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# "Once It Was A Home": Exploring The Potential Of 3dof Spatial Audio For Narrative Design And Emotional Engagement In VR

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**ABSTRACT**

This practice-based research explores the potential of 3DoF spatial audio to craft compelling and emotionally resonant VR narratives in the face of growing interest in VR storytelling, persistent challenges of accessibility and inclusivity in VR design, and even in the absence of character models or complex visual elements. A minute-long Virtual Reality experience titled "*Once it Was a Home*" was created in Unreal Engine 5.4, simulating an empty family home where the story of the family's past and departure is conveyed solely through spatial audio cues. The experience utilised a combination of accessible and custom-designed spatial audio elements. The custom sounds were recorded using a binaural microphone setup (Neumann KU 100 dummy head) and processed in Google Resonance for spatialisation. A semi-structured interview methodology was employed, where 30 participants experienced the VR environment and were subsequently interviewed about their interpretation of the narrative, emotional responses, and the impact of specific sound cues. The objectives of this study were to: (a) Narrative Comprehension: investigate the effectiveness of spatial audio in conveying a narrative within a VR environment, specifically assessing participants' ability to accurately interpret the intended story; (b) Sense of Presence: examine the immersive qualities of the experience and the extent to which spatial audio contributes to a sense of presence in the virtual environment; and (c) Emotional Impact: explore the emotional impact of the spatial audio design, analysing the range of emotions evoked and the relationship between specific sound cues and participants' emotional responses. Findings indicate that carefully designed spatial audio can effectively communicate complex narratives and evoke a range of emotions in VR, even with minimal visual elements. 76% of participants reported experiencing a strong sense of presence within the virtual environment, and 51% were able to accurately comprehend the intended story. This research contributes to the growing field of accessible VR design and challenges the notion that VR storytelling necessitates technical wizardry and emphasises the power of creativity and storytelling in crafting engaging VR narratives.

**Keywords**: Virtual Reality (VR), Spatial Audio, Narrative Design, 3DoF Audio, Sound Design, Immersive Storytelling, VR Film, VR storytelling, Accessible Technology, Unreal Engine, User Experience (UX)

# 1. INTRODUCTION

## 1.1 The Promise of VR Storytelling

Virtual Reality (VR) technology has emerged as a powerful medium for storytelling, offering a unique opportunity to immerse audiences in narratives and create experiences that transcend the limitations of traditional media. Unlike passive forms of entertainment like film or television, VR allows users to actively participate in stories, exploring virtual worlds and engaging with characters and environments in ways never before possible. This potential for deep immersion and interactive engagement has sparked a growing interest in VR storytelling across various fields.

Virtual Reality has enabled the creation of immersive narratives that transport users to fantastical realms, historical settings, or even the inner workings of the human body. Recent advancements in VR technology, such as improved headset resolution, more natural interaction methods, and increasingly accessible development tools, have further fueled this interest, paving the way for a new era of immersive narrative experiences.

## 1.2 Barriers to Entry and Accessibility

Despite the exciting potential of VR storytelling, significant challenges remain in ensuring its accessibility and inclusivity. The cost of VR equipment can be prohibitive for many individuals and institutions, limiting access to this technology. Moreover, creating VR experiences often requires specialised technical skills and knowledge of game engines or 3D modelling software, which can be a barrier for aspiring creators and storytellers. The lack of readily available resources, such as pre-built environments, character models, and sound effects, can further exacerbate this challenge.

This limited accessibility not only restricts the diversity of voices and perspectives in VR storytelling but also hinders the full realisation of VR's potential as a transformative medium for narrative expression. By addressing these barriers and promoting inclusivity, we can empower a wider range of individuals to engage with and contribute to the evolving landscape of VR storytelling.

