Tele-Immersion for the Training and Performance of Live Theatre

by

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Declaration of Authorship

I, Boyd M. Branch, declare that this thesis titled, 'Tele-Immersion for the Training and Performance of Live Theatre' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.

- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.

- Where I have consulted the published work of others, this is always clearly attributed.

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Signed: *Boyd Branch*

Date: October 19, 2022

"Theatre is the art of looking at ourselves."

Augusto Boal

UNIVERSITY OF KENT

Abstract

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This thesis presents the findings of a practice-based research project investigating how virtually co-locating remote users inside shared virtual environments affects creativity, collaboration, and social attunement. The main contributions of this thesis are novel findings on the impact of tele-immersion on the rehearsal and performance of improvisational theatre, and the development of Virtual Director, a digital platform for co-locating remote performers into shared virtual three-dimensional environments that can be accessed simply with a consumer level laptop. A case study of Virtual Director in professional use is first presented, followed by two qualitative and mixed method studies are presented that are the first of their kind for evaluating the impact of tele-immersion on the rehearsal and performance of remote improvisational and scripted theatre on performers, as well as the design, development, and employment of the Virtual Director platform.

First, I present a background establishing the unique demands of live performance, improvisation, and collaborative storytelling and how they are affected by traditional video conferencing tools. Then I review existing telepresence and tele-immersive technologies that have been used for remote performances. This introductory chapter draws from recent studies in psychology, social science, neural biology and creative performance to support a theory for how a mirror-based tele-immersive virtual performance space can foster a unique sense of presence that supports entering into optimal flow states and positively impact an improvisor's ability to spontaneously generate cohesive and highly context-specific narratives with other performers. I then present Virtual Director, an original digital performance platform designed to facilitate an immediate sense of presence between performers by visually immersing them in a shared mirror-based tele-immersive virtual environment. I further explicate a theory for how tele-immersion can exploit the phenomenon of top-down neural processing of visual fields that makes it easier for collaborators to ignore distractions from their physical environments.

A case study, published with the International Conference on Creative Computing, is presented that examines the use of Virtual Director for a series of performances with the improv theatre troupe *Improbotics*. The case study provides reports on audience and performer perspectives on the use of tele-immersion for entertainment, and examines in depth many of the considerations that must be accounted for when performing with a new technology and medium.

Two qualitative studies are then presented that were designed to examine the impact of tele-immersion specifically on improvisational performance with domain experts. Review of survey data, interviews, and qualitative and quantitative analysis of audio-visual recordings of participants engaging tele-immersively are examined to demonstrate how the sense of presence, flow, creativity, social attunement, improvisational style, and skills

are impacted. The first case study evaluates 6 different improvisational theatre 'duos' rehearsing and performing with Virtual Director over a 4-week period. The second study is then presented on randomly assigned remote partners given a creative storytelling task to perform both within a tele-present environment and traditional video conferencing environments.

Novel findings of the case studies indicate that tele-immersion significantly leads to increased physical movement during remote rehearsal and performance, heightened awareness and engagement with the present moment and given circumstances of a scene, incorporation of virtual scenery into performance, and sense of physical presence with remote partners. The case studies work together to demonstrate how shared screen space further facilitates novel interactions that can be guided by a facilitator to help performers reach states of flow and co-creativity. Analysis of surveys and interviews are further used to demonstrate a correlation between a high sense of presence and social flow with a shift from pessimistic to optimistic anticipation about the use of technology for creative performance. The thesis concludes with a discussion of the reflections of performers and audience members regarding their emotional reactions to being virtually co-located after significant periods of being in social isolation. The discussion continues by exploring the potential of using Virtual Director and applying the findings on presence, flow, and creativity in online leadership training, therapy, and conflict resolution. My work presents original insights in understanding how traditional computing display environments can be utilised to enhance co-creatively a sense of physical presence between remote partners, and how presenting virtual bodies in co-located space can provide sufficient aesthetic feedback for performers to restore the physical aspect of social flow for improvisation that is otherwise lost with existing telepresence technologies.

Acknowledgements

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Dedicated to my father, who taught me how to improvise.

Chapter 1

Introduction

Tele-immersion is a term for a kind of remote collaboration that aims to fully engage users into a shared sensory reality where 'each user stays and perceives his own location; however, at the same time, all users are immersed in one shared workspace' [1]. The nature and level of immersion can differ dramatically across tele-immersive platforms and employ a range of different techniques to exploit various cognitive features of visual and auditory processing [2–5]. The sense of immersion itself is a sensation that arises from within the subject as a response to both internal and external stimuli that the subject is inclined to become present with [6]. The physical world and the sensory world both offer a seemingly endless supply of information that could be processed, but we each have a finite capacity for the amount of information we can consciously process, and trade-offs subsequently occur around what we can pay attention to or be present with. Evolution has conditioned us to privilege certain kinds of information or stimuli over others that generally relate to our survival - from being able to distinguish the nuances of a human voice, to being able to notice changes in gestures and facial
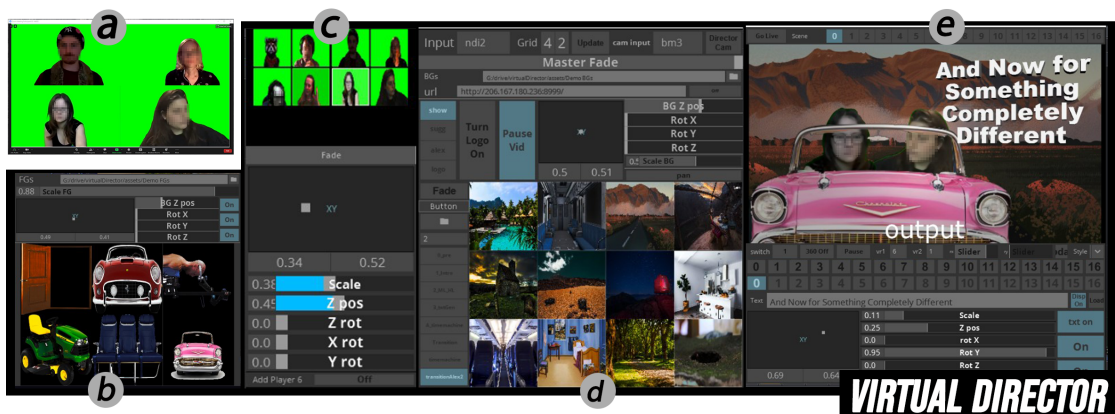
Figure 1.1: Virtual Director GUI, 2020: *(a) Zoom screen capture, (b) FG select, (c) Player select, (d) BG select, (e) Preview*

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expressions of the people we are talking to [7]. Communications technology as a subset of Human Computer Interaction (HCI) works to exploit these tendencies so that the user is inclined to pay attention to and be more present with the remote partners than the physically near environment they may find themselves in [8]. For instance, the telephone doesn't simply bring the voice of a remote partner into general proximity of the caller, it brings the voice right up to the ear such that it precludes the other sounds in the room. Near sounds generally take precedence over far away sounds for the obvious reason that what is nearby will likely have a more immediate effect on us than sounds that are far away [9]. (The increase in pedestrian accidents from crossing the road corresponding with widespread adoption of mobile phones is now a classic example of the phenomenon [10]).

