Envisioning VR Theatre: Virtual Reality as an Assistive Technology in Theatre Performance

A thesis

submitted in fulfilment

of the requirements for the degree

of

Doctor of Philosophy in Screen and Media

at

The University of Waikato

by

SAI KRISHNA SRINIVASAN

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2024

Abstract

This research project focuses on exploring the potential artistic advancements provided by the inclusion and incorporation of Virtual Reality (VR) within theatre. The incorporation of VR technology into theatre performance ultimately aims to alter a theatre experience by adding spatial presence for audiences and adding new production considerations for theatre practitioners. This project investigated the conceptual nature and practical aspects of using 360-degree cameras placed on stage to enable virtual teleportation onto the stage from the audience or remote viewing.

This thesis constitutes a PhD 'with publication' and includes reprints of quality assured peer reviewed scholarly articles produced at different stages on the project. The first study examines the early development and use of three-dimensional theatre prototyping to identify the technical requirements for VR theatre. A digital theatrical prototype was designed, along with mathematical calculations to determine the optimal placement of 360-degree cameras on stage. The study reveals multiple camera angles that can be utilized to capture a 360-degree/VR theatre experience.

Building upon the findings of the first study, the second study focuses on practical and technical factors such as visibility, sound, lighting, and visual intensity to enhance audience access and proximity to live performances. Different camera positions were found to be suitable for different theatre styles. The study suggests that the application of VR technology in theatre stages can yield highly satisfying results, as reported by participating actors.

Following initial prototyping and planning, the PhD then experienced the impact of COVID-19 that prevented planned collaboration with local theatre practitioners that would have enabled a substantive practical application of VR, technical refinements and, user and

audience testing. However, in response to the impact of COVID-19 on the theatre industry, the third study investigated the use of virtually designed spaces and the inclusion of 3D avatars/characters or real actors in performances. It explores the creation of photorealistic virtual worlds that mimic real-world environments and examines audience perceptions of virtual theatre experiences. The study presents a modernization of theatre performance by incorporating 3D virtual spaces, akin to VR games, but with limited interactive freedom for the audience.

The fourth and final study involved the development of a post-pandemic experimental theatre performance based on the insights and data collected from the previous studies. It focuses on the virtual teleportation of an audience onto the stage during a performance, facilitated by VR headsets and a 360-degree camera mounted on the actor. Within the experiment participants experienced the performance through VR headsets. The audience and theatre practitioners were then invited to participate in a post interview session, to note their feedback and comments regarding the experience. Despite the limited number of participants due to COVID-19 restrictions, the study highlighted the positive nature of the VR experience pointing to the possibilities for increased virtual access to live theatre beyond this research.

Overall, the results of these studies shed light on key practical considerations involved in the integration of VR into theatre performances. The approaches taken in each study support and guide best practice but also opens up VR-assisted theatre to grass roots level community and local theatre so that VR can become a common consideration and tool for all forms of theatre.

List of Publications

Chapter 3:

Srinivasan, S. & Schott, G. (2020). Virtual teleportation of a theatre audience onto the stage: VR as an assistive technology. *Advances in Information and communication*, *1129*, 477–487. Springer. https://doi.org/10.1007/978-3-030-39445-5_36

Srinivasan, S. (2021). Transforming audience into spectator/actor: Assimilating VR into live/theatre performance. *Advances in information and communication, 1363*, 935–944. Springer. https://doi.org/10.1007/978-3-030-73100-7_64

Chapter 4:

Srinivasan, S. & Schott, G. (2022). Envisioning new virtual spaces for performance and theatre artists. *Proceedings of the 13th International Multi-Conference on Complexity, Informatics and Cybernetics* (IMCIC 2022)*, 1,* 175-180. https://doi.org/10.54808/IMCIC2022.01.175

Chapter 5:

Srinivasan, S. (2023). Virtual 360-degree dramatic theatre: A new branch in experimental theatre. *7th International Conference on Virtual and Augmented Reality Simulations (ICVARS) (ICVARS 2023)*, March 03–05, 2023, Sydney, Australia. https://doi.org/10.1145/3603421.3603425

Srinivasan, S. (*under review*). Existing offstage, yet onstage: A novel VR theatre experience. *International Journal of Performance Arts and Digital Media*.

Acknowledgements

I would like to express my deepest gratitude and appreciation to all those who have contributed to the completion of this thesis. First and foremost, I would like to thank my supervisors, Professor Gareth Schott, Dr. Kyle Barrett and Dr. Laura Haughey for their guidance, expertise, and unwavering support throughout the entire research process. During my research, they contributed to a rewarding graduate research experience by giving me intellectual freedom in my work, supporting my attendance at various conferences, engaging me in new ideas, and demanding a high quality of work in all my endeavours. Every experiment conducted in this thesis was accomplished with the help and support of fellow technicians and collaborators. Oliver Stewart and I worked together on several different phases of the self-assembled gels project, and without his efforts my job would have undoubtedly been more difficult. I greatly benefited from his keen technical insight, his knack for solving seemingly intractable practical difficulties, and his ability to put complex ideas into simple terms. I would like to extend my sincere appreciation to Anne Ferrier-Watson, the academic librarian, whose invaluable assistance with the publishing procedure, literature-related queries, and overall support played a crucial role in ensuring the smooth progress of my work.

I would like to express my deepest gratitude to my family and friends for their unwavering encouragement and understanding throughout this journey. I am especially grateful to my late father, Srinivasan Lakshmanan, whose unwavering support has been a constant source of inspiration for me. I am truly thankful to my mother, Padma Srinivasan, my sister, Srividhya and my brother in law, Guruprasath, for their unwavering support and affection, which have provided me with the strength to persevere through challenges. Their presence has been invaluable in enabling me to pursue my goals. I like to thank my friends and colleagues Brendan, Ben, Sarah, Penny, Shaynah, Anthea and Jason who made my time at the

university fun and made these four years a wonderful period of my life. Many thanks to Ragavan, Harini, Ramkumar, Dhivya and Naveen, who always showed interest in my research and cared for my well-being throughout this journey.

Lastly, I would like to thank the entire Department of Screen and Media Studies at the University of Waikato for their constant support and inspiration.

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Chapter 1 Introduction to the Study

1.1 Introduction

Digital media is described as any form of communication that uses electronic devices as a medium of distribution (Martin & Betrus, 2019). Digital media can be created, viewed, duplicated, modified or transmitted across a range of electronic devices. Examples of digital media include websites, blogs, social media, games, virtual environments and holograms. Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) now constitute a developing field within present-day digital technology and research. Jason Jerald (2016) in his book *The VR Book: Human Centred Design for Virtual Reality* defines VR as a 'computer-generated digital environment that can be experienced and interacted with as if that environment were real' (p. 9). Whereas, he states AR 'cues onto the already existing real world and ideally undistinguishable by the human mind' (p. 29). Both VR and AR form a virtual continuum from enhanced real environments to complete virtual environments. Any environment which consists of a blending of real and virtual objects will be classified as mixed reality (MR) (Milgram, & Kishino, 1994). Online platforms, such as social media and video streaming websites, started incorporating VR, AR, and MR technologies to enhance user engagement by offering perceptually immersive interactive media experiences. Numerous research and innovations have been performed by incorporating VR in fields like games (Zyda, 2005; Meldrum et al., 2012), military training (Alexander et al., 2017), engineering (AlAwadhi et al., 2017), construction (Song et al., 2017), education (Englund et al, 2016), and medical simulations of surgical procedures (Gallagher et al, 2005). The incorporation of VR has proven to enhance these respective fields through its perceptual enclosed immersion and interactivity.

Regardless of the ways that VR has been successfully applied and explored in other fields (e.g. games, education), the depth of VR experimentation in the field of arts still remains relatively shallow. In the arts VR has been typically been applied to the creation and sculpting of 3D characters or concept and environmental design for films or 3D illustrations. This research seeks to apply VR within a theatre performance context, a preforming arts medium that has continued to evolve as a result of technological support and intervention. While traditional Ancient Greek performances took place during the daytime (utilising the sunlight) theatre only moved to indoor and to night time performances once it began to utilise lighting. The application of digital technology is one of the ways theatre has continued to evolve. It has been noted that digital applications in theatre have served to enhance appreciation of performances whilst also supporting the actors' task. For example, the introduction of digital technologies like microphones, stage lighting, ambience via background audio have served to enrich live theatre performance. Dixon (2006) states that 'although the computer was by no means new and digital arts had been developing since the 1960s, computer technologies became much more accessible to artists and led to widespread digital performance activity' (p. 87). This research advocates for further VR application on the basis of experiments, fundamentally identifying the compatibility of the affordances of VR for theatre performance. The increased demand for experimentation and use of networked and remote presence technologies gained momentum during the COVID-19 global pandemic and its lockdown restrictions. Dependency on a live audience meant that theatre producers called for effective digital tools to be able to continue their practice and sustain people during testing times (Chatzichristodoulou et al, 2022). A paucity of VR experimentation within theatre performance beyond high level productions and companies (see Section 2.2.3) stimulated this research into the effectiveness and accessibility of VR as a potentially customary digital tool that can be accessed and assimilated into theatre practices from a community levels upward. Many theatre-

associated VR projects to date have shown a tendency to employ VR only as an add-on rather than incorporate it into performances and make it a core component of audience experiences. For example, VR teasers have been created to advertise and promote performances and allow audiences to experience recorded/archived documents of live theatre performance in a virtual space after the event (BWW News Desk, 2017).

In this study, I aimed to explore the value of applications of VR and how it may play a role in how theatre might be performed, experienced using the properties of VR interactivity and immersion. In order for the theatre practitioner to be able to explore the characteristics of VR and how they influence the audience, the medium first has to be compatible, usable and flexible. Dixon (2006) advocates for VR's incorporation in the field of performance arts, theatre based on early attempts that can be dated back to 1991, referring to *Placeholder* by Brenda Laurel, considered a pioneering project in the exploration of VR application within theatre (discussed in Chapter 2). The possible affiliation between theatre and VR is based on the manner both create a means for an audience to experience an imaginative world presented via agents (actors or simulated characters). The nature of the affiliation that this thesis aims to develop further in application has been variously articulated over time by Antonin Artaud (1974), Aristotle (1991), Mark Reaney (1996), Diane Gromala (1996) and Oliver Grau (2003).

As the principal researcher for this project, I did not set out with the aim of writing or producing a new theatre performance using VR myself. The aim of the research was instead intended to be collaborative. That is, to use the construction of a theatre performance by local theatre practitioners as an opportunity to develop and study the effect of VR applications in support of a production. The majority of the experimentation contained in this thesis is therefore conducted from a digital technologist perspective. This thesis delves into the optimal placement of 360-degree cameras on the stage, aiming to enhance audience immersion and engagement with the theatre performance in a dynamic setting. The research explores technical

aspects such as audio-visual quality, minimizing viewer distractions, and preventing disorientation within the 360-degree space. The research can be classified as an application of creative media technologies to theatre practice utilising computer science perspectives and applications. Given the cross-disciplinary themes of the research it is important to define the terms employed throughout this thesis and establish their common disciplinary meaning. In Sections 1.5.1 and 1.5.2 key terms are defined so that it is clear from the onset how they were applied in the context of this research.

This research also focuses on the effectiveness of exploiting a cost-effective mode of VR suitable for community level theatre performance projects. The research utilised Google Cardboard, a Head-Mounted Device (HMD) developed by Google using cardboard to hold a viewing lens (Lee et al, 2017), typically a mobile phone. Its cost was minimal (approximately $25 NZD) compared to more high-end VR headsets available at the time of research. Google Cardboard was less than 30 times the cost of an average higher-end HMD like Oculus Rift or HTC Vive. Powell et al. (2017) have analysed the VR experience provided by Google Cardboard. In their investigation into its feasibility they concluded that the difference in experience and accuracy was very minimal compared to more expensive VR headsets, with Google Cardboard having the advantage of targeting a wider audience due to its low-cost. This research sought to capitalise on the feasibility and advantages of a low-cost solution like Google Cardboard to avoiding theatre practitioners and producers having to invest in a high-cost VR HMD that would take budget away from other production costs. With the advent of the metaverse[1], the latest advancements online (online classes, meetings, training) the capacity to deliver a VR experience to an audience with a cost-effective method is timely. VR applications in general, have to-date been associated with high resolution visual rendering via

[1] The Metaverse is the post-reality universe, a perpetual and persistent multiuser environment merging physical reality with digital virtuality (Mystakidis, 2022).

a high-cost Head Mounted Device (HMD). This has created the impression that the development of a VR experience comes with a major financial investment. This thesis aimed to address this, by also evaluating the effectiveness of Google Cardboard in providing an effective VR experience to audiences of a theatre performance.

1.2 Objectives of the Research

Pre-Covid research objectives for this thesis began as:

- Explore the functionality of VR as an "assisting technology" for use in theatre contexts, introducing VR as a means of virtually transcending the fourth wall to allow audiences to assume viewing positions closer to the performance than is physically possible in a typical theatre context.
- Test and evaluate camera execution, positions and angles in the context of theatre performers to evaluate the dynamic function and performance of cameras during performances.
- To explore whether the viewing conditions of VR constitutes an attractive, comfortable and engaging new experience for audiences when made available as part of live theatre.
- To collaborate with theatre practitioners in co-designing VR assisted sections of theatre performance with the aim of recording how theatre practitioners seek to accommodate, assimilate and innovate with a new creative technology tool.

Due to the restrictions imposed by the global pandemic, the capacity to fully meet the research objective three and four were significantly compromised leading to the addition of new research objectives:

- Test and assess the response to a theatre experience (from both theatre practitioners and an audience) in which audiences were provided with a remote viewing experience of performance conducted in a separate location.

- Expand the scope of VR application to include the incorporation of 3D virtual spaces into a performance. Observing their contribution to a performance and reception from an audience.

1.3 Research Aim

This research initially sought to work in collaboration with community level theatre practitioners to introduce, incorporate and support the implementation and use of accessible VR setups into live performance settings. The research always intended to focus on testing VR set-ups and their functionality, including assessments of its impact on a) audiences in terms of what it means to view and experience live theatre with an enhanced spatial presence and viewpoints, and b) theatre practitioners, in terms of performing to camera in addition to stage front. With the impact of Covid-19 and the global pandemic, however, all prior consent and agreements achieved from theatre practitioners to collaborate on projects were either discontinued or severely diminished when live events were ceased. The research continued to focus on how the use of VR can create an opportunity to shift traditional concepts of audience placement and distance between performance and spectators. Prototyping and experimentation continued with the rationale and propositions for the application and use of VR assessed via peer review and publication. Each stage of exploration and experimentation has been quality assured by disciplinary expertise in computing sciences to account for the impact of Covid 19 that prevented a broader range of user testing and audience research from taking place.

1.4 Conceptual Framework for Understanding VR

Michael Heim (1998) defines virtual reality as 'a technology that convinces the participant that he or she is actually in another place by substituting the primary sensory input with data produced by a computer' (p. 221). While Brenda Laurel (1991) states that it functions by '[surrounding] the human sensorium ... by (immersed in) stimuli that are partially or wholly generated or represented by artificial means' (p. 182). These definitions outline how VR is a medium that allows its users to feel wholly or partially transported to a new environment which is artificially developed. Although this has been a vital definition to qualify an experience as a VR experience, the recent definition of VR, stated by Jerald (2016) adds more detail and depth compared to Heim and Laurel's definition. He defines VR as 'a computer-generated digital environment that can be experienced and interacted with as if that environment were real' (p. 9). He further adds that VR is a medium that is used to make the audience believe that they are placed in a different environment from the one they are physically located in, and that that environment may be 'artificially developed or feature a live action footage of real world' (p. 9). This definition opens the idea that a VR experience can be achieved not only by creating an artificial virtual environment but also using live action footage of the real world. Jerald's explanation of VR holds relevance to the aim of this study as it emphasizes the virtual placement of the audience in a different environment without it having to be a computer-generated environment. Although Heim and Laurel promote a similar audience experience and placement, they address this in relation to designing artificial VR environments experienced primarily via computers. Even though Heim's account is dated in terms of VR technology, his work still holds value as he provided seven key VR concepts that guide VR design and applications. The seven concepts of VR introduced by Heim (1994) are fundamental and will support the assessment of VRs compatibility with more traditional longstanding performance arts (discussed in Section 5.1.5). Milgram & Kishino (1994) articulation of how VR can operate

across a real to virtual continuum, helps to situate this research as initially wishing to employ VR in a theatre context incorporating its purely real environment, 'consisting solely of real objects,' and how this was modified (due to the global pandemic) to incorporate aspects of virtual environments moving the research closer to the other end of the continuum and experiences that consist "solely of virtual objects" (p. 3). This research began on the side of purely real environments as it was designed initially around the needs of local community theatre practitioners.

During the last 15 years, Jerald's definitional statements regarding the nature and function of VR have been supported by research (McMillan, Flood, & Glaeser, 2017; Fennell, 2016; Shen, & Shirmohammadi, 2008). Such works have opened doorways to approach VR in two ways: 1) live action video filmed using 360-degree cameras, and 2) 3D Computer-Generated Imagery (CGI). In addition, Jerald (2016) proposes an iterative design approach which entails progressive improvisation for any VR project to be successful. Given that PhD research is representative of a large research project conducted over a timeframe of three to four years, it contains scope for testing and retesting of approaches and applications. Jerald's model stresses the progressive changes, improvisation and innovations that are important for a successful VR research study. Jerald's work has proved to be important for the research design of this study as it points to the value of breaking down larger research into smaller experiments or projects, that can be assessed, evaluated and refined along the way. Each stage of the research presented in this thesis, has been peer reviewed then published and/or presented at a conference, allowing the study to receive valuable expert feedback and commentary.

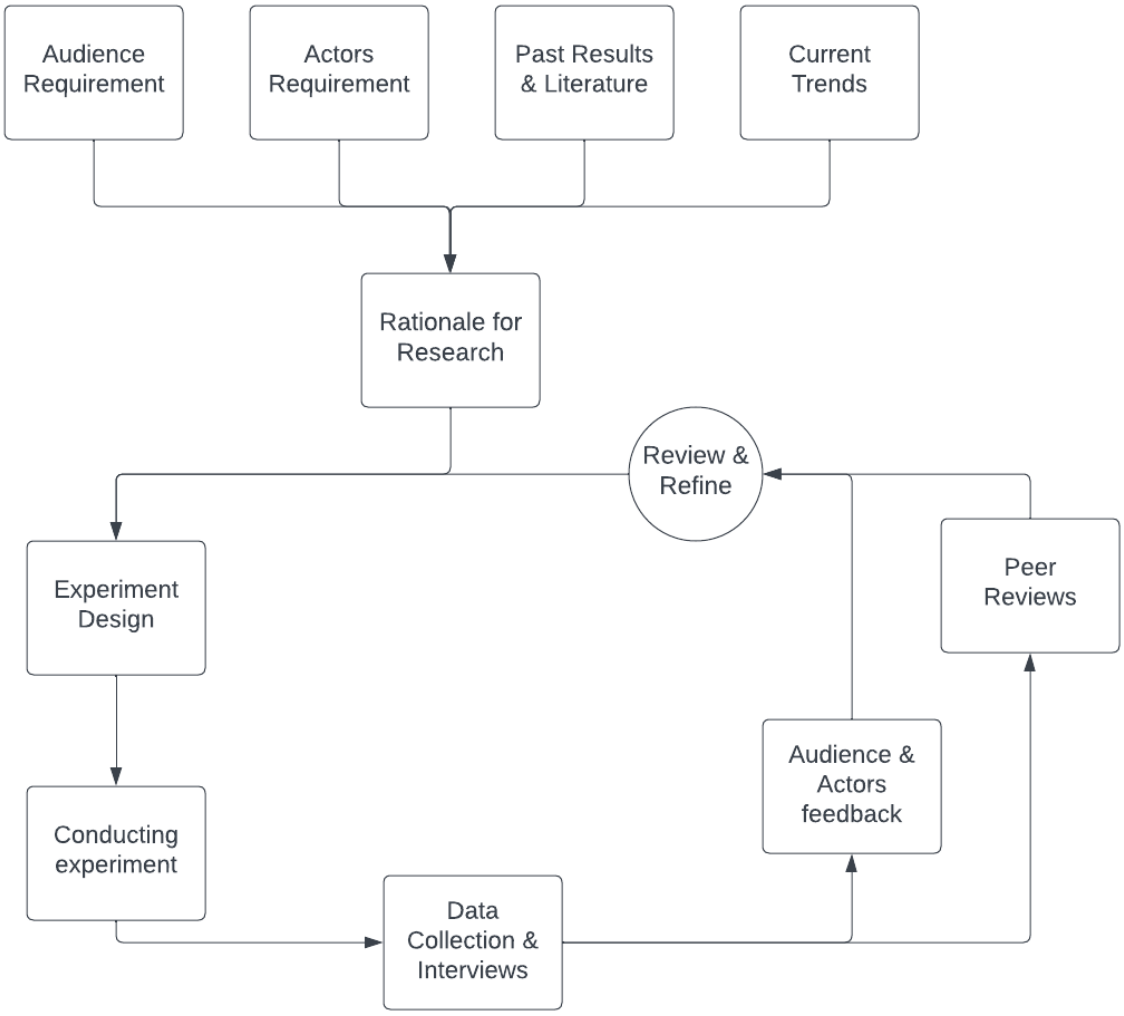


Figure 1.1 Research Framework

This thesis follows a structured framework, as depicted in Figure 1.1, where it is divided into smaller experiments utilizing 3D modelling, prototyping, (Study 1, Chapter 3), testing the prototype (Study 2, Chapter 3), VR algorithms (Study 3, Chapter 4), involving theatre participants (Study 4, Chapter 5) and involving audiences (Study 5, Chapter 5), where possible (see Section 1.3 for impact of Covid) experiments also engaged the views and assessments of theatre practitioners using the VR applications or audiences who viewed the experiments . The research comprised a combination (or triangulation) of literature informed VR-design and implementation, analysis of use and functionality (see Study 2, Chapter 3 for analysis of

equipment performance), qualitative interviews with participants (practitioners and audience), peer review and feedback on research reporting. Receiving peer review by experienced conference committees, editors and reviewers allowed refinement and editing of research reports prior to final publication. This iterative process of literature analysis, experimentation, data collection, and publication under peer review is consistently followed throughout the thesis.

1.5 A Review of Virtual Reality and Related Concepts

This thesis draws on a range of ideas and concepts employed across a range of different disciplines, requiring definition for how they were subsequently employed and used in this study's practical application:

1.5.1 Presence

Presence is a concept that is commonly used when describing what VR offers - the feeling of "being there" (Skarbez et al, 2018). Presence is a broad term and has a range of definitions. In the computer sciences presence is often or commonly defined as a service used to store or distribute information about the virtual availability of a person over a network (Rouse, 2011). Whereas presence in theatre performance is defined as the connection an actor establishes with other characters, audience and environment (Preeshl et al., 2015). At the same time, in media and communication 'presence is the extent to which a medium is perceived as sociable, warm, sensitive, personal or intimate when it is used to interact with other people' (Lombard & Ditton, 1997, para. 8). The primary focus of this research is to use VR as a means for physically viewing live performance from an audience or remote location but virtually teleporting to be inside or amongst that live performance, subjectively modifying the audience experience from an outside spectator to an active and present presence to the performance even though they are

physically situated external to the performance. This concept of presence correlates with Witmer and Singer's (1998) definition which states it is 'the subjective experience of being in one place or environment, even when one is physically situated in another (place)' (p. 225). This research focuses on providing an audience with the ability to pan around the remote 360-degree environment and audio-visual sensory input of a live performance with a focus on assessing how that corresponds to definitions of telepresence (Akin et al, 1983). An operational understanding of presence as it relates to VR in theatre is required to reflect how audiences attain a more inclusive, accessible form of theatre viewing. Scholarly work in this area suggests that presence is likely to come under three forms of understanding, 1) being there (being placed in a particular environment), 2) non mediation (lack of attention to the mediating technology), and 3) other (direct focus on the perpetual processing). These classifications are further explored and discussed in Chapter 6 and the article: Existing Offstage Yet Onstage: A Novel VR Theatre Experience (chapter 5).

1.5.2 Immersion

A broad range of understanding prevails over the concept of immersion as well. Immersion is a broader concept but is often associated with, applied to VR. Immersion in general refers to the idea of being fully absorbed in an experience, to the point where the line between reality and fiction becomes blurred. Witmer and Singer (1998) defines immersion as 'a psychological state characterised by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences' (p. 227). This definition is very broad and stated in the context of a psychological study on virtual environments. In order to simplify the definition of immersion as it applies to VR, I draw upon Slater's (2009) definition of immersion as 'the boundaries within which [presence] can occur' (p. 3552). In a virtual environment (like a game), it is easy to identify the boundaries within which actions or events take place because the participants are virtually teleported into the

performance space. A virtual environment provides a completely distinctive experience of telepresence to participants with the help of interactive objects and characters and 360-degree movement, that allow users to affect the space and objects within it. Employing VR in theatre aims to reduce the boundaries further, bringing the audience onto the stage and into the action. This however, comes with different complications such as potentially revealing aspects of stage and setting that are otherwise purposely hidden from audiences sat in the house section in traditional theatre settings.

The preference for “immersion” in this study differentiates it from “involvement” as defined by Calleja (2007), who distinguishes that game players actively participate in a game environment, requiring thought and focus, influencing how the game unfolds. Calleja's work responds to the notion that immersion is something that “happens to” the player, challenging our understanding of the player’s role in shaping events. Immersion appears to be a more fitting concept in this study, aligning with the audience's willingness to immerse themselves in and enter the worlds or experiences crafted by theatre practitioners. Immersion in virtual or gameplay environment has been subdivided further into “spatial immersion,” “emotional immersion,” “cognitive immersion” and “sensory-motoric immersion” by Bjork and Holopainen (2005). This study seeks to establish a form of spatial immersion by placing audiences within the sphere of action on stage, akin to how film director Mike Figgis used the Fig-rig (an early camera gimbal) to create a sense of audience presence during film scenes. However, in granting “spatial immersion” this may disrupt “cognitive immersion” due to the novelty of the experience and the control given to viewers to determine where they can fixate their gaze and the uniqueness or novelty of the experience of wearing a headset (“sensory-motoric immersion”). In contrast to film, where editing guides attention, “emotional immersion” in theatre relies on the actors' performance to capture attention and engage audiences in the performance.

Since this research eventually evolved to incorporate both real time environment (theatre stage) and VR environments (digital created environment), the immersion experienced by the audience participants can be closely associated with "spatial immersion" and "emotional immersion." Bjork and Holopainen's categories of immersion are discussed further in Section 5.2.4 in the context of this research virtually teleporting audience members onto the stage and upon the actor's position using a small, mobile 360-degree camera technology. It is reported how an audience was provided with a manoeuvrable 360-degree space using their Head Mounted Display with the aim of providing an experience spatial presence (Balakrishna et al, 2021). At the same time, it is hoped that the audience will be attuned to the events taking place within the theatre performance to provide an emotional immersive experience. In this way, this research has sought to experiment with providing both spatial and emotional immersion thus applying Slater's (2009) definitional work to a theatrical context.

1.5.3 Interactivity

Generally speaking, interactivity in a VR environment defines how it allows participants to influence the environment and receive feedback associated with their action. Jerald (2016) defines interactivity as the communication between user and a VR environment using various input and output devices. It can be interpreted as the reaction of the VR environment/characters/properties to the action or stimuli provided by the audience. The reaction or acknowledgement of the VR environment is important as it keeps the audience engaged and invested in an experience. In general, interactivity can be further classified into direct and indirect interaction (Skarbez et al, 2018). Direct interaction occurs in VR when there is a direct user involvement with an object or a character within the VR environment. Whereas, an indirect interaction occurs through a body part or a physical object without physical contact with the system (Li et al, 2017). Indirect interaction involves the use of tools or devices to control the virtual environment from a distance, often through gestures or movements.

However, in order to explain the nature of interactivity applied in this research, it is useful to distinguish between the interaction as active and passive (Pan, 2018). Active interactions in virtual reality refer to conscious user-initiated actions, where the user actively engages with the VR environment by consciously performing tasks such as pressing buttons on a haptic VR controller. In contrast, passive interactions occur automatically within the VR system based on the user's actions, without their explicit attention or conscious input. An example of a passive interaction is when the user follows a character or object in the VR environment, and the VR headset automatically adjusts the rendered view accordingly. These passive interactions occur seamlessly without requiring the user's conscious effort (Pan, 2018). Most interaction falls under the active interactivity in a VR environment. For example, picking up an object, throwing away an object, which involves direct manipulation of an object or through devices like a joystick or gloves. As there is no intention to use joysticks or haptic gloves in this research, interactivity is limited for participants. The participants instead reposition their head and gaze whilst wearing a Google Cardboard HMD to pan around the 360-degree view. In this instance, the HMD device responds to their external head movement to align it with movement within the recorded environment. Hence, the interactivity focused upon in this research experiment falls under the category of passive interaction.

Interactivity occurs only when the participant is inside the VR environment. However, in order to virtually teleport the participant into the VR environment, he/she needs to be virtually embodied into a character or object present inside the VR space or remain as an invisible observer in the VR space. For example, are they an invisible observer, are they a new character in the performance, are they acknowledged by the actors, are they a property on the stage or are they one of the actors on the stage. In computing literature this process of representation of an audience member in a virtually designed space is understood as embodiment (Skarbez et al, 2018). In common gaming and media context, the concept of

embodiment is achieved via avatar (Skarbez et al, 2018). In this research, the aim was to provide audiences with the experience of viewing a theatre performance in the vicinity of the actors, from the position or point of view of an actor, or from an object/prop stationed on stage. This creates a similar (of sorts) to the above-mentioned gaming and media context of embodiment, when the research is using an actor/on stage object instead of avatar. It is worth noting too that definitions of embodiment discussed thus far are quite distinct from the use of embodiment in physical theatre performance, where it refers 'to the eradication of a perceived separation between mind and body, allowing for a "pure" communication between dramatic impulses and bodily expression on stage' (Albu, 2019, p. 1). Within the context of this research experimentation occurred (see Chapter 5, Study 5) with placing audience members onto the lead actor of the theatre performance. That is, audiences were (perceptually) overlayed on top of an actor by placing a 360-degree VR camera on the actor's head. Such experiments fell within the scope of determining the parameters of providing audiences with different viewpoints or point of view (POV) that are untypical or have not previously been experienced within theatre performances. This nature of embodiment involves audiences as a passive interactive character, in contrast to how traditional audiences traditionally view theatre as static spectators that are positioned outside the stage environment (thus determining their viewpoint). The general experience of embodiment in a VR context is 'when we place a VR headset on, our virtual bodies at least momentarily substitute our real bodies' (Rogl, 2023, para. 3). The question posed of VR, when applied to the theatre participant audience, is whether it is capable of triggering embodiment from the experience of spatial proximity and being actor (or object) mounted during a performance which radically alters the conditions of spectatorship. In order to assess this mode of audience embodiment from the concept of embodiment in theatre studies, this thesis will seek to assess how well VR technology functions technically in support or hinder viewer's intense mental involvement in the theatrical world. Experiments work on the

notion promoted by Slater (2009) that "place illusion" can be achieved if a virtual environment provides participants with a strong illusion of being in the particular space even though they are physically placed elsewhere. There are a variety of processes through which "place illusions" can be achieved. For example, through a virtually created environment or through camera tricks and illusions. In this thesis, research explores two different processes to accomplish place illusion: 1) By using a 360-degree camera to offer the audience with a strong illusion of being on the stage (Study 5, Chapter 5) and 2) by creating a virtual environment using VR software and offering the audience with a strong illusion of being on a virtual theatre stage (Study 3, Chapter 4).

1.6 Thesis Outline

The thesis contains seven chapters of which this is the first. This chapter has served to broadly outline the scope and focus of the research that is then detailed in several smaller experiments and reported in subsequent chapters. Given that several quality assured publications are reproduced throughout this thesis, bridging sections and chapters are also presented to provide an introduction and context to publications offering additional detail that was not required for the published outputs (as determined by editors and reviewers).

