniques employed in Augmented Reality (AR), Mixed Reality (MR), and Spatial Computing has the potential to inform a wide range of applications.

In the rapidly evolving field of digital theater, the integration of VR technologies has opened up new dimensions of storytelling and audience engagement.[19] However, these technological advances also present significant challenges, particularly with regard to directing attention without interrupting the narrative structure or overwhelming the user [15, 20]. This paper addresses the need for effective attention-guiding techniques in spatial computing environments, drawing on theoretical research and practical insights from the production of *Symmetry*[1], a sci-fi thriller performance in which the audience can actively participate in solving the murder case. This performance has been developed fully in VR, from coding to animation and performing.

[1]https://www.staatstheater-nuernberg.de/en/spielplan-23-24/symmetrie/02-02-2024/1915

2 State of the Art

The recent availability of technologies such as VR, AR, MR, and Spatial Computing has opened up new possibilities for immersive and interactive experiences [10, 24]. These technologies enable the creation of three-dimensional spaces in which users can interact naturally with digital content [23]. However, directing attention in these environments presents unique challenges due to the high degree of user freedom and interaction.

2.1 Attention Guidance in Mixed And Augmented Reality Scenarios

There are a multitude of promising studies that concern themselves with the topic of immersive, intuitive, and effective attention-guiding in AR and MR [1, 4]. A lot of these conducted studies also highlight areas where further research or more detailed studies are necessary, providing a facilitated entry point for conducting exemplary studies.

Guiding the user's attention in AR poses to be more difficult than in traditional 2D media, as the user is usually in full control of the device and can, therefore, look and rotate freely. In an uncontrolled environment, the user cannot be physically forced to look in the direction desired by the author of the application. This raises the need to find intuitive ways to guide the user's attention without being too intrusive with the means. When it comes to interacting with technology, it is very important to not disrupt the player experience and immersion for the performance to have a meaningful effect on the user.[6]

2.2 Cue-Categories

Existing literature tends to categorize certain *cues* which have distinct features and purposes [6]. These *cues* are typically sectioned into four groups. [13, 17] Each of these groups is also divided into two subcategories as illustrated in Figure 2 from the work of Lasse at al. [13]

Explicit *diegetic* cues : Explicit diegetic cues can limit user interaction, such as events that force focus shifts, e.g., a guided tour in a VR that directs attention to specific locations. Conversely, non-limiting cues include virtual characters that use dialogue or gestures to emphasize items or diegetic signs that perform the same function. A HUD can also be diegetic, such as a cockpit display that is visible only to the pilot but is still part of the virtual world.

Explicit *non-diegetic* cues : A Heads-up Display (HUD) can serve as an explicit non-diegetic cue without limiting interaction if it provides information unavailable to the embodied character, such as a widget showing non-participant positions. Similarly, spatialized non-diegetic arrows and signs can direct attention without restricting interactivity. In contrast, a non-diegetic cue that limits interaction could be a system preventing access to areas without narrative content, akin to safety measures such as the safety wall in Meta Quest systems.

Implicit *diegetic* cues : Implicit diegetic cues that limit interaction include environmental constraints, such as virtual objects or characters altering the user's path or vision. Any salient object that draws attention without explicitly directing focus qualifies as an implicit diegetic cue that does not restrict interaction.

Implicit *non-diegetic* cues : Non-diegetic cues can similarly be used to implicitly guide the user's attention. Examples of non-diegetic approaches that constrain the user's interaction are systems that assume control of the user's viewpoint in a manner that is not feasible in the Virtual Environment.

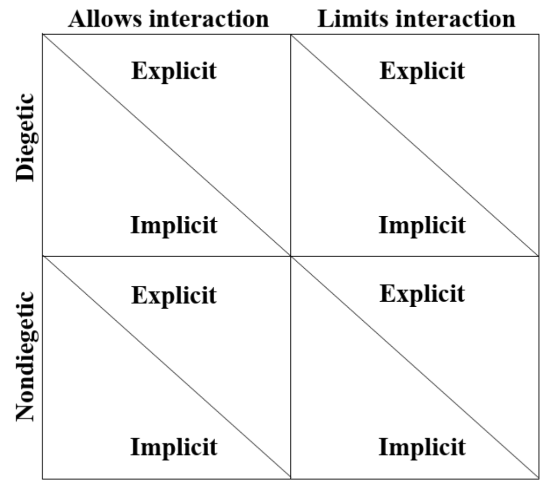

Figure 2: Taxonomy of cues for guiding the user's attention, as suggested by Nielsen et al. [13].