The telephone exploits this tendency by making the far away person sound physically closer to the extent that we lose the sense of what is actually physically around us, including other people and potential threats, like oncoming traffic [11]. The remote voice, brought close, operates to marshal the caller's cognition to work in service of paying attention to the remote partner by ignoring other phenomena that would compete for attention. The successful degree to which the technology inclines the user to concentrate most of their attention (feeling of presence with) on the remote partner is a general measure of success for tele-immersion [12]. Proximity is the most generally exploited feature of remote communications systems which work to dominate not just the auditory but also the visual field of the user by placing screens as close to the user as possible, or surrounding them in virtual reality headsets that completely replace the physical visual field with a virtual one. Besides proximity there are other features of human cognition and awareness that can be exploited to command attention.

Most of our sensory processing occurs at a subconscious level by subcortical regions of the brain that are constantly monitoring the flood of information and categorising it into what is familiar, novel, threatening, or presenting opportunities [13]. This is why we can be fully engaged in a conversation and unaware of a ball game taking place in the distance, but nevertheless be able to suddenly duck to avoid a ball aimed at our head, before we consciously realise what is happening [14]). Rapidly moving objects are processed in the amygdala before other sensory data, and based on proximity will hijack higher-order reasoning by triggering a fight or flight reaction [15]. Such aspects of human cognition are what magicians exploit for sleight of hand tricks that create the illusion that coins can appear from thin air or make entire buildings disappear with a wave of the hand [16].

Computer scientists and computer human interaction specialists can also exploit these traits of cognition to influence behaviour by careful manipulation of user interfaces and

displays. Research on human cognition and the various ways we process information is ongoing and findings do not always make their way into fields outside of psychology, particularly, as we will see with modern remote communication platform development that might take particular advantage of this research. One such area of study from the social sciences is the use and cognitive impact of watching ourselves in the act of communication in the presence of mirrors [17–20].

Mirror response and self-aware cognitive states are subjects of decades of research that are particularly salient for designing remote collaboration tools, as many modern systems involve the incorporation of video 'mirrors' into interfaces. In 2020 there was a global increase in the use of video conferencing software as a result of the Covid-19 pandemic which required the majority of the world's population to work from home [21]. As millions of new users began working with remote conferencing tools for hours each day, a phenomenon of 'Zoom Fatigue' emerged where users described a feeling of seemingly disproportionate exhaustion from meetings that were not experienced when face to face [22]. The video mirror has emerged in studies of zoom fatigue as one likely culprit for increasing cognitive load, anxiety around facial appearance, and increased rumination about imperfections [23]. Previous mirror studies from psychology, however, had long demonstrated such effects before the feature was designed into popular interfaces, and could have predicted the problems that have emerged [24, 25].

Besides the negative impact of mirrors being present during collaborative tasks, they also present several potential benefits for conferencing platforms that have yet to be formally studied in the field. Mirrors are a useful tool in particular for training and performance related tasks ranging from dance to basketball [26, 27]. Mirrors have been shown to induce a self-aware cognitive state that can enhance accuracy in a range of tasks and improve the ability to incorporate feedback from others [28, 29]. Mirrors cannot be easily incorporated into most face to face interactions, however, that retain the positive features without also bringing the more negative aspects to bear. Video conferencing however, presents a unique opportunity to explore how mirror perspectives might be incorporated that mitigate the distractions while offering the advantages for training. As noted earlier, most modern video conferencing platforms have long had the ability to incorporate mirrored perspectives into their interfaces, but have been rarely made available. A brief survey of the development of video conferencing platforms and remote communication is important to demonstrate the novelty of this feature, and how a different kind of design thinking must be employed to advance immersive communication platforms to meet the needs of collaborators beyond conferencing.

1.1 Cross-Disciplinary Scholarship

This work builds on a large cross-section of scholarship and practice to support its research methodology, and it will be important to carefully examine literature from a variety of fields to understand the contributions it makes. Specifically the historical development and failures of certain immersive communication technologies will demonstrate the need for a mixed method research approach to user studies with tele-immersion that is designed to discover utility rather than test for validation of a particular communication metric. A general examination of certain kinds of actor training and a focused study of improvisational theatre practice, in turn, informs the particular design decisions around the software developed specifically for the needs of remote performers, as well as the activities participants were invited to engage in. Theories regarding flow and the neurobiology of synchronized creativity as well as psychological research regarding presence and attunement will then provide a framework for evaluating the specific domains of remote collaboration the two case studies were designed to explore.

The subsequent literature review begins with a survey of findings related to mirrors and cognition that provide a rationale for developing a mirrored-perspective tele-immersive remote communication platform, despite recent criticism about video mirrors contributing to poorer communication. Bringing together research from social sciences, theatre, and cognitive studies alongside the new and emerging studies around the experience of 'Zoom Fatigue,' the potential of the mirror will be shown to have particular qualities uniquely conducive to training and performing theatre remotely. The next chapter outlines relevant studies related to mirrors and self-aware cognition that underscore design features built into a novel tele-immersive platform called VirtualDirector that was developed for this thesis, and tested on various populations of theatre artists focused on improvisation. A brief history and literature review of tele-immersive platform design and the impact of these interfaces will further contextualise the significance of departing from a teleologically driven design ethos in favour of an iterative approach that allows utility to emerge from design experiments or improvisations. Improvisational practice involves navigating fluidly between various cognitive states that makes it particularly well suited not only for studying how mirror perspectives might enhance training and performance, but also how it can guide design [30]. A chapter on improvisational theory concludes the review of tele-immersive platforms, contextualising the improvisational methodology that informed the experimental design of the studies which are the subject of this thesis.

Chapter 2

Background Theory

2.1 Remote Communication Platforms

Advances in communication technology have largely been driven by a focus on creating the experience of localised proximity-based natural communication over distance. From the telephone to broadcast television, the aim has largely been to allow the remote interlocutor to be presented in the natural range of the senses so that they sound and look nearby [31]. Technology, of course, has had to introduce artifices between communicating bodies in order to do so, from demanding us to speak directly into telephone receivers, to staring in a fixed direction at a screen to see the other person. These artifices do not passively support the communicative act, rather they change the nature of communication itself, providing new communications experiences altogether, as they wean us off natural conventions. The presence and design of mobile devices, laptop screens, and the visual interfaces of those displays not only impact our capacity to communicate, they alter the nature of those communications and directly impact our behaviour, cognition, and learning. As described by media communication theorists from Marshall McLuhan to Vilem Flusser, the mediums of communication themselves have been responsible for considerable social and cultural change ranging from 'retribalization', to dramatic fluctuations of feelings of nationalism, to changes in the concept of a self that is performed as technical image [32, 33]. The long list of companies, developers, designers, technicians, and governments who are responsible for the popular mediums of remote communication today could hardly have been aware of how the technology they developed would impact the individual and society now. It is generally a strange alchemy of factors that result in widespread adoption of a technology, but, by definition, a social technology cannot get adopted that has not been available to that society. Some primary components of communication technology are so expensive that only a handful of institutions have been