Chapter 2 contextualizes the subsequent research reports by first historically outlining the evolution and applications of VR. It aims to provide a broad understanding of how VR has developed and been applied. The chapter will also focus on the evolution of theatre performance from a media studies perspective (e.g. the digital and audio-visual applications used to enhance theatre performance) and its effectiveness (e.g. video clarity and audibility). Finally, the chapter focuses on exploring the perceived synergies between VR and theatre performance and considers the advantages and disadvantages of their mergence.

Chapter 3 introduces a theoretical and practical framework outlining how teleportation of the audience onto the theatre stage may operate. It presents two publications (a book chapter and article published in a peer reviewed conference proceedings), that explore the concept of this research through a theoretical understanding and implementation in a simulated virtual and practical scenario.

Chapter 4 discusses the concept of conducting and viewing "Performance from Home". It includes a published conference proceeding, exploring the idea of using a 360-degree VR application as a virtual medium for actors to perform/act from a remote location and have the audience experience the same performance also from a remote location. It also focuses on the idea of creating virtual theatre spaces and reducing the physical labour and cost associated with theatre production.

Chapter 5 presents actors and audience assessment of the addition of a 360-degree VR camera on an actor and how it modifies the actors' performance and audiences' experience. It includes two journal articles (under review). The chapter addresses the actor and audiences' impressions of using VR in theatre performances. It provides a critical analysis of the application of 360-degree VR into theatre space from both a performers and theatre goers perspective. Some of the difficulties encountered during the research process, associated with the global pandemic, are also discussed (see Section 5.1) for its impact on the research design and what was possible to complete within the PhD timeframe.

Chapter 6 provides a detailed conclusion of the findings from this research project. It focuses on evaluating the success and impact of the findings from the smaller experiments. It also presents recommendations and future possibilities for research on this subject.

1.7 Personal Commentary on the PhD

My previous research, academic and industry experience influenced the focus and reasons for doing this research. This section focuses on explaining the reason – "why" I was been motivated to pursue this research. Followed by a reflection on my progression in attaining the outcomes for the PhD.

1.7.1 Research Journey

My academic journey as a researcher in Virtual Reality began during my master's program, during which I was intrigued about how the technology of animation has evolved over time. I would categorize Virtual Reality as a branch of 3D animation, since a lot of techniques and skills used in Virtual Reality trace back to 3D animation principles. I started off my PhD journey with a vast research idea of how Virtual Reality can be used as a technology for immersive storytelling. Every medium like theatre, film, television, comics, animation, virtual reality contains storytelling as the core element. The opportunity presented itself in 2018, in the form of a PhD. I had to focus my research from a broader perspective and thus ended up focusing on the application of virtual reality into theatre performance as an assistive technology. Technological equity is a key motivation for my research. It is very important that the application of technology is equal in all the fields of research and helps for the betterment of everyone. VR has to a large degree been a technology that is limited to only a few fields of study that promise higher financial outcomes. Community theatre therefore became the focus for achieving wider application of VR, and providing a future tool for theatre practitioners to explore creatively, independently of this research. The focus of this project served my passion for implementing VR technology in the wider field of arts. Undocumented in the publications and experiments that follow was the process of introducing and educating theatre practitioners

about VR during recruitment, which stimulated their creativity and excitement for its use and application.

Despite the positive reception received from theatre practitioners, who agreed to work with me and VR as part of their theatre production process, what unfolded between 2019-2021 was unanticipated. During the research journey, I had to overcome a number of obstacles from a change in supervision panel which resulted in a delay in confirming my project to a significant close and personal bereavement. However, it was the outbreak of COVID-19 that resulted in international lockdown, that resulted in the most significant impact on my research and cost me precious time (over one year) as I was unable to return to Aotearoa / New Zealand in 2020 after attending my first international academic conference. Even during 2021, when I had returned to NZ, there was the second nationwide lockdown announced by the government from August to November, that meant I was not able to use research resources or conduct experiments for data collection. I share this because I think it is important to acknowledge how my research and experiments were initially set up with a different methodological emphasis (see Section 1.2) involving collaboration and greater levels of user and audience research (qualitative interviewing). That is, VR applications were initially meant to be guided by theatre practitioners ideas and creativity for its use. Functionality and user perspectives were meant to be key in revising and redesign as were audience reactions and reception to VR.

The research focus and design for this research was always intended to be divided into a series of smaller experiments, that would allow the PhD to address different dimensions of VR inclusion in theatre and the relationship between performers and audiences. With the disruption of Covid 19, the main implication for the research was the speed with which the theatre community was able to return and resume its practice. While study was able to resume and Universities re-opened, the theatre industry was a lot slower to recover, resulting in

productions being abandoned and suspended indefinitely. It is important to note that the first two publications reproduced in this thesis, carried the aims and expectations of the thesis prior to Covid 19, and may feel at odds with the eventual focus of subsequent experiments. The first two publications represent a different moment in time that was not realised fully in the context of the PhD. However, the project adapted and altered and it is hoped that aspects of the work that were not completed will be conducted as part of post-doctoral research.

Chapter 2 Integration of Virtual Reality within Theatre Performance

2.1 The Utility of the Affordances of Virtual Reality

The key and associated concepts attached to VR technology and software development outlined in Chapter 1 provided a broad overview of the experiential aims of the medium that this research is seeking to exploit and apply in a theatre context. This chapter aims to delve into the nature and function of how VR can work in arts contexts before moving on to report how VR was applied in the current research (Chapters 4-5). This chapter outlines examples of VR applications that have exploited its difference affordances to create novel advancement in the way art attracts, engages and involves audiences.

A fundamental characteristic of an experience or performance that can be classified as a VR is defined by the use of a specific viewing system, tracking system, and characteristics of interactivity and immersion (Izmofx, 2019). Viewing systems in VR comprise a key hardware components - a Head Mounted Display (HMD). A HMD in a VR experience blocks out the world around and plunges in, or transports users to a new world where they see and interact with a virtual environment that tracks and responds to their head movements. At the time of writing, HMDs are available from the range of inexpensive cardboard and plastic lenses for as low as $NZ10 to more elaborate devices that cost hundreds of dollars (Brown & Green, 2016). One of the goals of this research was to implement the use of a more cost-effective viewing system. As discussed in Section 1.1, this research utilised Google Cardboard - a low-budget, stereoscopic viewer that can be used with most smartphone devices (Lee et al, 2017, p. 155). It allows the user to view a 360-degree or VR video through their smartphone, by placing the smartphone inside the Google Cardboard. When creating a VR environment digitally, it involves a large amount of computing renders, colours and pixels, which will

require a more sophisticated viewing system like HTC Vive or Oculus rift. Yet, the majority of this research is focused on live and physical theatre which is captured through a 360-degree camera thus able to benefit from the use of cost effective VR hardware solutions. This decision also allowed the research to maintain representation of the real world (performance) whilst manipulating and adjusting viewers proximity and presence levels. This research focused first on capturing live theatre performances through a 360-degree camera and showcasing it to the audience using a panoramic 360-degree view. This research did not set out to produce a completely digitally designed VR space or performance, but sought to alter viewer access to theatre performance via VR technology. Consistent with the level of resources available to local and community theatre practitioners and their audiences the use of high cost or technologically sophisticated equipment was not deemed likely to extend the use of VR in further theatre contexts beyond this study. The research minimised demands on audiences by making the only compulsory equipment for this project a smart phone, which possesses an inbuilt tracking system.

2.2 The Application of VR

It is not the aim of this chapter to provide a documentation of the technical evolution of VR and its hardware/software development as various authors (Lum et al, 2020; Gigante, 1993; Hamad & Jia, 2022; Lum et al, 2020; Mandal, 2013) have already expertly charted this evolution. The primary focus of this chapter is to contextualize how VR has been applied in arts contexts to date. It seeks to outline the scope and nature of those projects and whether any principles can be extracted for grass roots level community theatre production and built upon. Outlining existing examples of VR application also aims to support the general thesis that VR possesses a compatibility with theatre that should encourage wider application of the technology in the future. Literature already exists that promotes the idea that VR possesses a compatibility with theatre, encouraging its use (Reaney, 1996). However, what is of interest is

the way in which theorists and pioneers of modern theatre, such as Antonin Artaud (1938) utilised the concept of theatre as a virtual reality as a means of expressing theatre's capacity to immerse audiences by engaging their perceptual senses and transport them to imaginative realms. For Artaud (1938), the theatre experience is a medium 'on which characters, objects, portrayals and in a general way everything which makes up theatre's virtual reality develops' (p. 35). In his book Virtual Reality*,* author and critic writer Howard Rheingold (1991), supported this notion by stating that 'theatre is a psychological process that uses language, rhythm, voice, myth and perception-altering technologies to achieve a specific state of mind in the audience' (p. 304). Modern expressions of virtual reality as a technology and a screen medium uses 3D-modelled characters, objects, and defined physics in a virtually simulated environment for the audience to experience a virtual world. Such systems take over the senses, overlaying the world that the viewer inhabits with a new and immediate world. Various scholars such as Mark Reaney (1996), Diane Gromale (1996) and Oliver Grau (2003) have expressed the potential of merging these two concepts of virtual reality in practice. For example, Mark Reaney (1996) has experimented with the use of VR as a scenographic tool, concluding that VR and theatre could be strong allies in producing more spatially expansive productions in the future. While there is a great deal more commentary that expresses positivity for the possibilities of VR for enhancing experiences of, or engagement with the performing arts, there are less examples of sustained practice in evidencing these possibilities. There are of course a small but notable range a high profile projects that are well-resourced and supported, but I contend that such examples do little to encourage creative assimilation and adoption of VR within other sections of the performing arts (e.g. community level theatre).

Like Mark Reaney (1996) and other scholars/practitioners (Pike, 2020; Iudova-Romanova et al, 2023; Sim, 2021; Camilleri, 2020; Kuksa, 2009), this thesis aims to explore if the concept of VR is practically and functionally compatible with performing arts, in an effort

to move the focus and attention away from the perception of VR as predominantly an extension of gaming technology and gaming experiences. To encourage such a perceptual shift requires research that encourages the adoption and application of VR, with clear guidelines and parameters for its use. Should the findings of the present research prove to be compelling and both the mediums support and enhance each other's strengths and weaknesses, it can be determined with research examples that VR in theatre can function effectively. It is hoped that the present research would go some way toward endorsing comments such as Dixon's (2006) that 'VR and theatre assimilation is a marriage made in heaven.' (p. 23). The following sections delve into diverse applications of VR in theatre performance, specifically highlighting the distinct categories of experimentation and research focus.

2.2.1 The Evolution of VR Applications within the Arts

Taking a historical view of the evolution of VR applications in theatre two phases were identified. The first phase is characterised by VR experimentation and exploration of which affordances translate and possess compatibility with the aims of theatre performance. This period of experimentation roughly spans from 1993 to the beginning of the current century. This was a period when computing and the digital media development of 3D spaces, 3D objects and characters was also evolving and developing rapidly, in doing so, providing new tools to inspire visionary creative artists and scholars to pursue new and innovative media applications in a wider range of spheres. Some notable implementations during this period include work by produced by Brenda Laurel (1993) in her installation *Placeholder* (Interval Research Corporation and The Banff Centre, 1993), and *Osmose* (1995) by Char Davies and Mark Reaney (1996) who produced a VR scenography tool (discussed in detail in this section). These exemplars of VR assimilation represent strong examples of art-based projects that have successfully introduced the sensation of "being there" and immersion to arts audiences. The implications being that they: 1) signalled that other modes of performance art could also be

successfully expressed and communicated through the use of VR, and 2) that VR should be given consideration as a viable tool for elevating and extending audience engagement and experience.

Released in the early 1990s, *Placeholder* by Brenda Laurel (1993) was considered an ambitious VR project. It showcased innovation by creating a virtual space through the use of digital assets and environments. The project garnered significant attention in academic circles, sparking extensive discussions about the potential applications of VR in the realm of performance arts. Its impact on research and critical discourse has been widely acknowledged (Hayles, 1996; Grzinic, 2001). Laurel work was unprecedented as it created a two-person VR simulation and enabled a theatre performance to unfold around the users. The project utilised both a 3D simulated environment and a real-world environment that was captured via cameras. The computer technology employed in this application was relatively uncomplicated and it was in its evolving stages. The graphics used in the project was very basic level, combined with image production and data processing. In particular the technology used in the project includes an SGI Onyx Reality Engine, equipped with 64M of main ram and 4M of texture memory which used C and UNIX programming language. The project used using the Minimal Reality Toolkit, as the primary VR framework. This particular experiment introduced two ways in which VR development could be applied to theatre contexts: 1) through the creation of three-dimensional virtual spaces as settings for theatre performance (Figure 2.1 and 2.2) incorporation of the projection of real-world environments in a virtual space thus combining cinema and theatre (Figure 2.2).

Figure 2.1 Virtual Environment designed by Laurel. *Courtesy Brenda Laurel*

Figure 2.2 Realtime Environment used by Laurel *Courtesy Brenda Laurel*

Placeholder focuses on two participants experiencing a virtual environment at the same time, allowing the participants to leave an audio mark like a leftover clue which can be experienced by future participants with the cycle going forward. Two participants enter the virtual world with the aid of a Head Mounted Display (HMD) and sensors around them to track their body

movements. Their entire experience is guided by an omnipresent voiceover (in this case voiced by Brenda Laurel) of a Goddess. The environment through which participants traverse is fairly sparse lacking high definition graphical details normally achieved via video and image quality and photorealism, common in modern computing, gaming and VR products released this century. The real-world environment design for this project instead used a segmented and composited 2D video and photography captured and stitched and projected into a 3D environment. The concept of presenting a real-world environment has been a significant inspiration for this research project. One of the significant outcomes of Brenda Laurel's research experiment is the idea of using a 2D photograph or video in a 3D space. In her experiment she was able to stitch 2D images into a single 360-degree image to patch a three dimensional space. Even though there were variations in the image quality or the flat composition of real-world visuals, the project successfully created a sense of telepresence by immersing users in a deliberately crafted environment, isolating them from real-world distractions. It is the very first instance where the participant experiences the concept of telepresence. This is a vital takeaway from the project, since picking up on the debates regarding the definition of telepresence and virtual presence in academic fields, Laurel's project indicates that realism nor photorealism is conditional for triggering the sensation telepresence, but suggests being placed in another world space or environment that is internally coherent and consistent. Conversely, there exists a concept similar to telepresence, often misconstrued as virtual presence, which positions an individual not merely in an alternative world but specifically in a virtual or simulated environment. In order to comprehend this thesis and research, it is crucial for the reader to understand the difference between telepresence and virtual presence. A comprehensive explanation of this differentiation can be found in Chapter 5 of the article titled A New Branch in Theatre - VR Dramatic Theatre. Telepresence is distinct

from virtual presence, referring to the experience of a participant in a virtually created environment through VR and HMD devices.

Following the development of a 3D virtual experience by Brenda Laurel (*Placeholder*, 1993), Char Davis developed a notable VR art experience named *Osmose* (1995) that focused on perpetual interaction between the user and the world. The technology employed to achieve the environment was innovative for the period - it used a HMD and a real-time motion tracking suit to sense and track the participants motion. It was one of the first motion capture suits used in VR controlled in real-time using the participant's breathing and balance for the environment to respond to participants' actions. Aesthetically, it uses a variety of environments in a wireframe render model including forest, tree, cloud, pond, earth and abyss. The idea was to induce the participant's 'awareness of one's own self as consciousness embodied in enveloping space,' through virtual environments and digitally designed wireframe objects (Neves, 2022, para. 1). This application of self-consciousness was in line with *Placeholder*'s concept of spatial presence to influence participants to immerse themselves into the VR space. Steve Dixon (2006) acknowledges the resemblance between the two projects in terms of their core idea, which he summarises as the use of 'Virtual Reality to place the user in space and accord with natural reality - with nature' (p. 33). That is, both these projects introduce the user to a novel virtual space for audiences to explore, distinct from their physical surroundings. The foundation upon which VR theatre assimilation is based in this research is the immersive experience of live theatre performances taking place on stage. Using a VR HMD, it is hoped that it possible to send the audience deeper into the fictional space of the performance. Unlike interactive games, the performance maintains its real-time dynamics, offering the audience a passive yet engaging level of interactivity (to inspect, engage and explore).

From 2000 there are numerous examples of research that was conducted focused on applying VR in a range of fields and mediums such as gaming, engineering, medicine and

construction (Cipresso et al, 2018). This period of exploration and innovation produced interesting outcomes and products such as immersive games, surgical simulations using VR, engineering and construction layouts rendered for VR, arguably taking priority over the application and growth of VR in other settings, like theatre. While VR applications grew in other spheres, research continued to advocate and focus on developing notions of immersive theatre (White, 2012) (Alston, 2013), incorporating concepts of immersion, presence and interactivity (White, 2012). Notable examples of immersive theatre are Sleep *No More* by Punchdunk (2011), and *Goodnight, Sleep Tight* by ZU-UK (2017). Such projects sparked heightened interest (Biggin, 2017) in exploring the impact of VR on theatre, particularly for its ability to foster and engage increased levels of interactivity. As a result, a newer branch of theatre, since it provided the audience with an interactive theatre experience (White, 2012). With theatre branching off into immersive spaces, data was becoming available on audiences' capacity to welcome innovative theatre performances.

For theatre production *My Name is Peter Stillman* (2017) a VR prelude was created. Developed by 59 Productions, this production was more reminiscent of immersive gaming experiences, and likely resonated with audiences who were familiar with such interactive forms of entertainment. Prior to entering the theatre, the audience were invited to enter a VR booth that was installed outside the theatre to introduce users to the world of the story. This pre-performance engagement via VR aimed to captivate the audience and prepare them for the world they would go on to experience at a distance (on stage) (City of Glass, 2017). Projects of this nature would have benefitted from research evaluation to highlight the impact (either positive or negative) for viewers of the subsequent expectation for, and experience of the theatre production, having been briefly immersed in the world before shifting to a more traditional theatre experience.

Also in 2017, Curious Directive developed *Frogman*, took a closer step to merging VR experience with theatre, as audience were virtually placed with the help of a VR headset inside the room where a narrative unfolds. Consistent with the aim of the present research, the experience did not involve a 3D-generated space or models. Instead, a performance unfolded in front of the audience in a 360-degree visualised space. The key difference here, is that the experience involved a blend of live performance and a VR environment. Audiences witnessed the action alternating between real-life segments performed by Tessa Parr and virtual reality replays. While the technology employed in the project was described as having a "stop-start quality" and lacking "exquisite fluidity," it undeniably laid the groundwork for the integration of VR into the performance space (Garner, 2017). The entire scene unfolds in a house where the actors intervene with clips of video footage. However, a year earlier in 2016 theatre director Felix Barette orchestrated a short production (*Believe Your Eyes*) that did experiment with mixing live-action, VR film and physical performer interaction. The performance comprised a ghost story with different possibilities for its ending. Although the performance was only available for a limited period to small audience numbers, writer Kelly Ohannessian (2016) was fortunate enough to view the performance and wrote:

> *Punchdrunk* gave me five minutes of art and technology working together to create something dream-like and powerful. We all may find ourselves sitting in such situations soon, living something beyond headsets and real life (para. 9).

As suggested by Ohannessian, these technological experiments highlights the potential of technological interventions to act as a portal to novel encounters that can enrich the artistic experience, transform the landscape of performing arts with increased sense of immersion, significant participation and involvement.

2.2.2 Big Budget Productions

A new phase of VR application in theatre performance became evident from 2015. This is a period where VR experimentation and installations in theatre performance have been driven and conducted on a much larger scale by larger theatre production companies with greater capacity to fund VR development. One of the first theatre production companies to re-engage with VR was the Royal Shakespeare Company and National Theatre in the UK. They formed a designated research team to explore and create VR theatre shows. In a recent interview with *The Guardian*, Toby Coffey, the head of digital development at the National Theatre stated that they view application of VR into theatre performance as an opportunity to develop and 'pioneer dramatic storytelling' (Brown, 2016, para. 4). Works including VR included *The Tempest* (2016), which incorporated a VR-accessible digital avatar, the character Ariel, that was rendered live in real time. The portrayal of Ariel, combined live performance with CGI, allowing the character to transform into various ethereal forms. Despite the impressive nature of the technology, the theatre production ensured that live actors and the technology were given equal importance throughout the performance. The light addition of VR received a positive response from more traditional audiences (Billington, 2016) indicating the possible acceptance of further VR dimensions in future productions. Enthusiasm for technological advancements in theatre have seen the Royal Shakespeare Company also employing a director of digital development.

Following the success of *Fabulous Wonder.land* (2015), a ground breaking production by the National Theatre based on Lewis Carroll's Alice in Wonderland, the creative director at 59 Productions and director of *My Name is Peter Stillman*, Lysander Ashton, was inspired to explore the integration of VR technology in their theatrical performance. The innovative storytelling and utilization of art and new media technologies in *Fabulous Wonder.land* earned it recognition and even a showcase at the prestigious Sundance Film Festival. Specifically,

Fabulous Wonder.Land (2015) was regarded as a convergence of storytelling in film, art, and new media technologies. This captivating and immersive encounter involved the audience using a VR headset (Oculus Rift) to transport them into a world characterized by a distinctive soundscape and vibrant multi-colour brilliance. The innovative technological approach behind this experience integrated custom-built set pieces within the theatre space, coupled with the use of creative technologies such as Oculus Rift, Kinect, 3D modelling, Google Cardboard, and Augmented Reality face-tracking (Westall, 2015). This achievement propelled Lysander Ashton to incorporate VR into their subsequent productions. They have reflected on the similarities between VR and theatre:

> In many respects creating virtual reality experiences has more in common with theatre-making than with film production, so we are using our experience of integrating technology into theatre to explore the creative possibilities of VR (para. 5).

This provides support for the idea that the application of VR technology in theatre performance allows the audience to familiarise and connect themselves with a fictional world and in doing so, allows them to locate themselves in the story world.

Lastly, amidst the COVID-19 restrictions and lockdowns (dates 2019-2021), the theatre industry has responded with the introduction of online theatre productions. These digital experiences have proven highly effective in providing audiences with accessible and immersive theatrical encounters, overcoming the challenges posed by the pandemic. Various theatre companies have embraced this new medium, offering online productions to deliver a fulfilling theatre experience during these unprecedented times (Chatzichristodoulou et al, 2022). Theatre producers were forced to seek ways of providing audiences with a remote virtual presence when it was not possible to attend theatre in person. Like other changes in practice like

zooming, flexible work arrangements, etc. theatre practitioners have been introduced to new possibilities of working and presenting theatre so that the medium is capable of reaching larger remote audiences (Chatzichristodoulou et al., 2022).

2.2.3 The Artistic Instigation of Embedded Spectatorship

While progress has been made in the incorporation of digital technology into theatre and performance arts, other VR projects can also be examined for the manner in which they create engaging, interactive, and immersive spectacles. For example, in 1996, Eduardo Kac designed a gallery installation named *Rava Avis*, using a real-time environment in which participants viewed inside an aviary using an HMD (Dixon, 2006). The HMD is connected to a parrot model placed inside the aviary among 30 real birds. It uses real-time feedback, with the rotation of the HMD mirroring the rotation of the parrot's head. This project represents one of the earliest examples of telepresence being achieved in a real-time environment from a remote location. It is also an example of telepresence that has direct relevance for research into VR for live performance contexts as users were placed among those being observed in a manner that is not perceptible to the subjects of observation.

In a similar project, exploring the notion that telepresence fulfils spectator curiosity of close access, Eduardo Kac's *Darker Than Night* (1999) placed a telerobotic bat among 300 Egyptian Fruit Bats in a cave in Blijdorp Zoo in Rotterdam. The telerobotic bat contained a frequency converter so that the audience could hear the sonar waves emitted by the Egyptian Fruit Bats as an audible sound. This experiment provided the audience with a sense of telepresence as the telerobotic bat became an object around which the flight of the other bats had to navigate around and respond. To be more precise, the audience was immersed in the sensation of being part of a colony of bats through the utilization of a VR headset. As Dixon (2006) stated: 'the artificial bat significantly affects the behaviour of the real ones' (p. 34).

VR project *Good Night, Sleep Tight* designed by ZU-UK directors in 2018 sought to proffer a critical engagement within the audience/participants with the aesthetics of VR, by combining VR and binaural technologies, the project transported participants to a dreamscape composed of childhood imagery and aerial cityscapes. This was also one of the initial experiments to introduce the importance of the cost effective HMD, Google Cardboard. As Dunne et al. (2018) explain, the initial proposed idea involved having participants placed on a bed with a dreamscape (childhood images and aerial cityscapes) projected on the ceiling. However, the projections proved to be too expensive to set up for individual participants, resulting in the execution shifting to the use of Google Cardboard. In *Good Night, Sleep* the use of Google Cardboard embraced its seeming limitation of not possessing any interactive tools compared to VR headsets such as HTC Vive or Oculus Rift. Instead, it signalled its effectiveness as a tool for viewing 360-degree VR experiences. It functions equally well to deliver an experience that embraces the appeal as delivering 'childhood dreams of invisibility and voyeurism' (Jennings, 2018, the para. 2) achieved from allowing audiences to remain invisible despite being present in a space of interest and intrigue.

There has been a growing interest in the utilization of 360-degree video technology within theatrical settings, leading to significant advancements in both technical implementations and narrative innovations for theatre audiences (Perkovic, 2016). A notable experiment conducted by James Martin Charlton and Magnus Moar (2018) involved the use of 360-degree cameras and head-mounted displays (HMD) to bring audiences onto the stage, providing them with an "on the stage" experience. The experiment also explored the concept of changing perspectives for the audience, allowing them to view the theatre performance from different points of view (POVs) and introducing the idea of virtual teleportation for the audience. This particular experiment serves as a source of inspiration for this thesis, as it aims to delve into the possibilities of virtually teleporting the audience onto the stage and examining

the potential of virtual reality (VR) as a tool for enhancing audience embodiment and empathy. Despite the limited academic evaluations and subsequent projects linked to Charlton and Moar's work, an experiment of this scale and potential, particularly in the realm of VR applications, necessitates additional supporting evidence and user (audience) reception. Evaluating the success of the experiment is significantly reliant on the user perspective.

2.2.3.1 Interactivity and Narrative Revelation

The emphasis on the application of VR to increase (or introduce) audience participation and interactivity has been explored with respect to spacing and triggering of new sections of narrative explication and plot progression. *The Whist* (2017) by Esteban Fourmi and Aoi Nakamura is a notable VR theatre production for the manner in which it incorporates audience presence and movement within a space alongside the progression of a theatrical experience. Over a one-hour period, audiences experience physical theatre, Virtual Reality and Augmented Reality. At first, the audience views a symbol through their HMD upon which they are instructed to walk in the space and match it with an object containing the same symbol in that space. Once the symbol is matched the environment in the HMD blends with a virtual space where the performance begins. This particular form of VR theatre allows a narrative story to by triggered by audience interactivity. The main performance consists of three actors and an algorithm which measures the time spent by the audience on a particular character. The character to which more attention is initially given becomes the protagonist in the subsequent scenes adding audience preference and customisation (unconsciously) to the performance (Fromell 2018). The performance contains up to 76 different narrative paths to account for user/audience actions and choices, resulting in personalised experience for audience members. Potentially, the concept of accessing multiple storylines within a single performance, triggered by the audience's gaze, also increases the re-engagement value of the performance. Fromell (2018) reflects on how both audiences and actors are kept engaged by this innovation:

> VR allows for this type of strategic manipulation of space and objects within the environment, which can spring alive, morph and transform, in response to the gaze of the viewer. I would suggest that this is a new type of interactivity. Whereas site-specific performances have allowed audiences to explore environments, VR offers opportunities for live transformations in response to the audience's attention. (p. 141)

Unlike traditional performances, VR enables real-time responses drawing on the user's attention, resulting in a personalized and interactive experience. This form of interactivity enhances engagement, as viewers actively shape the unfolding narrative through their presence and visual exploration. By incorporating these capabilities, VR performances have been able to offer captivating and immersive storytelling, revolutionizing audience engagement and pave the way for new possibilities for designing interactivity into theatrical performances. Author and critic

The majority of the experiments outlined in this chapter lack academic documentation and evaluation that would inform future projects. These experiments have primarily been documented through journalistic reviews, which makes it challenging to experience them as a researcher and provide detailed academic analysis. There is also a notable absence of comprehensive analysis across all stages of VR implementation and application, from design to production. This gap hinders the documentation of processes for further academic work and evaluation. This particular research aims to bridge this gap and focus on a specific VR technology - 360-degree cameras and Google Cardboards. It aims to explore and establish a research framework that can serve as a benchmark for future research in the field of VR technology applications in theatre performance.

2.2.4 Present day Technology and Theatre

In the article Seeing Alone Yet Together: Modern-day Tiresias in VR theatre, Hakyung Sim (2021) examines the application of VR in theatre and particularly VR's approach on the performance, stage, actors and the audience. Hakyung Sim (2021) used a case study and concentrated on a single VR performance *A Theatre for an Individualist* was produced and commissioned by the National Museum of Modern and Contemporary Art, Korea (MMCA). The commissioned theatre ran for about three days with three showings. It was a pay per view for the audience and the structure of the project. The project was well-structured to divide the audience into two groups: Group A, experiencing it through a VR headset, and Group B, observing Group A explore the VR environment. However, the author did not proceed to further investigate the VR theatre experience from the audience's perspective. Despite being one of the audience members, the author did not provide an analysis or reflection from the audience on how VR and theatre can coexist or potentially diverge. While the author presented a robust research design and argued about 'addresses how the act of watching has evolved in theatre, from a singular and linear experience to an alinear and plural one.' (p. 69), the research lacked insights from the consumer (audience) perspective and their reflections on the VR theatre experience. The author posits that theatre is required to utilise technology as much as it draws on bodies of live performers in order to attract new audiences and keep the medium interactive and engaging. It supports the claim made by this thesis that technological application has become a recurrent direction in theatre innovation and evolution. At the same time, maintaining human action at the centre of the experience, whilst exploring new means for relocating audiences closer to the craft and performance in acknowledgment that it remains the key medium through which theatre is expressed. In other words, it would be controversial to have a theatre performance without live performers, as it raises questions about its differentiation from a conventional VR game or VR experience, thereby losing its unique

characteristics. However both the idea of creating a VR theatre show with live performers and without live performers are explored as separate chapters in this thesis (chapter 4 and chapter 5).

2.3 Similarities with Virtual Reality and Theatre Performance

The previous sections have outlined examples of various VR development projects that relate to VR in performance and theatre. In this section, it is important to elaborate and conclude the chapter on why this research focuses on assimilating VR into theatre performance in particular. Academic researcher and writer Steve Dixon (2006) states that:

> theatre itself has always been a "virtual reality" where actors imaginatively conspire with audiences to conjure a belief (otherwise known as "suspension of disbelief") that a bare stage is in fact the courtyard of an ancient Theban palace, or the 1692 witch trial courtroom in Salem (p. 24)

In this statement Dixon compares the theatre stage to a virtual reality machine which aids the audiences' imagination according to the story enacted by the actors. This concept of actors' performance aiding the audience to imagine or conjure a story on the stage is what makes theatre an animated and entertaining medium. If this idea is taken away from the performance then it results in a mere recital of a story on the stage, eliminating the stimulating and enjoyable experience. This concept is one of the foundations of this thesis.

2.4 In Summary

This chapter served to outline key projects or works that have inspired and influenced the current research, identifying the elements that produced critical acclaim or interest among audiences. Different projects have sought to emphasise and exploit different forms of compatibility between VR and theatrical experiences that are difficult to replicate and assess

with the context of a single PhD research (particularly given the budget and personnel involved in the most recent wave of higher profile projects). In order to overcome this limitation, this research project focuses on implementing and assessing particular applications: Staging theatre performance in a virtual space or remotely through live streaming technology, introducing the audience to the idea of a shift in point of view (e.g. first person perspective theatre performance), experience of different degrees of interactivity or immersion once inside a performance (e.g. unfolding the performance around the audience), devising performances based on 360-degree viewing and assessing audience focus.