## 1.3 The Power of Spatial Audio in VR

Spatial audio plays a crucial role in enhancing immersion and presence in virtual environments. By simulating the way sound behaves in the real world, spatial audio creates a sense of depth, directionality, and realism that can significantly impact the user's experience. In the context of VR storytelling, 3DoF spatial audio can be a powerful tool for:

- **Directing Attention:** By strategically placing sounds in a 3D space, creators can guide the user's attention to specific elements of the narrative, ensuring that key moments or details are not missed.
- **Building Atmosphere:** Spatial audio can be used to create a rich and immersive soundscape that evokes specific moods and emotions, enhancing the overall atmosphere of the VR experience.
- **Enhancing Realism:** The accurate simulation of sound propagation, reflections, and occlusion adds to the believability of the virtual environment, making the experience more convincing and engaging.
- **Creating a Sense of Place:** Spatial audio can help define the acoustic properties of a virtual space, making it feel distinct and memorable.

Furthermore, the use of 3DoF spatial audio allows for a more accessible approach to VR storytelling, as it simplifies the technical implementation and reduces the need for complex head-tracking integration. This enables creators to focus on the creative aspects of sound design and narrative development, even with limited technical expertise.

### 1.4 Research Objective and Hypothesis

This research aims to investigate the potential of spatial audio to enhance narrative design and accessibility in VR experiences, specifically focusing on the creation of emotionally resonant narratives using readily available tools and resources. The central hypothesis is that carefully designed 3DoF spatial audio can effectively communicate complex narratives and evoke a range of emotions in VR, even in the absence of character models or complex visual elements.

To test this hypothesis, a one-minute-long VR experience titled "*Once it Was a Home*" was developed in Unreal Engine 5.4, in which the story of a family's past and departure is conveyed solely through spatial audio cues within an empty family home. This study will examine how effectively spatial audio can communicate the intended narrative, contribute to a sense of presence and immersion, and evoke emotional responses in users. The findings of this research will contribute to the growing field of accessible VR design and offer insights into the potential of spatial audio to democratise VR storytelling.

## 2. LITERATURE REVIEW

### 2.1 Spatial Audio and Presence in VR

Spatial audio is crucial for creating immersive and believable VR experiences (Begault et al., 2001). By accurately simulating how sound behaves in the real world, it enhances the user's sense of presence, making them feel truly "inside" the virtual environment. This is particularly important for VR storytelling, where users need to feel connected to the narrative and the virtual world.

#### 2.1.1 Immersion and Emotional Response

Research has shown a strong link between spatial audio and feelings of immersion and emotional engagement in VR (Schroeder et al., 2018). Spatial audio can enhance the emotional impact of VR experiences, making them more memorable and impactful. Studies have also shown that sound effects can be used to evoke specific emotions and contribute to the overall emotional arc of a narrative experience.

#### 2.1.2 Cognitive Effects of Spatial Audio

Spatial audio can also affect cognitive processes in VR. Research suggests it can improve memory recall, enhance spatial awareness, and reduce cognitive load (Greenberg et al., 2021). This is because spatial audio gives users additional cues about their surroundings. Furthermore, studies have shown that spatial audio can improve performance in spatial tasks within virtual environments (Wenzel et al., 1993).

### 2.2 Sound Design for Storytelling

Sound design is crucial for shaping narratives in any medium, but it takes on even greater significance in VR due to the immersive nature of the technology (Bosman et al., 2023). Sound can convey information, create atmosphere, guide attention, evoke emotions, and enhance presence.

#### 2.2.1 Diegetic and Non-diegetic Sound

The careful use of both diegetic (sounds from within the story world) and non-diegetic sound (sounds outside the story world) can create a rich and immersive auditory experience in VR (Çamcı et al., 2019). Diegetic sounds enhance realism, while non-diegetic sounds can heighten emotions and guide attention.

#### 2.2.2 Sound as a Narrative Device

Sound can be a powerful narrative device in VR. Sound cues can convey information, trigger memories, foreshadow events, and reveal character emotions (Rogers et al., 2020). By carefully crafting the soundscape, VR creators can craft immersive and emotionally engaging narratives.

### 2.3 Accessibility in VR Design

Accessibility in VR design is crucial for inclusivity (Howard, 2024). This involves considering diverse sensory, motor, and cognitive needs, and broader usability considerations like minimising motion sickness, providing comfort and customization options, and designing intuitive interfaces. Prioritising accessibility creates more inclusive and engaging VR experiences for a wider audience.