able to develop them. The most obvious examples include the design and distribution of telephone lines and development of personal computers. On top of those technologies however, has often emerged a much more accessible playing field for innovation to shape how we communicate. Video conferencing technology in particular presents a historically low barrier to innovation as web standards and advances in data compression and speed of transfer have made it possible to develop boutique conferencing solutions with relatively minimal cost and technical knowledge [34]. Similar to the mobile phone industry however, in the early stages of an emerging technology there is a lot of experimentation until one or two products become popular and eventually establish the standard that only changes by significant disruption from a competing company capable of aggressively marketing a product ie flip phone, to blackberry, to iPhone [35]. Skype and Zoom have set the current standard for video conferencing, however immersive technology including virtual reality and mixed reality are poised to usher in a new level of remote communication [36]. Immersive communication however is still not widespread in use, meaning there is significant room for innovation that will dictate the way we communicate for years to come. A particular kind of immersive communication is now possible, which has not received much attention in the communication industry, and is actually often considered more of a 'bug' than a feature - specifically the ability to see video of yourself while tele-conferencing [37]. Initially, the feature was set up to allow the user to check in and ensure they are properly broadcasting [38], however as the world shifted to almost exclusively working from home over the pandemic, the phenomenon of the 'cocktail effect' has resulted in a degraded experience [39]. The cocktail or 'Troxler' effect is a term used by psychologists to describe our ability to detect when our name is mentioned, despite being in a loud and crowded environment. In a Zoom call, we are drawn to pay more attention to ourselves than others, not necessarily out of vanity, as much as it is a reflection of our tendency for noticing what appears the most likely to impact us immediately and ignore things outside of that focus [40]. With more immersive communication technologies, developers have gravitated toward designing first person experiences that mimic natural communication that usually does not have a mirror constantly present to distract us. If we look at the phenomenon from another perspective however, we might see that the compulsion to look at ourselves might be leveraged as a tool for enhancing certain kinds of collaboration rather than as a software 'bug.'

2.2   Mirrors and Performance Training

Mirrors have been condemned throughout history and culture as a source of vanity and precursor to narcissism, while simultaneously emerging all around us as essential tools for navigating the modern world [41]. The remarkable ability to put a powerful camera

in the pockets of individuals around the world has not resulted in widespread documentation of the outside world nearly to the degree that is used to document our own face [42]. A unique feature of tele-immersive communication is that the 'selfie' is forced into perspective with others, such that to stare at yourself is no longer a private experience, but becomes a fundamentally social one. The ability to see ourselves in the act of socially engaging is a surprisingly novel experience given that we have had the technology to do so for quite some time. Dance of course is one of the few disciplines that uses the mirror itself as a tool, establishing precedent for the value of real time visual feedback in training [26]. In other disciplines however, such as sports and drama or film, the mirror is generally used asynchronously as video played back after the performance [43]. In these cases it makes sense, as such activities require us to dynamically change perspective to interact with others such that seeing ourselves would be an obvious interruption. With remote conferencing however, the gaze is already fixed, and the nature of the social interaction is a virtual one, which means one can observe oneself with others in real time, with potential to take advantage of a third person perspective to improve performance. To a certain extent, all of our communication activities inherently involve a kind of performance of ourselves. To effectively communicate we must maintain some kind of awareness of how our words and actions are being received [44]. Actor training is in many respects primarily aimed at enhancing this ability in order to maximally engage affective capacity on the other [45]. When the actor performs, they learn to be aware of an ever present audience and must, to a certain extent, be able to see from their perspective while simultaneously performing the primary task of the scene [46]. This is how actors engage in 'extra-daily' postures of communication that are able to be more effective than the 'daily' or traditional communication postures [47]. Naturally when in dialogue, it is more intuitive and comfortable to face our partner when we speak, but for cameras and theatre audiences, the actor must often position themselves in relation to a camera or audience in a way that allows them to effectively communicate not only with their partner, but also the audiences (both real and imagined) [48]. Developing this skill requires substantial feedback both in real time from audience members and coaches who make themselves heard or seen, and asynchronously from coaches who report back the success or failure of the performance to maximally affect the audience. The video mirror of tele-immersive conferencing potentially provides another mechanism for training this awareness, and perhaps enhancing some aspects of remote collaboration beyond the boundaries of traditional co-located communication. This thesis is the first of its kind to examine the phenomenon of tele-immersive communication that specifically presents a visually co-located mirror for users as a tool for actors, to see the affordances and challenges this perspective might present.

FIGURE 2.1: Depiction of tele-conferencing user seeing themselves in a video feedback mirror.

2.3 Tele-Immersive Mirrors and Cognition

Since video conferencing platforms capture video of each participant to display to a remote partner, that same video feed can be displayed to the user as a video feedback mirror. This feature of most platforms is primarily made available to allow the user to check in with their camera feed in order to ensure they are broadcasting correctly [49]. In this context, the video feedback functions exactly as a literal mirror would if one was placed in view of two people in conversation - it triggers a self-reflective state [50]. Research examining self-reflective cognition in social contexts indicates that such mirror triggered self-reflective states can lead to a range of positive and negative outcomes related to social interaction, which have consequences for tele-conferencing in the presence of video feedback mirrors. Negative effects observed by psychologists and social scientists include 'higher state social physique anxiety' [51] to increased cognitive load that slows down reaction time [52]. Data from over 10,000 participants in a study on the impact of mirrors during exercise specifically demonstrated that 'mirror anxiety' correlated with higher fatigue for the same activities compared with control [53]. The cognitive state of self-reflection itself has been linked with neuroticism [54], anxiety [55], and depression [56–58]. The negative impact of mirror-induced self-reflection seems to carry forward into the experience of video conferencing platforms that feature this 'mirror view' as reports of difficulty users have with being distracted by their own video feed have only confirmed these earlier studies, leading some to suggest the feature

FIGURE 2.2: Three possible configurations of video conferencing. Left: No video feedback mirror, Middle: Tele-Immersed, Right: Video Feedback mirror in the corner.

should be designed out of interfaces [59]. Jeremy Balienson, who directs Stanford University's Virtual Human Interaction Lab and is one of the leading researchers of immersive communication platforms further argues that the default 'mirror mode' on Zoom and other video conferencing platforms is one of the 4 main contributors to the phenomenon of 'Zoom Fatigue' described as 'the exhaustion you feel after any kind of video call or conference' [23]. The impact of seeing ourselves on screen has also recently been linked to more than just Zoom Fatigue. A 2021 article in the Aesthetic Surgery Journal reported a sharp increase in demand for cosmetic surgery correlated with the increased use of video conferencing software [60]. Around the same time, the journal Dental Nursing reported a significant update in requests for cosmetic dentistry associated with the increased use of video conferencing tools [61]. These findings reinforce the powerful effect user interface design can have on the well-being of users and the need to better understand and take into consideration information about human cognition from as many sources as possible in the design process.