Chapter 3 Theoretical and Practical Framework to teleport Audience onto Stage

3.1 Methodology

This chapter reproduces the first two peer reviewed published articles produced in the early stages of the research in order to gain feedback for the approach adopted in this research (pre-Covid). These publications serve to outline the "prototyping" stage of the project, which involved the creation of a virtual (3D representation) pre-visualization to outline potential set-up and integration of cameras with performers. The concept of the virtual prototype was planned to support recruitment, collaboration and planning as it intended to support participant visual comprehension of the research intervention into theatre production. The virtual prototype was also instrumental in predetermining positions for the placement of 360-degree cameras within the theatre space, thereby reducing the time experimenting within development. Given the novelty of the research, it was unknown to what degree collaborators would wish to incorporate technical experimentation into production development or the degree to which conventional leadership roles (e.g. director) within theatre would accommodate a technical collaborator in their thinking and leadership. It was not a key aim of the research to examine the professional ecology of a production and role integration and communication. The research therefore aimed to be assistive in a manner that did not detract from routine production methods or processes.

The significance of the first article (refer to section 2 of this chapter) lies in its publication before the commencement of participant recruitment. It served as a valuable resource in shaping the early stages of the project, aiding in the planning, participant recruitment and visualizing the entire process. Subsequently, after the recruitment of participants, the first article, focusing on virtual prototype creation, also proved invaluable as

a visual aid during the conduct of focus groups and interviews with participants. It facilitated the visualization and testing of the virtual prototype within a live test group (recruited participants) and a controlled environment before the development of a VR assisted performance. The outcomes of this testing were reported in the second article (refer to section 3 of this chapter).

In summary, the initial stages of the methodology (pre-COVID methods) for this thesis involved virtual prototyping, participant recruitment, focus groups, participant interviews, and participant engagement (including prototype testing).

3.1.1 Methodology Framework

The first stage of the research was devoted to deepening practitioners engagement with the possibilities of VR and incorporating VR into production development and planning to support envisioning and crafting of VR Assisted Theatre. The research aimed to participate in a theatre production process that would eventuate in audiences (participants) physically experiencing live theatre in real time through VR headsets to be able to reflect on the affordances of VR (see Chapter 1) and how they compare with traditional modes of theatre engagement. Creative collaboration and outputs were all planned to be assessed by participants (performers and audiences) via focus groups and individual interviews with participants to reflect on the sensation, appeal and benefit of VR within a theatre experience. These methods were intended to be consistently applied throughout the entire project in evaluation of design decisions taken within collaboration.

Focus groups were also employed to gather opinions and encourage discussion on the benefit of VR within a theatre experience. Both focus groups and interviews with each participant (conducted pre-COVID) were conducted and was recorded using video cameras. These recorded sessions were later transcribed and analysed, forming crucial datasets for the

composition of the second and third articles (refer to chapter 4) in this research. The tests conducted with participants were similarly recorded, and the available visual and textual data can be found in the second article (see chapter 3). These recorded findings and interviews became vital once the COVID-19 lockdown period began as obtaining participant engagement became problematic as individuals became focused on negotiating the pandemic. They significantly contributed to the development of the two articles presented in this chapter, given the limitations on direct engagement with participants during the lockdown.

3.1.2 Recruitment and Procedure

The initial phase of selecting and enlisting performers commenced with the submission of an ethics committee application to the FASS Human Research Ethics Committee at the University of Waikato (see appendices). The FASS Human Research Ethics Committee granted approval to recruit participants from the theatre production community in the Waikato and Bay of Plenty regions. This included collaboration and engagement with participants, as well as the ability to conduct interviews and focus groups. The entire methodology for participant involvement was carefully planned for the project. However, due to the unforeseen challenges posed by the COVID-19 pandemic and the subsequent nationwide lockdown spanning from March 2020 to December 2021, adjustments were made to the framework of participant involvement throughout the research project.

The collaborative nature of the research was emphasized, engaging theatre practitioners to explore the integration of VR within the context of devising their own theatre productions. This approach positioned the theatre practitioners as creative leaders, allowing them the autonomy to experiment with VR and generate ideas for its application in their work—an approach that is relatively underexplored globally, but especially in New Zealand. The research aimed to facilitate and execute the ideas and possibilities generated by these practitioners.

Throughout the research, a positive and constructive relationship was developed with the theatre practitioners serving as participants. However, the research was structured to respect the autonomy of participants, allowing them the option to discontinue their use of VR if it did not align with their creative objectives. The right of participants to withdraw from the project was a fundamental aspect, clearly communicated in the Information Sheets and Consent Forms (see appendices). This approach ensured participants had the freedom to make decisions that best aligned with their creative goals throughout the research.

Contact with local theatre producers was facilitated by Dr Laura Haughey, a Waikato-based theatre practitioner, award winning theatre maker, director and dramaturg. She established Equal Voices Arts as Aotearoa's first professional touring deaf and hearing theatre company, creating original bilingual and bicultural performances accessible to both D/deaf and hearing audiences. Driven by her expertise, connections, and commitment to inclusivity, she facilitated introductions to local theatre communities for potential collaboration in this research project.

In line with the ethical guidelines set forth by the University of Waikato, participant information was treated with confidentiality to ensure unbiased research results and to honour the personal requirements of the participants. Despite the enthusiastic response from two local theatre communities, the scale of the PhD research project necessitated selecting only one theatre production to begin experimentation. The chosen production stood out due to the diversity among its performers, encompassing variations in age, gender, and cultural backgrounds. This production house shared a similar vision, aspiring to create and devise innovative performances through theatre to achieve broader goals in arts and performance. This aligns with the project's focus, incorporating technology (VR) as a tool to enhance outcomes in arts and performance, further solidifying their suitability for collaboration. The identification

of the right participant group was crucial for the realization of this project. In addition, diversity was a pivotal factor in the selection process.

Potential participants were initially contacted via email, which also included an attached Information Sheet (see appendices) to complete upon agreeing to participate. Having read the Information Sheets participants were then invited to attend information sessions where the concept and possibilities associated with VR was introduced, the technology was presented, and theatre practitioners were introduced to possible theatre applications that could be explored as part of the collaboration and prototyping work reported in this chapter. Once potential participants were comfortable with the nature of the project and their contributions, they completed a Consent From (see appendices) that outlined the expectations of participation, withdrawal rights and intentions for the use of data.

The initial participant group comprised seven actors (performers) engaged in focus groups, individual interviews, and collaborative activities during the project's early stages. They played a vital role in gathering essential information and data pertaining to the value of theatre performance, production and consumption statistics, and the local community's history and culture related to theatre. The collected data are thoroughly reflected upon and critically analysed in the published articles 1 and 2, included in this chapter. The seven actor participants were very excited and curious to work on the project. In the initial phase of the project, the seven performers constituted the primary collaborators, contributing significantly to qualitative results and the research progression. For instance, they played a key role in assessing the local theatre community's familiarity with VR technology and determining which 360-degree camera would best suit the research and enhance the performers' capabilities.

The research's subsequent stages were designed to involve additional participants as an "audience" during the middle and final phases. These individuals were intended to experience

the performance devised in the earlier part of the research, known as VR Dramatic Theatre, both in person and through VR headsets. The project initially anticipated the participation of approximately 20 to 25 audience members who would engage in viewing the VR Dramatic Theatre and partake in individual interviews with the researcher. This envisioned dataset was deemed essential, as it would have provided a well-rounded and balanced perspective to complement the literature collected for the research. The inclusion of this data set was expected to contribute significantly to a valuable reflection and critical discussion within the thesis. However, the plans were disrupted by the impact of COVID-19 and the subsequent nationwide lockdown, which affected the intended scale of audience participation. Due to these challenges, the VR Dramatic Theatre could only be showcased to a limited audience of 10 participants. Consequently, adjustments were made to involve audience participants by streaming the VR Dramatic Theatre online. This approach allowed the available audience to view the performance and participate in individual interviews for data collection, overcoming the limitations imposed by the lockdown and physical distancing protocols.

3.1.3 In Summary

The period of COVID-19 lockdown, sandwiched between the pre-COVID focus groups, interviews, engagement, and the final (smaller) experiment in VR Assisted theatre performance, played a pivotal role in the success of this research. While the lockdown posed challenges to the original methods and data collection plans, it provided a unique opportunity to critically analyse the data gathered before the pandemic and reflect on the structure and devising of the performance.

In my capacity as the primary researcher, organizer, and data collector, I took on the responsibility of keeping the participants well-informed about the schedule and planning of the performance during this timeframe. This involved consistent meetings with the actors,

including in-person sessions and brainstorming meetings whenever possible, adhering to necessary physical distancing precautions. These sessions generated a multitude of ideas for devising and enhancing the VR theatre performance. Concepts such as incorporating visual and audio cues, streaming and recording the performance, and utilizing both 360-degree and traditional video cameras for recording and streaming were among the ideas explored. The detailed methods employed for the performance are elaborated in articles 4 and 5 (see Chapter 5).

As the primary researcher, my role extended to actively engaging with the actor participants and organizing the VR theatre workshop, which encompassed rehearsals and the final performance. The workshop spanned over three months, acknowledging that this research was an experimental endeavour. To manage expectations, only a portion of the theatre performance (10-15 minutes) was planned for execution. All five rehearsals leading up to the performance were recorded, and it served as a practical workshop and a brainstorming session where my research expertise and technical knowledge of VR converged with the participants' creative performance. This period significantly strengthened the working relationship and facilitated the harmonious integration of VR technical applications with creative performance to complement each other.

The performance was scheduled at the Black Box Theatre on the University of Waikato campus. This choice was deliberate, as the rehearsals and performance acted as workshop by itself, devised and developed spontaneously (see above). Opting for a traditional performance space with a proscenium stage could potentially shape and constrain the final outcome, as it imposes fixed front and back orientations for the performance, requiring actors to act (perform) according to this particular orientation and placement. In contrast, the decision to use a simple black box space allows for greater flexibility, enabling performers to experiment with various stage configurations and audience interactions.

After rigorous rehearsals, the performance was executed, streamed, and recorded at the Black Box Theatre. Promotion of the event was carried out online, particularly through social media platforms like Facebook, targeting the local student community at the University of Waikato. The performance garnered a positive reception, with 20 viewers watching it through Facebook live streaming, and an additional 5 viewers watching the recorded version. Despite the overall audience count of 25, only 12 individuals responded for one-on-one interviews. These final interviews were conducted virtually through Zoom, and they were recorded for subsequent analysis, reflection, and critical review. These datasets proved invaluable for the research outcome, shedding light on how VR can be effectively applied in theatre spaces and examining its influence on actors, audience members, and the overall performance dynamics.

3.2 Publications

This chapter includes two publications, quality assured and peer reviewed - both are book chapters. They present the basic structure and the theoretical foundation of the thesis; that is an exploration of virtual teleportation by placing a theatre audience onto the stage. These publications were developed and written to foreground the experimentation stage of the thesis, prior to application. The aim was to report on the 360-degree theatre technology in the context of assessing the technical and digital enhancements required for a fully functional VR Dramatic Theatre.

The first proceeding introduces the concept of a VR dramatic theatre prototype, developed using 3D computer generated software. It discusses the idea of placing 360-degree camera on the stage or an actor, exploring the ideal position for the 360-degree camera placement. Given that VR is a developing medium, research and development related to VR occurs both in academic and non-academic areas. Given that technology developments can move at a fast pace and PhD research is a longer process (3 to 4 years). Therefore, research and

findings were best published or presented at each step of the process. The research was first introduced at the *Future of Information and Communication Conference*, 2020, (FICC 2020), held in San Francisco, USA, from March 5 to 6, 2020, later published in Vol. 1129 of the *Advances in Intelligent Systems and Computing Proceedings*. Introducing the first publication was a crucial step in this thesis, since it served as an official statement on the idea of VR dramatic theatre and introduced the use of 360-degree camera on actors to achieve virtual teleportation of audiences. The theme of the conference was to address state-of-the-art intelligent methods and techniques for solving real-world problems along with a vision of future research. The conference delegates were receptive to the research and preliminary findings, as the presentation into theatre spaces sparked series of compliments, questions and debates. Some of the feedback mentioned the idea of applying VR as a means for rehearsals for actors, designing a virtual 3D environment and objects to enhance the audiences' imagination and engagement and use of real time and photorealistic 3D rendering environments for believable and immersive experiences. This submission followed a double-blinded review process. This process was vital for this research and publication since the reviewing process took account of paper novelty, technical depth, elegance, practical and theoretical impact, and presentation. The blind review process was beneficial to the thesis research overall, as it evaluated the foundational theoretical prototype for the production-based research and provided the much-needed validation for the research. The reviewers highlighted the need to address certain aspects, such as the practical implementation of theoretical calculations for real-time camera positions and the consideration of any existing limitations or shortcomings. These comments suggest the importance of refining the methodology to ensure that the proposed camera positions can be effectively implemented in a real-time setting, while also acknowledging and addressing any potential challenges or limitations that may arise. The reviewers' comments helped to consolidate the future experiments and achieve the best

implementation standards. In particular, one reviewer suggested the inclusion of the motivation behind the practical use of the theoretical results obtained. This was addressed in the final submission by adding in the motivation for the research, shortcomings and the key components of the approach and the results. Upon submission of the camera-ready article, the reviewers' praised the addition of the specific objectives of the application to the theatre, techniques employed and the significant results. The statistical data presented in this article is highly compelling, highlighting its substantial readership within the academic community on ResearchGate. With 67 reads, the research conducted in this article has begun to capture attention and interest. Additionally, it is worth noting that the article has also received user reading statistics of 415 and downloading statistic of 302 in the University of Waikato's Research Commons.

The second publication included in this chapter, was published as a peer-reviewed conference proceeding. This was published in the *Advances in Information and Communication Proceedings* (2021), Future of Information and Communication Conference (FICC), Volume 1. This publication extends the theoretical examination evident in the first publication by introducing the practical application of 360-degree camera during actor performances and rehearsals evaluating how it alters or affects the experience. In particular, this paper reports technical requirements required for a 360-degree camera application in a performance. It also predicts the impact of VR on audiences, actors, their performance and access to live performances. The evaluation considers practical implementations such as field of view, obstruction, and framing, involving a three-dimensional theatre prototyping and video analysis techniques. The findings of the study provide insights into how VR can enhance audience engagement and presence in a live performance setting contributing to the idea of virtual presence and its impact on audience perception. In particular, it evaluates the audience experience based on the nature, lucidity and quality of the performance through the 360-degree

camera, effects of lighting and quality of the audio in the performance since there are possibilities of audio feedback. These findings served as vital for the VR incorporation into theatre or stage performance, as it has direct effect over the production pipeline of a theatre company.

Both these conference presentations were completely online due to the effect of COVID-19. Though it limited the involvement of, and discussions with fellow researchers, this publication attracted feedback and comments, which helped to strategize the upcoming experiments and fine tune them such as: the significance of reflection in research experiments emerged as a key takeaway, providing valuable insights for future investigations and influencing the direction of research; emphasising the equal importance of considering both the production (actors/producers) and consumption (audience) aspects of the technology; highlighting the significance of establishing a strong theoretical foundation before practical application. The statistical data for this article reveals that it has generated interest and engagement within the academic community on ResearchGate, with 71 reads to date.

Virtual Teleportation of a Theatre Audience Onto the Stage: VR as an Assistive Technology

Saikrishna Srinivasan(✉) and Gareth Schott

University of Waikato, Hamilton, WA 3216, New Zealand
sks61@students.waikato.ac.nz

Abstract. For more than a decade, virtual reality (VR) has been employed to enrich and heighten media experiences. Despite the recognized potential and promise of VR, and ample investment, it has yet to fully transform or replace existing screen-based experiences (e.g. film or gaming). This research forms a part of a larger project to shift VR applications beyond otherwise apparent areas of screen-based media, in order to enhance audience access and propinquity to a live performance. This study is being conducted in the field of theatre, a dramatic medium in which audience are traditionally static and where an individual's seating position determines their perceptual experience (distance, angle, lights, obstructed vs clear view). This paper introduces the broader project and its experimentation with VR as an assistive technology. The project seeks to utilize VR as a means of converting an otherwise static experience to provide collective moments of visual teleportation, onto stage, into props and on actors. VR offers a non-invasive means of introducing variance in viewer proximity or position relative to performance. This paper reports on the early development and use of a three-dimensional theatre prototyping in order to explore the technical requirements for application to a VR theatre experience.

Keywords: Virtual reality · 360-degree camera · Assistive technology · Emancipation · 3D-prototype · Perspective · Theatre · Invisible

1 Introduction

1.1 Project Scope and Aims

The scope of our first set of experiments in a broader VR-theatre project that aims to incorporate virtual reality (VR) technology into a theatre experience, is to establish functional and impactful camera position/placement that will ultimately transform, augment and enhance a static experience of a dynamic performance. The aim of employing VR is to alter the nature of audience engagement and alter their sense of presence in a positive way. Initial experiments constitute a vital first step as they provide a finite number of practical test-case results that will later be implemented in live testing in conjunction with theatre practitioners. Our ultimate aim is to have VR stimulate new approaches to theatre practice and performance by offering and empowering theatre practitioners with a means to experiment with audiences' proximity and presence. In order to achieve this aim, key parameters like camera positioning in or around the stage, relative to the performers and the number of performers on the stage will play an

K. Arai et al. (Eds.): FICC 2020, AISC 1129, pp. 1–11, 2020.
https://doi.org/10.1007/978-3-030-39445-5_36

important role. The first set of experiments sought to ascertain potential heightened and concentrated perspectives through which a two-person on-stage interaction could be experienced via VR. It is posited that through on-stage presence an audience may gain greater sense of intimacy, typically achieved in film via close up and extreme close ups, or engender new perspectives in theatre such as first-person perspective or providing perspective from an inanimate object found on stage.

1.2 Experiment

This experiment was focused on the production of a 3-D prototype of a theatre setting in order to identify possible areas for camera (and in doing so, audience) placement on stage. Charlton and Moar [3] conducted a comparable study in which they too introduced theatre audience to the experience of being inside the stage and amidst performance. They employed VR with the aim of inducing a state of deeper engagement from bodily presence. The play 'Fellow Creature', consisted of only two actors plus a camera (GoPro rig) that was placed in a central position on stage. The camera viewpoint, viewed through a Head Mounted Display (HMD), permitted audience members to experience the play amid the actors. This experiment focused on the effect of the perspective change on audience, sense of voyeurism and its similarities in theatre and VR. This experiment helped to bring audience 'onto the stage' and transform their status and role from non-participatory witnesses outside the play to co-presence. However, it simply aimed to place the audience at the center of the stage. The series of experiments supporting the current project pursue a similar line of thinking to Charlton and Moar, but with greater focus given to the technical installation and application of VR on what is the best position/angle for the camera on stage, determining the appropriate vertical height for the camera view and assessing the effect of camera movement and motion blur on audience viewing. The project also seeks to extend the use of augmented objects (AO), visible through the HMD, to enrich the setting of the performance. Finally, the current project will also examine the application of VR in two distinct theatre conditions - a more traditional theatre experience in which a story is enacted or played out uninterrupted on the stage and a devised theatre or a collective creation which emerges from collaboration and improvisation. A comparative analysis will be conducted of the relative merits of VR to both theatrical contexts.

The primary aim of the experiment reported here is to begin the process of narrowing down the number of viable camera positions that can be made available to theatre practitioners to work around, and for an audience to teleport into from a seated position. A simple stage-bound performance comprised of two actors in conversation can be captured in a finite number of angles, typically conveying 25–40° angles when a standard camera is used [5]. When introducing VR into theatre performance, the possibilities for wider perceptual field increases exponentially due to its 360-degree field of view. This brings an additional set of considerations concerning the visibility of otherwise unrevealed offstage areas such as the wings, crossovers or voms, lighting rigs and also the audience. The aim of this first experiment was to use the 3D prototype of a simple theatre-stage context to filter out a finite number of inciting camera positions, that will act as a centroid for all adjacent and approximate camera positions. Successive experiments will aim to evaluate, test and validate the impact, appeal and advantage

associated with different camera positions as well as its impact for the actors/performers. Ultimately the project seeks to explore how the addition of a dynamic perspective changes the audience experience of a theatre experience and its future evolution. The intention is to follow prototype experiments with a physically staged experiment that consists of real performers (who will also serve as research participants). The acquired camera positions will eventually be tested and evaluated by an in-house audience (who will also serve as research participants).

The prototype is designed with only two static characters placed on the stage, to mimic a real-time conversation between two actors. Since this was a pilot study the complexity of a real-world theatre performance is purposely reduced and simplified to a situation comparable to black box theatre. This experiment aimed to identify possible at pivotal or centroidal positions for camera placement to provide an inciting stage view available to all audience members seated from downstage to upstage. From initial discussions with theatre production companies based in Hamilton (New Zealand), it has been noted that employing subtle facial expressions to convey emotion or feeling is difficult in a theatre context as it is difficult to guarantee that audience will perceive them or if they will even be attentive to the particular and relevant zone of information conveying a potentially crucial aspect of the play. Also if we consider the experience of a stage show, a sports event or live concert in person compared to viewing a framed and edited version on screen, while a live experience allows the audience to experience the energy and absorb the atmosphere of an event, there is a real likelihood that smaller gestures, looks or moments on stage or on field will be lost due to audience distance and where attention is being directed. For this reason, large digital display screens have now become standard in sports or concert stadiums (even when not televised), to some extent acknowledging what is lost or missed when viewing solely from the crowd. Similarly, the application of VR to theatre provides a window of opportunity for an otherwise quiet and static audience to gain even greater intimacy via proximity and presence. Indeed, Wendell Cole writes: “since the final quarter of the nineteenth century it has been apparent that major efforts of architects and designers have been directed toward bringing audience and actors into more intimate contact with one another” [18].

In the broad context of the study, prototyping will serve as a key tool and methodology over the course of the research project – as it provides a means to evaluate and test camera use, placement and viewing prior to testing and application with real actors and viewers within a theatrical rehearsal or performance. Focus groups, workshops (testing experiment with actors), interviews and questionnaires will be used to evaluate limitations and potential of VR, at a later stage of the research. Once prototyping is completed, it will be followed by focus groups with selected theatre production company participants/artists to determine the perceived affordances of the medium and identify any significant challenges that needs to be resolved prior to adoption and application by practitioner for use with audience. On completion of focus groups and analysis of the data collected, experimental workshops will be conducted in which VR will be assimilated into theatre practice, guided by the results of prototyping and consultation with practitioners concerning the perceived need, application and challenges. Experimental workshop will aim to reach rehearsal in front of a test audience in order to assess the performance of the VR technology, actors’ interaction

with or performance in the presence of VR technology on stage, and audience engagement with VR alongside traditional viewing. Once actor and audience testing are complete, participants will evaluate their experience via a questionnaire and short feedback interviews in order to provide insights into the success of the experience aesthetically and technically, as well as the level of absorption and immersion provided by VR.

1.3 Prototype

As stated above prototyping aims to help in the evaluation, and determination of the number of camera positions that can provide a 360-degree view of the performance from the stage. Evaluation of the prototype is based on theoretical analysis of the stage and the performers placement. The findings will be further evaluated through data collection with practitioners and mock-audience during rehearsals before commencing successive experiments.

The aim is to assist the audience to achieve absorption and immersion in their engagement with theatre performance. As theatre has continued to evolve, more immersive modes of theatre have been explored. Nicola Shaughnessy suggests immersive theatre provides an idea of engaging the audience/spectator in a common shared space with performers, in doing so, submerging them in an experimental space which neglects real and fictional boundaries [14]. An example of immersive (and also promenade) theatre can be found in British theatre company Punchdrunk's adaptation of Shakespeare's Macbeth in 2011 entitled *Sleep No More*. For the New York performance of the play, warehouses in Manhattan's Chelsea neighborhood were transformed into hotel-like performance spaces allowing audience to move freely through five floors and settings, allowing them to interact with props, or observe the actors at their leisure [16]. However, like a seated audience the *Sleep No More* audience were asked to remain silent (and also masked) at all times, refrain from using phones or cameras and maintain a respectful distance from the performance. Nevertheless, a performance accessible in this way catered to senses like touch, smell, sound and physical proximity to the actors (presence). This example, experimented with the idea of group immersion or 'productive participation' drawing on audience's capacity and inherent productivity to build up the story of their own [1].

In 1974, philosopher Robert Nozick [12] invited us to imagine an 'experience machine' capable of artificially stimulating the brain to induce our desired experiences. As De Brigard outlines Nozick "seems to suggest that most people's intuitive reaction after considering the thought-experiment would be just like his: they would feel very little inclination to plug in" permanently [4]. Nozick posits people care too much about "living in contact with reality" [12]. The application of VR proposed in this project instead offers multiple perspectives as a witness to a dramaturgical performance taking place in front of the audience. Not confined to a seat or single position the audience, via VR, is able to employ a type of locomotion that allows them to access the stage without requiring any physical transfer (teleportation). Like Alston's notion [1] of collaborative theatre immersion, VR immersive experiences hold the potential to offer an escapist experience from within the real world, occupying the audience in a constructed

immersive experience and 'tricked out spaces' that allows the audience escape their seats and penetrate the stage as an imperceptible spectator and voyeur in a performance.

2 Technical Evaluation Criteria

A prototype was developed in 3D modelling and animation software Maya. The 3D characters and the models employed are royalty-free and do not require copyright. The 3D characters and set are retopologized and change in textures were applied as per the experiment's requirements, such as various lighting setups (spot light, area light). The benefits of a three-dimensional setup, is an infinite possible camera positions were broken down into potential camera positions that can enhance audience viewing. Considering two basic orthographic views - top view and front view, both orthographic views play a significant role in determining and drawing the three-dimensional view of any object [7]. A two-dimensional top view and front view for the whole setup and an imaginary circle around the two characters was developed, as shown in Fig. 1. The imaginary circle is formed by the camera when it is revolved around, with the performance as its center. This provided two variables 1. The center of the circle which will be the focal point and 2. the radius of the circle which will be the focal length of the camera. Still, there are infinite possible camera positions along the circumference of the circle. The circle is divided into four equal quadrants with respect to the straight line between the two characters. Since all four quadrants are identical, I have taken the first quadrant (0–90°) as my sample. This reduces the number of camera position to a finite number, unlike the previous scenario of all four quadrants.

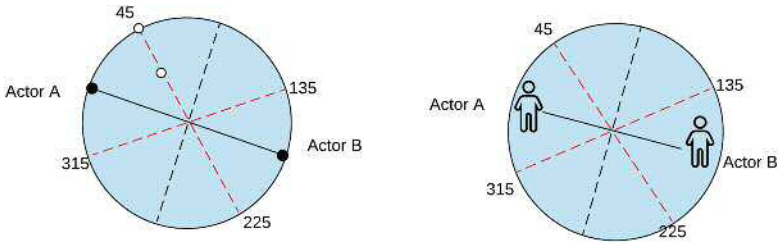


Fig. 1. Top view and front view of the performance space to breakdown the camera placement position

By evaluating the single quadrant, the best camera position inside the quadrant can be determined. Using the same principle, the camera positions in the other three quadrants can also be determined. There are two possible ways to determine the best camera position. Since it is considered as a defined shape quadrant, the centroid of the quadrant would serve as one of the best possible positions for the camera.

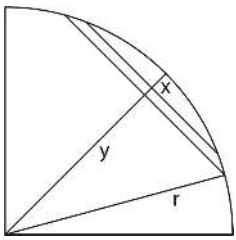


Fig. 2. Quadrant 1 - 0 to 90°

A single quadrant from the entire circle is considered, as shown in Fig. 2. Considering an infinitely small horizontal strip of thickness 'dy', at a distance y from the base.

The length of the strip will be 2x.

The moment of all such strips of the semicircle about the base divided by the area of the semicircle would give us the distance of the centroid from the base.

$$\bar{y} = \frac{4}{\pi r^2}\int_0^r 2xydy$$

By Pythagoras theorem, $x = \sqrt{r^2 - y^2}$

$$\bar{y} = \frac{4}{\pi r^2}\int_0^r 2y\sqrt{r^2 - y^2}\ dy$$

$$= -\frac{4}{\pi r^2}\left[\frac{2}{3}\left(r^2 - y^2\right)^{\frac{3}{2}}\right]$$

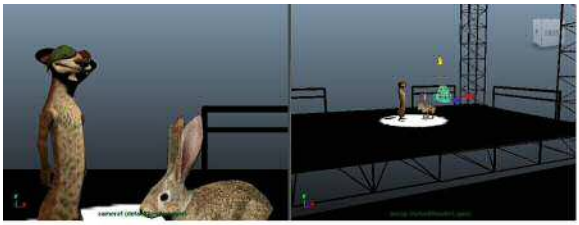
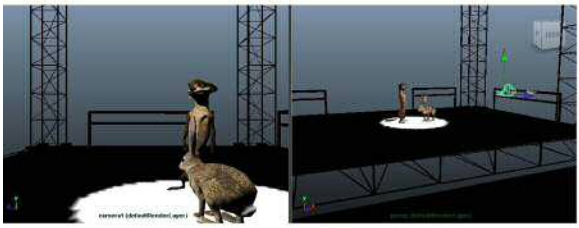
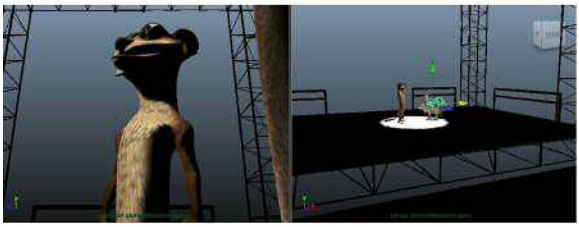
$$= -\frac{4}{\pi r^2}\left[-\frac{2r^3}{3}\right]$$

$$= \frac{8r}{3\pi}$$

So the centroid would be (0, 8r/3 π). The other possible position would be at an angle of 45° at the edge of the circle [5]. The best positions for the other quadrants can also be determined the same way. Using this method of calculation, there would be eight possible 'optimal' positions from the top view.

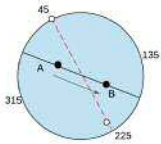
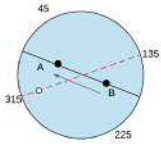
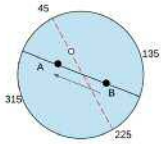
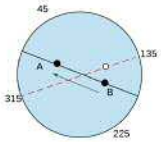
Similarly, with the same calculation, the best position from the front view can be determined, and it will be four positions, unlike top view since the other four positions in quadrant 3 and 4 will fall beneath the ground. When the findings of the top view and front view positions are correlated that results in eight possible positions, which will be evaluated further in the successive experiment using real-time stage, actors and theatre practitioners. Some of the camera positions that have been tested using the prototype are tabulated in Table 1.

Table 1. Various iterations of camera position from the prototype design

	Camera on the front of the stage
	Camera on the side of the stage (45 degree)
	Camera on the person for perspective

Evaluation of filmed theatre or live performance or music concert provides useful information regarding traditional camera positioning and camera angles that audience may be familiar with. In order to add a layer of filter with the concluded results of the camera placement, a video analysis of the 'Hamlet - Rehearsing the sword fight' directed by Robin Lough was done [10]. The reason for the choice of this particular piece of artefact is because it stands in the similar interest of this research and similar to the type of experiments which are proposed further in the research. The sword fight takes place between two characters within a defined circle in the stage, restricting many complex movements. The two characters, Kobna Holdbrook-Smith and Benedict Cumberbatch are represented as character A and character B respectively. The analysis result of the '*Hamlet - Rehearsing the sword fight*' is tabulated in Table 2.

Table 2. Findings from the analysis of '*Hamlet - Rehearsing the sword fight*'

Camera Placement	**Camera Height**	**Action/ performance**	**Representation**
Shot 1- Left of Character B	Eye level	Character A is attacking and advance, character B retreating	
Shot 2- Right of Character A	Eye level	Character B is attacking and advance, character A retreating	
Shot 3- Left of Character A	Mid level (to focus the hand movement and sword) (Character B is right handed)	Character B is attacking and showing some sword skills	
Shot 4- Left of Character B	Eye level (to show the facial expression)	Character A advancing aggressively	

When comparing the findings from this analysis of *'Hamlet: Rehearsing sword Fight Analysis*' against findings of the prototype experiment, it coincides with most of the valid camera placement. However there are a few more new interesting camera positions and placements found in the analysis and in the prototype. All of these camera placements will be put to test in the successive physical experiments to derive a better understanding and usage of VR 360° camera in theatre performance.