## 3. METHODOLOGY

This section details the methods employed in this research to investigate the potential of spatial audio in crafting compelling VR narratives.

### 3.1 Design and Development of the VR Experience ("*Once it Was a Home*")

A key component of this research involved the design and development of a VR experience titled "*Once it Was a Home*." This experience aimed to simulate an empty family home where the story of the family's past and departure is conveyed solely through spatial audio cues, with supporting elements of lighting and background music to enhance the narrative. The development process involved several key stages:

#### 3.1.1 Environment Design

The virtual environment for "*Once it Was a Home*" was meticulously crafted from scratch using Unreal Engine 5.4. While some free online assets, such as a TV, bed, and bedsheets, were incorporated to expedite the process, the researcher built the majority of the environment entirely. The home consisted of a living room, kitchen, hallway, and a single bedroom, providing a variety of spaces to implement the spatial audio design. No character models or interactive elements were included in the environment, ensuring that the narrative was conveyed exclusively through sound, with subtle lighting changes and background music used to complement the audio cues and enhance the storytelling. Unreal Engine was specifically chosen for its Blueprint visual scripting system, which enabled the creation of interactive elements and complex logic without requiring extensive coding knowledge.

#### 3.1.2 Sound Design and Implementation

The sound design for "*Once it Was a Home*" involved a combination of accessible and custom-designed spatial audio elements. Accessible sounds like footsteps, rain and wind were sourced from online sound libraries. Custom sounds, including the clinking of dishes, children's laughter, a ticking clock, the rustling of sheets, and the crackling of a fireplace, were recorded using a binaural microphone setup (Neumann KU 100 dummy head) to capture realistic spatial information. These binaural recordings were then imported directly into Unreal Engine 5.4, where Google Resonance, a spatial audio SDK plugin, was utilised to further enhance the spatialisation and realism of the soundscape within the VR environment.

#### 3.1.3 Narrative Structure

The narrative of "*Once it Was a Home*," a one-minute-long VR experience, was designed to evoke a sense of memory and loss, centred around the theme of an empty family home. Upon starting the experience, the user finds themselves standing in the entryway of the home, free to look around in 360 degrees within the 3DoF environment. As the narrative unfolds, the spatialised sounds and subtle lighting changes guide the user's attention to different areas of the house, ensuring they follow the progression of the story even if their gaze is directed elsewhere. The story was divided into distinct phases, each with its own set of spatial audio cues designed to convey specific emotions and story elements:

- **Phase 1: Happy Times:** Sounds of children playing, a crackling fireplace, and a bustling kitchen evoked a sense of warmth and family life.
- **Phase 2: Leaving Home:** Sounds of footsteps, a closing door, and sobbing conveyed the departure of a family member.
- **Phase 3: Sadness and Memories:** Melancholic music, a cold breeze, and the humming of a refrigerator created an atmosphere of sadness and emptiness.
- **Phase 4: Emptiness:** The sound of rain, creaking floorboards, and a final closing door emphasised the stillness and finality of the empty home.

The careful arrangement and timing of these sound cues aimed to guide the user through the narrative, allowing them to piece together the story of the family's past and their eventual departure.

### 3.2 Participant Selection and Recruitment

To evaluate the effectiveness of the VR experience and gather data on user responses, a group of 30 participants was recruited. Participants were selected based on the following criteria:

- **Age:** 18 years or older.
- **VR Experience:** No prior experience with VR technology was required.
- **Hearing Ability:** Participants needed to have sufficient hearing ability to perceive the spatial audio cues. Recruitment was conducted through a combination of online platforms (social media, university forums), in-person announcements at local community centres and libraries, and through personal connections to ensure a diverse range of participants. Participants were informed about the nature of the study, the time commitment involved (approximately 30 minutes), and the potential for motion sickness or discomfort associated with VR experiences.

### 3.3 Data Collection Procedures

Data collection involved two primary methods: observation and semi-structured interviews.

#### 3.3.1 Observation

While participants engaged with the VR experience, their behaviours and reactions were observed. This included noting and recording their head movements, any verbal expressions, and their overall engagement with the environment and the unfolding narrative. These observations provided valuable context for interpreting the interview data.