2.3.1 To See or Not to See (myself)

Such findings as above may suggest that video conferencing tools would do well to design mirror perspectives out of the default interface and experience; however there is perhaps more to see in the mirror than our limitations. There is another way to use the video mirror that does not insert the user's own video feed as a separate window, but instead embeds the user into a 'scene' with their partners. Embedding user video feeds together into a shared environment is technically a possible configuration for most modern video conferencing systems that involve capturing and segmenting the subject from the background. This configuration, however, is rarely presented as a primary feature and there has been little study of how such a configuration might affect communication. The previously mentioned tendency of mirrors to induce anxiety when present during social interaction is one possible reason this configuration has been underexplored. Notably however, the available literature around the difficulties people have with mirrors while trying to collaborate with others generally stops short of examining the specific cognitive mechanisms identified in decades of research on self-reflection that may be

specifically at play in driving the distraction, and in turn how some of the negative at-
tributes of self-reflection might be mitigated while preserving some of the benefits which
have been underexplored. The 'tele-immersive mirror perspective' is the major subject
of this thesis, and it will be shown that far from a liability, this configuration can, coun-
terintuitively, create very satisfying kinds of remote collaboration that would not be
possible without it. To better understand how and why this configuration has been gen-
erally overlooked, and what cause there might be to explore 3rd person tele-immersion,
it is important to understand some of the leading theories around the role mirrors more
generally play in human psychological development, and the various cognitive states at
play when we are presented with opportunities for reflection.

2.3.2   Mirrors as Windows to Ourselves

Mirrors simultaneously present the self as both subject and object, and are reasoned by
both phenomenologists as well as neuroscientists to be the mechanism which enables us,
by degrees, to understand others [62]. In early development, whether by virtue of a
reflective glass or the reflection of our other senses experienced in the natural environ-
ment, the child is confronted with themselves as 'other', not only creating an internal
rupture, but also an external rupture with others [63]. Lacan's theory of ego devel-
opment is hung precisely on top of a mirror that he argued, in presenting the subject
to itself, instantiates a psychic ego, forming a rift between the self as now both object
and subject. In seeing ourselves, he argued, we are presented with an abstraction of
selfhood that appears to exist outside of our subjectivity - extending into a previously
unknown social reality. This reality forces a reconciliation between the undivided self
and the divided self presented. When the child recognises themselves in the mirror, they
are forever locked into a relationship with themselves as an object; an object that must
negotiate with other objects for attention. While the physical mirror might be removed
from view, the imago remains, instructing conscious and unconscious behaviour of the
subject who now performs full time for their reflection as an attempt to resist or be-
come the elusive abstraction. Engaging with others from this perspective is merely an
extension of this process where we seek to identify with or distinguish ourselves apart
from others. Neuroscience research into 'mirror neurons' has demonstrated that 'action
performed by one person can activate motor pathways in another's brain responsible
for performing the same action' providing biological support for the idea that to under-
stand others is to experience them as a reflection of ourselves [62]. From a biological
perspective, the self comprehends the other, to the degree that they cognitively experi-
ence themselves performing the action of the other. This sense of performing is not the
same as reasoning that the external action is like one's own action; rather the action is

experienced instantly at the motor level [64]. So what happens when a video feedback mirror forces us to choose between identifying with ourselves or with the other?

2.3.3 Performing for Mirrors

Given our understanding of mirror neurons, we can understand behaviour as actions directed at a kind of mirror that grows and shrinks inversely with the size of the ego [63]or sense of separate self). The greater the sense of the singular un-relating self and its importance, the less sense we have for and identification with others; the reflection in the mirror is narrowed to include just what sets us apart from others. Conversely, the reduced ego creates the conditions for fewer demarcations between self and other, in effect expanding the 'mirror' to include others and enabling us to identify or in other words empathize with them. Looking out on the world, some of what we see is a reflection of what we understand and what we identify with, and some will fall outside of understanding and identification. When faced with reflective glass we are given immediate visual feedback that corresponds with the relevant motor neurons firing, and strong identification naturally ensues [65]. The face of the other, however, does not provide this level of feedback, and we must identify only abstractly. The muscles of the mouth bending up in the other are similar enough to our mouth bending up in a smile, that the same neurons fire, albeit they fire in the context of extra visual information that does not conform so neatly to our own reflection [62]. Careful observation and time spent experiencing the smile of another would likely increase our ability to identify with that smile, especially if we experience ourselves being to some degree responsible for the smile; making others laugh is making myself laugh [66]. The immediacy of a physical mirror being significantly greater than the abstracted mirrors of other faces would reasonably command more cognitive attention to one's own face than the face of the other when a mirror is presented next to another person, perhaps explaining why we experience such a 'distracting' force from the physical mirror during conversation. Besides our conscious awareness of the mirror distracting our attention from others to ourselves, mirrors have also been associated with several prosocial behaviours potentially relevant for designing remote communication systems.

2.3.4 Non-conscious Effects of Mirrors

Various studies on cognition from the fields of psychology and social science have demonstrated that the mere presence of mirrors within a visual field can trigger various kinds of 'self-evaluative' cognitive states [67]. Studies on self-awareness using mirrors have been carried out in psychology since Shelley Duval and Robert Wicklund defined a theory of

self-awareness that treats the 'self as a socially evaluable object' [68]. These studies have shown how, in addition to the negative effects described earlier, self-aware states also correlate with enhanced moral reasoning, greater success with fixed task completion, and increased motivation to accomplish goals, as well as the alleviation of psychological stress [67]. The seeming contradictions of these studies when evaluated together with the earlier mentioned studies has itself been a subject of interest in the field, well summarized by one psychology researcher as 'The Empathy and Self-Absorption Paradox' [58]. A variety of factors evidently can impact whether a self-reflective state leads to the 'rumination' associated with greater anxiety and stress or the 'mindful' states associated with conation [68]). According to self-awareness theory, focusing attention on the self brings about a state of self-evaluation in which people compare the self to salient standards of correctness.

2.3.5 Mirrors Trigger Self-Reflection

Standards of correctness are defined as the context-sensitive internalized sense of what is correct for a given situation. Our standards shift according to the situation, most notably in relation to being in a self-reflective or object-reflective state which, as will be seen, correlates with having a video mirror present (self-reflective) during remote conferencing, or not having it present (object-reflective). The phenomenon of cognitive standard shifting was first demonstrated by a mirror study and sentence completion task by Charles Carver and Michael Scheirer in 1978 [19]. Their study demonstrated that subjects responding to a sentence completion task with a mirror responded with more self-focused completions than control groups. When asked to complete sentences such as 'It's fun to daydream about:', subjects with a mirror present were more likely to complete the sentence with self related subjects (i.e 'being loved, my success') than control groups who would respond with external-world-focus completions (ie. 'marrying Tom, giving a party for friends'). This specific effect is potentially one of the mechanisms at play in the many studies on the effects of video conferencing tools on communication that show how 'perceived image concerns have a considerable impact on the comfort level of users and may hinder effective communication' [69]. As mentioned in the introduction, current research on the topic has focused on 'facial appearance dissatisfaction' from 'viewing video self' and even shown how it explains differences in Zoom Fatigue' [37]. The finding however, seems to generate more questions than it does point to a solution. Is the video mirror causing a new problem, or revealing an existing one? Is dissatisfaction with facial appearance best solved by limiting opportunities to see ourselves so we are not reminded of our dissatisfaction? Or should we be making better use of digital enhancements to our appearance? The study by Carver and Scheirer provides us with

an opportunity to move past the surface of our dissatisfaction by looking at how the mirror triggers a particular cognitive state that conditions what we are likely to perceive.