Audience experience of fictional events or a performance can be altered radically when it is conveyed from a first or second-person perspective, point of view (POV). A subjective experience is widely accepted as spontaneous and distinct [17]. Indeed, the subjective or first-person POV is often used to emphasize reactions and response to a protagonist, instill immediacy and connection, and garner empathy from an audience [9]. The idea of permitting an audience to experience a close-up camera position or a first-person POV opens up the possibilities of theatre benefitting from cinematic insights.

As cinematographer Benoit Delhomme explains, when discussing his approach to filming *At Eternity's Gate*, a biographical re-imaging of Vincent Van Gogh: The camera "can be like a microscope. The way I was using close-ups in this film was to capture van Gogh's soul … The face becomes a landscape. What is more interesting than the face? So much to see in the face." The introduction of 360-degree view from a character's perspective will only enhance the audience's experience and involvement [6]. Theatre is often conceived as a 'third-person' art form in which 'on stage' characters do not see, they are typically seen. POV through VR is a means for the audience to teleport into the actor's space and adopt a similar perspective thus also gaining a psychological reading. Since individual audience typically consume performances from a single position, this project helps to amplify the idea of liberation from a single site and consider when it is most effective for freedom to be given [13]. Individual immersion via VR intends to heighten spatial presence and give prominence to the feeling of 'being there' or the illusion that what is happening is occurring to the spectator as much as the performer [15]. Even though this idea of audience spectatorship would be considered unorthodox, particularly when contrasted with traditional spectatorship, it has been explored as a topic of discussion for some time, seeking to open the door for experimentation in theatre performances [6].

Camera placement could become highly valuable as a means to allow the audience to interrogate, study and relish the drama and intensity of any performance [8]. Studies show that multiple camera placement is vital for Image MAGnification (IMAG) in any stage performance. The purpose of Image MAGnification is to magnify the person's "image" so people farther from the stage can more easily see them [19]. This is one of the reasons, various camera positions and composition rules have been followed for recording stage performance. Some of the basic camera positions followed are close in on a subject, closeup headshots - to capture facial expressions, moderate close-ups - to capture body language and movement, wide angle shots in combination with a low angle to create a more dynamic feel of the entire stage, triangle or split group formations - to capture group performance [8]. These findings from the existing literature coincides with majority of the results from this experiment. All of these camera positions will be examined and evaluated with a physically staged experiment that will consist of real performers (who will also serve as research participants) under various evaluation criteria of the number of performers, lighting setup, nature of performers (height, age, sex) in the successive experiments and the effect of application of VR in theatre performance will be evaluated.

3 Conclusion and Findings

The fundamental purpose of this experiment was to begin examination and evaluation of the infinite number of (stage 1) camera positions and filter them to a finite number, which has been achieved. Since the acquired camera positions for an inciting viewing are finite, we can proceed to further check the actual viability of the camera positions in the subsequent experiments. Charlton and Moar [3] have already conducted a similar experiment to examine the effect of having a static 360-degree camera at the center of the stage. However, in this scenario there was no defined or specific reason for the

selection of the camera placement, as they were aiming to examine the invisible, passive, voyeuristic viewer 'in the room' whilst a dramatic scene unfolds. The present work stands in contrast to Charlton and Moar's work as it focused more on determining a viable or centroidal camera position and inciting a view from inside the stage. This research will not only prompt the audience to explore the performance and construct their own impressions of performances but also help to evaluate how the virtual presence of an audience can induce a sensation of being inconspicuous yet close at hand [11] and quite removed from the audience. From this experiment eight positions from an orthographic view, camera positions from the actor's perspective, were identified to offer a change of perspective to an audience, emancipating the story from a single-perspective experience.

Future audience that experience VR immersion during a live dramaturgical performance will be introduced to a different modality by which a performance is conveyed. Moving forward, we aim to examine how such dynamic perspective changes in a theatre performance, will effect and affect both performers and audience and whether it is to the benefit or detriment to a theatre experience.

4 Reflections

From a media technician perspective, it is very intriguing to investigate the affordances that the VR medium possesses, and how that can be applied to a more traditional and historical storytelling medium that conventionally has its audience wedded to a single space. There is some significant technical testing and research being conducted on VR by the British Royal National Theatre who are exploring the use of VR studio to develop dramatic models for viewing in the 360° medium. [2]. However, very few theatre practitioners and performers to-date have been given the opportunity to expand their practice by moving the audience to view a performance from different vantage points throughout a performance and the opportunity experiment with this technical opening. It is our hope, that if the risk of investing in the application of a new technology is broken down, testing is completed on small units of activity/presentation with convincing findings, and presented linearly, then adoption of VR might happen sooner. By exploring and evaluating VR, and promoting prototyping as a pre-production practice prior to testing within theatre practice, it is hoped that VR might assume a role in the process of theatre practice.

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Transforming Audience into Spectator/Actor: Assimilating VR into Live/Theatre Performance

Saikrishna Srinivasan(✉)

University of Waikato, Hamilton, WA 3216, New Zealand

Abstract. Virtual Reality (VR) is a medium that is used to teleport audience virtually from one place to another in the physical world or into a virtual world. VR does prove to bring a different and more enhancing perspective to the audience by immersing them into the performance. This paper is a continuation of a prototype project on the early development and use of a three-dimensional theatre prototyping in order to explore the technical requirements for the application to a VR theatre experience, which is a part of more extensive research to use VR as an assistive technology in order to enhance audience access and propinquity to a live performance. This paper explores and investigates the relative position of the audience on the stage (virtually transported to the stage using VR) with respect to their traditional off-stage seating position. The evaluation between the two situations is based on perceptual experience along the lines of the field of view of the audience, obstruction and framing. This experiment is a part of a larger research and its evaluation will be critical to the result of integrating VR inside theatre performance. The study of the larger research was to introduce VR into the theatre and induce a state of deeper engagement from bodily presence. However, this experiment not only introduces VR into the theatre space but also helps to evaluate how the virtual presence of an audience can induce a sensation of being inconspicuous yet close at hand and quite removed from the audience. The project aims to exploit the idea of having the stage cameras either mounted on a pole (stage) or on the actor (participant) and comparing them with the traditional audience perspective using the technique of video analysis. This paper will account for the findings and comparison between the audience position outside the stage and on the stage using VR technology, providing the necessary foundation of assimilating VR inside of live performance.

Keywords: Virtual Reality · 360-degree camera · Assistive technology · Emancipation · Google cardboard · Perspective · Theatre · Invisible

1 Introduction

1.1 Project (Scope)

Virtual Reality is primarily defined as a medium used to virtually teleport audience into a virtual world with the help of VR headsets and software [12]. The primary aim of the experiment is to virtually teleport the audience from their traditional off-stage

K. Arai (Ed.): FICC 2021, AISC 1363, pp. 935–944, 2021.
https://doi.org/10.1007/978-3-030-73100-7_64

spectator space in a proscenium theatre and gradually introduce them into the performance arena. The experiment aims to compare the two positions of the audience and evaluate based on perceptual experience along the lines of the field of view of the audience, obstruction and framing. This experiment constitutes the initial phase of a larger research to have VR stimulate new approaches to theatre practice and performance by offering and perhaps empowering theatre practitioners with a means to experiment with closer audience proximity and interactive set projection. This may help in developing or devising a novel approach or branch in the field of theatre performance. Affordable VR technologies, such as Google cardboard [6] crafted from low cost cardboard have been used in this experiment. The overall aim of the research is to exploit the cheaper cost of the VR technologies and help the audience to get a novel experience of the live performance. In order to achieve the required result, the different available camera angles are being experimented and evaluated in this experiment to give the best experience to the audience.

1.2 Experiment

Studies in cinema show that camera angles play a major role in determining the perception of any character or object in the audience's mind [5]. Supporting the same fact Joan Meyers-Levy, and Peracchio Laura experimented to study the effect of camera angle on the audience and how it affects the audience's perception [8]. The experiment involved participants viewing a product (object - an Everex 386/20 personal computer) from three different camera angles. Their result suggested that the camera angle at which a product is shown in advertising can affect product evaluations. When observed at eye level, the product was regarded less favorably than when it was viewed from a low camera angle (looking up at the product) but more favorably than when it was observed from a high camera angle looking down at the product.

It provides a valid conclusion on Joan Meyers-Levy, and Peracchio Laura statement that camera angle plays a major role in affecting the audience's perception [8]. Similarly in this experiment the audience is made to experience the same scene in a different camera angle (person's perspective) to determine the impact of the scene on the audience.

This experiment is a progressive development to the previous prototypic experiment, which was focused on the production of a 3-D mock-up of a theatre setting in order to identify possible areas for camera (and in doing so, audience) placement on stage [13]. This experiment is aimed to evaluate the camera position similar to Joan Meyers-Levy, and Peracchio Laura's [8] approach using the method of video analysis to evaluate the camera positions based on perceptual experience along the lines of the field of view of the audience, obstruction and framing. The prototype experiment helped to find out the suitable camera positions for the audience on the stage, however it is required to test out the camera positions in real time to find the viability of the previous findings.

This experiment uses four actors inside a proscenium rehearsal space, which will be further conducted in a black box theatre atmosphere with a higher number of participants. The experiment consists of showcasing a theatre performance scene of a monologue and a duologue between two characters, which will be captured and recorded using a 360 degree camera (Insta X 360). Figure 1 and 2 showcases the performance in

different angle with the same actors performing the same duologue scene. The theoretically derived camera positions from the previous experiment are implemented here to capture the performance and evaluate them. Since this is the first experiment of its kind, only three camera positions were tested. Figure 1 shows the actors performing from the audience's perspective, while Fig. 2 shows the same performance on the stage from the actor's perspective. However, it does give rise to a lot of novel camera positions and ideas which can pivot theatre performance to a whole new interactive medium using Virtual Reality. The entire scene in this experiment is enacted by the four actors for four minutes. The reason for the selection of such a short scene is due to the fact that theatre audiences need to get accustomed to this new technology, also it should not be a hindrance for the actors and theatre producers. The experimentation on a short timed scene of four minutes might be a step behind the work of Charlton and Moar experiment [2], in which the 360° camera was placed on the center of the stage for the entire length of the play (nearly 20 min). However, the justification for taking a step behind and re-examining the effect of using 360° cameras in a theatre space is because theatre audiences need to gradually be introduced to the use of this new technology. Compelling the theatre audience to use VR headset and gadgets for an entire long performance is very questionable.

In the previously concluded experiment "Virtual Teleportation of a Theatre Audience Onto the Stage: VR as an Assistive Technology as an assistive medium" [13] I have recreated a duologue sequence in an theatre environment, in 3D using 3D modelling softwares and calculated possible desirable camera positions for the audience. The experiment was concluded with six major impactful camera positions, which would be very apt and delightful for the audience in a duologue sequence. The concluded six positions were two positions on top of each of the actors, four positions at an angle 45° and −45° from each actor.

Fig. 1. Audience perspective from the camera on the actor

1.3 Method (Procedure)

Every camera position from the previous experiment is tested in different scenes and character setup to maximize the randomness of the result and to conclude an accurate result. The video analysis of the same has been performed using a suitable method of Grounded Video Analysis (Strauss, A. and J. Corbin). These recorded scenarios will be later showcased to the participants in the upcoming experiments. Both the theoretical result from this experiment and the practical conclusion from the participants' showcase will be compared to get a better and self-standing result.

The experiment is conducted in a proscenium space for rehearsal of a theatre play in order to get the better out of the lighting setup. As lights play a major role when experimenting with cameras and its placement. A group of 4 theatre artists have been employed as volunteers for the experiment. For this experiment they were asked to enact a short scene of Shakespeare's writing 'Constellations' [11] to test the various camera angles. To organize the experiment and data collection in a linear framework, a monologue and a dialogue scenes were enacted by the employed volunteers. These enacted scenes were captured and recorded using the 360-degree camera which were placed in the theoretically calculated positions (in front, behind, in between and physically on the actor). This experiment is in line with the experiment conducted by Charlton and Moar [2]. Unlike Charlton and Moar's experiment of using a single camera at the centre of the proscenium space, here the various available and enticing camera placement are being experimented and devised upon.

There are various recent studies and research being undertaken in the field of performance art and VR like Professor Gareth White [16] conducted an experiment by devising a cleverly structured theatre interior which helped the audience to feel their bodily presence in the environment. Pearlman [10] developed a brain opera which had cleverly structured confined interior space with display monitors on all the surrounding walls with the audience in the center. This experiment will be a successor to those experiments in technology and artistic innovations, focusing more on the capabilities of

Fig. 2. Audience perspective from the camera on the actor in the stage

the technology. However it focuses majorly on the artistic innovations available using technological advancements. The technologies being used in this experiment are a highly stabilizable 360-degree camera, Insta 360 X along with cheapest possible VR headgear, the google cardboard [6] which is clearly an enhancement from the previous experiments and research and providing the audience and artist their personal space.

2 Technical Evaluation

2.1 Evaluation Criteria

The evaluation is performed by comparing the two camera positions (one on the actor and the other from the traditional audience position). By this way, the perceptual experience like distance, angle, lights, obstructed vs clear view, objects in a frame, performance expression will be evaluated through video analysis.

This experiment was planned and conducted for a blackbox theatre for an arrangement of proscenium space with the audience seated from a single direction. The experiment is performed to compare and evaluate the audience vision from the tradition off stage seated perspective to the virtually teleported audience vision using 360° camera. The evaluation will study if the virtually teleported audience will experience the same level of audio and visual experience to that of the naked eye viewing from their seats. This experiment concentrates on the visual detailing, lucidity from the 360 camera, obstructions and deviations due to the other technicalities such as varied lighting, audio and actor interactions and movements.

2.2 Process of Evaluation for the Video Analysis

Whole to Part Analysis (Grounded Video Analysis)
The first part of the analysis will be following the method of Whole to Part analysis. This method consists of breaking down the video as a whole into individual smaller pieces and analyzing more [4]. This will help in finding and analysing all the data from the video recorded and categorize the necessary data accordingly.

The data (video) is split into smaller parts and put back into new categories and it will be open coded. From the smaller parts the concepts are identified separately, which are further grouped into categories. From the separate categories the properties and dimensions are identified. This is a very useful method of video analysis, as it helps to analysis the small details and parameters in the video [14].

In this particular research the concepts will consist of events or happenings or instances (scenes). Categories will consist of the group of concepts (type of scene). The properties will be the unique characteristic of the category (visible elements and actions in the scene). The dimension will be the frequency of the properties happening (how often the elements and actions are visible or repeated).

The dimensions measured in this experiment are basically camera properties (dimensions) that are necessary to provide a high dynamic range video experience to the audience similar to naked eye view. Image/visual quality is very important for the reproduction of the same performance from a different angle [9]. Hence the sub dimensions

of the visual quality: lighting, sound and dynamic range effects are examined in this experiment. Light is an important factor to be considered when experimenting with cameras. Since a 360 degree camera captures all the surrounding space, lighting will be very much vital even in the corner of the proscenium space. The physical measure of light that is the most appropriate for imaging systems is luminance [9]. The luminance of the light is kept constant throughout the experiment by using a bright light source from the ceiling to have the consistent luminance throughout the performance space. Sound is the next important factor after light, since it can be used either as a cue to the audience or a distraction. The digital video revolution has given rise to cameras and camcorders with greater image resolution and cleaner sound reproduction than that of older analog formats [Holman, Tomlinson, and Arthur Baum]. The final measurement is the signal-to-noise ratio (SNR) is most often used to express the dynamic range of a digital camera. In this context, ratio is between the brightest and the darkest parts of a scene given in luminance [9]. In order to minimize the dynamic range of the camera the intensity of the light is kept constant throughout the experiment.

In addition to these dimensions, the visual distractions by the ambience and the immersive are noted by examining the tone reproducing ability of the camera. If the camera could not reproduce the same tone due to the external lighting or luminance factor, distortion. The lighting setup in a theatre performance is very vital to convey the mood or tone of the entire play [15]. When recording or watching the play through a camera lens, the camera should be able to convey the same mood and tone without distractions like lens flare (unless it is necessary for the performance itself). Similarly, sound plays a major role in any video to convey the mood and tone of the video [7]. Hence, these parameters for the various camera angles are noted and tabulated in Table 1 and Table 2 for analysis. Table 1 shows the parameter captured from the traditional audience view, while Table 2 tabulates the parameter captured from the position of the actor.

3 Findings

The data findings from the above concept of duologue, compares the camera position on the stage/actor to the traditional audience seating position. A consistent lighting set up is used in this experiment for the overall comparison between the two positions. It can be noted that in this experiment, only the technical variables of the 360-camera, the theatre space, lighting setup are examined. The primary aim of the experiment is to compare the two viewpoints of the audience: on the stage/actor and traditional seating arrangement. The primary goal of the total research is to bring the audience into the stage virtually using a camera on the stage.

Camera angle plays a major role in conveying a story to any audience [1]. Hence, it has been considered as the primary factor for experimentation and various camera positions are recorded for the same performance of a duologue, under the same lighting condition. The camera placed on an actor shows more likeness to the audio-visual technicalities and thus encapsulates the best capabilities of the technology. It provides a better visibility to the character B's expressions, gives a feel of better ambience with comparatively fewer visual distractions. The visibility of the character's facial expression and gestures are

Table 1. Video analysis of various dimensions from traditional audience view

Concept	Category	Property	Dimension	Range
A conversation between two characters	Character's self - explanation about his/her past	Character A's facial expression	Visibility	Poor - Medium (depending on the audience seat)
			Lighting	Constant white light from ceiling
			Intensity of the visual	Medium intense white light
			Sound	Dialogue exchange
			Dynamic range	Consistent due to the usage of same luminance of light
			Lucidity of the visual	Continuous flow of performance
		Character B's facial expression	Visibility	Poor- Medium (depending on the audience seat)
			Lighting	Constant white light from ceiling
			Intensity of the lights	Medium intense white light
			Sound	Dialogue exchange
			Dynamic range	Consistent due to the usage of same luminance of light
			Lucidity of the visuals	Continuous flow of performance
		Ambience (stage and set)	Visibility and Auditory Cues	Not necessary for this set up
			Immersiveness	Cannot achieve visual immersion
		Distractions	Visual and Auditory distractions	Depends on the seating placement
			Maintaining the tone of the play	Yes

very clear and captured with detail using the camera on the actor/stage. The technical capabilities of the camera on the stage provides the audience with the same visual impact from that of the view from a seated position. It in fact enhances and captures a lot of minor details like the actor's gestures and facial expression. The tone or the mood of the entire performance is kept intact by controlling the luminance, dynamic range of the camera so that it does affect the performance. The other major takeaway from this experiment is the use of sound. Sound constitutes of both the dialogues delivered by the actors and also the background music or the ambience noise inside the performance. Sound can be used as an audio cue for the audience to look at a specific direction, if they are overwhelmed or lost in the 360-degree space. At the same time, it can be used as a distraction if there needs to be any in the performance. Similarly, by experimenting with

Table 2. Video analysis of various dimensions from the position of actor

Concept	Category	Property	Dimension	Range
A conversation between two characters	Character's self - explanation about his/her past	Character A's facial expression	Visibility	Poor
			Lighting	Constant white light from ceiling
			Intensity of the visual	Medium intense white light
			Sound	Dialogue exchange
			Dynamic range	Consistent due to the usage of same luminance of light
			Lucidity of the visuals	Continuous flow of performance
		Character B's facial expression	Visibility	Medium
			Lighting	Constant white light from ceiling
			Intensity of the lights	Medium intense white light
			Sound	Dialogue exchange
			Dynamic range	Consistent due to the usage of same luminance of light
			Lucidity of the visual	Continuous flow of performance
		Ambience (stage and set)	Visibility and Auditory Cues	The intensity /luminance of the lights and the background sounds can be used as cues
			Immersiveness	Audience can see the environment in 360 degree providing with immersion
		Visual Distractions	Visual and Auditory distractions	It can be added or removed as per necessity
			Maintaining the tone of the play	Yes the tone is maintained by adjusting the camera settings and lights

the luminance or the intensity or the color of the light audience can be provided with visual cues. If these technicalities are used as per need the performance can contain a lot of visual and audio Easter eggs in it.

4 Results and Future Work

The findings suggest that each camera position has its own pros and cons depending on the nature of the scene. It is similar to the idea of cinematography in movies and games where you need the specified camera angle in order to provide the best visual and audio experience to the audience [3]. The primary aim of this experiment was to find if an audience is allowed to view a theatre performance through a 360-degree camera on the stage/actor, will they have the same audio and visual experience compared to their traditional off stage seating position. The finding suggests that using the 360-degree camera on the stage/actor and the VR technology audience can virtually teleport themselves onto the stage and the visual experience can be maintained on par with their traditional naked eye experience from off stage. In fact this on stage camera enhances their visual experience by being amidst the performance and helping them to capture minute details of the performance.

However, this idea will not be suitable for all theatre plays and performances. As a starter, this idea could be suitable for performances and theatre styles, that can be devised and re-constructed based on what the VR technology could offer to the audience's virtual participation and the actor's performance. This idea of having various camera positions and placement available, can provide the audience with a choice of changing their field of view to different cameras or to the traditional naked eye view providing them to be the story creator or the editors of their own. However this idea does come with a shortcoming of the relay and lag between the live performance and performance viewed through the Google Cardboard [6], which are proposed to be addressed in the upcoming experiments and research. The other future work from this experiment would be to study the effects of placing a camera on the stage/actor. How does the camera on the stage affect the performance of the actor and virtual realities overall effect in the field of theatre performance.

Even though there is a room for a lot of experiments, breakthroughs and applications using virtual reality, like the virtual teleconferences, virtual gaming and virtual training experience, it is high time that the focus of VR should also fall on other mediums such as arts, theatre and movies. This experiment stands as implementing one of the first and novel ideas of using VR in a theoretical experience and addresses its effects on the audience. This could be one of the first steps in illustrating theatre performance to a new branch, where environment and set properties can be virtually superimposed on the stage and the audience could visualize it using the VR headset. This could result in reducing the time, money and physical efforts involved in creation and designing of set properties and helping the actors and producers to focus more on the content. This opens the scope of the research to a wider prospect and it will be addressed in future projects.

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Chapter 4 - Breaking Boundaries: Exploring the Hybrid Experience of Virtual Reality Spaces in Theatre Performance

4.1 Introduction

This chapter presents a peer-reviewed conference proceeding publication conceptualizing the idea of creating new virtual spaces for theatre performance. This article was submitted to The 13th International Multi-Conference on Complexity, Informatics and Cybernetics (IMCIC 2022). The publication introduced the main thesis of this research to an academic readers in the fields of computing sciences, foregrounding the aims of the study in terms of the rationale for, and application of VR to live theatre performance, but also providing a project reference point and citation for the publication of subsequent experiments thus removing the need to repeatedly justify the aims of the project. This article and experiment was again performed during a period of COVID-19 restrictions that made physical theatre impossible for both the actors and the audience. It became increasingly clear that the research had a more immediate role in facilitating and maintaining live performances so that practitioners could keep working and audiences had alternative means of accessing live theatre. This article covers the creation (designing and building a 3D digital space) of "theatre as a virtual space," building on the previous articles that focused on providing audiences with an on-stage experience. The research builds upon the concept of the metaverse, which is a unified and immersive 3D virtual space shared by both the audience and actors. It explores various aspects of presence, such as virtual presence and telepresence, and examines how the integration of VR technology can influence and facilitate different forms of stage movement and interaction among performers. It involved 10 participants, who experienced the 3D designed virtual space and recorded their feedback through interviews and focus groups. In particular, this article aligns with the thesis aim of not only exploring the application of Virtual Reality but also progressing VR towards a branch of theatre performance.

This article was blind peer reviewed. It was submitted in full to the IMCIC 2022 conference panel before acceptance to the conference. In particular, the peer review committee acknowledged the potential pragmatic value of the article and its potential applications to other performing arts areas, as well as arts education. The detailed peer review provided by the committee was very welcoming since it provided the necessary feedback and criticism related to the article. The article received positive feedback from the blind peer review process stating the article's significance lies in its ability to inspire creative analogical/logical thinking in science, engineering, philosophy, and the arts. The reviewers extended the assessment of how VR can provide invisibility for creative and democratic purposes in art, to the realms of science and technology, emphasizing that human characteristics, including the potential for corruption and unethical behaviour, are present in those fields as well. The reviewers appreciated not only the content of the paper but also the subsequent reflections and reflections, noting that such reflections are essential in scientific and engineering papers, although they are often overlooked. This article was submitted, presented and published under the category of "technological innovation" in areas other than games.

Envisioning New Virtual Spaces for Performance and Theatre artists

Saikrishna SRINIVASAN
Screen & Media, University of Waikato
Hamilton, New Zealand

Gareth SCHOTT
Screen & Media, University of Waikato
Hamilton, New Zealand

ABSTRACT

Since 2020 working from home has, for many, become the norm since the outbreak of the COVID-19. Furthermore, with large public gatherings either prohibited, limited, or subject to social distancing measures live theatre performed in front of a live audience have been deeply affected. This project experiments with executing performances from home to enable theatre actors to continue to practice and connect with audiences. A series of experiments were conducted to test the possibility of having performers or actors conducting performance from their personal spaces and integrating their work using virtual reality in a combined space for an audience to engage with. This research aims to examine Virtual Reality as an assistive technology in contexts such as theatre performance and use of digital environmental design for actors and performers. The nature of this research project was to determine various scenarios in which a virtual 3D environment can enable, assist and/or enhance a theatre performance for both audience and the actors. For this project a 3D virtual theatre setup was designed, experienced and evaluated by participants drawn from theatre practitioners in the context of focus groups. This article reports on the design and practitioners' responses and how it resulted in an informed VR solution for theatre performance.

Keywords: Virtual Reality, 360-degree camera, Virtual theatre, Assistive technology, 3D-Prototype, Perspective, Theatre, Invisible.

1 INTRODUCTION

The creation of digital environments is becoming an increasingly urgent during a global pandemic, sparking a number of initiatives that attempt to explore and advance how access to art practices might evolve and adapt to maintain or increase accessibility. As Feinstein, a freelance arts and culture writer has commented, with reference to the arts during a global pandemic: "It's a terrible time to go out." [11] The art world has responded with virtual exhibitions, and Virtual Reality (VR) life-streaming of performances of Opera [15] and Ballet [21]. Indeed, VR in particular, has offered "new life and unprecedented access to some of the world's cultural touchstones, some previously financially or physically inaccessible" [ibid]. While the present study shares a broad interest in facilitating accessibility to the arts, research was initiated prior to the global pandemic and focused initially on the assimilation of VR and 360 degree camera technology into live theatre performance. Similar kind of technological intervention has been proposed in order to stimulate different notions of presence for audiences as well as assess how the presence of VR technology might shape and promote different forms of stage movement and address from performers [28].

During several periods of lockdown it has been necessary to adjust the broader research agenda leading to the current experimentation into the design of a 3D virtual theatre environment and examining its differences compared to traditional theatre environment. As professor Elleström reminds us, the "transfer of media characteristics among different types of media always involves transformation to some degree: something is kept, something is added, and something is removed" [10]. This paper addresses the experimental phase of this extension of our larger research project by inviting actors to perform from their personal spaces and integrate them into a virtual environment created using virtual reality software.

The initiative explored in this paper draws on the concept, technology and principles of virtual multiplayer gaming [8], in which players in different locations are able to converge and participate in real-time gaming in a virtual space. Although the notion of utilizing MMOGs appears to align well, the concept of virtual gaming is based on the real-time execution of predefined commands by the user. In the context of VR, factors such as restriction of movements often leads to perceptions of incomplete and disappointing VR experience [3] and seen as a barrier to immersion and act of self-exploration. To date, the greatest benefits from exploring the relationship between theatre and games have so far arguably come from adaptation and incorporation of game concepts into live theatre rather than the use of game technologies to host theatre. For example, embracing categories like 'promenade performance' and 'site-specific play' [17], immersive theatre has sought to increase audience members presence in scenes. As writer and journalist McMullan highlights, audiences are being "given bodily involvement in the action. Sometimes the audience is ushered from one place to another, sometimes they're allowed to explore the space of the play all on their own."

2 DIGITAL ADVANCEMENT IN THEATRE

In recent years, there has been a notable increase in the implementation of technology in theatre [5], however, the roots of current digital or technological advancements can be traced as far back as the early 5th century BC [12]. One such notable advancement to the theatre arena was the introduction of a crane to assist in the illusion of actor flight [12]. As an art form, theatre has demonstrated an openness to the introduction and application of technology throughout its history and evolution. Advancements in technology have been quickly been applied to update audience experience from lighting, sound (e.g., tracked and pre-recorded music) to set design (e.g., rigging, automation). Catherine Love, in writing for The Stage, highlights how today the 'blending' of video or CGI with live action performances have given stage directors "near endless possibilities to work with" [16]. Yet, for theatre to be able to continue to hold up its mirror to human experiences

ISBN: 978-1-950492-60-2
ISSN: 2771-5914

https://doi.org/10.54808/IMCIC2022.01.175

Mezzocchi (2021) has warned that it requires theatre to "stop making films during the pandemic" [19] and find ways to continue to practice.

Returning to the manner in which digital technology has played a role in enhancing the theatre experience and aiding audience imagination, a notable example is the 2D video projection technology has been employed by Timothy Bird of Knifedge [27]. In his collaboration with director Mitch Sebastian and lighting designer Ken Billington in a retelling of Pippin, Bird was able to create an immersive environment that places the audience within a virtual video game. As, Bird notes:

Theatre is different than working for a screen, like TV or film. What fascinates me is working with the projected image on 3D scenery, anything that is on stage, and mapping the images into places you don't expect it. I'm not as interested just in the animated image but also the physical space itself and how it supports the imagery helps communicate the storytelling to the audience.

In this way Bird does not seek to treat screens as separate from performance but maps 2-dimensional projections directly into and onto the stage set so performers can interact with, and respond accordingly.

The Virtual Theatricality Lab (VTL) in Henry Ford Community College, Michigan, USA is likewise seeking to establish itself as a pioneer and a "risk-taking institute that combines artistic and technological disciplines" [23]. In a re-working of Shakespeare's The Tempest they explored "3D stereoscopic projection and real-time VR navigated scenery to give new life and meaning to Shakespeare's classic and make it accessible to a new generation of theatre-goers." [24] In this same vein, the internet offers potential that requires exploration. As Lavender argues: "networked connectedness of people as a feature of temporal presence (or, being in the 'now'); its invitation to absorption and a form of immersion; its disposition to … personal presentation. All these lend it to the warp and weft of theatrical presentation, albeit through a medially distinct set of operations" [14]. Following these examples, the current research project also seeks to facilitate theatre performance via the application of Virtual Environment design and remote performance. The role of technology in the evolution of theatre was recognized by the practitioners participating in this research, providing support and rationale for the current experimentation:

Theatre was and is always evolving, because even during the earlier centuries of 5th century BC, they didn't have light, they'd just use daylight. And then obviously, with technology changes, they use candles, then stage lights and change the actual staging. Similarly, they used different props to create sounds, but now they can use recordings

The experiments outlined in this paper address initial steps in the application of Virtual Reality and 360-degree cameras within theatre performances.

3 PROJECT

3.1 Objective and Significance

The main objective of this study was to evaluate the impact of experimenting with site-specific theatre performance in a virtual space in which two or more actors are driving a performance from their own personal space. This improvisation in the application of VR as an assistive technology, is a consequence of the current global pandemic caused by Covid-19, that is shutting down productions, affecting livelihoods and removing cultural practices and events that support individual wellbeing [18]. Many industries and organizations have the option of allowing employees to work from home (e.g. via email, zoom or skype meetings). Like other professions, theatre needs to craft a space of its own. Indeed, the term theatre refers to a space for a group of people (a public) to witness presentation. Theatre as David Wiles suggests, "is pre-eminently a spatial medium, for it can dispense with language on occasion but never with space" [31]. How actors and audiences are configured in those spaces can vary considerably within live and site-specific theatre. The way in which the shared enterprise of theatre brings people together is preserved so long as the "present-ness derived not only from the presence of the performers but the affective engagement of the spectators (or indeed participants)" [14] is maintained.