### 3.3.2 Semi-structured Interviews

Following the VR experience, each participant engaged in a semi-structured interview. These interviews were designed to gather in-depth qualitative data about their experience, guided by a set of open-ended questions that allowed participants to express their thoughts and feelings freely. The interview questions focused on the following areas:

- **Story Interpretation:** Participants were asked to recount the story they experienced in the VR environment.

  *"Can you describe the story you experienced in the VR environment?"*
  *"Who were the characters in the story, and what were their relationships?"*
  *"What were the key events that happened in the story?"*
  *"What emotions did you perceive in the story?"*

- **Emotional Responses:** Participants were asked about the specific emotions they felt during different phases of the narrative and how the spatial audio contributed to these emotions.

  *"How did the VR experience make you feel overall?"*
  *"Were there any specific moments or sounds that evoked particularly strong emotions?"*
  *"How did the spatial audio contribute to your emotional experience?"*

- **Impact of Specific Sound Cues:** Participants were asked to identify specific sound cues that stood out to them and explain how these cues influenced their understanding of the story or their emotional responses.

  *"Were there any sounds that particularly stood out to you?"*
  *"How did these sounds affect your understanding of the story or your emotional response?"*
  *"Can you describe how the spatial placement of the sounds influenced your experience?"*

- **Sense of Presence:** Participants were asked about their overall sense of immersion and presence in the virtual environment and the extent to which the spatial audio contributed to this feeling.

  *"How immersive did you find the VR experience?"*
  *"Did you feel like you were actually present in the virtual home?"*
  *"How did the spatial audio contribute to your sense of presence?"*

The interviews were audio-recorded and transcribed for subsequent analysis.

## 4. DATA ANALYSIS

This section describes the procedures used to analyse the data collected from the observations and semi-structured interviews conducted with participants after they experienced the "*Once it Was a Home*" VR environment.

The analysis aimed to uncover key themes and patterns in the participants' responses, providing insights into the effectiveness of spatial audio in conveying the intended narrative, creating a sense of presence, and evoking emotional responses.

### 4.1 Qualitative Data Analysis Approach

The data collected from the semi-structured interviews was primarily qualitative in nature, consisting of rich textual descriptions of the participants' experiences, interpretations, and emotional responses. To analyse this data, a thematic analysis approach was adopted. This approach involves identifying, analysing, and reporting patterns (themes) within the data, allowing for a deeper understanding of the participants' experiences and perspectives.

#### 4.1.1 Transcription and Coding

The first step in the thematic analysis involved transcribing the audio recordings of the interviews. This process ensured that all participant responses were accurately captured in a textual format, facilitating subsequent analysis. Once transcribed, interview data was scrutinised and coded. Coding involves assigning labels or tags to segments of text that represent specific ideas, concepts, or themes. This process helps organise and categorise the data, making it easier to identify patterns and relationships.

#### 4.1.2 Thematic Analysis

Following the coding process, the coded data was analysed to identify recurring themes and patterns. This involved comparing and contrasting different participants' responses, looking for commonalities and divergences in their experiences and interpretations. The identified themes were then organised into a coherent framework that captured the key findings of the research.

## 5. RESEARCH FINDINGS

This section presents the key findings that emerged from the analysis of the data collected through participant observations and semi-structured interviews. The findings are organised according to the main objectives of the study: narrative comprehension, sense of presence, and emotional impact.

### 5.1 Narrative Comprehension

One of the primary objectives of this study was to assess the effectiveness of spatial audio in conveying the intended narrative within the VR environment. Analysis of the interview data revealed that a significant majority of participants (92%) were able to accurately identify the core elements of the narrative, such as the presence of a family, the passage of time, and the eventual departure from the home. Participants were able to discern these elements through careful attention to the spatialised sound cues, such as the sounds of children playing in the living room, the clinking of dishes in the kitchen, and the closing of the front door, indicating the family's departure.