2.3 Attention Guidance in Virtual Reality Scenarios

Guiding attention in VR applications is a central research topic since an adequate focus on the main plot points, objects, or actors contributes significantly to the immersion of the user. There are visual methods that use contrasting colors, light accents, geometric shapes, or animated objects to specifically direct the user's attention, using the manipulation of depth of field and perspective as a means to generate focus [18].

Auditory cues play an important role, as spatially positioned sounds or specific acoustic signals act as directional indicators and thus support multisensory integration. This concept is complemented by haptic feedback, in which vibrations or tactile impulses are used in conjunction with visual and auditory stimuli to dynamically modulate attention. These haptic impulses are not only transferred via the controller or the VR device itself but can also be achieved by specific haptic equipment such as haptic vests, gloves, or face-pads.

The integration of these multimodal methods not only reduces cognitive load, but also optimizes immersion and situational awareness in virtual environments, which is highly relevant for educational applications as well as entertainment and training simulations. The research conducted in this field is relevant to Augmented Reality applications as well, as these technologies do not differ too much from each other.

2.4 Saliency Modulation

In addition to the different types of *cues*, existing literature examines *Saliency Modules* [21]. *Saliency Modulation* describes a method in which the focus subject is made distinct from the rest of the scene by applying different forms of alteration to it. There are a multitude of methods that can be applied to the hero object to make it stand out [14, 22, 26]. Based on existing literature, the following list and its description of the individual modules can not be taken as a complete overview of all the existing ways of performing saliency modulation. This list is much rather a broad overview of the most common methods used in video games.

Color and Contrast Manipulation: By deliberately altering color saturation and contrast, certain areas of an image are emphasized to draw visual attention to them. In a video game interface, interactive elements such as quest markers or collectibles can be emphasized by using higher saturation and contrast compared to their surroundings [2, 7].

Intensity and Brightness Control: Changing the brightness of an object or area relative to its surroundings changes its saliency. Bright objects in dark surroundings, or vice versa, attract the eye [9]. In a horror game, a door to the next section can be highlighted with a subtle light source while the rest of the scene remains in darkness [11].

Motion Salience: Moving objects or animations stand out due to the biological motion detection mechanism of the human eye. An enemy Non-Player Character (NPC) moving in the bushes is immediately noticeable, even if it is well camouflaged.

Peripheral Salience Direction: Subtle changes in the peripheral areas of the visual field subconsciously direct attention in a desired direction. In a narrative adventure game, a slight change in brightness in a side alley can direct the player's attention in that direction without the use of a direct cue.

Auditory Salience Modulation: Sudden or unusual changes in sound can serve as auditory salience mechanisms to control attention. The gradual increase of threatening background noise signals to the player that danger is approaching.

Space and Depth Composition: The strategic placement of objects in the virtual environment uses perspective, linearity, and depth of field to guide the eye [6]. A level designer might arrange pathways and architectural structures to guide the player's eye toward a goal naturally.

Reduction of extraneous sources of salience: By reducing the salience of irrelevant elements, attention can be focused on an important object or area. During a boss fight, the User Interface (UI) could be automatically minimized or hidden to make it easier to focus on the fight [5].

Dynamic Salience Control through Adaptivity: Salience can be dynamically adjusted for the player based on their behavior or current game state. A tutorial could provide increasingly intrusive visual cues when a player has trouble recognizing a new gameplay mechanic.

Cognitive Salience through Semantic Meaning: Objects with narrative or gameplay relevance are automatically more salient to the player because of their meaning. A glowing sword in a cut scene could be identified as a legendary weapon without the need for explicit markers.

These means of modulation are a handful of operations that ensure that the user is noticing the hero object. Almost all of these saliency modules can be separated or combined in the Cue-Categories elude before.

2.5 Diegetic Cues

Especially the work of Rothe et al. [18] focuses on *Cinematic Virtual Reality* and is therefore looking very closely at diegetic cues in this context. Diegetic cues are integral parts of a scene and have the potential to specifically direct the visual attention of the audience within an immersive environment. In contrast to non-diegetic cues, which exist outside the narrative (e.g., background music or a voice-over), diegetic cues are inherent elements of the cinematic world and can, therefore, be perceived as natural without affecting immersion. As with the list of methods for saliency modulation, this list and its cues are not an overview of each existing cue but were much rather chosen as the most relevant for the performance.