While pre-recorded theatre works or performances can be viewed through online platforms such as Youtube or Facebook, immersion cannot be achieved through these experiences as they do not account for "the creative and constitutive role played by audiences" [1]. In an article exploring the value of 'liveness' in the current climate, Alice Savill cites Musical Theatre Director and Producer Adam Lenson, who comments: "We're just giving people more excuses to argue that digital theatre is just crap film" by promoting pre-recorded content [25]. The article identifies key elements missing from the viewing pre-recorded theatre include a) the 'power of assembly' (meeting point in time), b) 'wonder' that it is 'happening, right now' c) ephemeral nature of the moment and d) the possibility of interactivity and witnessing the live performance as a group (creating a shared experience). The significance of this study, is that it explores Virtual Reality which does possess the capacity to trigger immersion and interactivity as the audience and actors are virtually teleported to a virtual space [28]. This study aims to design the virtual space in order to provide the mood, tone and theme to the audience as well as the actors. The study does not aim to concentrate on the aesthetic side of immersion, mood or tone of the performance, rather the technical side of designing a virtual environment and its Possibilities for actors and audience.

3.2 Experiment Study

This experiment was designed to create a virtual space or environment using a VR game engine in order to evaluate the idea of producing a theatre performance within a virtual space. Creating a virtual environment from scratch is time-consuming, so pre-designed assets that can be constructed and customised to build a virtual environment (available via a game engine) were utilised for the current experiment. The space was tested with single and two character setup.

3.3 Procedure

A virtual environment was designed using the open source game engine Unreal Engine 4.0. Two virtual environments scenarios were created: 1) An environment in which the actor can move around and operate using the touch pad sensors on a wireless hand controller and 2) an environment in which the actor can move around and operate using a teleportation mechanism using the wireless controller. These test environments were employed to study and evaluate how having performers in a virtual environment changed or affected their performance. Both the scenarios revealed different results from the participating actors and this article reflects on those findings using a focus group interviews, which were conducted on the participants after their VR experience.

3.4 Virtual Scenario Design (Environment)

A virtual environment is a 3D modelled space created using 3D software: Autodesk Maya and Unreal Game Engine 4.0. The software provides certain tools and functionalities which aided the design of a functional virtual test environment. Since this study revolves around the idea of performers working within a virtual space, there were no requirements at this stage in terms of complex algorithms, coding or programming. A more important strategy was the identification and selection of a scene with narrative and context that prompted curiosity, connectivity, arousal, and social connection [4] between performer and audience. It was possible to 'build' a scene with practitioners by adding detail such as designing and placing properties within the virtual environment to support and situate the performer. Steps were taken to design and create a space, containing the necessary ambience, properties and lights for a scene to take place. The 3D designed scene consists of an interior theatre space, containing a stage, curtains, audience seating, textures and lighting to provide an experience of a traditional theatre space. This was constructed by, the chief researcher of this project, with the help of certain 3D modelling softwares and royalty free 3D models. Previous interaction with the participants, prior to the experiment and literature pointed out the fact that lighting, colour and textures would play a major role in creating a 3D VR environment and hence the priority and focus were concentrated on creating realistic textures to the models. The reality of environment is an important component to enhance engagement in digital mediums [4]. In order to enhance realism textures were collected from a theatre performance space situated at the Gallagher Academy of Performing Arts inside the University of Waikato in Aotearoa New Zealand. Upon designing the VR space the participants were allowed to explore the VR environment both statically or with free motion depending on their preference, in order to get the maximum experience.

3.5 Movement using Teleportation

This is a test scenario in which the actor/participants only movement was from a designated point A to point B. This is not a continuous or flow movement and the actor just vanishes from point A and reappears at the selected destination of point B, which can be anywhere inside the virtual space. This is a most basic form of movement tool used in VR softwares. Teleportation is proved to be faster than walking or touch pad sensors [13] and Bowman et al. found that instant teleportation is correlated with decreased spatial orientation [9]. The performers were provided with interactive objects in the environment and given the opportunity to first explore the space on their own. For the most part performers attempted to scrutinize the entire environment to assess how it might be incorporated or usable in the context of their performance. The program allowed the actor to perform certain interactions with the objects like pick up the interactive object, stack them, throw and catch them. According to Nield's definition [22] such objects and scenarios qualified the environment as a potentially "immersive theatre space". Nield defines immersive theatre as participants positioned inside an 'experience' rather than at an exhibition-within a tricked-out space with props as well as artefacts (2008: 531). This environmental setup also provides the necessary essence and idea for the larger research project that intends to allow the audience to have a presence on the stage using the VR gadgets in a way that they are not a hindrance for the actor or the performance. For example, viewing a performance from objects or props positioned on stage.

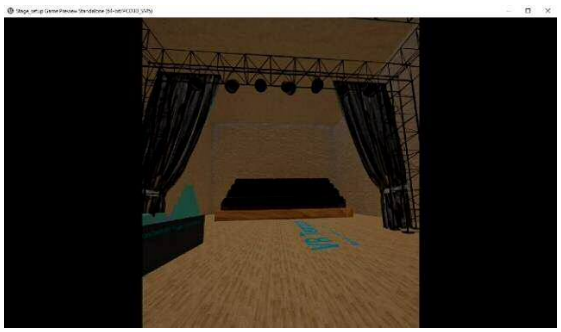

Figure 1: VR environment with teleportation.

3.6 Movement using Touchpad Sensors in the Wireless Hand Controllers Significance

This is the second scenario which has been edited for this experiment study. It is also designed with respect to Nield's definition of immersive theatre space. In this environment the actor is able to make fluidic movement inside the defined space using the touch pad sensors in the wireless controllers. The movement of the character inside the space (moving front, back and sideways) are controlled by the touch pad sensors, however in order to turn and look in any specific direction the actor must use his or her HTC Vive head controller. The performer was provided with similar exploration time. This scenario is different from the previous one as it involves fluidic movement of the actor from point A to point B rather than just teleportation. This helps in the continuity and flow of the entire sequence, but with the limitation of using the touch sensor for the movement. The fluidic movement of the actor in the space potentially offers more immersion as the performer is able to connect their touch pad movement to the virtual movement however they are confined seated in one single place in the physical space, restricting their natural movement. This test can be viewed in a positive frame of mind because it shows that movement and interaction in a virtual space is not reliant on the body of the performer to be able to move in a particular direction, this has potentially unrestrict the performer from any physical contraints (e.g. injury) and can use this type of scenario for their own advantage. This is a just branch of one possible outcome in a way VR can assist people with regards to disability who can still chase their dreams in the field of theatre and acting.

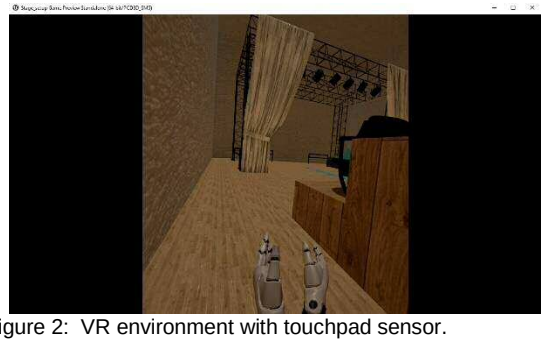

Figure 2: VR environment with touchpad sensor.

3.7 VR Experience and Focus Group

The designed VR environment was tested with participants who are associated with theatre (practitioners and actors) as well as regularly theatre audience members to achieve a better understanding result and outcome. The health and safety protocols such as fire hazard, clarification about visual, auditory issues and

motion sickness associated with the VR experiement, were maintained during the VR Experience and Focus group session as per the ethical norms

The participants were briefed with instructions about the aim of the project, how to use the VR equipments, what to be expected and about the gadgets involved for the experiment. They were allowed to experience and free explore the virtually designed 3D theatre space. The experience was not documented and instead they were asked to participate in a focus group after they finished the VR experience.

4 FINDINGS

The focus group was directed in such a way that the participants' understanding of Virtual Reality, theatre performance, its evolution, comments about this particular experience along with the future enhancement and its possible applications were discussed. The idea of digital enhancement being a great improvement for the theatre performance itself [27] was acknowledged by the participants in the focus group, for example:

Theater was and is always evolving, because even when they began, they didn't have light, they would just use daylight. And then obviously, with technology changes, we use candles, then stage lights, we changed the actual staging. We changed how things were set with like seats, affects us and different technology now.

An interesting perspective was put forward by one of the participants that the theater in itself is intrinsically classist and in the present time theater has become a bourgeois activity while cinema has become more of a thing for everyday folks, when hundreds of years ago theater had that role. This statement can be supported by the findings of Aleksandra Wiśniewska et al [32]. Their findings state that cinema which has substantially higher viewers compared to theatre, contributing about 215 million EUR more than theatre productions. The use of VR highlighted a tension between increasing accessibility and popularity whilst maintaining its status as a high art form. However, the experience of engaging directly with VR in this context provided a more balanced response from participants than maybe solely interviewing practitioners. This would have run the risk of a more negative evaluation of VR to preserve the status of the medium.

From engaging with VR participants expressed very positive thoughts about the VR design of this experiment, the textures, colour and the lighting made the experience feel more in-context and added an immersive element to the VR space as a performer. Color and lighting of the environment seem to have an impact on peoples' affect and behavior [26]. Therefore the detailing in the design of the VR theatre space was given top priority, since realism is an important component to enhance engagement in digital mediums [4]. In order to attain the maximum possible immersion (which will create the feeling of real environment in the participants' mind) audio and visual interactions must also be given the same priority as the visual textures and lighting. Scholars Anıl Çamcı and Rob Hamilton emphasize the importance of every digital possibility (hardware, software, visual, audio and human perception) together can encapsulate the nature of how VR will evolve [6]. Similar observation and comment was also passed on by one of the participants stating the VR environment can be improved to better quality if there is some ambience theatre sound, along with sounds of footsteps. In addition the movement inside the VR space was also criticized stating that the process of traveling from point A to point B is not as effective as walking through. It deteriorates the immersive experience and the essence of being in a theatre stage. A participant stated :

When I see a stage, I want to kind of walk normally. And using the buttons it's not organic. So teleportation did not make you feel like it's a smooth transition.

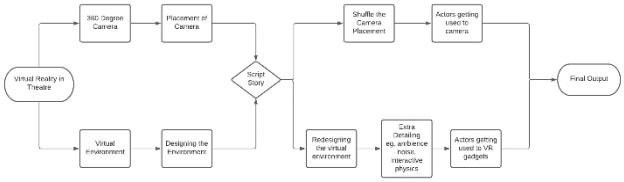

Figure 3: Production blueprint for a VR assisted theatre.

This project has helped to develop a basic understanding for the production pipeline for a theatre production assisted by Virtual reality. It is explained in the figure above. This research has also pointed out the importance of an effective coherent story and narrative to keep the audience engaged, curious and connected with the actor [4].

4.1 Impact of VR on Actors

The virtual environment designed for this experiment study was tested with the participants exploring the space to gain the insights from an actor's perspective in order to understand how virtual environments can be modified or designed to suit the needs of a theatre performance in general. Though the environment was designed using a game engine, this research study analyzes the environment as a virtual theatre space and the character as an actor. Since the participants were required to move physically in order to explore the VR setup, they were provided with a rotating chair, so that they can comfortably access the entire 360 degrees. The participants did find the controls and navigation to be simple and user friendly, however the physics inside the VR environment was a tricky to get around in the beginning. One of the participants stated:

I wanted to play with the interactive blocks and create absolute blocks, but at the very beginning I got confused why I can't do that. I didn't realize that just because I put one block into another one.

Both the scenarios give out new and different findings & perspective about the application of VR. The teleportation environment was considered a basic virtual immersive environment for the actor and the movement was binary from point A to B. Although it did not help in the fluidic transition it was interactive, immersive and it can be better compared to having the actor docked to a single point in the environment where they do not have to move and just deliver a monologue. It can also be considered for the use of having the audience use this docked position and view, experience and immerse themselves in the play. This style of play was tested by James Martin Charlton & Magnus Moar [7]. However they state that engaging the audience in such an invisible perspective, will have them ghosted and the audience will not be 'in' the play. This statement can be argued enough if the entire play is being devised around a static object and the audience is able to view the entire play from the position of the static object. This scenario can still be under consideration for application and would definitely suit many devised theatre performance.

Similarly the second scenario of providing the actor with touch pad sensor has a different application impact, which is a novel idea and finding from this particular research study. The use of touch pad sensors to move in the virtual environment does provide immersiveness and interactivity to the actor or participant who is actually being seated in a chair (in the physical world). Physically the participant/actor is denied his or her motion of legs but in the virtual environment he/she can walk or run anything inside the VR space. This is a very novel idea of applying this technology in the theatre spaces to the people who have temporary or permanent disability. Fidelity is integral in design decisions to enhance the realism of the experience[30]. The fidelity in designing the VR environment is important for the actors to experience the realism and the immersion of the same environment.

4.2 Impact of Virtual Scenarios in Theatre Performance

Virtual reality and its application can afford more than just the gaming and immersive experience. If these affordances are exploited in their right context and if the theatre performances are devised as per technological necessities, it can result in a unique form of immersive theatre experience. Since 2000 Punchdrunk has pioneered a game changing form of immersive theatre in which roaming audiences experience epic storytelling inside sensory theatrical worlds. ("Punchdrunk", description on the Sleep No More New York website). Audiences can be easily placed inside the virtual environment and the technology also provides the option to have the audience invisible or visible to the actors. The importance of the audience has always been a theatrical truism [3]. The main essence of this research study is that neither actors nor the audience are required to be physically present in any common space, yet they can experience the feeling of togetherness. Rose Bigging in her book explains the act of immersion and immersive theatre as the audience and performer sharing the same space; presence is merely the act of being present for the gaze of another. [3]. Virtual reality can afford the application of projecting the actor or audience as a character designed specifically for the environment or with finer investment and research it is also possible to have the projection of the audience in order to achieve a better sense of immersion.

Virtual Reality has been the experimental medium for more than a decade [2]. It has been applied and used as an assistive technology in many fields especially in the gaming industry. This project is a predecessor for the idea of implementing virtual reality in the field of theatre performance. Nevertheless the idea of this research is to slowly and gradually experiment virtual reality in the theatre medium, which is why the entire idea of using VR as an assistive technology in theatre is being broken in smaller research studies and experiments. The entire aim or focus of this research study is to assess the effectiveness and impact of using a virtual environment as a medium to bring the actors and audience together virtually at the same time keep them physically distanced from each other. In this particular study the actor is allowed to experience two virtual scenarios as mentioned previously. The test experiment and the scenario is very preliminary and low budgeted, the actor/participant is provided with VR gadgets like an HTC vive and two hand controllers. They are restricted to a confined chair and the movement in the virtual environment is controlled using the hand controllers only.

5 CONCLUSION AND SIGNIFICANCE

The overall takeaway from this experimental study is that how VR assist theatre production and performance from the perspective of an actor, who is an integral part of show and production. It helps to mimic the idea of immersive theatre with the application of virtual technologies and gadgets. Any actor who is performing in physical or virtual space and if they are acknowledged or felt immersed in the environment is a successful performance, since actors thrive on the audience and the interactions between themselves [20]. This same technology can be applied on the audience to have them virtually present in the performance, by which they qualify as an active participant through the actors acknowledgment and the immersive experience provided by the VR technology.

The other outcome of using a scenario based on the idea of using touch pad sensors in hand controllers for virtual movement is quite debatable due to the effectiveness of being confined in a static chair and being able to move around the virtual space is quite tricky and contradicting for the mind to read and get used to. However this experiment scenario did help in finding out that this idea of virtual movement using the touch pad sensors can work for certain specific or devised plays or performances. Also it can be effective for certain types of actors and audiences who dream of experiencing or be a part of the play but limited due to their physical or mental illness.

The aspect of voyeurism in the VR version of Fellow Creature brings into play the notion of touching things which do not belong to the viewer. This points towards Dixon's dreaded VR porn dystopia. But the voyeurism of Fellow Creatures is part of a basket of affects and purposes. In watching the drama as an invisible presence, the viewer can consider the meanings and implications of the scene in which they lurk. We move away from the fields of pornography and avaricious desire, towards art's abilities to encourage those encountering it to think, to feel, to consider, to empathise, and to wrestle with the existential problems of human life. In De Officiis, Cicero refers to Plato's use of the story of Gyges and suggests that a good person would not use invisibility to wreak evil, as they possess moral rectitude. We do not have to accept Cicero's neat division of humanity into those with moral rectitude or without seeing that VR offers us a means of invisibility which can be used for the creative and democratic purposes of art.

6 REFLECTIONS

Evaluating the experimental study from the perspective of a media technician it is fascinating to explore the affordances Virtual Reality can bestow on theatre medium. Video calling, skype sessions and zoom meetings have shrinked the world and reduced greater distance and made the world a better place during the present crisis of COVID. Similarly Virtual technologies and the softwares has the potential to do similar achievements in the field of theatre and performance. There are research institutes and laboratories who are keen to invest in this modernistic idea of VR application in theatre performances and this experimental research study would serve as a benchmark for the future exploration of Virtual theatre performance, which could be a new branch of theatre production. This also gives rise to the possibility of rendering environments in 3D and projecting them in real theatre space or vice versa, which will be researched in the successive experiments of this research.

This project also provides the opportunities for bringing theater to others, rather than providing opportunity for gamers to get into a theater space. It can be valuable for people living in isolated areas so that they can easily watch a production company conducting performance in a major city like Auckland or Wellington while they are physically present in Gisborne. In addition it can also be useful for people undertaking long hours of travel in bus or train or in an

aeroplane, where at least 4 out of 10 people would be keen to try the experience during their travel.

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Chapter 5 Actors and Audience Reception of 360-degree camera on stage

5.1 Introduction

This chapter is an extension of previous chapters, building upon the theoretical framework of audience virtual teleportation onto the stage. It implements practical installation setups of VR and 360-degree cameras to further explore how these technologies can enhance and complement the actors, audiences, and overall theatre performance. This chapter presents two articles, one article that at the time of writing is *in press* having been reviewed and accepted[2] and the other article remains "under review." Both focus on actor and audience experiences with the application of 360-degree VR technology. They explore the intricate relationship between VR and theatre performance, with a particular focus on enhancing the experiences of both audiences and actors.

This thesis has already identified synergies between VR and theatre performance (see Section 2.2). Through practical experimentation, the two articles aim to further explore and demonstrate these synergies by hosting a dramatic VR theatre performance involving participants, including actors and audiences. The experimental process is complemented by participant interviews, which serve as crucial evidence supporting the previously established connections between VR and theatre. These two articles play a significant role in the overall progress of the thesis, as they contribute to the ongoing development and validation of the ideas presented in Chapter 2. My primary research goal was to adapt VR applications by extending their application beyond traditional fields like film experience, games, education and training. However, with the progress of the thesis, in each article it became evident that VR and theatre

[2] NOTE: The first chapter which was *in press* at the point of thesis submission was then published during the examination period of the PhD.

share a harmonic connection. It provides the performance medium with an endorsed sense of immersion, visualising story elements and offering changing viewpoints. The vital focus of this application is how the audience can be provided with numerous points of view that impact the manner in which stories or narrative experiences differ as the audience's virtually experiences align with different characters throughout the process.

The first article in this chapter is titled: Virtual 360-Degree Dramatic Theatre: A New Branch In Experimental Theatre (in press) submitted to ICVARS 2023 conference. This article is the experimental phase of the theory put forward in the previous articles (See Chapter 3). Drawing from the primary focus of this thesis, it explores "remote viewing" for the audiences using VR, this article explores and experiments with applications of VR from a theatre actor/performer mind-set. This article also focused on the importance of visual and auditory cues and how it helps the participants to focus and follow the VR dramatic performance (Cidota et al, 2016). Motivated by the desire to explore the integration of a 360-degree camera on an actor's head, the research journey involved collaborating with theatre performers. Despite the challenges posed by COVID-19 and its associated lockdown restrictions, I persevered through constant rehearsals, experimentation, and investigation. While the restrictions were still partially in place, it was possible to work with a limited number of participants, adhering to COVID-19 protocols such the use of face masks and physical distancing. Three theatre actors joined me physically, while the live-streaming capabilities of the 360-camera setup allowed me to engage with ten audience participants. Two audience participants were able to attend the post-performance interview in person, while the remaining interviews were conducted remotely using online platforms like Zoom. These collaborations were meticulously planned and scheduled well in advance, with initial arrangements made in late 2019 before the global pandemic disrupted my plans. Despite the setbacks, I successfully connected with the participants, both actors and audiences, in February 2022, marking a significant milestone in

my research. The experience as a media technician was both interesting and exciting, involving the implementation of innovative production ideas that seamlessly worked together in synchronization. It provided a valuable learning curve and opportunity to explore new approaches in the field.

The second article in this chapter is titled: Existing Offstage Yet Onstage: A Novel VR Theatre Experience (under review) submitted to the *International Journal of Performance and Digital Media*. In contrast to the first article that primarily explored the production of a dramatic VR theatre and gathered actors' perspectives on the use of VR in theatre, this article shifts its focus towards the audience experience. It delves into the opinions and experiences of the audience members who engage with theatre performances through VR technology. In this article, the audience were placed/located in the centre of the project. The audience were provided with Google Cardboard in which they placed their smartphones and view the VR Dramatic theatre from their personal space. This article is inspired by Charlton and Moar's (2018) experiment with 360-degree cameras on stage. By reading Charlton and Moar's work, it was evident that they were focusing on exploring the voyeuristic nature of spectatorship and how it evolves when the audience attains closer proximity, all while maintaining an undetected presence. shared by VR and theatre. I was interested to explore the compatibility between VR and theatre and what possible theatre genre branches with this assimilation. My exploration of VR applications attained its apex with this article since the outcome of the article produced the concept of VR Dramatic theatre, referring to theatre that can be produced online, and offline (in person) using VR installations, along with the cost-effective hardware (Google Cardboard). These two articles provide experimental verification of the compatibility shared between theatre and VR.

In addition to conducting analysis and interview transcription for the article, I also examined the visual patterns of the audience during their experience of viewing the VR

dramatic theatre. I observed several common patterns in how the audience used their VR headsets and focused on specific areas of the stage. For instance, during the opening scene where Leo runs through the pedestrian signals, the audience was engaged in locating the source of the pedestrian signal sound. This observation suggests the potential placement of a digital traffic signal that the audience could view through their VR headsets. This concept further highlights the possibility of incorporating digital properties and characters to enhance the audience's viewing experience. When questioned about their perspective on adding digital properties and avatars, the majority of the audience responded favourably to the idea. They expressed that combining visualizations with ambient sounds would create a more immersive experience. For example,

> If a character steps on the floor, opens a curtain, or throws a brick, having both the ambient sound and visual representation of the action would provide a more precise understanding for the audience. (a response not included in the research report but shared here)

These findings demonstrate the audience's interest in exploring the intersection of theatre and technology and transforming the actors' performances into a more advanced art form.

One other argument that can raise from this proposed idea is how can this application make it less similar to VR games. This is a very fair argument, and it needs to be addressed. VR games, be they single-player or multiplayer are often based on a first character's POV. Hence if a player tries to play the VR game a significant number of times, he/she will be playing and experiencing immersion and interactivity from the same character's POV. The incorporation of 360-degree VR into theatre allows the audience to experience immersion and interactivity from multiple perspectives. They can experience immersion and interactivity from any character in the performance or even a static object's POV. This breaks the limitations of

single-dimensional interactivity found in VR games and introduces the audience to a captivating world filled with numerous possibilities.

Furthermore, when observing the audience's visual patterns, it was evident that many of them had difficulty noticing the lead actor (Leo) playing the guitar. The placement of the 360-degree camera on top of the actor's head obstructed the view below, leading the audience to search for the source of the guitar music. Additionally, the audience tended to avoid direct stage lights as they caused glare, affecting their visual experience. These patterns highlight the need for specific applications, such as designing and placing digital properties and characters, to fully harness the potential of VR viewing. Overall, this research points towards the future direction of incorporating digital assets alongside the 360-degree view to enhance the VR theatre experience.

Virtual 360-Degree Dramatic Theatre: A New Branch in Experimental Theatre

Saikrishna, Srinivasan
PhD Research Candidate, University of Waikato, New Zealand
sks61@students.waikato.ac.nz

ABSTRACT

This paper is about the development of an experimental project that focuses on discovering a new possibility in theatre performance and production using the application of a 360-degree virtual reality camera. The focus of this paper is on how a fully functional virtual theatre production can be achieved and translate the audience viewing experience into VR first-person experience. This paper discusses the technical and production aspects of the new experimental virtual theatre. The technical setup of the experiment and devising the performance in accordance with the technology and vice versa are discussed in particular. From a technical point of view, this paper explores if experimental theatre can stand on its own as a new branch in theatre or just be a part of traditional performance. This research experiment is a part of a larger project encapsulating the idea of the application of Virtual Reality technology into theatre production and performance.

CCS CONCEPTS

• **Applied computing** → Arts and humanities; Media arts; • **Computing methodologies** → Computer graphics; Graphics systems and interfaces; Virtual reality.

KEYWORDS

Google Cardboard, Theatre Performance, Remote Performance, VR Theatre

ACM Reference Format:
Saikrishna, Srinivasan. 2023. Virtual 360-Degree Dramatic Theatre: A New Branch in Experimental Theatre. In *2023 the 7th International Conference on Virtual and Augmented Reality Simulations (ICVARS) (ICVARS 2023), March 03–05, 2023, Sydney, Australia.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3603421.3603425

1 INTRODUCTION

Digital applications are used in various fields and mediums at the present time. The COVID-19 pandemic and lockdown restrictions have impacted every field, requiring industries to develop creative ways to conduct their activities. The field of arts and theatre is one of the areas impacted and needs to find new ways to conduct its activities during the pandemic [8]. This project brings in the idea of assimilating the affordance and application of VR 360-degree camera technology into theatre performances and investigating if this assimilation enhances both VR and theatre performance. This project focuses on using VR 360-degree camera as a means for viewing live performance from a remote location and exploring the possibilities if it can stand alone as a theatre genre or be used as a mixed element to enhance a story or performance. This project would fit under the experimental branch of theatre, because of the implementation of VR 360-degree technology into a theatre performance. Through this project, I argue that there is a very close resemblance between Virtual Reality and theatre. Reney adds value to this similarity by stating VR and theatre both offer fleeting, metaphysical experiences and create fictional worlds in which hypothetical concepts can be given perceptible form [28]. This paper discusses the various technological investigations, tests and problems encountered during the seamless integration of 360 VR integration into the field of theatre. Integrating creative technologies into performance arts has been tested and implemented in a variety of areas, with more than 90% of the integrations being successful. However, creative and VR technology is used only to a minimal extent in most cases and not to the performance itself [32]. To date, there seems to have been little interest and investment in VR technology in theatre, due to higher cost and hardware investments. This paper bridges the integral gap between technological investments required for the virtual 360-degree dramatic theatre and the importance and cost-effectiveness of VR headsets (Google Cardboard). In order to overcome the existing integration model of Virtual reality into performance arts and to accommodate the growing concept of the metaverse, several methods of tests and trials including recording the actor's interaction with the 360-degree camera, and interviews with the actors are employed. It is also followed by the lead actor and fellow actor's comments on their own recorded footage with the 360-camera.

2 THE EXPERIMENT

This research experiment aims to use a 360-degree camera on an actor and allow the audience to watch the performance through a Virtual Reality headset, or their smartphones and google cardboard. It focuses on analyzing and exploring the application of VR as a means for viewing live performance from a remote location and how it affects or induces any change to performance. A considerable amount of literature has been published on the application of VR in theatre. Pioneer in this topic, Mark Reaney points out that there is a wide range of possible outcomes with this integration [28]. However, he worked on the basic idea of using virtual reality as a Scenographic tool, to reduce the use of labour-intensive instruments and the time required to design the stage props. Arguably, Reney's integration involves the idea of using Virtual Reality as a

ICVARS 2023, March 03–05, 2023, Sydney, Australia

ACM ISBN 978-1-4503-9746-9/23/03…$15.00
https://doi.org/10.1145/3603421.3603425

scenic medium in itself with the use of projected visual settings. Furthermore, the majority of the research has tended to focus on exploiting VR as a design tool for performance or interactive medium. Other studies in the past have considered the idea of applying VR as an interactive tool for performance narrative, for example Laurel, Murray, Cline, Toby Coffee Nation theatre, Christiane Paul [6]. A comparative study by Charlton and Moar on a nearly similar set-up of having a 360-degree camera on the stage examined the shared voyeuristic quality of both VR and theatre [6]. This research experiment is different from the above-mentioned scholars' idea for VR integration. Through this experiment, I propose to apply VR as a means for viewing live performances from a remote location. It also focuses on providing the audience with a view of the performance from the position of the actor, since the 360-degree camera will be mounted on the actor's head.

Besides exploring the affordances and effects of VR 360-degree cameras on the actors and on performance, I have also investigated the technical difficulties and parameters associated with the camera, required for the integration process. This Virtual Reality theatre experiment was planned to be conducted in a black box theatre using a 10 minutes performance written exclusively for this experiment named *Barefoot on Queen* by Mel Martin Booker. The entire set of technical tests is conducted in a black box theatre space. In order to set up the performance and introduce a 360-degree camera into the performance, I use *'practice as research' [24]* to explore the application and technological scope of a VR 360 camera placed on the actor during the performance. This methodology has a number of advantages, such as allowing us to document the different ideas that are implemented to address a problem, find things out, establish new insights [Robert Nelson], providing various new ideas and tests. Every test and trial has been documented and it has produced different results. These tests were done from a media technician's perspective, like experimenting with the exposure of the camera, lights and the function of the lights. The exposure of the camera, being the essential parameter can be adjusted and experimented with using the camera settings: ISO, Shutter speed and Aperture [15]. These parameters are varied and tested in each assessment. Similarly, the basic parameters of stage lighting viz. intensity and colour direction of the lights were also varied and tested. Evaluation of these parameters resulted in many permutations and combinations in which the best possible visibility, atmospheric mood, image quality and narrative were identified and established. Every trial was compared against a standard camera recording placed from an audience seating to tune and match the same quality.

2.1 Setting up the Experiment

Rogers states that the theatre industry has been experimenting with creative technologies like Virtual Reality and Augmented Reality in the past decade [29]. Some of the examples are the National Theatre, Royal Shakespeare Company, SOMNAI, ARShow, Cosmos Within Us and The Under Presents [29]. These production companies have started experimenting with VR inside the theatre. The National Theatre, in particular, reports that the results have shown that 94% of their audience feels that this integration is a positive step in theatre and increased their expectation of experiencing VR in theatre more. Along similar lines, this experiment is focused on exploring the technical parameters, their enhancement and difficulties associated with the performance from an actor's and technician's perspective. Since this experiment is primarily focused on the use of a 360-degree camera on an actor and explores its application and affordances on the actor as well as on the performance as a whole, structuring and setting up of the 360-degree camera technology for theatre is very much significant. The experiment was structured and devised around the actors' rehearsals. It is a 10 minutes performance and consists of three main or lead characters, which made the rehearsal trials and devising of the experiment flexible. The director of the performance, who was also one of the actors Kate Martin Booker played a significant role to help in devising the performance according to the 360-degree technological requirements. This experiment has equally explored both VR and theatre against each other. The results and the process show how complementary VR and theatre work with each other. This view is supported by Reney who argues that VR and theatre have remarkable similarities [28]. They can be considered more of an ally, coordinate and fit like a jigsaw puzzle. The participants did reflect on the similarities between VR and theatre. For example:

Something about theatre that really blew me away was having the audience so close to me. I could see them. I could feel their presence. It has an impact on you when you're performing. This is also the same driving force in VR.