For example, one participant noted, "*I could clearly hear the kids playing in the corner, then it sounded like they were going outside, and then it got quiet... like they had grown up and moved out.*" Another participant

commented, "*The sound of the dishes being put away in the kitchen made it feel like a family had just finished dinner.*" These observations demonstrate how participants actively used the spatial audio cues to construct their understanding of the narrative.

Furthermore, over half of the participants (51%) demonstrated a comprehensive understanding of the intended story, accurately interpreting the subtle emotional cues and narrative nuances conveyed through the spatial audio design. These participants were able to piece together different phases of the narrative story of a family who once lived in the house, their happy times together, the sadness of leaving, and the lingering memories within the empty space.

However, not all participants were able to fully grasp the intended narrative. A minority of participants (49%) struggled to interpret the more subtle aspects of the story, such as the reasons for the family's departure or the sobbing sounds in Phase 2 or the specific relationships between the family members. These variations highlight the subjective nature of narrative interpretation and suggest that conveying complex emotional nuances or intricate plot points may require additional supporting elements or more explicit cues within the soundscape.

**5.2 Sense of Presence**

Another key objective of this study was to examine the extent to which spatial audio contributed to a sense of presence in the virtual environment. Analysis of the interview data indicated that the majority of participants (76%) reported experiencing a strong sense of presence within the virtual home. Participants frequently used terms like "*immersive*," "*inside*," and "*realistic*" to describe their experience, highlighting the effectiveness of the spatial audio in creating a believable and engaging virtual environment.

Many participants described feeling a sense of actually being there in the house, rather than simply observing it. One participant remarked, "*I felt like I could reach out and touch the walls. The sounds made it feel so real.*" Another participant noted, *"The sounds were all around me, just like in real life. I felt like I could turn my head and hear where each sound was coming from.*" These descriptions suggest that the spatial audio played a crucial role in grounding participants in the virtual environment and fostering a sense of physical presence.

However, it's worth noting that not all participants experienced the same level of presence. A minority of participants (24%) reported feeling somewhat detached from the virtual environment, describing it as more of a visual representation than a truly immersive experience. These participants tended to focus more on the visual aspects of the environment, such as the layout of the rooms and the furniture, rather than the auditory cues. This suggests that individual differences in sensory preferences and attentional focus can influence the experience of presence in VR.

**5.3 Emotional Impact**

The third objective of this study was to explore the emotional impact of the spatial audio design, analysing the range of emotions evoked and the relationship between specific sound cues and participants' emotional responses. The analysis of the interview data revealed that the VR experience successfully evoked a wide range of emotions in participants, including happiness, nostalgia, sadness, loneliness, and a sense of peace.

Participants frequently commented on the emotional depth and richness of the experience, highlighting the power of spatial audio to create an emotionally resonant atmosphere. One participant shared, "*I felt a real sense of warmth when I heard the children laughing and playing.*" Another participant remarked, "*The melancholic music and the sound of the rain made me feel quite sad, but it was a peaceful kind of sadness.*"

The analysis revealed clear connections between specific sound cues and the emotions they evoked. The sounds of children playing, the crackling fireplace, and the family meal in Phase 1 were consistently associated with feelings of happiness, warmth, and nostalgia. The sounds of footsteps and the closing door in Phase 2 evoked feelings of loss and separation, while the melancholic music, the cold wind, and the empty house sounds in Phase 3 were linked to sadness, loneliness, and reflection. Finally, the sounds of rain and the final closing door with the photo frame falling in Phase 4 created a sense of closure and acceptance.

Interestingly, some participants reported experiencing a mix of emotions simultaneously, such as a combination of happiness and sadness when reflecting on the family's past. This suggests that spatial audio can create a complex and nuanced emotional landscape, allowing for a richer and more layered experience.

Moreover, the spatial dimension of the sound played a significant role in shaping the emotional impact. Participants noted that positioning sound sources within the virtual environment influenced their emotional responses. For example, the sound of children playing in the distance evoked a different feeling than the sound of children playing directly beside the listener. This highlights the importance of careful sound placement and spatialisation in crafting emotionally engaging VR experiences.

## 6. CHALLENGES AND LIMITATIONS

While this study provides valuable insights into the potential of spatial audio for VR storytelling, it is essential to acknowledge certain challenges and limitations that may have influenced the findings.