2.3.6   Reflection Informs Perception

Mirror based tele-immersive environments are different from traditional video mirrors in that they provide video feedback in a different context from each other. Tele-immersion generally provides a single large window where all participants are located, while traditional interfaces provide boxes and chat windows one must navigate. The interfaces of both types of conferencing are inherently different, asking the user to pay attention to different things. In any given situation, including tele-conferencing, there is more information available than anyone can possibly be aware of, so designers of conferencing platforms must be especially aware of how information that gets presented gets noticed. One may be tempted to credit conscious choice for what one notices, however our consciousness is operating at a 'higher-order' level on the 'lower-order' information that was already (unconsciously) selected, and is not the mechanism that allows us to be aware of what we sense [40]. There can be sounds in a room that we could technically hear, but which do not make it to our awareness, just as we even have the ability to hear sounds that are not actually there [70]. In the same way we can lose conscious awareness of the presence of a mirror while focusing on a remote partner, but the image in the mirror is nevertheless still being processed behind the scenes of our awareness. So there are automatic cognitive systems at work which are constantly monitoring the available information and selecting what fits the assumed context as relevant for consciousness [71]. Loud noises automatically trigger fight or flight responses that happen long before we can consciously make an assessment of the situation [72]. There are many more cognitive states than our extreme fight or flight response. Mirrors do not necessarily cause us to have more anxiety or think more in terms of ourselves or others because we are choosing to look at ourselves. The mirrors in the Carver and Scheirer study were not prominently displayed so that subjects spent time looking at themselves, but were instead situated obliquely on a desk as if incidentally left by the researchers [19]. The awareness of the mirror, therefore, appeared to impact the subjects indirectly, on a subconscious level, which we will see has implications for the video mirror present during conference calling.

2.3.7 Positive Effects of Mirrors

The presence of a video mirror in traditional video conferencing interfaces has been shown to present non-trivial obstacles to remote communication, and the self-focus induced by these kinds of mirrors is credited as the reason for the increased strain, cognitive load, and emotional harm users are experiencing [37]. Self-awareness, however, in other contexts, has been demonstrated to actually be beneficial for certain kinds of task completion and social engagements relevant for enhancing remote collaboration. For instance, in early self-awareness research, subjects were presented with the task of copying text by hand for a given period of time. The half completing the task with a mirror present performed at a significantly higher rate (more text copied) than those without [73]. Another study on the impact of mirrors on motor task performance found that fewer errors (collisions) were made in the presence of a mirror than without, as subjects guided a small metal ring around the path of a wire [18]. The presence of mirrors has also been shown to enhance performance in children with attentional deficit disorder solving word search puzzles to such a degree that it effectively 'normalized' performance to match peers without the disorder [29]. Mirrors have been shown to benefit novice and intermediate powerlifters doing squat exercises [74], improve static balance performance in young and old adults, and 'enhance learning and performance of a dance sequence among experienced dancers' [75]. Taken together, such studies indicate that the most generalisable impact of mirrors is a measurable shift in cognitive state, but the implications of the shift in state are highly dependent on the activity being engaged in, and the presence of the mirror does not by itself present an obstacle to engaging with externally focused tasks such as remote communication.

2.3.8 Mirrors for Enhancing Specialised Remote Collaboration Tasks

The positive effects of mirrors that have been shown to improve technical accuracy and speed of external task completion are potentially helpful for remote collaborative tasks that require participants to be not only aware of what remote partners are saying, but also what they are expressing. Theatrical collaboration, for example, relies not only on exchanging dialogue, but quickly and accurately identifying emergent patterns and themes from improvised discourse, as well as the 'stage picture' they are forming for an audience. Being able to see how oneself appears in relation to a remote partner would seem to provide better opportunities for performers to keep track not only of partner expressivity, but simultaneously their own, making it easier to conform to a shared reality and present a cohesive story between them. On the other hand, the tendency for mirrors to stimulate an internally focused cognitive state could lead to the negative

effects video mirrors have also been shown to have on video conferencing. These two questions underlie the motivation for this thesis and the development of a novel tele-conferencing platform to formally explore for the first time the actual impact of video mirror feedback on performance.

2.3.9 Directing Internal and External Focus

Whether mirrors induce internal (IF) or external focus (EF), however, seems dependent on the goal and intention of the activity itself. When one looks in the mirror to check on the 'suitability' of their appearance, it would seem to naturally follow that an internal focus is engaged. On the other hand, when externally focused goals are directing the gaze, an external state can be induced. For example, a mirror study related to strength training observed that 'most participants in the multi-joint experiment reported that the mirror was perceived more as an EF rather than IF' [76]. While the video mirror of traditional video conferencing seems to trigger the internal focus state that corresponds with Carver and Scheirer's findings with the sentence completion task [19], the results from the multi-joint experiment show that mirrors don't always trigger the same state, and that how video mirrors are arranged into an interface for remote collaboration might be designed in a particular way to help a user to strategically move between internally and externally focused states to more effectively communicate. As will be described more in detail in the chapter on improvisational theatre, understanding of internal and external focus has important implications for being able to effectively co-narrate an original story together. It is one of the effects the subsequent case studies set out to explore in more depth.

2.4 Applying Cognitive Studies to Build a Tele-Immersive Platform

Contemporary theories about cognition, self awareness, and empathy may provide clues for how to effectively design such a tele-immersive platform that maximises the positive effects of mirrors while minimising the negative effects that lead to Zoom Fatigue and distraction from the primary task of communication. Self-focus is understood as a cognitive state where attention is directed within the subject as opposed to externally toward the objects of the given subject's environment [77]. As demonstrated above, self focus is associated both with enhancing memory, focus, and accuracy in the completion of various cognitive tasks, as well as encouraging some prosocial behaviour, while also

paradoxically being associated with many negative effects including anxiety and depression. This seeming paradox has been captured from results of a series of tests examining the degree to which subjects experience self-rumination, self-reflection, and empathy. The results showed empirically that higher degrees of self-reflection significantly correlate with higher degrees of empathy [58]. The finding appears counterintuitive to the notion of empathy generally understood as one individual's "reactions to the observed experiences of another" [78]. How can a focus on the self result in a heightened awareness of the other's experience? One theory is that "an individual's sense of self develops, in part, as that individual engages in role-taking, suggesting that self-consciousness and empathy are, in a general sense, intertwined" [79]. Role-taking here seems to correlate with the earlier mentioned mirror neurons that "can activate motor pathways in another's brain responsible for performing the same action" [62]. A remote collaboration tool aimed at enhancing empathy between remote partners should, in turn, focus on providing not only access to the behaviour of the other, but also our own behaviour as a reciprocal relationship from which mutual empathy can emerge, which a tele-immersive platform appears especially equipped to provide.