Acoustic cues: The role of sound in directing the viewer's attention is particularly important in both traditional cinematic contexts and VR environments [25]. Acoustic signals can draw attention to certain areas even if the viewer's gaze is currently directed elsewhere. The mechanism behind this effect is well established in psychology: people tend to localize the source of a new sound, especially if it implies narrative relevance. It turns out that not only sounds that are correctly localized in space have a directional function, but also sounds that originate outside the direct field of vision can trigger the impulse to turn around and identify the sound source [8].

Lighted objects: Light is a classic cinematic tool for focusing attention, but it has a different effect in a VR environment. As discussed in the pervious subchapter of Saliency Modulation, this suggests that light is less effective as an isolated fixed point and more effective in conjunction with motion. An example of this is a moving cone of light or a sudden change in light intensity that appeals to the viewer's peripheral vision and triggers a natural tendency to shift their gaze.

Scene transitions: Transitions between scenes pose a particular challenge for eye tracking in CVR. Unlike traditional movies, where hard cuts or montage techniques are used to direct the viewer's attention to a new element, the 360-degree environment lacks direct control over the field of view. Research has shown that it is particularly difficult to direct viewers at the beginning of a new scene because they are in an orientation phase and their line of sight does not necessarily correspond to the narrative focus.

3 Expert Interviews

To estimate upcoming challenges and opportunities of *attention-guiding* in these technologies within theatrical environments, six expert interviews were conducted with professionals in the fields of theater, technology, and interactive media. The purpose of these six interviews was to gain valuable insight into the practical aspects of implementing *attention-guiding* techniques and to supplement theoretical findings with real-world experiences and perspectives. The experts were selected to provide perspectives from a wide range of production departments, including technology, dramaturgy, acting, and screenwriting. The interviews were conducted using a structured guide that included specific questions about the challenges and solutions associated with directing attention in MR environments. The experts were asked to share their experiences and opinions on various aspects of directing attention, including the use of visual and auditory cues, the integration of interactivity, and overcoming technological hurdles. The interviews were recorded and then transcribed for detailed analysis.

3.1 Technological Challenges and Distractions

A recurring theme in the interviews was the challenge of effectively directing user attention in MR environments without breaking immersion. Experts emphasized that technological difficulties, such as operational problems or interaction delays, can significantly affect immersion. One expert noted that even small technical glitches are often interpreted as “the technology not working”, which can undermine user confidence in the technology. A key aspect to overcome these challenges, was the conduction of training and onboarding processes that help users become familiar with the technology before they are immersed in the immersive experience. Interactive learning environments in which users can experiment and make mistakes without fear of negative consequences are a important component of the onboarding process. These environments offer users the opportunity to explore the technology in a safe and controlled setting, which facilitates learning and reduces the fear of making mistakes later on during the performance. One expert emphasized the importance of feedback mechanisms in such learning environments. Real-time feedback can help users track their progress and understand which actions lead to the desired results.

3.2 Interactivity and Tactile Experiences

Another important aspect highlighted in the interviews was the importance of interactivity and user control in MR environments. Users who feel in control of their experience are more likely to engage more deeply and stay immersed significantly longer. Interactive elements, such as the ability to interact with objects in the virtual world or explore the environment, were seen as critical to maintaining user attention and interest. One expert pointed out that the balance between guidance and freedom is critical to creating an immersive yet navigable experience. Too much control can overwhelm users, while too little can lead to disinterest and distraction. The interviews emphasized the importance of considering the tactile and cultural experiences of users, as well as their tactile abilities, for *attention-guiding* in MR environments. They pointed out that younger users who have grown up with digital technologies are often able to interact with MR environments more quickly and intuitively than older users. Generational differences in technology acceptance and cultural differences in perception and interaction influence how users interact with technology and navigate the immersive environment. Ease of use and non-intuitiveness can significantly impact immersion, making adaptive technologies

Figure 3: The audience experiencing the performance.

and personalized onboarding processes critical to ensuring a seamless and inclusive user experience. By adapting technology to the individual needs and abilities of users, MR applications can be made more immersive and accessible, resulting in greater audience retention and engagement.

4 Technical Implementation

Symmetry is a theatrical performance developed and performed entirely in VR. The application was developed on the *Resonite* platform, an established Metaverse platform that covers many of the basic requirements for such a production. The platform offers features such as multiplayer, voice chat, and integrated coding tools for creating complex game mechanics within the system. Building on this solid foundation, the technical team was able to program and create the necessary game mechanics for the users and stagehands directly in the VR within the application.