Finalising the system architecture was the critical part of the experiment. I had to work on combining the architecture of standard camera live streaming and 360-degree camera live streaming, to make it accessible enough for the viewing audience. The initial architecture was planned, revolving around Open Broadcaster Software (OBS) [18]. It is the standard and commonly used free/open-source streaming application. Hence the idea of merging the traditional camera feed from the audience position and 360-degree camera feed from the actor's head/shoulder through the OBS platform and live streaming it into YouTube or Facebook social media for audience consumption was determined. Though this framework implies a simple theoretical architecture, it had a few practical shortcomings viz.

1. The 360-degree video feed will be flattened when processing through OBS, giving up the 360 panning feature.
2. OBS combines the two video feeds and mixes them into a single output stream by laying them adjacent to another, making it difficult for the audience to watch.

In order to overcome these shortcomings, I had to break up the architecture for the two cameras and stream them separately. In fact, this process made the technical setup required for the architecture less complex. The traditional camera which was placed on the audience seating followed a very basic architecture for live streaming with the help of the OBS application. OBS has a variety of helpful functions such as real-time capture, scene composition, recording, and broadcasting through the Real-Time Messaging Protocol (RTMP) [18]. RTMP is widely supported by a wide range of streaming services, including YouTube, Twitch, Instagram, and Facebook and is a very useful feature for the audience. It helps the audience to emphasize their comments and feedback in real-time.

Having said that, this real-time feedback does not reach the performers/actors in this particular experiment, since it is difficult for the performers/actors to access the comments during the performance. Arguably, academics have stated that this lack of audience interaction or energy, is one of the reasons which makes VR and theatre differ from each other [3]. The actor/participant did mention the idea of the importance of a live audience in a theatre. For example:

Performing as a theatre actor is all about steering a reaction in the audience. That's causing them to have an emotional response. I'm moving my emotional experience toward the audience. In return, we are feeding off their emotional energy and reactions.

At present, the lack of live audiences is definitely a shortcoming of using VR in theatre performances. However, this can be overcome in the future with the application of digital displays on the walls around the stage, so that the performers can watch and thrive on the live reaction of the audience [30]. In future, it is also possible to apply innovations like hand held haptic controller systems in which the audience can interact with the actors and the actors can acknowledge those interactions. There are examples and prototype systems developed to achieve real time feedback between the performers and the audience like Pamungkas, D S. & Ward, K, Ko et al and Abidi et al [1] [17] [25]. In particular Ko et al propose one such prototype system in which the character/actor can extract the user interaction and requirement effectively using a haptic feedback system [17].

Designing the architecture for the 360-degree camera live streaming was a complex and critical part of the research project. I used an Insta-360 One X camera for the experiment. Though it was a better choice of hardware compared to the previously available Nikon key mission 360 (), constructing an architecture for live streaming the performance from the actor's head was challenging. The Insta-360 One X camera required a specific connector cable (Android Transfer Cable) to a smartphone, through which the live streaming feed can be broadcasted [9]. Upon purchasing and using the android transfer cable, there were successive shortcomings like the short length of the transfer cable. Raising an issue on how or where should the smartphone be positioned on the actor, so it does not affect the actor's performance. It also needed to be positioned in such a way that the setup is simple and optimal enough to operate. The whole process of setting up the architecture was like a triggering maze, overcoming one obstacle, and opening the door for the next challenging obstacle. In order to overcome the drawback of the shorter cable length, I had to use two rigs on the actor. Nowadays camera rigs and improvised properties are popular and used commonly by any film or movie artist in order to aid the production process [19]. Similarly, two camera rigs were fitted on the actor/participant viz., the Head camera rig and the Shoulder camera rig. The head rig was assigned to fix the Insta 360 X camera and the shoulder rig was assigned to fix the smartphone, hence it is easy to be connected using the shorter android transfer cable [Figure 1].

2.2 Devising the Experiment

In the book, *Guide to Filming Live Theatre*, an overall explanation and guide for archival filming has been elucidated by Noelis Marquez et al [21]. Marquez stated that there is no single method to film

Figure 1: Camera rig prototype.

or record live theatre. However, if the entire process is planned and devised as per the needs it can maximize the quality of the work. In line with that, Katrina McPherson [23], author of the book *A Step-by-Step Guide to Creating Dance for the Screen*, also argues that every performance (music or film or dance or theatre) has a different starting point from others and that devising a pre-production plan is very much essential to develop one's work in any particular direction. This project has taken inspiration from the above-mentioned academics and I have worked along similar guidelines to plan and schedule the entire process. This project also modifies the technology and the performance to complement each other. During the experiment, it was evident that theatre actors/participants were happy to devise and improvise their actions in accordance with the 360-degree VR technology in order to produce a good output. For example:

It's those little things that are so important to your stage acting. It's like when you walk out on stage and stand in a different position blocking the lights, and you're in a position you should not be moving for the next 2 minutes, you use your eyes or your little eyebrow raise to be like, bro, like, I need help. Either the fellow actor or the technician improvises and covers for it.

Despite the improvisations and devising actions during the rehearsals and performance, the entire architecture and schedule were planned well in advance in order to get the best quality of work. For this experiment, I recruited two actors and one other person who acted as an actor as well as the director for the 10 minutes performance. The actors participated in an interview (including both open and closed ended questions), once the rehearsal and performance was finished. Being a media student and the researcher of this experiment, I was in charge of the technical requirements and lighting setup. The performance was rehearsed and staged, keeping in mind that the number of audience members was small. The set properties were minimal, however, aluminium rods and glow-in-the-dark sticks were used as visual cues. The visual cues proved to be vital as they guided the audience on where the staging area was located and does not make them feel lost in the vast 360-degree field of view. Jacqueline M. Fulvio states that visual cues are an important factor in a Virtual Reality environment, as an observer can learn to unlock the information contained within

specific sensory cues, using visual feedback [10]. The rehearsals and performance did not have any live audience and the 360-degree camera was placed on one of the actor's heads. This places the audience in the shoes of the actor and watches the entire performance from the actor's position. This type of performance is different from traditional theatre performance (proscenium, thrust or arena) and only a few have experimented with 360-degree camera in theatre. Charlton and Moar have recently experimented with a 360-camera in the centre of the stage, placing the audience inside the stage [6]. However, in this experiment, I try to take a step further by bringing the audience inside the stage and having them watch the performance from the position of the actor. Charlton and Moar also talk about how difficult it is to hide the crew and lightning rig since this is a 360-degree view. In order to curtail this issue, I propose to direct the audience toward the staging area with the use of sensory cues. Furthermore, this experiment wants the audience to watch it from the actor's position. The actors are always prone to have lights and glare directly on their faces, hence I did not attempt to hide the crew or lighting rig.

The rehearsal schedule was planned over four weeks with ample time to experiment with VR and theatre performance, devising them together for a final Virtual 360-Degree Dramatic Theatre. The rehearsal process reflected a filmmaking production style approach. I had to work with the lighting setup, light intensity and direction and camera settings, similar to a film production style to investigate the optimal parameters. This is one of the very first approaches in experimenting with a camera as a prop on the actor's head. Recent developments in theatre performance suggest that most theatre performers are required to wear extra props like face masks and body mics [19]. Natalie Koking, writer and storyteller reported on *The camera in the theatre: Staging a show for film* that the face masks used by the actors were improvised into cloth masks painted with a neutral expression. The actors did not find any problem with the masks and embodied physical movements to express their emotions instead. The participant actor with the camera on his head, for this experiment, stated a similar statement. For example:

As a theatre actor, I should be able to perform with the properties of myself and my costume. As long as the camera is firmly attached to the head rig, I do not think it will affect my performance and I would not worry about wearing it [2].

Other actors were also thrilled with the use of the 360-degree camera in the performance. The camera did not distract the other actors from their performances. Though in the first few rehearsals, it was noted that the actor with the camera was performing with caution making sure that the camera does not collapse onto the ground. After a few rehearsals, the actor was confident about the camera and shifted their entire concentration on their performance. For example:

In the beginning, I was worried that the camera might fall off my head rig. I restrained myself from running faster. But later on, I found that the camera was firmly fixed by a screw-type frame, making me get used to it and I even forgot that I had the camera fixed onto my head.

Figure 2: Actors rehersal with the 360-degree camera rig.

2.3 Devising the Experiment

The primary focal point of evaluation for this experiment is if Virtual reality can be assimilated into theatre performance using a 360-degree camera and examining the possibility of this particular assimilation from a media studies perspective. This evaluation is extended by examining the exposure of the camera, lights and the function of the lights using camera settings like ISO, White Balance (WB), shutter speed, Aperture and Exposure Value (EV) in accordance with a theatre setup and performance.

With the current rise in the popularity of *metaverse [*34*]* and other technological developments, it is high time that theatre and art performances need to strengthen for the competition. This experiment is an attempt to incorporate VR into theatre space with a precise amount. The affordability and standard of the present-day broadcast media and VR could raise a few difficulties with the implementation of 360-degree cameras in theatre [6]. Some difficulties faced would account for the recording quality of the camera. This issue was encountered at the start of this experiment, due to which I had to switch from using a Nikon key mission camera to Insta 360 one X camera. Since there was no opportunity of having a live audience during the execution of this theatre experiment live streaming was chosen, which resulted in the constant issues of loss in quality. Broadcasting a live stream with the help of a normal camera in general encounters a great deal of hardship due to loss in quality in a standard network or WiFi signals [27]. Experimenting with the same live streaming using a 360-degree camera increases the streaming rate since there is more information to be transmitted than a linear HD video frame with a 16:9 aspect ratio. Even with all these technical difficulties, the 360-degree camera selected for this experiment was able to broadcast reasonable quality video with a stable quality network or WiFi.

Two cameras were tested for this experiment viz., Nikon key mission camera () and Insta 360 one X camera (). The KeyMission 360 camera was released in 2016 and was popular for a few years but it did not possess the required features for this particular experiment. For example, The KeyMission 360 requires the user to download the SnapBridge application, on the user's smartphone to access the camera. Though it provides the impression of being a simple setup,

making a connection to the camera from our smartphone was very difficult and most of the time there were connection issues [26]. It also raised two other major issues. One of them was that the user will not be able to view the footage when the camera is recording, causing a major inconvenience for the user. Secondly, it lacked the feature for live streaming, which directly eliminates the camera for this particular experiment. On the other hand, Insta 360 One X provided a lot of features that were vital for this experiment. It was released in 2018 and is considered to be very user-friendly [26]. Although it required a similar method of operation to KeyMission 360, an application from the play store or apple store *Insta 360 application* was required to access the camera [14]. It was much simpler to use, record and modify. One feature that was unique and advantageous was that it used cloud storage to store the recorded footage, making it easy to download the video wireless [14]. Hence there were no issues with recording a number of footage and saving them for future use. In addition to all these features, the Insta 360 application provided a few more additional features like real-time stitching of the 360-degree video footage and assisting with the live streaming video footage.

The application also provided an essential feature which was more accessible than other 360-degree cameras - Controlling the camera using the features of ISO, White Balance (WB), shutter speed, Aperture and Exposure Value (EV). In hindsight, these settings became vital and pivotal for the experiment's aim. In film and media, the placement of the camera and the camera angle play a major role in conveying a story to the audience [15]. However, this is where the experiments deviate from the film & media genre and adapt to the theatre genre. The theatre performance is a single-take performance, hence I cannot experiment with multiple camera angles and editing cuts. Hence, it would render the output as a single-take film recorded in theatre-style performance and lighting, which is not the aim of this experiment. The 360-degree camera is fixed on the actor's head and the camera settings are the only features I can experiment with to provide a refined Virtual 360-Degree Dramatic Theatre to the audience.

Lighting was the secondary parameter adjusted and experimented with, in this experiment to provide an engaging viewing experience to the audience. Though basic stage lighting setup was used throughout the process, the lighting rigs, light intensity and directionality of the light were experimented with and modified to find the optimal theatre ambience, when viewed through the 360-degree camera.

The consumer aspect of the VR dramatic theatre was also examined in this experiment. It has been widely noted that the majority of VR research is experimented with and tested by highly established or well-funded theatre production companies [29]. This experiment aims to break such stereotypical realizations about Virtual Reality that it requires expensive investments. Contrary to the expectation, it is noted that VR does not always require sophisticated and expensive Head-Mounted devices, Hand Controllers or Haptic Sensory Gloves. In retrospect, it is also unrealistic to provide these hardwares to every single theatre audience. An important finding to emerge in this study is the use of a cost-effective VR headset made out of cardboard named Google Cardboard, in which the audience can place their smartphones and view the entire VR dramatic theatre experience [12]. The idea of using google cardboard is also supported by the fact that the number of people using smartphones is relatively high [33] at present and is increasing progressively. Hence the implementation of Google cardboard is a viable and cost-effective investment, [GC] providing the audience with an easy and simple VR experience.

3 ENHANCEMENT AND DIFFICULTIES OF VIRTUAL REALITY ON THE PERFORMANCE AND ACTORS

Positioning a 360-degree camera over an actor's head presents an argument and conflict with the current use of VR technologies in games and other mediums. Virtual Reality has been used to develop first-person shooter games, role-playing games (RPG) and industrial training for a long time [16]. For example, there is a huge difference in the field of view, when a person drives a real car, to a person driving a car in Virtual simulations or digital displays. The virtual technology develops a setup to mimic the car driving experience from the driver's perspective, however, it does not provide 100% with the same range and field of view [16]. The audiences consuming VR are adapted to this particular simulated first-person field of view. With the introduction of a 360-degree camera on the actor's head, it could be difficult for a certain percentage of the audience to adapt and get accustomed to this field of vision. In order to address this issue, I propose to further research and interview the audience in the future after they had a chance to view the experience. If required the position of the camera can be altered in order to match the range and field of view with a VR first-person simulated experience, as the actor does consider the 360-degree camera as an acting property and extension of their costume. For example:

I am getting used to having the camera attached to my head with all the rehearsing. I have been paying less attention to the camera and more attention to my performance, as I am considering the camera as a part of the costume required for the play, like a hat.

Adding on to the subject of positioning the 360-degree camera on the actor's head, there were also other technical parameters that required more attention to provide a better and ideal viewing experience. The performance is dynamic and flows in a streamlined manner. As the camera is placed on the actor, the entire performance unfolds around the camera engaging the camera to adapt to different lighting setups, light exposure and light directions. Natalie Koking, states in her article *The camera in the theatre: Staging a Show for film* that in order to stay faithful to the originality of a theatre show and also make sure the camera does not pick up any major contrast and shadow, the lighting setup should be basic and standard throughout the performance [19]. I wanted to explore and apply the available camera technology, showcasing the authentic theatre experience and lighting through the 360-degree camera lens. Throughout the rehearsal process and final experiment, I made sure that only a minimal amount of lighting parameter (intensity) adjustments were made but various lights were rigged for different scenes, similar to a traditional theatre performance. This was followed to make sure that the VR 360 technology was considered as an accessory to the existing theatre performance and by no means should the theatre quality or lighting be compromised in this process. Noelis [21], points out the importance of adjusting the Iris of

the camera using settings like F-stop, shutter speed and Exposure Value (EV). They are responsible for the amount of light captured by the camera. In this project, the use of Insta 360 One X was suitable, as adjusting the camera to a low lighting environment was simple. The camera is inbuilt with various shooting moods viz, HDR video, bullet time, time-lapse video and photo capture. The HDR video was the most applicable setting for capturing this theatre performance. In addition, it also provided us with automatic settings in which the camera adapts to the lighting and environment automatically or I could manually change the settings of ISO, shutter speed, and aperture to control the exposure. Sean T.McHugh states in his book *Understanding photography* that we can use many combinations of the above three settings to achieve a proper exposure due to which I experimented with various trials and tests and recorded them in the form of practice as research [22]. In order to achieve a good exposure using an optimal combination of the camera settings, I proposed to maintain the light intensity constant throughout the rehearsal and experiment with the ISO, shutter speed and aperture value of the camera for the majority of the rehearsal.

4 FINDINGS AND REFLECTIONS

Taking the newly experimented VR dramatic theatre architecture into consideration, the technical enhancements were implemented in such a way that the scope of the actor's performance did not get compromised. The introduction of VR technology into theatre spaces should not provide an overwhelming sense to the actors, audience and also to the performance itself. Dooley points out that cameras have been used in live performances, concerts and other arts at present and it has been adding more value to performance and attracting more audiences from a wider category [7]. Could 360-degree cameras (VR) provide a new branch in theatre performance and attract a different set of audiences? Could 360-degree cameras (VR) use as a subordinate part of a larger performance, thereby introducing the audience gradually to this contemporary style of performance? Stephen Langston states that there was an increase in consumption of *Back catalogue streaming* - recordings of an older theatre play during the lockdowns and it satisfied the thirst of the live theatre audience [20]. He further adds that the back catalogue streaming was only a temporary substitute and not a permanent solution to the theatre during the pandemic. I agree with Langston's statement since back catalogue streaming is a pre-recorded piece of theatre work and it lacks the live essence of the performers. Harriet Sherwood has reported that more than 50% of theatre productions in the UK have invested in online live production during the last couple of years [31]. It has also indicated the increase in audience consumption of these online productions since online live theatre production is accessible to a wider theatre audience including audiences associated with disabilities. It may be the case that not every theatre production has the luxury and budget to cater for audiences with special needs for their live show. Jamie Hale, a disabled theatre director and playwright, states *"many people were not ready to return to packed auditoriums"* implementing that disabled audiences enjoy and can access online theatre regularly [31]. The most obvious conclusion is that both online and live performances need to be produced in the future, proving VR dramatic theatre is a potential candidate moving forward. It has the capability to establish a performance which can accommodate live audiences and online audiences at the same time.

In addition, this research also focuses on criticizing if 360-degree VR has the potential to accommodate and enhance performance without removing the magic of the performance? Filming and recording a theatrical performance under theatre lights is complicated due to the change in light intensity throughout the performance, making the camera adjust constantly across the performance. This experiment successfully uses a 360-degree camera on an actor's head, providing substantial support that the idea of applying VR in theatre is worth exploring and provides potential future branching research. In the experiment, there was also a traditional camera placed in a spot where the audience would normally sit and watch the performance. This provided a guideline to check for the quality of the video recorded in the 360-degree camera and it was practised throughout the rehearsals. Moving further into the experiment rehearsals, it was pointed out that though the cameras are exposed and captured the same light setting, the 360-degree camera was exposed right under the lights (since it was positioned on the actor's head) and the traditional camera was away from the lights. This resulted in the 360-degree camera capturing the lights directly and over-expose at times or capturing dark areas when there were no lights. Although this made the recording footage inconsistent, this inconsistency in lighting is what the actors are experiencing when they are performing. This inconsistency also includes the view available behind the screen and curtains making the experience even more live and immersive for the audience. The director/actor participant agreed to the same. Example:

When I am in the audience, I always want to know what is happening on the stage and behind the stage, I want to be a part of the tension. I think the 360-degree camera on the actor, will help me to achieve that feel and experience. What happens when a dialogue is delivered faster or slower, how do other actors cover it, and what happens when the lights turn down or the curtains are lowered?

At the same time, it is also important to keep the audience focused on the staging area. Audiences when experiencing VR tend to easily get lost in the 360-degree space and fail to focus on the narrative or story. In order to help the audience focus on the staging area, the use of glow sticks as visual cues was employed. Jacqueline M. Fulvio points out the importance of having artificially induced sensory cues in any VR experience and it helps the participant to focus accurately [10]. In this experiment, I concur with Jacqueline's importance of providing artificial sensory or visual cues. We employed glow sticks as a prop to the performance and actors had them randomly in their bags, pockets, guitar case and on the ground so it is more dynamic the performance. The actors agreed to the idea of using visual cues. Example:

As an actor, we use our performance and properties like hats or books to get the audience focused on the play. The idea of using glow sticks really sounds amazing for a VR viewing.

This experiment talks majorly about the technological potential of VR available to the theatre in the present day. The secondary focus of the experiment is on showcasing the similarities and differences between VR & theatre and exploring how efficiently they work together in producing an engaging live performance. The resemblance of theatre to a virtual reality machine has been previously noted and explained by Mark Reaney in his work [28]. For

example, in his writing, Reaney describes that "*in the past thespians used theatre to create virtual worlds*". The audience in this case uses theatre as a medium to imagine a fictional world in which the story takes place. The actors and their performances are compared to agents to convey concepts and stories in a distinct way. This perspective shows how identical the concepts of Virtual Reality and theatre are to one another. Considering this comparison, the only contrast to be noted is the process of how it is consumed by the audiences. For example in a traditional theatre audiences are placed outside the stage of the theatre (fictional world), whereas in Virtual reality the audiences are placed inside the Virtual simulation (fictional world). This experiment provides the bridge that contrasts and has the audience be placed inside the staging area using the help of a 360-degree camera and explore the various possible branches of theatre it can generate. Christie Carson argues that theatre is more of a spatially-based event than a time-based event and the majority of the historical research on theatre acknowledges the importance of space [4]. VR also offers the opportunity to recreate the theatre space by helping in designing the stage and the properties on the stage reducing time, budget constraints and schedules [Mark]. In this experiment, the 360-degree VR technology assisted the director of the play in designing the stage in an efficient manner. The director of the play had much more liberty in using the properties on stage since the director had the opportunity to view the performance rehearsals from the actor's position. The Director expressed it in the interview. Example:

The view from the 360-degree camera helped me to be present in the shoes of the actor, thereby providing me with the idea of how the performance can be improved and revised. It also provided me with insights of how we can focus the audience's attention on a particular part of the space and design the entire stage on where the properties need to be placed.

The latest research by Hakyung Sim also relates theatre to VR using Michael Heim's seven concepts of approaching VR: "simulation to mimesis, artificiality to poiesis and interaction, immersion, full-body immersion, networked communication to concepts in contemporary performance aesthetics" [13]. However, she argues that the seventh concept of telepresence is related to bodily co-presence [32]. It can be argued that bodily co-presence is common between actors on stage but sporadic between actors and audience, unless it is a special immersive or devised piece of performance. The literature has strong implications that there are a lot of similarities between VR and theatre.

In recent times, there has been a lot of investment and production for online theatre performances. For example Sol Rogers (2019), Hakyung Sim (2021), Amiah Taylor (2022), and Harriet Sherwood (2022) [35]. As mentioned previously online theatre production follows the idea of streaming recorded performances to the audience. Charles and Moar took one step forward in bringing the audience into the performance space using a 360-degree camera, although they also followed the idea of pre-recording and broadcasting [6]. Their experiment satisfies the idea of telepresence but lacks the liveness. Through this experiment, the concept of telepresence, along with liveness. Since the audiences are positioned to watch the performance from the actor's head in a 360-degree panorama, it provides them with 'temporal proximity' with their fellow actors satisfying the concept of telepresence [2].

The final major challenge when arguing about using VR in theatre performance is the sophistical hardware requirement for audience consumption. For example, a theatre production can not provide VR headsets to all the audiences turned up for their performance, hence it limits the VR usage to a very minimal audience. This predominantly proves why the majority of theatre producers are happy to employ VR technology only to their production and designing process. Providing VR headsets to every audience can prove to be very expensive and also need to consider the safe seating of every audience. In order to overcome these difficulties, the use of Google cardboard can be employed which will be beneficial for the theatre producers. Google cardboard is a device made out of cardboard, shaped like a VR headset, with special plastic lenses [12]. The landscape display is split into left and right views for your eyes, the audience can place their phone inside the cardboard and the phone accelerometers help in a 3-DoF (degrees of freedom) head tracking and cost less than $5 each. It proves to be an efficient and cost-effective substitute for a VR headset and also helps to accomplish the goal of the research [Wendy Powell et al (Getting Around in Google Cardboard– Exploring Navigation Preferences with Low-Cost mobile VR)]. The results from this research are significant in two respects, VR dramatic theatre can either enhance the existing theatrical experience or move it into a newer branch of theatre. It also provides a concept in which the audience can have a traditional seating position as in a proscenium theatre and still give the luxury of viewing the performance through 360-degree VR technology. Further research is required and will be executed along the lines of the audience to investigate the implications of VR dramatic theatre.

5 CONCLUSION

The collective findings from the experiment and literature suggest VR and theatre have more commonalities than differences. VR is one of potential future in theatre performance [5]. They prove to compliment each other similar to how the digital age of technology has been complimenting primary art forms. For example, Photoshop and digital cameras have become a pervasive influence among artists for creating and appreciating art [11]. This experiment proves that 360-degree VR technology can be used as a medium to have the audience view a performance from remote access and also its effective usage. In addition, it also proved how critical and valuable enhancement it can be, for the director and producer of the performance. The idea of the audience viewing the performance from the stage and from the actor's position has always been a dream. This experiment explored the technical shortcomings and how to overcome those with cost-efficient solutions that have opened the doorway for such a dream concept. It also provides materials for future research on audience interactivity in the space and driving a theatre performance based on the audience's interaction.

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Existing offstage Yet onstage: A Novel VR Theatre Experience[3]

5.2 Abstract

Virtual Reality (VR) allows people to connect, entertain and collaborate remotely with individuals from all over the world. However, there is still the challenge of knowing or experiencing the adventure, tension and excitement happening on a stage from an audience's point of view; how does it feel to be in the shoes of an actor? Virtual and online theatre productions became popular in recent years due to the effect of COVID-19 and the lockdown restrictions. This particular research is a subset of a larger experimental project that focuses on discovering new possible ways of enhancing theatre performance with the application of Virtual Reality. In this paper, I focus on how a fully functional 360-degree Virtual theatre production can be designed to translate the audience viewing experience into a first-person VR experience. In particular, the audiences' experience and how beneficial VR technology for remote viewing are discussed in this paper. My research findings indicate that the application of VR enhances the audiences' experience in a way that VR dramatic theatre helps the audience to achieve telepresence with cost-effective means (Google Cardboard). In addition, VR dramatic theatre helps to provide the audience with a different perspective and experience of the story/performance along with an achieved means of immersion on the stage through the non-mediating telepresence. It also directly impacts the performance so that VR theatre could branch out as a separate theatre production, inviting a mix of newer and traditional theatre audiences.

[3] This is a reproduction of the final version submitted for review.
Saikrishna, S (under review). Existing offstage Yet onstage: A Novel VR Theatre Experience. *International Journal of Performance Arts and Digital Media.*

5.3 Introduction

This article explores the application of Virtual Reality (VR) as an Assistive Technology in Theatre Performance along with an innovative idea of audience telepresence on the stage. Additionally, this article explores the media technology and hardware required to achieve the audiences' telepresence on the stage. With the recent exploration in the field of metaverse, telecommuting, remote and virtual work, individuals are increasingly open to embracing innovative approaches and technological concepts in their professional and leisure activities. This eagerness stems from the desire to enhance the quality and effectiveness of their work and entertainment endeavours [31]. This research follows the logic that technological changes in people's work and leisure activities leads to a trajectory where experimentation in the field of arts, especially in theatre might also be welcomed by audiences curious to try and experience a new technology that may enhance viewing pleasure and expectations [24]. Additionally, theatre has always been a medium which is open and adjusted well with technological experimentation over the years, since technology has been employed to enhance the way in which theatre is experienced [21]. This aligns with the current trend of embracing innovative technologies in various domains, offering potential for enhanced audience experiences and expanded artistic possibilities.

Furthermore, a large number of theatre performances have experimented with the narrative point of view and it has gained positive results. For example, Keeping the audience curious about narrating a story from a different point of view (POV) is a key element for keeping the audience engaged and curious throughout the performance. [6] Virtual Reality (VR) theatre provides the audience with an idea of human subjectivity and multiple points of viewing, as it is aided by the 360-degree camera/Google Cardboards or head-mounted displays (HMD) to achieve the same. However, the performing actors still act as the medium to convey the narrative from the required point of view. This retains a key component of theatre, as stated

by Klich and Scheer (2012) who state that physical actors performing on the stage are considered more of a medium through which a story is conveyed, than a prominent visual enhancement or object [10]. According to their perspective, the presence of actors on stage breathes life into the narrative, making the storytelling experience more powerful and engaging. The primary aim of this article is to provide the audience with a feeling of telepresence by virtually teleporting them onto the stage with the help of a 360-degree camera. It also aims to explore the effectiveness of VR dramatic theatre through the audience experience, if it can branch out as a separate genre of theatre. In addition, the work of Hakyung Sim supports the aim of this research, stating newer technology and enhancement introduced in a theatre performance takes more significance and attention to the audiences' consciousness [26]. This literature grounds the aim of this particular research to be critical with respect to the benefits of the theatre performance since the VR theatre technology while seeking to enhance performance by providing proximity to the performance via different points of view.

This experiment aims to have the audience experience a "virtual" presence on the stage from a remote location using VR technology. In order to explore if the audience achieved any kind of presence, the term presence needs to be defined with respect to this research. Gonçalves et al state that in designing virtual worlds and environments the sense of "being there" is often referred to as "presence" [7]. However, when examined closely, presence is a broader term and there has been a greater discussion in the literature and there is more than one definition for "presence". Skarbez et al in their article *A Survey of Presence and Related Concepts* provide a clearer definition of presence in the computer literature [27] and classify presence under three categories, based on the definition provided by the earlier academics, namely, being there, non-mediation and other. Each of these categories has its own sub-category and definitions. The classification of presence under "being there" corresponds to Wirth's definition of "feeling of being in an environment" and is subdivided into active and passive based on the ability to act

in the environment [33]. The classification of presence under “non-mediation” corresponds to Rosakranse and Usoh’s definition of lack of attention to the medium or the mediating technology [25] [32]. It is also subdivided into external and internal based on the medium used to achieve the feeling of presence (external technology or one’s own thought). The final classification “other” corresponds to Lee's and Parola’s definition of experience as virtual objects are real or sense of feeling real [13] [17]. The final classification of presence involves psychological focus hence it is not taken into account for this particular research.

5.4 Point of View

One key problem with the introduction of 360-degree VR technology into theatre spaces from a VR user experience perspective, would be that this particular experience denies the audience the traditional interactivity afforded by VR. For example, any digitally created VR environment allows the participants to interact with the objects, characters and environment through input devices like joysticks or haptic gloves. However, when a participant is encountering a 360-degree real time video experience, he/she is only provided with the passive interactivity of a viewing experience. This experience can be defended by re-claiming the primary focus of the research, which is to provide the audience with a change via Point of View (POV) and an interactive theatre experience, by being amongst the performance. A point of view or focalisation in narrative media is defined ‘as a view of a thing as it presents itself from the personal subjective point of view of a character or narrator’. (p. 42) [8] This experiment explores the possibility of introducing a change in POV from the audiences’ subjective POV with the implementation of 360-degree VR technology.

Richardson suggested that drama and theatre have always been a mixture of mimetic and diegetic representation hence it is worth exploring different POVs [23]. Expanding from Richardon’s statement, a considerable number of experiments have been conducted in theatre performances to explore the idea of a change of POV. One such example is *The Father,* a

French stage play by Florian Zeller, which was later translated and adopted by Christopher Hampton. The stage play revolves around the theme of dementia, offering the audience an intimate exploration of a person's mind. To provide an immersive experience, the audience is introduced to the show from a quasi-first-person perspective. This effect is achieved by incorporating a character who portrays the role of the daughter in the story, reappearing in subsequent scenes with a different performer. Peter Crawley, writer and reviewer (Irish Times) calls this change of POV experience, as an experience in which 'we became both the spectator and the protagonist' (para. 9) [3]. Experiments of this nature indicate a distinct possibility for the theatre audience to undergo a transformative change in their point of view (POV) experience, it places a lot of new responsibilities on the shoulders of the theatre director and the producers to work out each and every scene in a performance to make this work effectively. For example, it will have implications for the performance to have the necessary stage set up and props so that the audience can maintain the same POV throughout the entire performance. However, a VR theatre technology offers the change in POV experience without modifying the majority of the theatre writing. This can be accomplished by immersing the actors in a digitally created virtual environment or incorporating VR/360-degree camera installations on the stage. Therefore, VR technology serves as an additional tool that enhances the overall theatrical performance. For example: assisting the theatre producer and director in actors and properties placement

At the same time, a limited number of experiments have been conducted in the field of theatre performance for applying VR technology as a viewing medium. An example is *Fellow Creature* by Charlton and Moar (2018), the predecessor to this research experiment. In *Fellow Creatures*, Charlton and Moar use an invisible and voyeuristic point of view for the audience to view the entire performance [2]. This is achieved by using a 360-degree camera in the centre of the stage allowing the performance to unfold around it. The actors do not interact with the

camera on the stage, hence making the audience, an invisible observer. The concept of allowing the audience access to the stage via a 360-degree camera is new and engaging; however, their analysis was done from a theatre practitioner standpoint, lacking the audiences' opinion and outlook. Arguably it was first of its kind research on experimental, interdisciplinary dramatic theatre making it very critical in the field of theatre and VR technology. In this article, I bridge the gap and assess VR dramatic theatre based on audiences' experiences. The major difference between the two research experiments would be, in *Fellow Creatures* the audience was considered to have a POV of an invisible spectator, on the stage without any involvement or interactions, and in this research experiment, the audience can view the entire performance from the POV of the lead actor.