2.5 Co-Creative Storytelling

Exclusively seeing the remote partner on the screen may not be sufficient for triggering the sense of self that implicates the other in our sense of shared meaning, which is an essential part of co-creative storytelling like theatrical improvisation which will be explored in subsequent chapters. The private video mirror, seen as a separate object, while triggering self-awareness in turn, it would seem, may contribute to widening the gulf between ourselves and the other. Placing both our reflection, and the other, into a shared environment, however, may allow the user to merge their awareness of themselves and the presence of the other into a larger sense of self that treats experience as shared and fosters the role-taking implied in empathetic capacity. Bringing remote collaborators into such a space is one of the defining features of a tele-immersive collaboration system that is distinguished from simple remote conferencing. The impact of a tele-immersive view as compared to traditional video conferencing perspectives such as the exclusive partner view, and partner with a separate video mirror/feedback view has not ever been tested on co-creative tasks. The second case study explored in this thesis appears to be the first time these three views have been tested in a comparative task.

Tele-immersion, as described earlier, is a broad category of communication platforms that does not inherently imply a mirror perspective. In fact, prior to the very recent inclusion of tele-immersive perspectives provided by Microsoft Teams and Zoom most

tele-immersive platforms that have been developed have not featured this perspective [80–85].To appreciate the novelty and possibility of a mirror-based tele-immersive platform, it is useful to examine more closely how such platforms have been historically developed and the governing design principles that have steered human computer interaction developers to prioritise recreating traditional face to face interaction rather than designing novel communication experiences tailored to the emerging needs of users.

2.6   Tele-Immersion

Tele-Immersion is a term that has been used in a variety of computing contexts to describe social computing experiences that involve participants experiencing a shared visual reality   [86].   The term can define a wide range of different experiences and technologies, but is defined for this thesis as remote communication experiences that attempt to immerse participants into each other's realities, rather than presenting video windows of each other on laptop or desktop screens. The term is a subset of 'telepresence' technologies that have the aim of increasing the sense of presence between remote parties, distinguished by a focus on shared visual reality to achieve the sense of co-presence [87]. An early study of telepresence video communications explains that telepresence is 'the degree to which participants of a telemeeting get the impression of sharing space with interlocutors who are at a remote physical site' [88]. Different technologies can achieve a sense of presence between parties to varying success in different ways   [89].   The most basic form of video telepresence presents the live video feed of the remote partners on a screen near the user   [87].   The screen exists as a physical reality of the space the user is in. Tele-immersion differs from this kind of telepresence by attempting to bring the users together into a sense of a shared virtual space rather than bringing each other into their respective rooms [1]. For Jaron Lanier, who coined the term 'virtual reality' and broke ground in developing some of the first tele-immersive technologies, tele-immersion specifically implied volumetric capture of remote participants displayed in life-size dimensions to each other   [90]. More recently, however, tele-immersion has come to include a broader range of technologies for social virtual reality experiences that allow users to control avatars inside of the same virtual world with other collaborators [1]. Finally, tele-immersion can also include experiences where remote users see video of themselves situated alongside their remote partners in a shared visual space either as background segmented 2-dimensional videos, or as 3-dimensional avatars modelled on their own features [91].

2.6.1 Disambiguating Tele-Immersion

The original term 'tele-immersion' is reported to have first entered the field of computing in 1996 at the University of Illinois as a workshop title for researchers breaking ground in virtual reality and computing [86]. For the EVL, the term was used to describe a subset of networked VR experiences that particularly focused on image-based technologies. For these researchers, and most of the researchers of tele-immersion to come, studies have focused on technical innovations and challenges in networking the high volumes of data required to render and accurately sync realistic virtual environments that simulate physical co-presence [81–85]. Since the EVL workshop in 1996, there has been tremendous innovation in virtual reality technology, data compression, and networking capacity, making the possibility of tele-immersive communication described in the 1990s, a reality.

At present, there are diverse forms of tele-immersive platforms available for enterprise applications as well as individual consumers that can be experienced with head mounted displays (HMD), large-scale projection, LED walls, custom built video desks, holographic technology, as well as more simply with a laptop or desktop screen [1]. Despite the growing availability of these technologies, however, most remote business and social collaboration still takes place on traditional video conferencing platforms [92]. The tele-immersive platforms that are being used are also generally focused on 1st person perspectives rather than third person or 'mirrored' immersive views. Studies on the adoption and use of more immersive collaboration tools across business and social sectors vary, but generally they concede that cost and accessibility of the hardware and software are still the major factors in wide-scale adoption [93]. The public marketplace for accessible immersive communication platforms is still relatively new, and no dominant platforms have yet to emerge, with most consumers still largely unaware of what is available [94]. Perhaps more importantly, there is little understanding on how a more visually immersive environment will add significant value to remote communication [95].

2.6.2 The Slow Adoption of Immersive Communication Platforms

Despite tremendous innovation in the field, no existing immersive collaboration technology is as intuitive or easy to use as traditional video conferencing tools [96]. Virtually all immersive communications technologies still require specialised hardware and quite often specialist technical support for onboarding, so without a clear argument for what might be gained over traditional video conferencing, the technology remains the subject of speculation more than consumer interest [97].

Short of making the experience of tele-immersion as simple to experience as video conferencing with a laptop, developers of immersive technology are responsible for demonstrating what problems the various features of tele-immersive technology might solve that would make the effort to adopt it worthwhile. Consequently, there is a need for qualitative field studies of people using tele-immersive technology in the wild, rather than in controlled laboratory settings to discover how specific collaborative groups might be able to take advantage of the unique features of tele-immersion to solve novel domain-specific problems. The early researchers of tele-immersive experience have necessarily been limited to laboratory settings, because, as will be seen in the following chapter, most systems for tele-immersion relied on specialised proprietary hardware not available to the public or outside of the research institutions developing them. Furthermore, most studies in the field have been focused on testing for specific markers of immersion to validate a particular technical innovation such as improved data compression [82], latency reduction [86], and more accurate depth capture [84]. While markers for the feeling of immersion are naturally important for the study of tele-immersion, it is important to remember that immersion is only one quality of remote communication experiences that ultimately are focused on a larger experience of collaboration. A feeling of immersion is demonstrated to enhance remote collaboration, but immersion is not equal to collaboration itself. In other words, remote collaboration is the primary target of a successful tele-immersive system in a remote communication context, of which immersive experience is one component.

2.6.3   Immersion

The experience of immersion itself is a psychological state which many different external conditions contribute towards but by no means determine [52]. A user needs only redirect their thoughts away from a visual display to be immersed in an experience completely unrelated to the visual accuracy of an immersive system. Subsequently, the problem of remote collaboration cannot be reduced to a problem of immersion; it is first and foremost a problem of collaboration, of which a sense of immersion plays various roles depending on the collaborative intent. Chapters 3 and 4 will more closely examine the metrics used for evaluating the sense of immersion, as well as presence, flow and social creativity which will be shown to be more relevant to the particular domain of remote collaboration on which this thesis is focused. As tele-immersive technology has become more widely available as features for existing conferencing platforms, there is a need for more targeted studies on how tele-immersion impacts domain-specific collaborative behaviour such as the performing arts.