An important goal for the team was to keep the complexity of the system as low as possible for the user to ensure a seamless and immersive experience. This meant that all interactions had to be intuitive and self-explanatory so that users did not have to interact with additional user interfaces. The entire experience was designed to work without additional technical barriers, allowing users to focus on the action and explore the virtual world. To achieve this goal, the results of the research and interviews were analyzed and reduced to a few test cases. Discussions with experts in other fields and people outside the production provided an objective insight into the progress of the production and the intuitiveness of the system.

4.1 Worldbuilding

An integral part of *Symmetry* was the ability for users to freely explore the open world at certain stages of the game to find clues and hints to the story. The design of the world and the integration of *attention-guiding* techniques were based on insights gained from expert interviews and research on diegetic cues. Color saliency was used to direct users’ attention to specific locations by highlighting important objects or places with targeted lighting. Important objects were also outlined when the user was nearby. Auditory cues signaled proximity to points of interest, while NPC dialog provided subtle to obvious cues about important locations.

The saliency modulation techniques proved to be particularly helpful in the expansive sections of the open world. Users were usually able to find all of the hidden clues because the level structure was designed so that there were always lines of sight to important clues, and users could orient themselves within the level at any time. The deliberate placement of objects and use of directed lighting and color helped to effectively direct the user's attention without breaking immersion.

4.2 Chroma Salience

At certain points in the story, it was critical that users focus their attention on specific dialog or avatars. Chroma saliency was used here, a technique where only the important area is displayed in color while the rest of the scene is monochrome and completely desaturated. This method ensured that users were not distracted by the environment or other distractions and could focus on the central elements of the action. The use of chroma saliency was particularly effective in scenes where important information was being conveyed or the plot was taking a decisive turn. By reducing visual distractions and focusing on the relevant areas, the user's attention could be directed in a targeted manner, resulting in a more intense and immersive experience.

Symmetry demonstrates how important the integration of certain attention-guiding techniques and a focus on user experience is to create an intuitive and immersive theatrical performance in virtual reality. The use of color and chroma salience, combined with auditory cues and intuitive world design, allowed users to focus on the main plot points without being distracted by the technology or faults of the technology.

5 Conclusions and Shortcomings

The implementation of the attention-guiding system in *Symmetry* was successful, with most audience members remaining engaged throughout the performance and not feeling lost. Observations over the 10 performance days showed that the attention-guiding techniques were effective in directing the audience's attention to central narrative elements without being intrusive. Quantitative feedback, as well as critics' feedback, helped assess the success of the play and shed some light on the experience that users had with the system. Users were not only able to orient themselves in the virtual environment effortlessly but could also contribute to the plot by finding clues and hints within the open-world exploration parts of the play. Most users reported an increased confidence to engage with the system due to the tutorial that was provided directly before the performance.

However, some users experienced difficulties interacting with the technology due to some technical difficulties. Every user was briefed and was provided with a comprehensive onboarding tutorial. Nevertheless, some users experienced motion sickness or similar symptoms. This is likely due to inexperience with this kind of technology, and additionally, performance problems in the form of frame rate drops whenever *Resonite* or the VR Headset could not handle the demanding task. For users that did not cope well with Virtual Reality, the whole play was being shown on a big screen through the lens of a spectator camera within the virtual play. Being able to take a break or even experiencing the whole play this way proved to be a preferable option for a significant amount of people. Virtual Reality, in particular, is known for being polarizing when it comes to being affected by motion sickness [3]. The interviews and observations from the performance clearly show that the technical aspects of the performance did not pose as much of a problem after the introduction. Known issues such as motion sickness need to be addressed by future iterations and research.

6 Future Research Directions

Future research should focus on extending and refining these techniques, with a particular interest in integrating multimodal approaches that combine visual, auditory, and haptic stimuli. Implementation of such systems could not only further increase user immersion and engagement but also reduce cognitive load by engaging multiple senses simultaneously. Interdisciplinary collaboration between psychology, computer science, design and theater studies is crucial to develop innovative solutions that consider both technical and artistic aspects and thus contribute to a holistic user experience. The evaluation and validation of the developed techniques in real-life application scenarios using quantitative and qualitative methods will provide a comprehensive picture of the user experience.

Ethical and societal implications, such as privacy and user autonomy, should be considered to ensure responsible use of the techniques. Especially, when the performance is being held online. Future research should also consider other forms of mixed reality technology, such as augmented reality, as there are significant overlaps and similar challenges and solutions. The integration of accessibility features is also crucial to ensure that these technologies are accessible to all users, regardless of their physical or cognitive abilities. Further development and application of these techniques can significantly increase user engagement and immersion in digital theater productions and other MR applications, although ethical and societal aspects should always remain in focus.

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