5.5 Virtual Reality Dramatic Theatre

This study builds on the production and experimentation of a VR dramatic theatre developed from the idea of virtual teleportation of the audience onto the stage using a 360-degree camera and VR headset. It contributes experimentation and analysis of audiences viewing a theatre performance from the POV of an actor. The particular performance used for this study was a 10-minute performance consisting of three actors called *Barefoot on Queens*, written by Mel Martin Booker, a local theatre writer in Hamilton. The performance was introduced to the audience "as a 360-degree theatre performance" [FB event]. The collaborative engagement with the local theatre community had been carefully planned in the early stages of the research, but unfortunately, it had to be postponed due to the outbreak of COVID-19 and subsequent lockdown restrictions. Initially, the plan involved involving 4 to 5 actors as participants and performing in front of a live audience consisting of approximately 20 participants. The intention was to provide the audience with both a direct viewing experience and the option to use VR Google Cardboard, allowing for an assessment of the advantages and disadvantages of VR application. However, the impact of the COVID-19 restrictions and the New Zealand

government's guidelines on public gatherings and physical distancing necessitated a reassessment of the plans. Adapting to the situation, the VR dramatic theatre performance was instead live-streamed, enabling the audience to watch the event in real-time and also providing the opportunity for them to rewatch it at a later stage. Even though the Facebook live streaming event was advertised only two days before the event, nearly 10 to 12 people showed up to watch the 360-degree live streaming of the performance. In addition to the audience who viewed the broadcast in live streaming, some audience members watched it at a later stage as well. As the researcher, I delivered a concise introduction and provided general instructions to the audience on how to view the 360-degree performance using their smartphones before the start of the performance. It was evident from the audience's comments and responses that they were able to easily access and engage with the technology. (See next section). In addition to the 360-degree live streaming broadcast, a traditional camera was placed away from the stage to recreate the traditional audience's point of view. It was also live-streamed and broadcasted through YouTube so that the audience will be able to view either of the broadcasts and provide them with comparative broadcasts.

Numerous studies have explored the application of VR in the field of theatre since the 1990s, and ongoing experimentation continues in order to achieve a seamless integration [4]. By establishing a well-defined architecture encompassing elements such as the story, script, actors' rehearsals, and VR hardware/installations, along with meticulous staging achieved through rehearsals, improvisation, and familiarity with the VR hardware, it is plausible to hypothesize that assimilation can be accomplished within a relatively short timeframe. Additionally, the architecture implemented in this research experiment has been meticulously staged through carefully planned rehearsals, ensuring that the actors are familiar with the VR cameras and devising the performance in a manner that allows the audience to seamlessly adapt to the new VR technology while experiencing it from their regular audience point of view. The

audience were given three choices to view the performance. The first option was the audience could view the performance during its live streaming and participate in the interview at a later stage. The second option was the audience can watch the recorded version of the performance at a later stage and participate in the interview. The first two options were advised for the participants who could not travel out of their bubble due to the COVID-19 restrictions. The third option involved inviting the audience to the researcher's office and view the 360-degree theatre performance. Through this method the audience were asked for their consent to record their viewing experience. At a later stage, this recording was overlaid over the actual theatre performance video for analysis purposes. The overlay video was shown to the audience participant prior to their interview to triangulate and analyse their action and thought process during their viewing.

Figure 5.1 Audience experiencing the performance from remote location

There were only a limited number of audience participants available for viewing and analysis. The targeted audience participants were 20 to 25 participants. Altogether the analytics of the performance broadcast shows that the VR dramatic theatre had an audience of 61 at the start.

However, only 23 continued to watch the entire performance. Ten audience indicated their interests to participate in the follow up interview. There were three groups of audiences representing each method of viewing (live stream viewing, recorded stream viewing and in person viewing). Follow up interviews covered audience opinions on live streaming of VR theatre, its effectiveness, and the idea of VR theatre serving as a bridge between online and offline theatre productions.

The performance unfolds from the lead actor's point of view since the 360-degree camera is attached to the actor's head. The audience was virtually teleported onto the lead actor, who could see 360-degrees from the camera placement via the use of mounted VR Google Cardboard. In this way the audience will experience "being on the stage", shared same stage position as the actor. They can view the fellow actors interacting with them (since the camera is placed on the lead actor), providing the audience with a feel of first-person engaging VR experience. The audiences are limited to passive interactivity which corresponds to viewing and hearing the performance. They move along with the lead actor, however, the audience could explore the available 360-degree field of view in every possible direction, by pivoting their smartphones/Google Cardboard around themselves. The scenes in the performance were distinguished by turning down the lights, similar to a normal/traditional theatre performance so that the audience can sense the scene transitions. Nevertheless, it was observed that some audience members encountered challenges in readjusting themselves to the new staging space in the subsequent scene. Example,

> If I had to point out a thing I find distracting, maybe the lights? (participant-audience)

Despite being perceived as a relatively weaker aspect of this experiment; the dimming of lights served a crucial role in maintaining a clear distinction between scenes. It not only

facilitated the audience's anticipation of scene transitions but also heightened their curiosity and engagement with the unfolding story. The lighting and props used in the performance were determined to be simple and minimal resembling a traditional theatre performance. It was also made sure that VR technology or 3D visual technology was not used for the design and production purpose of the experiment. The point of view took the audience through the entire stage, along with other actors and stage props. The lead actor and the actors moved around the stage and the audience could view the hands of the lead actor resembling the hands of the audience members themselves. The virtual view of the lead actor's hands should have induced the idea of "being on the stage" and an immersive feel to the audience. However, the audience responses found that since most of the viewers were aware of their surroundings prior to the performance, they showed a better awareness of the environment and could not help them achieve the total "being on the stage" experience. For example,

> There was still quite a good level of immersion. It was sort of a semi-detached first person, sort of like, 0.5 person. It wasn't quite like complete immersion-focused, but it was sort of character-attached viewing. (participant-audience)

Since the audience could not achieve complete immersion due to the fact that they are aware of their physical surroundings and their physical lightings did not match with the lighting of the stage, it can be concluded that the physical ambience plays a vital element when introducing the audience to any virtual world or environment. Furthermore, it is worth considering the critical perspective that when utilizing cost-effective VR headsets such as Google Cardboards and experiencing the performance through smartphones, there may be certain compromises in terms of the overall immersive experience, as there is no specific physical setting to align with the performance lighting and quality standards. In contrast, this experiment is the initial starting point in achieving VR dramatic theatre and bringing theatre and performance into home.

Figure 5.2 Audience view from the lead actor's POV

The performance begins with the lead character, Leo, running across the stage while expressing his annoyance with the sounds of the traffic lights. As the audience views the scene from Leo's point of view, they are unable to directly see his dialogue delivery, creating a voice-over narration effect. This prompts the audience to question Who is speaking? Who they are addressing? And Where they can be seen? These questions are answered when the other actors, Petra and Mr. Donahue, enter the stage and engage in conversation. The play progresses with the interaction between Leo, Petra, and Mr. Donahue, focusing on Leo's music career. Once the audience gains a clear understanding of the three characters and their interactions, it fosters the notion that the audience is virtually embodying the lead character, as they perceive the events from Leo's point of view. Virtual embodiment is the idea of achieving 'the same sensations of ownership over a virtual body inside an immersive virtual environment' (p. 1) [15]. In addition to delivering dialogues, the incorporation of body movements, rotations, and hand actions played a significant role in the process of achieving a sense of virtual embodiment. Some of the participants enjoyed the idea of virtual embodiment and stated that it added to the tension of the performance. For example,

I had the VR set up, making me view through the actor's shoe. When the character of Philip turned up, they seemed very tall, imposing and scary, which sort of I think added to that whole gravitas when you then find out later, this is an important person in the music industry. And I think it actually sort of awestruck me that VR could really do some stuff here. (participant-audience)

Figure 5.3 360-degree stretched view from the actor's POV

5.6 A Case for Newer Audience Experience

A considerable amount of literature has been published on using Virtual Reality technology in the theatrical production process. Yet the predominant amount of applications is using VR as a design tool to reduce labour-intensive work in the production process [22]. This is a critical application from the standpoint of artists, directors and theatre producers as it helps to reduce the time-consuming stage setup, lighting setup, manual properties design, etc. VR and AR is used for creating mock stage ambience in the version of a previs or set design and update it in real time corresponding to the director of the play. The new VR/AR technology is developed where a 3D model can be designed and placed tangible to the play directors, rather than

visualizing in their mind during a rehearsal [18]. Some notable theatre production companies which use VR/AR in their design and production process are National Theatre, Collaboration between Piehole, a theatre company in Los Angeles, and Tender Claws, a game development company, Commonwealth Shakespeare Company [29]. Dixon (2006) in his article A history of virtual reality in performance suggests that artists have been using VR technology for creating and designing environments. One question that needs to be asked, however, is how VR technology can be implemented inside theatre performance as a portal for audience and as a means for remote viewing. This exploration will open up branches in theatre on how VR technology can be used to create a virtual presence on the stage from a remote location, having the performance navigable for the audience and attracting new audiences for VR dramatic theatre. While VR is majorly used in gaming and educational applications, this research can further create the vast potential for VR dramatic theatre to act as a bridge between online and offline theatre production shows along with the opportunity to create a full-length production or a branch in experimental theatre genre.

The research primarily focuses on exploring the concept of audience presence on the stage. While an external technology is employed to create a sense of presence, the ultimate goal of the research is to offer the audience a remote viewing experience through the use of VR. Additionally, the research aims to enhance the audience's overall experience and ensure their comfort throughout the viewing process. For example,

> I felt like being on the stage at some point. Yes, I was part of it. But at a certain time, I felt distracted. Yeah, because I felt I wanted to see the play from each and every angle. So do I want to do it from the top? Do I want to do it from the bottom? Do I want to see this side? No. Do I want to see the other side and some like, and I could not see that the actor was playing guitar? Yeah. Because I was just focusing on like, here and there. I did not scroll

> down to see that he had a guitar because he was talking to a lady and it did not pop into my head that I should look down. Yeah. So yeah, I felt a little bit distracted. Yeah, but I loved it. Like, overall. And I felt I was part of it. (participant-audience)

The statement made by the audiences highlights the perceived distractions arising from the introduction of VR technology into the theatre space without a gradual transition. However, these so-called distractions can be seen as catalysts for curiosity, encouraging audiences to explore the virtual space while experiencing the performance. It is worth noting that the brevity of this particular performance (20 minutes) may not have allowed sufficient time for the audience to fully immerse themselves, adapt to the virtual stage, and follow the actors' performance. This suggests that a longer devised performance could potentially ease audience apprehension regarding VR theatre. Furthermore, the audiences expressed their curiosity in exploring the virtual environment and the unique perspective offered by the 360-degree camera, which supports the notion that a change in POV can be highly effective through VR installations. The responses from the participants in this research experience further emphasize their curiosity and interest in experiencing the shift in POV.

> I mean, watching from different angles and point of view is one thing that would complement the rewatching idea, because like, every time you rewatch, you see different and new things from different angles. Yeah. And, and you understand more when you watch from different angles. (participant-audience)

This statement not only enriches the idea of viewing the performance from different POVs but also contributes to the idea of rewatching a particular performance. The majority of the participants indicated their curiosity about experiencing the change in POV. It provides a new

dimension to the performance on how its story is being narrated. This technique of changing POV in the performance was highlighted as a valuable asset by the participants in this experimental research. For example,

> I think a change of POV in a theatre performance would really heighten the performance. So, I think that being able to switch perspectives and point of views from, to various people would be useful too. I guess they'll all act as an opportunity to shine in a performance. (participant-audience)

These results and audience response evidently prove that the presence which is achieved in this research experiment falls under the category of external non-mediating presence. However, other studies in computer applications examine two separate forms of presence - telepresence and virtual presence. The earliest systematic study on telepresence was reported by Marvin Minsky stating that in order to achieve telepresence the sense of "being there" must be achieved [16]. Though it is a very vague statement, it led to further development in the idea of telepresence in the field of computing. Lombard and Ditton proposed that telepresence or virtual presence is 'the perceptual illusion of non-mediation' (para. 29) [14]. Much recent literature by Bay-Cheng et al provides a clear distinction between telepresence and virtual presence. They define virtual presence as the sense of being in a virtually created environment and telepresence as a sense of "temporal proximity" within the audience participants [1]. This literature provides clarity regarding "presence on stage" in this experiment, and its tendency to fall under the category of external non-mediating telepresence.

Apart from achieving the sense of presence on the stage, it is also important how it is achieved. A 360-degree camera and Google Cardboard as Head Mounted Displays (HMD) play a significant role to achieve the required external non-mediating telepresence within the audience. It was assumed that the performance of the actors is the key and essential element to

create the perceptual illusion of non-mediation. Contrary to expectation, the research did identify a few issues like ambience, navigation and sound system to help in achieving the illusion of non-mediation. Specifically, dark-themed rooms with low lighting setup are the choice for a VR simulation or VR game which are the other means of guiding fixation. The idea behind the selection of a dark-themed setup is that it has the audience to easily adapt to the virtual environment and it helps to achieve the illusion of non-mediation. This characteristic was pointed out by the majority of the audience in their interviews. For example,

> The experience wouldn't be as involved in the play as I would if I were in a theatre, in the actual theatre. If I'm sitting in my house and my room under a blanket and watching it through a phone, I don't think I will have the same experience sitting in a theatre with the lights. The ambience wouldn't be the same. (participant-audience)

This statement presents a compelling argument emphasizing the significance of ambience and the overall event experience. It highlights the notion that VR theatre experiences may lack the "event" of physically going to the theatre, sitting among fellow audience members, and absorbing the atmosphere and thematic essence of the performance. Consequently, it diminishes the audience's sense of fascination with the performance, reducing it to a mere video viewing experience through their smartphones. This gap was discovered in this research and should be addressed in future research.

Another challenge to the concept of achieving non mediating illusion is navigation, as it varies from the type of VR gadgets used. There is a wide range of VR gadgets in use like the HTC Vive headset, Oculus Rift Headset, Google Cardboard headset, Joystick controllers, Haptic gloves, VR mat, etc. In this research the Google Cardboard headset is used, exploiting its low-cost effectiveness. In terms of freedom of navigation, the audience was provided with

the option to rotate around their position and view the entire 360-degree field of view. It did not provide the audience with a fully immersive or on-stage experience, however, it worked well as a cost-effective solution. It provided a partial stage experience since the viewer was able to look in every direction of the stage front, sideways, behind the stage, top and bottom of the stage. On the contrary, providing the freedom of rotation, took a few minutes for a few audience members to understand the performance however it was also partially due to the lighting of the performance as well. For example,

> It took me a while to understand where the camera was positioned. And I thought maybe the characters were just voices. But I realized midway through the video that there are actual characters in the play. It truly gave the perspective of the camera being on the actor. (participant-audience)

This provides the argument that the audience requires more experience, instructions and time to get accustomed to the performance environment, however, every performance is different and based on different stories and genres. Hence a generic instruction would be sufficient for the majority of the audience to understand the technology. One other audience participant provided a remark that only a minor percentage of the general public undergo difficulty in adapting to new technology, however, they easily grasp the working of technology with time and it is how the introduction of mobiles phones and social media worked in the past. Example,

> I think the navigation is sort of simple enough, I don't think that it would be particularly difficult for somebody to figure out how to do this. I'm just trying to think of an analogy, you know, when the iPhone was introduced, and people hadn't really done touchscreen before unless they had a Nintendo. Everybody had to get used to how that worked, and how that screen worked and there were no longer keys on a phone. Yeah, I think that this would be a

> similar thing to that where VR theatre/cinema would come into play and people initially would sort of have to learn what to do. Eventually, people find out the best way to do these things and you might get different methods of it. And it would just become another part of that, particularly as we live in a world where virtual reality and augmented reality is becoming more mainstream and more accessible to everybody. (participant-audience)

At the given rate, it is evident that the audience can get used to the new technology since more than 50% of the participants in this research are certain regarding the general public adapting to the new technology enhancement. This observation is further supported by the historical openness of the theatre community towards technological innovations. Throughout its history, theatre has continuously embraced advancements, from utilizing natural sunlight during daytime performances before the invention of artificial lights, to incorporating stage lighting, music, microphones, and other technological enhancements. Moreover, the interviews with the audience raise an intriguing question: is it time for technological advancements and enhancements to transition from being limited to the stage and move beyond? This suggests that audiences have been receptive to technological changes in theatre and have evolved alongside them. As for the minority of the audience who may initially be uncertain about the use of 360-degree technology, it is likely that they will gradually familiarize themselves and become more comfortable with the technology over time.

5.7 A Bridge for Online and Offline Production

Hakyung Sim reports that COVID 19 pandemic and lockdown has pushed audiences to virtual and remote forms of spectatorship, example: online streaming services [26]. The same situation has created opportunities for the audience to experience VR dramatic theatre and online theatre productions. It would be a steep learning curve for the audience as well as for the actors if theatre performances are entirely produced online. At the same time, the pandemic and

lockdowns were a definite wake-up call for theatre performers and producers that an alternative means of production are possible. During the COVID 19 lockdown in 2020-21, a vast majority of theatre production companies tried to broadcast their shows online and it had mixtures of reviews from the audience. For example, one of audience comments from the article The pandemic nearly killed theatre – the creative way it fought back could leave it stronger reported by Stephen Langston [12] through The Conversation states that

> Theatre is an audience in a (usually dark) room with actors (in bright light) live performing - immediate, unique and engrossing. Online ain't it.

It impacts on the liveliness of the performance and digital medium lacks the liveliness and intriguing experience to the audience. However, Biggs states that online theatre production has offered a level of equilibrium and access to both normal audiences and audiences with disabilities [9]. For example streaming a theatre performance online with closed captions allow the audience who are deaf to enjoy the performance, since not many live theatre productions have disability support during their performance. The same can be attributed to wheelchair access; many theatre productions are not equipped with wheelchair access, hence online production and home-viewing options maybe a convenient option for some audiences. [9] This argument clearly points out the need for a bridging production for the audience and actors to adapt to the new idea of online theatre. VR dramatic theatre can act as the bridge between offline and online theatre production for a variety of reasons. The Google Cardboard headset is cost-effective and reliable, making it easily available for the audience. In any theatre performance, with the actor having a 360-degree camera on his head/shoulder, any audience member who is experiencing the performance from a traditional theatre seating will have the ability to use the Google Cardboard anytime he/she wishes to experience the performance from the stage.

Furthermore, having the performance live and broadcasted through the 360-degree camera, it will be available to a wider range of asynchronous audience members. It includes people from remote locations and people with personal and parental responsibilities. Statistically, audience members are more likely to miss watching a theatrical performance due to the above-mentioned reasons. Hence, enhancing the performance with a 360-degree camera broadcast will increase the audience numbers and also the popularity of the show. For instance, any theatre performance will be scheduled for only two or three nights. There are two sides to this consequence, firstly it is reducing the number of the audience attending the performance, with the limited number of theatre shows. Secondly, the hard work and creative element invested in the performance and actors are limited with a minimal audience turnaround. This brings upon the question if the actors' rehearsal and the producer's creative ideas need to be limited according to the audience turnaround. How can the efforts of the actors and producers be measured based on the audience numbers? The efforts and creative ideas cannot be quantitatively measured, also any artist or producer tends to put in maximum effort for the audience's satisfaction. In order to balance the scales, increasing the audience numbers using online 360-degree broadcasting can serve as a game changer in theatre and art performances. This idea was supported by the audience participants in this research experiment. For example,

> I definitely think that online and offline shows should coexist, live theatre should never die out, that would be a tragedy. However, it is not always possible for people to engage in live theatre. And I think that for online VR theatre to become a thing as well, would be brilliant. And those two things absolutely can and should coexist alongside one another, to enable the largest possible number of audience numbers for shows and to sort of just broaden the number of experiences that humans can get while making them accessible to the largest number of people. (participant-audience)

Perhaps, the online production - VR Dramatic theatre could evolve into a separate branch in theatre depending on responses from the audience, actors and producers. However, participants in this experiment have stated that they see the potential in introducing VR into theatre performance. Even though this particular experiment showcased 8 minutes of 360-degree VR theatre, the audience participants and the actors are intrigued to experience a full-length 360-degree VR theatre performance. The change of POV, kept the participants engaged and stimulated with thoughts on how a VR enhancement could develop and progress. One such giveaway from the participants was the idea of switching between the actors' POVs. Example,

> It would be great if each of the actors had their own cameras and when the person speaks, I could see from the other person's camera., so I get what he's doing, his body language. Because they do this in movies and in series. Yeah. But it's great if we could actually achieve this here. It would be like a totally different level. (participant-audience)

This was a very interesting idea put forward by the participant. Although this implication is very futuristic involving plenty of investment, as it requires more than one 360 camera and technical complications, it provides a window for the idea of rewatching a theatre performance from a different actor's POV. Watching a theatre performance from more than one vantage POV, strengthens the story conveyed through the performance. This enhances theatre performance to be more than just an entertainment medium and has the audience experience and learn from the actor's POV, which may make the audience connect with the character's story with ease. This also provides the audience with the odds of noticing newer details, artistic improvisation and other "easter eggs" in the show. In recent times, the introduction of artistic detailing, references, callbacks, and easter eggs have become the driving force and crowd-pulling elements in movies, television, and games medium [28]. An Easter egg in the general sense is an intentional inside joke, hidden message, or feature in a work such as a computer

program, video game, movie, book, or crossword puzzle [34]. These elements have been used in theatre performances as well, such as a signature lighting set-up used by the director or a trademark theme in set designing. The introduction of 360-degree technology will improve the rewatching capacity of the performance and help the audience to note the efforts and creativity of the producers.

5.8 Newer Audience

‘An actor feeds off from the audience's response’. This is a statement recorded during the interview with one of the theatre practitioners. Many other participants and online media claims have agreed upon the statement as well. However, studies have indicated that there is no significant impact on an actor's performance resulting from physical or vocal interaction behaviours between the actors and the audience [19]. This challenges certain claims within the academic community that emphasize the necessity of a live audience to enhance a performance, as well as raises questions about the potential effects of modernizing theatre through online productions. To summarise, it can be seen that application of VR in theatre performance and having a remote audience will not affect the performance or the actors. Hence providing the audience with the choice of remote viewing is an enriching experience. Previously, the majority of the technological research and development in the theatre spaces have been executed from a theatre producer’s perspective. This is also backed up by a few existing research articles like Mark Reaney, and Charlton [22] [2]. Major emphasis is provided to reduce the artists’ and producers’ labour, expenses and time. Though this mindset is welcomed, it is also necessary to implement technologies and enhancements that benefit the audience experiences and welcome newer audiences to theatre performance. Perhaps the growing popularity of metaverse and the previously discussed idea of external non-mediating telepresence achieved through this experiment can pave the way for audiences to experience theatre from home or remote location. Though Taylor [30] argues about the lack of human/physical interactions between actor and

audience in recent times due to the global pandemic restrictions, it is important for the field of arts to evolve and benefit from the available technologies and enhancements in order to move forward and gain more audience.

Statistical data on the theatre audience shows that the majority of the audience falls under the age category of 40 years and above (older generation) [5]. Games, 3D stereoscopic, visual effects, Virtual Reality, Augmented Reality and Mixed Reality have the majority of audiences between the ages of early teens to late 30s (younger generation). 23% of VR/AR device users sit within the age category of 25 to 34 years [36]. Furthermore 38% of gamers in the US are aged between 18 and 34 [35]. This can act as a sample indicator on how popular gaming, VR/AR/MR (digital technologies) are among younger generations. Combining VR in theatre will serve as a perfect amalgamation of two art mediums into a newer branch in theatre, VR dramatic theatre which will be popular among both the category of audience. In addition, it also provides the audience with the ability to choose between the viewing mechanism - Offline (live theatre experience) or Online (VR-360 Degree experience). Hence it will be a perfect intersection for both the mediums without losing their importance and capitalize on each other's enhancements. However, this entire research does not involve physical co-presence. Hayuking Sim argues that if the concept of physical co-presence is not a required condition in a theatre performance, the audience can watch the performance from their personal spaces individually [26]. This statement is true with regards that most performances require the co-presence between the audience and actors, not the co-presence between the audiences. This experiment provides the idea of co-presence using external non-mediating telepresence for the audiences and not for the actors. It is like a one-way journey to achieve the idea of telepresence for the audience. The actors fail to achieve any form of telepresence or physical co-presence due to the lack of audience in the performance space. However, this can be achieved by incorporating live audiences into the performance space. As a result, the actors could possibly

perform for both the live audience and remote audience, thereby achieving offline and online theatre performances. Considering the VR Dramatic theatre as a bridge between online and offline production, it appreciates performance as a traditional theatre play, fulfilling the needs of a traditional theatre audience, at the same time it introduces the idea of remote viewing for the audience and achieving telepresence on the stage developing a new audience circle.

The introduction and application of VR technology onto any medium have always increased the consumer count. For example, a recent survey and statistics on the Steam website indicate that new VR users grew by 11% in 2021 [11]. Similarly, it can be noted that there was a significant increase in the revenue growth of VR games, about 39% in 2020 with the release of Half-Life: Alyx in 2020, which in turn points to the fact of an increase in consumers [11]. An implication of these findings is that the application of VR has proved to be successful in revenue and audience consumption. In addition, this experiment uses cost-effective hardware like Google Cardboard for the audience to experience VR theatre.

5.9 Reflection

Expectations around the audience have always been a crucial factor in exploring, enhancing and improving theatre shows. For the past decade, there have been innovative and exciting developments in the field of theatre viz., proscenium theatre, devising theatre performances, and interactive theatre performances. The audiences' expectations are difficult to compromise since they always search for new and innovative tools to experience. Parallelly, there has been an equal increase in VR spectatorship in other mediums. This proves to be the perfect time for an amalgamation of VR and theatre performance. This is also supported by the interview data collected in this research that the audiences are excited to experience VR dramatic theatre as it helps the audience to achieve telepresence with cost-effective means. Provides the audience with a different perspective and experience of the story/performance and achieves means of immersion on the stage through the non-mediating telepresence.

The idea of technological application in theatre spaces is not new in the field of arts. Shane Pike notes how theatre has evolved over time with the help of technological applications such as the introduction of lights, microphones, background music and digital displays [20]. Along these lines, non-mediating telepresence achieved through the 360-degree camera on the actor builds on the possibility of enhancing theatre and also keeping the audience and actors connected even though they are remotely away from each other. It also satisfies the present scenario of social distancing and enables the audience to experience the performance virtually from the stage. The present-day theatres require an enhancement according to the audiences' needs and VR dramatic theatre can provide a novel VR theatre experience of existing offstage Yet onstage.

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Chapter 6 Analysing the Application of Virtual Reality in Theatre Performance

6.1 General Discussion

The goal of the thesis was to explore the potential expansion of VR as a collaborative medium, branching into new applications. It focused on key characteristics of VR as a technological medium: change in perspective (POV), remote viewing, immersion and participation. Though operationalising these characteristics in a theatre context was the focus for this research, this process also helped establish whether the similarities shared by VR and theatre performance were initiated and experienced the same way across the two mediums. In other words, the research explored the characteristics of VR and its affordances in the applied context of theatre. Towards the end of each experiment, the experimental and factual results showcased that VR and theatre share a compatibility making the further mergence of technology and theatre performance appear a strong possibility. Figure 6.1 demonstrates the direction through which this entire research travelled, while also outlining key findings for each stage of the study and the overall takeaway from this research.

The first experiment was conducted to gain a better understanding of how and where the VR 360-degree camera can be placed on a theatre performance stage, so that it does not affect the actors and their performance. Specifically, the positions were examined theoretically so that it benefits both the actors and the audience, to produce an enhanced theatre performance. It was essential to evaluate the camera positions theoretically to narrow down the best possible camera placement, in order to provide the audience with an enticing view. The results from the experiment revealed the possible camera placement position and also indirectly qualified the theatre stage to a live VR environment. Although this result was only theoretically derived, it needed to be experimented in a performance space with actors in order to arrive at its practical feasibility.

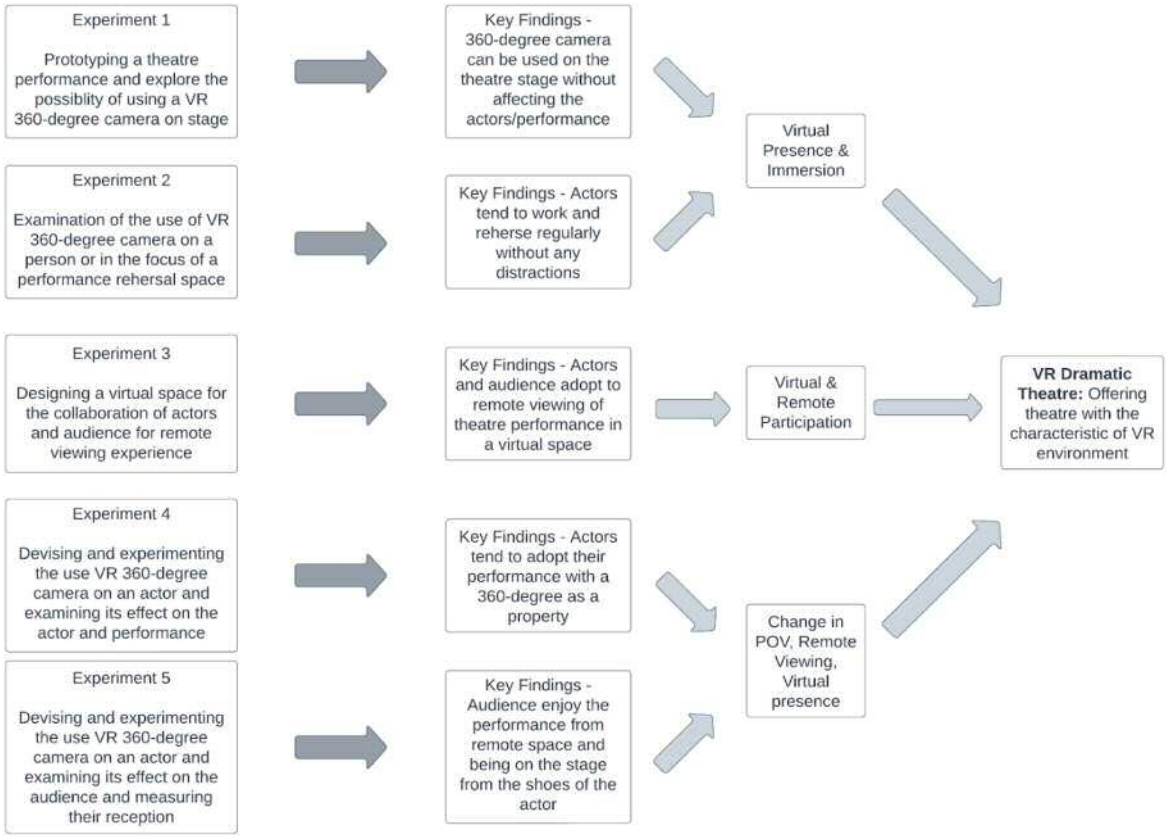

Figure 6.1 Overall Structure of the thesis

The theoretical findings provided a starting point for the research to move forward and test the viable camera positions based on the camera parameters. The findings established newer camera positions possible for a VR Dramatic theatre in addition to previously conducted experiments (Charles & Moar, 2018), particularly the idea of placing the 360-degree camera on the actor's head or shoulder opened a new door in the application of VR into theatre performance. Traditional theatre performance, on the other hand, can also be produced and offered to the audiences, which contributes to a larger satisfaction (Liodaki & Velegrakis, 2022). The findings also reported that multiple cameras can be employed in a single performance, providing the audience with the satisfaction and the level of comfort corresponding to each audience separately. The overall findings of the first experiment

showcase the level of enhancement and comfort application of VR can bring into theatre performance designing, devising and during the show. The main implications from the result of the first study states that VR 360-degree camera can enhance a theatrical experience, however not every theatrical experience requires a VR upgrade. For instance, studies show that the audience and supporters of traditional theatre show steady and reliable attendance to view the performance and introducing VR into all forms of theatrical performance could potentially upset and disappoint these audiences. This is because they view theatre as a community and audience fail to relate with online theatre production since it lacks the communal sense in a gathered physical space (Liodaki & Velegrakis, 2022). One possible solution is to utilize the affordability of VR into certain devised theatre performance as a new branch in theatre - VR Dramatic theatre. For example: The theatre performance Barefoot at Queens was devised and infused with the VR technology and experiment with the actors and audience. It can also be produced as a stand alone theatre production in a traditional theatre stage. Similar experimenting of traditional theatre epic like National theatre's Punchdrunk has been tested with newer applications like introducing the idea of immersing theatre or interactive theatre (Ohannessian, 2016). Furthermore, theatre producers and directors can be provided with the ability and option to showcase their work either in a traditional setting or a VR infused setting based on their targeted audience, place where they perform and their financial budgetary needs. Given that the later experiments also focus on the low cost utilization of Google Cardboard, making the technology and research cheap and affordable to all the theatre production and audience. In summary, in addressing the research question what are the possible camera positions available in a theatre stage, in order to provide an inciting and dynamic perspective change to the audience, it is clear to point out a reasonable amount of camera positions, however each particular performance and story determines the best camera position for the audience to enhance their viewing experience.