2.6.4 The need for domain specific design and research

Domain specificity is critical to distinguish, as various features of tele-immersion may be beneficial in some contexts and counterproductive in others. Furthermore, the tool of tele-immersive technology, like any technology, does not simply solve a defined problem that existed prior to the emergence of the tool. The mere presence of the tool fundamentally changes the ecosystem of the work itself that the tool emerged from. The hammer, by analogy, does not arrive to simply better fasten pieces of wood together; it arrives to absorb wood fastening into a new eco-system of fabrication that becomes carpentry. We cannot understand the hammer or a tele-immersive system for its parts alone, we can only begin to understand both by their use [98]. It is the aim of this thesis to move from exclusively studying the tool of tele-immersion to studying the tool in the context of an eco-system of collaboration that might form up around it. Understandably, the research related to tele-immersion up to this point has largely been concentrated on examining how well the immersive tools perform the function of simulating the features' co-located experience, thus generally overlooking the potential utility of 3rd person/mirrored communication - which is not natural. Traditional research and development into tele-immersion has been focused on discovering novel methods for rendering photo-realistic environments [99] or capturing high-fidelity markers of user gestures and movements to control 3D avatars formed in the likeness of the user [100]. This kind of research and development is driven by speculation (theory) on the desired experience of a given user, and subsequently takes a user's desire for granted. When the user's desire is coherent, this of course makes sense; however, when we are researching a phenomenon that is new for people, their expectations will be less useful as a guide. The hammer, to continue the analogy, in even its earliest conception, already had the capacity to revolutionise the nature of construction from houses to boats, but it would take centuries of use breaking and chiselling rock in the hands of masons before it became used to fasten wood together [101]. So too, tele-immersive technology is poised to revolutionise the way we collaborate, not just remotely, but in all contexts of the data-driven social environments characteristic of the current age. Yet this will not be until more industries, social, and political groups begin adapting it to their particular needs.

2.6.5 Business Communication Needs are Not Everyone's Needs

Until recently, most of the technology of tele-immersion has formed in the context of facilitating conference-focused business communication, generally based on the premise that the technology would need to significantly advance before it would have utility in

other domains [102]. The global pandemic that began in 2020 mandating social distancing around the world, however, saw that even the most basic forms of tele-immersion have utility for collaborative disciplines that had not been traditionally considered by tele-immersive researchers [103–105]. In particular, many in the performing arts have found novel utility for this technology to not only enhance remote collaboration, but to foster creativity, develop new communities, perform in new modalities, and even better understand traditional arts practices [106].

2.7 The Performing Arts and Tele-Immersion

The performing arts have, in fact, long been significant players in the field of tele-immersion, though the computer scientists and tele-communications companies often associated with the field appear to only be tangentially aware of the innovations occurring alongside the development of hardware and software systems that make tele-immersion possible. This next chapter will attempt to thread the research across the many converging disciplines that have been working directly and indirectly alongside each other for several decades to form a general theory regarding the aesthetic experience of the varying forms of tele-immersion, with a particular focus on third-person tele-immersive systems that are the major focus of this thesis. There have been several attempts to collect and summarize the history of tele-immersive research and innovation by various scholars over the last decade which will inform my own analysis. Studying the available literature, however, indicates that tele-immersive studies cannot be reduced to any particular history as a linear progression from idea to innovation. Like most technologies, both the presence of new tools and the idea of new tools operate to change not only what is possible, but what is practised and remembered simultaneously across recorded and lived history. The photograph itself radically presented the possibility and reality of collapsing space and time to bring remote bodies into presence with each other. Earlier still, we might start with prehistoric cave paintings as the first (albeit asynchronous) tele-immersive act, firelight animating the walls stretching along the entire field of view of our ancestors watching their own ancestors communicating to them the rites and passages of the hunt, the tribe, and the secrets of immortality [107]. Plato described in detail the features of our modern notion of tele-immersion in his cave allegory, warning (unheeded) future generations about the peril of fabricating immersive displays that would lock the human gaze inside of what is only a shadow of a larger more complex reality [108].

2.7.1 Barriers to Innovation in Immersive Communication

Modern tele-immersion aesthetic experiences are in some ways simply better lit and drawn cave paintings [109]. The real novelty of modern technology is the way it affords a notion of real presence not just with ancestors but with living (live) remote partners who can adapt their message to respond to our own. On the surface, such an ability would seem to offer unprecedented new opportunities for social diversity, dialogue, and the formation of a community unbounded by geography. In practice, however, adding visuals to screen-based remote dialogue has so far resulted in what one may argue to be just greater self-absorption as we stare at ourselves bemoaning how the video mirror flattens us, makes us look older, less attractive, and agreeable [110]. Equally true, however, tele-immersive technology has provided many with the ability to form intricate and meaningful social and romantic relationships that could not have formed in any other way [111]. Virtual reality is being regularly used to allow remote people to dance together, meditate, make love, play games and share art, and there is considerable research in this space, with every indication that as HMDs get smaller, lighter, and higher definition, it will be adopted by the mainstream [112]. Experts still disagree however on the timeline for such development, with the most optimistic projections starting at least a decade from now [113]. As tele-communication still predominantly takes place on the ubiquitous laptops and mobile devices at hand, there is good reason to look at what tele-immersive technology can do to enhance remote collaboration that is not dependent on a headset. It is estimated that there are a total of around 26 million headsets currently in distribution, which is a small number compared to the estimated 5 billion people with access to a traditional computer, and even more with video capable mobile phones. Screen-based tele-immersion, it would therefore seem, has the greatest potential to enhance remote collaboration in the immediate future. There is a need however, to discover its utility for such consumers in order to drive developers and communications enterprises to make tele-immersive experiences available with the existing hardware for remote communication that is already in most homes.

2.7.2 A Short History of Immersive Communication

Most immersive communication systems that have been developed since networking real time visual data became possible have primarily been focused on embedding remote partners visually into naturalistic perspectives for each other, as opposed to with each other. The early work of the Electronic Visualization Laboratory (EVL) in the 1990's at the University of Illinois at Chicago (UIC), for instance, focused on systems that presented remote partners as extensions of the visual landscape, with large projection

surfaces attached to desks that could provide the illusion that the remote partner was seated at the cubicle facing you [114]. Cisco TelePresence systems in 2006 released one of the first commercial tele-immersive systems that added projection surfaces along a conference table, effectively presenting multiple remote partners around the table in life size perspectives [115]. While each of these systems differ in the hardware involved and the degree of visual immersion, they all have in common the attempt to bring remote partners into each other's real spaces. In the early 2000's, Bell Labs announced a new kind of immersive communication platform that offered real-time background segmentation and placement of remote participants in a shared virtual background they called 'Immersive Communication' [116]. Rather than bringing the remote partner into the remote physical space, this system proposed placing remote partners into a shared virtual environment. Notably, the environments did not present the user themselves in the display alongside the remote partners. This platform however, never came to market [117]. Many researchers afterwards developed their own tools for co-locating remote collaborators into virtual spaces using camera arrays and depth modelling [118], real-time wide-area stereo scanning [81], geometry-based 3D tele-immersion [119], or arranging displays to simulate a side by side collaboration [?]. However, each of these technologies were developed in research labs and never appears to have been released to the public. This follows the larger history of tele-immersive research that has focused on the novelty of technology, but has not examined user experience of tele-immersion in great detail. Furthermore, the mirror based tele-immersion that is the subject of this thesis does not appear to have been the subject of any tele-immersive research from a technical or user experience perspective.