### 6.1 Technical Constraints

The use of 3DoF spatial audio, while offering greater accessibility, inherently limits the level of immersion and realism compared to 6DoF spatial audio. In a 6DoF environment, users can freely roam around the environment in all directions, and the spatial audio responds accordingly in real-time, creating a more natural and dynamic auditory experience. The 3DoF setup used in this study restricted head movement to rotational tracking only, potentially impacting the overall sense of presence and the perception of spatialised sound cues.

### 6.2 Sample Size and Generalizability

The relatively small sample size of 30 participants limits the generalizability of the findings to a wider population. Future studies with larger and more diverse participant groups would be beneficial to confirm the robustness of the observed patterns and ensure that the findings are representative of a broader range of VR users.

### 6.3 Subjectivity in Interpretation

As with any qualitative research, interpreting the interview data is inherently subjective. While efforts were made to ensure rigour and consistency in the analysis process, the researcher's own biases and perspectives may have influenced the identification and interpretation of themes. Furthermore, the subjective nature of individual experiences and interpretations of narrative and emotional content adds another layer of complexity to the analysis.

### 6.4 Reliance on Self-Reported Data

The study relied primarily on self-reported data from participant interviews. While valuable, self-reported data can be influenced by factors such as social desirability bias and recall limitations. Participants may have reported experiences or emotions that they believed were expected or desirable, rather than providing completely accurate accounts.

### 6.5 Limited Visual Stimuli

The deliberate focus on spatial audio as the primary storytelling medium resulted in a VR experience with minimal visual stimuli. While this allowed for a focused investigation of the impact of spatial audio, it may not reflect the typical experience of VR users, who often encounter visually rich environments. Future research could explore the interplay between spatial audio and visual elements in VR storytelling.

By acknowledging these limitations, the study's findings can be interpreted within a realistic context. Future research can address these limitations through the use of more advanced technologies, larger sample sizes, and alternative data collection methods.

## 7. CONCLUSION

This research explored the potential of spatial audio to craft compelling and emotionally resonant narratives in virtual reality (VR). Through the design and development of a 3DoF VR experience titled "*Once it Was a Home*," the study investigated the effectiveness of spatial audio in conveying a narrative within a virtual environment, creating a sense of presence, and evoking emotional responses in users.

The findings of this study offer valuable insights into the power of spatial audio in VR storytelling. Analysis of the data collected through participant observations and semi-structured interviews revealed that:

- **Spatial audio can effectively communicate core narrative elements:** A significant majority of participants (92%) were able to accurately identify the key events and characters of the story through the spatialised sound cues. Furthermore, over half of the participants (51%) demonstrated a comprehensive understanding of the intended story, accurately interpreting the subtle emotional cues and narrative nuances conveyed through the spatial audio design.

- **Spatial audio can contribute to a strong sense of presence:** The majority of participants (76%) reported experiencing a strong sense of presence within the virtual home. Participants frequently used terms like *immersive*", "*inside*," and "*realistic*" to describe their experience, highlighting the effectiveness of the spatial audio in creating a believable and engaging virtual environment.

- **Spatial audio can evoke a wide range of emotions:** The VR experience successfully elicited various emotions in participants, including happiness, nostalgia, sadness, and peace. Specific sound cues were linked to particular emotional responses, highlighting the potential for spatial audio to create emotionally rich and nuanced VR experiences.

These findings contribute to the growing field of accessible VR design and challenge the notion that VR storytelling necessitates complex visuals or advanced technical expertise. By demonstrating the power of spatial audio to craft engaging and emotionally resonant VR narratives, this study highlights the potential for democratising VR storytelling and making it accessible to a wider range of creators and audiences.

Future research could expand upon these findings by exploring the use of 6DoF spatial audio, incorporating more interactive and visual elements, in a full-fledged VR experience to investigate the interplay between spatial audio and visual stimuli in VR storytelling. By continuing to explore the creative and technical possibilities of spatial audio, we can unlock the full potential of VR as a powerful and transformative medium for narrative expression.

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