The results from the first study planted the seeds for the second experiment in this research. The possible camera positions were derived theoretically from the first experiment, now it had to be experimented and tested to assess their practicality and viability. The main objective of the second experiment was to test the camera positions and evaluate them based on the visibility, lighting, lucidity of the visuals, dynamics and sound quality. The results were based on video analysis of the 360-degree camera placed at the various camera positions derived from the first study. The major takeaway from the results of the second experiment was 1. the camera did not affect the performance or actors and the actors tend to adjust their performance according to the camera position and 2. The quality of the recording changed based on the number of actors on the stage, proximity of the actor to the camera, obstruction caused by the fellow actors. Thus, the overall conclusion of the second experiment depended on the nature of the performance and story since the actors had to adapt and improvise based on the camera position on the stage, interfering with their creativity.

Hence the result posed with the next question on what is the best way to place a camera inside a performance space, at the same time it does not hinder the performance and obstruct or lower the quality of the performance to the audience. This resulting question laid the groundwork for the fourth experiment in this research- Devising and producing a VR Dramatic theatre performance with the 360-dgeree camera placed on the top of the actor. However due to the COVID-19 and lockdown restriction, this proposed experiment had to be postponed.

On the other hand, the result from the second study also proposed a research question: Can the audience and actors experience a remote performance in a virtual space and how can it affect the actors in particular, since they have to get involved and interact with fellow actors but they are physically in a separate location. This laid the groundwork for the third experiment as it also aligned with the lockdown period and required actors/audience participants only at the end of the experiment. The result was collected based on the virtual development of a 3D

space where audience and actors can exist virtually and engage in the performance. The experiment expected the participants (actors and audience) to experience the virtual theatre space and provide feedback in the form of an interview session which included both open and closed ended questions. However, during the experiment as a media researcher, I received ethical consent from the participants and recorded their experience. The video analysis and interview transcription showcased the level of interactivity and immersion the participants could achieve and their excitement for the experiment. Due to considerations such as the scope of the experiment, time constraints, budget limitations, and participant involvement, the exploration of interaction between multiple participants simultaneously was not included in this experiment. In other words, keeping the focus and scope of the experiment on the participants' interactivity and feedback about the virtual theatre space resulted in a great success. The interaction and the interview demonstrated that the participants welcome the novel application of incorporating virtual theatre spaces into the traditional theatre. However, the results did not provide sufficient evidence for the entire theatre community to use virtual spaces. It was evident that participants still welcomed traditional theatre and preferred to enjoy a performance in a theatre stage experience, however virtual theatre spaces can be a part of the performance. It should be noted that the participants are excited to apply VR and other technology to enhance their viewing experience but at the same time they do encourage having traditional theatre performance from a third person seated perspective along with the crowd, noise and obstruction. The overall conclusion can be summarised as applying novel technology can excite and invite newer audiences to theatre but should not seek to replace or eradicate aspects of the experience of a traditional performance. VR dramatic theatre and traditional theatre performance will tend to co-exist. The results from the third study also pointed out the advantages of having a virtual theatre space, particularly at the times of COVID-19 and lockdown. Some of the reasons were it exhibited physical distancing and yet the actors can

rehearse and perform. Thus it was concluded that introducing virtual spaces can provide certain advantages to the actors and audiences depending on the performance type and theme.

The main implication of the result from the third study proposed the idea to unite virtual theatre space and traditional live theatre performances. This was in line with the result obtained from the study two - Devising and producing a VR Dramatic theatre performance. However devising and structuring an entire VR dramatic theatre performance is a large scope of work. Hence the fourth study 'Virtual 360-degree dramatic theatre: A new branch in experimental theatre' focused on the actors and their opinion about using a 360-degree camera in a stage performance. It included an interview with the actors, consisting of both open and closed questions on their opinion and feedback of the application. The results supported the idea of using a 360-degree camera as a property on the actor, similar to a hat worn by an actor. The actors were excited and thrilled to use a novel application of VR technology. The actors case showed a strong likelihood towards the use of a 360-degree camera. Surprisingly, the director of the performance greatly benefited from the VR technology. It allowed the director to view the entire performance from a position they wanted to picture the experience. It provided the director with the artistic visualisation and freedom to adjust and improvise the entire performance. For example, the director was able to position the actors and properties precisely and modify the performance to every minute detail. As the creator of the performance this VR technology allowed the director to view the performance in all possible positions and angles, thus helping in reducing the flaws of the performance.

This result guided to the final study of this research on the reception of the VR dramatic theatre by the audience and the impact on the art of theatre and audience experience. The audience study was conducted by having the audience view the performance (either live streaming or recording) and interviewing the audience to gain a better understanding on how the VR technology has impacted their experience. The reason behind this study is that affinity

towards VR technology and novel theatre performance changes for every audience. Some audiences will be benefited through this application while the others could have an inclination towards traditional performance. This final study provided a clear understanding by pointing out the advantages and disadvantages of applying VR 360-degree technology into theatre performance. One solution to carefully examine this difference of opinion among the audience is by producing a theatre performance in both traditional methods and using VR dramatic theatre style. This was actually proposed to be performed in this particular research as well: having the audience experience both the type of theatre and having them choose during the interviews. However, due to the COVID-19 outbreak and lockdown restrictions it was difficult to invite and provide them with the traditional theatre experience. They had to compare the VR dramatic theatre experience with their previous traditional theatre experience of a different stage play. Though this was a shortcoming faced by the researcher, I could make use of the audience interview answers to provide a strong impact statement that VR technology is a definite advantage to the field of arts and theatre.

The overall outcome of this research study are as follows:

Barries to interactivity:

- The audience did not perceive the experience as traditionally interactive, highlighting a distinction in the overall experience compared to other VR applications, such as VR games.
- Audience interview transcription shows that the experience was exciting, not problematic and simple to follow.

Effectiveness of the theatre experience:

- Audience were able to focus on the performance and adapt to the new 360-degree view of the performance.
- Audience reported that they could feel their virtual presence on the stage, increasing the level of immersion and engagement.

Change in perspective:

- Audience reported that they will be able to feel embodied into the actor's position, making them experience the entire performance as an actor on the stage.
- Majority of the audience stated that the experience provided a realistic stage environment in which they were a part of.
- Most of the participants stated that the VR Dramatic theatre through the Google Cardboard removed external stimuli and distractions, keeping them occupied within the virtual space.
- Three of the participants reported that they could not feel being amidst the performance since they were aware of their physical surroundings and the hardware needed to be enhanced.

Visual and Audio Cues:

- The audience were successful in maintaining their focus within the performing space with the help of visual and auditory cues.
- A few participants reported on the direct glare of the stage lights interfering with their experience and reducing the quality of the performance.

Discrepancy:

- Few audience members reported that the traditional viewing of the performance was much preferred over the 360-degree viewing, yet most of

the participants found the 360-degree viewing more novel, exciting and entertaining.

- The actor participants were more interested and invested in the VR dramatic theatre compared to the audience participants.
- The actor participants had more excitement because their interview reported that they wanted to produce a new type of performance and get distinguished from a traditional normal performance.

There was variable response from the participants regarding the level of engagement and interactivity provided to the participants. The level of interactivity was compromised in this research due to the introduction of the idea of cost effective VR technology. Further work is required to make it sufficiently interactive and immersion at the level of a digital VR experience or VR game and to find out if the audience interaction can influence the flow of the performance and story.

6.2 Advantages and Strengths

There are several aspects of this research that are unique and novel in comparison with the existing application of VR in theatre and entertainment. One of the advantages of the research is the useful application of VR in a low effective way. By considering the high cost hardware components associated with VR, the research found that audiences and participants tend to enjoy the affordability provided by Google Cardboard. For example: Google Cardboard is useful in various factors associated with the audience. The factors include economics, immersive pleasure, social status and ecological benefits. Furthermore the research also tends to focus on actors and theatre producers, the study four (article 4) focuses on the audiences in particular, which allowed to gather information and data from the audiences. It helped to conclude that audiences tend to favour the cost effective feature of the Google Cardboard HMD. Particularly this version of VR-HMD is easy to carry, simple to assemble and

compatible with the majority of smartphones. Thus the study proposes future researchers to focus on studying the various methods of providing interactivity to the audience and evaluate it with Google Cardboard as the primary HMD.

Additionally, another study of the study is that VR can be used as a tool for rehearsal and designing an entire theatre performance. Dixon (2006) has already tested and evaluated the use of VR as a tool for designing stage environments and properties. However, this research provides the creator to visually picturize the entire performance and the freedom to alter and modify the performance. For example: the creator can be present from anywhere in the stage or as any character in the performance, providing them with the ability to criticize and improvise the performance before the audiences are given the chance. Furthermore it always provides the creators to work in detail and place various associated easter eggs corresponding to the performance and story, making the audience's experience more exciting and entertaining. For example, the audience stated in the interview that this study increases the idea of rewatching the performance since it provides a new perspective to a traditional and normal story. If the study simply concluded on experimenting and interviewing with the actors, it would not know the exact reason for why this incorporation is successful. Hence the research suggests future researchers to explore and evaluate the audiences' view as a factor in any technological application.

The strength of the first and second study was that it evaluated theoretical and practical aspects of incorporating VR 360-degree cameras into a theatre stage instead of a random placement of the camera on the stage as done in previous research (see Charlton & Moar, 2018). By considering the audience as a factor in this research, it has provided the study a much better structure and argument for this particular VR application. Knowing about the audience and actors evaluation on the importance of remote performance and remote viewing, formulated the framework and results obtained from the study to a better structure. In other words, by

exploring and studying the actors and audiences reaction, this research has established a connection between VR and theatre performance. This experimentally proved the theory put forward by Dixon on VR and theatre performance are more similar and alike (2006).

The primary reason for choosing a 3-DOF headset for this project is due to the fact that the camera were planned to be placed on the actor's head. This choice serves as an initial step in acquainting the audience with VR theatre. Introducing a 6-DOF headset was deemed challenging and potentially confusing for the audience, given that the camera is confined to the actor's translation. Moreover, it would have expanded the research scope, demanding more time and resources. Another consideration against a 6-DOF headset was the potential alienation of the audience from the performance, affecting immersion. However, the third experiment did delve into the intricacies of using a 6-DOF headset for the audience.

For a 6-DOF headset to be effective, a virtual presence of the audience on the stage, as "an audience," would be preferable. This setup would grant them the freedom to explore the stage and the performance independently. The core focus of this research revolves around virtually teleporting the audience onto the stage, enabling them to view the performance from the actor's perspective. Considering this research focus, the 3-DOF headset emerged as the most suitable choice.

While the current study concentrates on 3-DOF, it does propose the prospect of future experimentation with 6-DOF. Numerous opportunities arise with the application of 6-DOF, including interactive performances, storytelling within a performance, and even in the realm of interactive cinema.

6.3 Future Work

The study was conducted with fourteen participants (including actors and audience members) from New Zealand and also outside New Zealand. The sample-related limitations were due to

the loss of time and engagement with theatre practitioners and audiences due to the lockdown restrictions of COVID-19. Although for an interdisciplinary research study, fourteen is considered a satisfactory number of participants, extending the study to include more participants would enable the researcher to capture more variation and draw strong conclusions representative of the theatre community and theatre consumers. The participants were not based on a single local community, hence it provided the necessary age and cultural and ethnic diversity for the project. In the future, this research can be extended to a particular local theatre community and adjust the VR application to suit their requirements and necessity.

Looking towards the future, there are numerous opportunities for further research on the association between virtual reality and theatre performance. One possible avenue for exploration is the development of VR technology specifically for use in theatre productions. As technology continues to advance, it may become possible to create virtual worlds that can be seamlessly integrated into live theatre performances, providing a new level of immersion for audiences. For example, A mixed reality stage where live actors can perform along with virtually created properties (hologram) and have the audience virtually experience the performance from the centre of the show.

Another area of research could explore the impact of VR on the theatre industry. As VR technology becomes more widely available, it is possible that it could transform the way that theatre productions are created and experienced. For example, it may be possible to create alternate versions of popular plays that can be experienced virtually from anywhere in the world, opening up new opportunities for global audiences to experience live theatre.

Although the research planned to execute a VR technology application for a larger and more diverse range of participants (theatre audience), the influence of COVID-19 and pandemic lockdown affected the research requiring it to be conducted on a reduced scale due

to social distancing and government rules surrounding social gatherings. Although this research was successful in conducting the quantitative analysis of applying VR technologies into theatre, the future research requires to dive deep into the quantitative analysis of this particular application, exploring the various diversity of audiences based on age, ethnicity, cultural background, technological literacy, VR limitations like motion sickness.

Furthermore, this research has explored the smallest potential collaborations between VR and theatre production. By working together in the future, theatre companies and VR developers could create innovative new forms of entertainment that combine the best of both mediums. Overall, the association between virtual reality and theatre performance is an exciting area of exploration that holds numerous possibilities for future research and development. By continuing to push the boundaries of technology and creativity, it may be possible to create entirely new forms of entertainment that engage audiences in a way that was previously unimaginable.

The overall conclusion derived from this research is that the actors and audience were satisfied and excited with the VR application in theatre and the remote viewing experience, however, to find out if it will work for a full-length theatre production with a larger audience, future work should focus on a longitudinal study of a full-length VR dramatic theatre with a larger set of audience and collecting the audience and actors feedback and evaluating the strengths and the practical difficulties faced during the study.

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Appendices

Co-authorship Form 1 - Virtual Teleportation of a Theatre Audience onto the Stage: VR as an Assistive Technology

Co-authorship Form 2 - Envisioning New Virtual Spaces for Performance and Theatre artists

Ethics Approval

Participants Consent Forms

Participants Information Sheets

Geography Programme
School of Social Sciences
Faculty of Arts and Social Sciences
Te Kura Kete Aronui
The University of Waikato
Private Bag 3105
Hamilton 3240
New Zealand

Phone +64 7 838 4466 ext 9174
E-mail colin.mcleay@waikato.ac.nz
www.waikato.ac.nz

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Sai Krishna Srinivasan
Dr Gareth Schott
Dr Kyle Barrett

Screen and Media Studies

2 May 2019

Dear Sai Krishna,

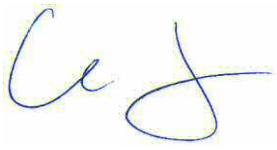
Re: **FS2019-02: Formless, Incorporeal and Floating Audiences: Examination of the application and assimilation of Virtual Reality in Theatre Performance**

Thank you for submitting your revised application to the FASS Human Research Ethics Committee. We have reviewed the final version of your application and the Committee is now pleased to offer formal approval for your research activities, including the following:

- conduct focus groups with members of theatre production companies based in the Waikato and the Bay of Plenty.
- collaborate with members of Waikato and Bay of Plenty theatre production companies around engagement with processes of integrating and assimilating Virtual Reality within a theatre context.
- question in-house theatre audiences on their experience and engagement with Virtual Reality.

We encourage you to contact the committee should issues arise during your data collection, or should you wish to add further research activities or make changes to your project as it unfolds. We wish you all the best with your research. Thank you for engaging with the process of ethical review.

Regards,



Colin McLeay, Chair
Faculty of Arts and Social Sciences Human Research Ethics Committee.

UNIVERSITY OF WAIKATO
FACULTY OF ARTS & SOCIAL SCIENCES
SCREEN AND MEDIA STUDIES

Information Sheet – Workshop Practice

Title of Project: Formless, Incorporeal and Floating Audiences: Examination of the application and assimilation of Virtual Reality in Theatre.

About the researcher

I am Saikrishna Srinivasan, a PhD student in Screen and Media, at the Faculty of Arts and Social Science, University of Waikato. I can be contacted through email sks61@students.waikato.ac.nz. My chief supervisor is Associate Prof. Gareth Schott from the Screen and Media program, Faculty of Arts and Social Sciences, at the University of Waikato, who can be contacted at gareth.schott@waikato.ac.nz.

What is this research about?

The research is about conducting experiments to produce dynamic immersive theatre by examining the possibilities, potential impact and limitation of assimilating the use of a 360-degree field of view (Virtual Reality) on theatre performance, stage performers and audiences. I would be asking the participants to be part of the four stages of the research. Focus groups, workshop practice, experiencing an immersive VR theatre performance and a feedback interview about the VR theatre.

What is the aim of this research?

The research aims to study about the audience impact and opinion on experiencing theatre performing using 360-degree VR Head Mounted Display (Google Cardboard) and the performing artist assessment on having a 360-degree camera on or near them.

What do you need to do as a participant?

As the participant, you will be asked to represent the workshop practice group for the data collection. The workshop will be recorded using a camera with your permissions. The recording will happen within the theatre production rehearsal premises.

The workshop practice will be branched out of the focus group with the theatre production company, whose interests matches with the research and willing to work together and be part of this experiment. In this activity, the participants (the theatre actors and technicians) and the researcher will be working together to create the content for the VR immersive theatre. The activity will be recorded and edited with your permission so that it can be used in the creatively lead research output for the research.

What will be in the Workshop Practice?

In the workshop practice, you will be working alongside the researcher to devise the VR immersive theatre. It will consist of small or micro experiments that cover both the theatre and VR side of research, example – placement of the camera, low lighting issues, etc. The experiments will be recorded and edited with your permission for the development of the Practice Led Research and thesis of the research.

Potential Risks

The experiments might have the potential risk of the cameras getting displaced or fall off during the performance by the actors. It will be minimised by having the participants have the camera attached using a safety belt.

Participants rights

- As a participant, you have the choice to remain anonymous. By doing so, only the researcher will have access to your name.
- The data collected from this research will be stored securely on a password protected personal computer in the researcher office inside the University of Waikato for five years, after which the data will then be deleted.
- You can request a copy of the data collected and the findings from this project.
- You can withdraw from the VR experience at any time during the process.
- You can decline to answer any question after the experience.
- You can withdraw from the complete research up to one month after the VR experience/interview has taken place.

Finally, this research project has been approved by the Human Research Ethics Committee of the Faculty of Arts and Social Sciences. Any questions about the ethical conduct of this research may be sent to the Secretary of the Committee, postal address,

Faculty of Arts and Social Sciences,
Te Kura Kete Aronui,
The University of Waikato,
Te Whare Wananga o Waikato,
Private Bag 3105,
Hamilton 3240.

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more, you can contact the researcher using the details as mentioned earlier.

UNIVERSITY OF WAIKATO
FACULTY OF ARTS & SOCIAL SCIENCES
SCREEN AND MEDIA STUDIES

Information Sheet – Immersive VR Theatre

Title of Project: Formless, Incorporeal and Floating Audiences: Examination of the application and assimilation of Virtual Reality in Theatre.

About the researcher

I am Saikrishna Srinivasan, a PhD student in Screen and Media, at the Faculty of Arts and Social Science, University of Waikato. I can be contacted through email sks61@students.waikato.ac.nz. My chief supervisor is Associate Prof. Gareth Schott from the Screen and Media program, Faculty of Arts and Social Sciences, at the University of Waikato, who can be contacted at gareth.schott@waikato.ac.nz.

What is this research about?

The research is about conducting experiments to produce dynamic immersive theatre by examining the possibilities, potential impact and limitation of assimilating the use of a 360-degree field of view (Virtual Reality) on theatre performance, stage performers and audiences. I would be asking the participants to be part of the four stages of the research. Focus groups, workshop practise, experiencing an immersive VR theatre performance and a feedback interview about the VR theatre.

What is the aim of this research?

The research aims to study about the audience impact and opinion on experiencing theatre performing using 360-degree VR Head Mounted Display (Google Cardboard) and the performing artist assessment on having a 360-degree camera on or near them.

What do you need to do as a participant?

As the participant, you will be asked to be a part of the VR Theatre Experience for the data collection. **You will be required to have a smartphone.** The VR theatre experience will be recorded using a camera during the activity with your permissions.

You (in-house audience/ non-performing artist) will be asked to experience the VR theatre performance. You are required to wear the Google Cardboard (HMD) and experience the performance. You will be allowed to try the VR gadgets before the experience to check if you have any issues or if you are prone to motion sickness. If so, you will be asked to withdraw from the activity for health and safety reasons.

What will be in the immersive VR theatre performance?

The immersive VR theatre performance will be designed and developed theatre performance for about 10 to 15 minutes of runtime (will be amended as per the progress or focus group and workshop). You will experience the theatre play from the perspective of an actor.

Potential Risks

Virtual Reality is always related to visual, auditory issues and motion sickness, as it has the potential to be very sensitive. The above-mentioned immersive VR theatre will be designed in such a way that it will be structured and produced within the visual and auditory wavelength of average humans. The worst case of any potential harm will be, due to motion sickness during their VR experience by wearing the headsets. The participants will be checked if they have any past motion sickness related issues and will also be asked to check a trial by wearing the VR gadgets so that they can withdraw from it if they are not comfortable.

Participants rights

- As a participant, you have the choice to remain anonymous. By doing so, only the researcher will have access to your name.
- The data collected from this research will be stored securely on a password protected personal computer in the researcher office inside the University of Waikato for five years, after which the data will then be deleted.
- You can request a copy of the data collected and the findings from this project.
- You can withdraw from the VR experience at any time during the process.
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Finally, this research project has been approved by the Human Research Ethics Committee of the Faculty of Arts and Social Sciences. Any questions about the ethical conduct of this research may be sent to the Secretary of the Committee, postal address,

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Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more, you can contact the researcher using the details as mentioned earlier.

UNIVERSITY OF WAIKATO
FACULTY OF ARTS & SOCIAL SCIENCES
SCREEN AND MEDIA STUDIES

Information Sheet – Questionnaire / Interview

Title of Project: Formless, Incorporeal and Floating Audiences: Examination of the application and assimilation of Virtual Reality in Theatre.

About the researcher

I am Saikrishna Srinivasan, a PhD student in Screen and Media, at the Faculty of Arts and Social Science, University of Waikato. I can be contacted through email sks61@students.waikato.ac.nz. My chief supervisor is Associate Prof. Gareth Schott from the Screen and Media program, Faculty of Arts and Social Sciences, at the University of Waikato, who can be contacted at gareth.schott@waikato.ac.nz.

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What is the aim of this research?

The research aims to study about the audience impact and opinion on experiencing theatre performing using 360-degree VR Head Mounted Display (Google Cardboard) and the performing artist assessment on having a 360-degree camera on or near them.

What do you need to do as a participant?

As a participant, you will be asked to be a part of the questionnaire/interview for the data collection. The interview session will be recorded using a camera, with your permission.

You will be asked to answer the feedback questionnaire/interview session individually, based on your VR experience. An opportunity will be provided on the questionnaire for participants to indicate their preparedness to be further involved in the project and willingness to complete follow up to an interview.

What will be in the Questionnaire?

You will be asked to answer a questionnaire, consisting of both open-ended and closed-ended questions regarding the topic of Difference in VR immersive theatre and traditional theatre, Effect of VR theatre in conveying a story, Reducing the distance between audience and actor, Change in the perspective of audience, VR and theatre performance are complementing medium?

Participants rights

- As a participant, you have the choice to remain anonymous. By doing so, only the researcher will have access to your name.
- The data collected from this research will be stored securely on a password protected personal computer in the researcher office inside the University of Waikato for five years, after which the data will then be deleted.
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Private Bag 3105,
Hamilton 3240.

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more, you can contact the researcher using the details as mentioned earlier.

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PARTICIPANT CONSENT FORM – FOCUS GROUP

[A completed copy of this form should be retained by both the researcher and the participant]

Name of participant: _____

I have received a copy of the Information Sheet describing the research project. Any questions that I have, relating to the research, have been answered to my satisfaction. I understand that I can ask further questions about the research at any time during my participation and that I can withdraw my participation at any time [up to four weeks] after the interview.

- Activity 1: During the focus group activity, I am aware of the recording session, and I give my permission to use it for the research purpose. I can leave the discussion at any point in time if I am uncomfortable.

When I sign this consent form, I will retain ownership of my recording and interview, but I give consent for the researcher to use them for the purposes of the research outlined in the Information Sheet.
[I understand that my identity will remain confidential in the presentation of the research findings]

Please complete the following checklist. Tick [ ] the appropriate box for each point.	YES	NO
I wish to view the transcript of the activities.		
I wish to receive a copy of the findings.		
I wish to view the recording of the focus group session		

Participant:	_____	Researcher:	Saikrishna Srinivasan
Signature:	_____	Signature:	_____
Date:	_____	Date:	_____
Contact Details:	_____	Contact Details:	sks61@students.waikato.ac.nz
	_____		0225045727

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PARTICIPANT CONSENT FORM – WORKSHOP PRACTICE

[A completed copy of this form should be retained by both the researcher and the participant]

Name of participant: _____

I have received a copy of the Information Sheet describing the research project. Any questions that I have, relating to the research, have been answered to my satisfaction. I understand that I can ask further questions about the research at any time during my participation and that I can withdraw my participation at any time [up to four weeks] after the interview.

- Activity: I give my consent and permission to record the activities during the workshop (developing the VR theatre experience) and edit it for the research purpose.

When I sign this consent form, I will retain ownership of my recording, but I give consent for the researcher to use them for the purposes of the research outlined in the Information Sheet.
[I understand that my identity will remain confidential in the presentation of the research findings]

Please complete the following checklist. Tick [ ] the appropriate box for each point.	YES	NO
I wish to view the transcript of the activities.		
I wish to receive a copy of the findings.		
I wish to view the recording of the workshop		

Participant:	_____	Researcher:	Saikrishna Srinivasan
Signature:	_____	Signature:	_____
Date:	_____	Date:	_____
Contact Details:	_____	Contact Details:	sks61@students.waikato.ac.nz
	_____		0225045727

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PARTICIPANT CONSENT FORM – VR THEATRE EXPERIENCE

[A completed copy of this form should be retained by both the researcher and the participant]

Name of participant: _____

I have received a copy of the Information Sheet describing the research project. Any questions that I have, relating to the research, have been answered to my satisfaction. I understand that I can ask further questions about the research at any time during my participation and that I can withdraw my participation at any time [up to four weeks] after the interview.

Tick the activity you are participating:

- Activity 1: Before the VR theatre experience, I accept to try the VR hardware and make sure I am comfortable and get used to the hardware, after which I will proceed with the activity. Also, I have a smartphone available with me.

- Activity 2: During the VR theatre experience, I am aware that the activity will be recorded and used for the research. I can stop my participation at any point in time.

When I sign this consent form, I will retain ownership of my recording and VR experience, but I give consent for the researcher to use them for the purposes of the research outlined in the Information Sheet.
[I understand that my identity will remain confidential in the presentation of the research findings]

Please complete the following checklist. Tick [ ] the appropriate box for each point.	YES	NO
I wish to view the transcript of the activities.		
I wish to receive a copy of the findings.		
I wish to view the recording of my VR experience		

Participant:	_____	Researcher:	Saikrishna Srinivasan
Signature:	_____	Signature:	_____
Date:	_____	Date:	_____
Contact Details:	_____	Contact Details:	sks61@students.waikato.ac.nz
	_____		0225045727

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PARTICIPANT CONSENT FORM – QUESTIONNAIRE/ INTERVIEW

[A completed copy of this form should be retained by both the researcher and the participant]

Name of participant: _____

I have received a copy of the Information Sheet describing the research project. Any questions that I have, relating to the research, have been answered to my satisfaction. I understand that I can ask further questions about the research at any time during my participation and that I can withdraw my participation at any time [up to four weeks] after the interview.

Tick the activity you are participating:

- Activity 1: After the VR theatre experience, I accept to answer the **questionnaire.**
- Activity 2: During the **interview**, I understand that I do not have to answer any questions that I feel uncomfortable to discuss. I can stop the interview at any time, and to have the recording device turned off at any time.

When I sign this consent form, I will retain ownership of my recording and interview, but I give consent for the researcher to use them for the purposes of the research outlined in the Information Sheet.
[I understand that my identity will remain confidential in the presentation of the research findings]

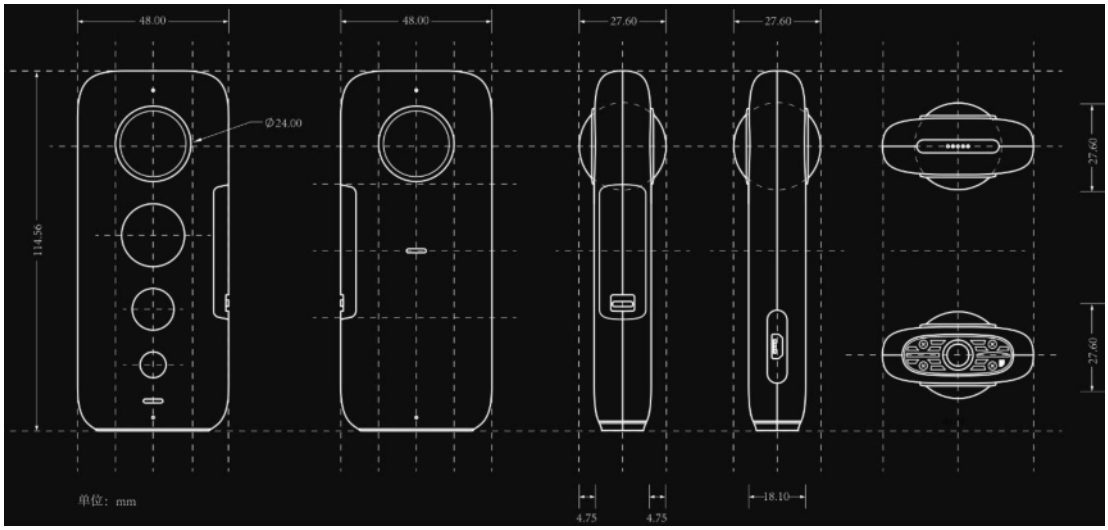
Please complete the following checklist. Tick [ ] the appropriate box for each point.	**YES**	**NO**
I wish to view the transcript of the activities.		
I wish to receive a copy of the findings.		
I wish to view the recording of my interview		

Participant:		Researcher:	Saikrishna Srinivasan
Signature:		Signature:	
Date:		Date:	
Contact Details:		Contact Details:	sks61@students.waikato.ac.nz
			0225045727

RESEARCH INSTRUMENTS

Google Cardboard with mobile phone

Insta360 One X



Insta360 One X - Dimensions

Ricoh Theta V