2.7.3   Mirror Based Immersive Environments

Mirror based immersive environments have been a small subject of some research that has analysed user experiences of collaboration in virtual environments [120] and studies of presence in virtual worlds [121]. An early experiment in 1991 demonstrated the immersive potential of mixing live captured video with 3 dimensional environments, reporting that out of 160 participants using a system placing chromakey extracted video of their bodies into a virtual world, 71 percent of those who tried the demos considered the 'being on the screen' to be their real self. The study went on to report that respondents described feeling both physical and emotional responses when they touched animated graphical objects in these worlds [122]. As noted earlier, most of the developments in tele-immersion have been related to 'expanding the boundaries of computer vision, tracking, display, and rendering technologies' for computationally expensive displays of complex 3-dimensional geometry [123]. The experience of feeling present in

a virtual space however is not dependent on accurate 3-dimensional representations of physical space as the early experiments of background segmentation and projection have shown. Instead, chromakey background removal was all that was required to provide a convincing illusion of being in a shared space [122].

2.7.4 A New Tele-Immersive Reality

Advances in computer-vision have allowed popular video-conferencing platforms to perform real-time adaptive background segmentation without the need for users to have access to complex studio lighting and chromakey environments [124]. This feature makes a 2D form of tele-immersion in a virtually 3D space a possibility for any video conferencing platform. During the course of writing this thesis, Microsoft Teams and Zoom have begun providing some tele-immersive functionality publicly, and it remains to be seen to what degree users will be able to make use of the feature. Prior to these recent additions, the accessibility of tele-immersive platforms for the public, there have been few opportunities to explore how a shared virtual environment affects remote collaboration in real-world environments generally, let alone how it might affect actors rehearsing and performing online. The decades of research of tele-immersion systems nevertheless clearly demonstrates that when users have been able to see themselves co-located, they have experienced an enhanced sense of presence over dislocated video interfaces, as well as increased productivity [125]. This early research provides the theoretical scaffolding to support the thesis that a mirror-based tele-immersion might enhance the experience of remote collaboration tasks like theatrical rehearsal and performance that require a significant physical co-presence between partners.

2.8 The Unique Communication Demands of Improvisational Theatre

Improvisation in theatre is a rehearsal tool, a process for creating new work, and a genre of performance [126]. As a genre, it is a form of live theatre where artists perform real-time, dynamic problem-solving to collaboratively generate interesting narratives [127–130]. Improvising involves engaging a cognitive state called flow described by psychologist Mihaly Csikszentmihaly as 'an almost automatic, effortless, yet highly focused state of consciousness' [131]. Improvising and entering into flow in performance requires collaboration that is supported by a deep awareness of the presence of others [132]. Improvisers rely on constant verbal and visual feedback from scene partners and audience members to construct a shared reality. It is through this feedback that improvisers can

synchronise around invented relationships that appear so cohesive they 'lose their fictitiousness of time and place' [133]. The visual environment of the improviser plays an integral role in the ability to agree and collaborate with other performers, as partners must be keenly aware of each other in order to converge creatively. The perceived visual environment of course is not exclusively experienced directly from the actual environment, but is born out of both conscious and unconscious cognitive processes. To understand what improvisers need from each other and their environment requires an understanding of some of the cognitive processes at play in improvisation, as well as an understanding of how improvisers train themselves to take advantage of this processing in a way that maximises creativity and narrative cohesion with their partners.

2.8.1   Cognition of the Improviser

What precisely is the act of improvisation and what activities are the improviser engaged in when they improvise that are different from other cognitive states? Keith Johnstone, an early pioneer of improvisational pedagogies, quotes Schiller describing the improviser as one who has withdrawn the 'watcher at the gates of the mind, who examines ideas too closely.' [134]. Viola Spolin, who invented the early games and theories of improvisation that are the basis of many modern pedagogies related to the subject, describes improvisation similarly: 'Through spontaneity we are re-formed into ourselves. It creates an explosion that for the moment frees us from handed-down frames of reference, memory choked with old facts and information and undigested theories and techniques of other people's findings.' [135]. Both here seem to be describing some kind of disengagement of normal cognitive practice, an activity where ego is dissolved and we are freed to draw from the uninhibited unconscious, allowing a kind of novel and creative force from within ourselves to play out more forcefully in the outside world. The opaqueness and near-mysticism of their language however has led to scepticism in the scholarship of some performance and cognition theorists such as John Lutterbie: 'The claim that a choice can be made to avoid thinking is an illusion' [136]. However, recent discoveries from neuroscientists such as Charles Limb, who studies the brains of improvisors, have identified that in fact improvisors are disengaging normal cognitive functioning, and this experience of 'not thinking' actually shows up in neuroimaging [137]. Similarly, Sing Liu and a team of neuroscience researchers from the U.S. National Institutes of Health recently conducted a study with hip hop artists in which they observed a network of cognitive functioning that linked motivation, language, affect and movement that was stimulated outside or in lieu of normal executive functioning: Lyrical improvisation appears to be characterised by altered relationships between regions coupling intention and

action, in which conventional executive control may be bypassed and motor control directed by cingulate motor mechanisms. These functional reorganisations may facilitate the initial improvisatory phase of creative behaviour. [138]. What their research shows is that the areas of the prefrontal cortex that are typically lit up with neuroimaging while subjects are engaged in normal waking activity are shut off when improvisors fall into what many describe as their flow state [139].

2.8.2   Flow States

Flow states were introduced to the academic world through the work of Mihály Csíkszentmihályi who laid out the groundwork for the field of optimal performance research [131]. Csíkszentmihályi's now classic text Flow: The Psychology of Optimal Experience provides nine categories of experience associated with flow which have been used as a tool for evaluating improvisational performance by a number of researchers in the past [140–143]. The dimensions are summarised as (1) an equal balance between challenge and skill level, (2) a merging of 'action-awareness' or being fully absorbed in the moment, (3) a clear sense of purpose, (4) direct and immediate feedback meaningful to the task, (5) the ability to concentrate on the task, (6) a sense of control, (7) a loss of self-consciousness, (8) a distorted sense of time, and (9) it is an 'autotelic' or intrinsically rewarding activity [131]. For improvisers, flow does not simply involve being able to creatively manufacture novel utterances; those utterances must be contextual and coherent with what their partners are uttering and presenting as well. Many might assume improvisers are primarily engaged in a creative enterprise, however in practice they must enter a heightened state of learning where they can rapidly process what others are saying and suggesting in order to appropriately add to the emerging story [136]. There is no time to think about what others have said and try to manufacture something creative; instead improvisers must rely on a kind of preconscious awareness to process/learn what is being said and organically add to it.

2.8.3   Improvisational Learning

Learning is a complex phenomenon that involves many different regions of the brain that cognitive science is still only beginning to understand. We do know that learning essentially involves the building up of neural networks in the cerebral cortex that allow effortless cataloguing of specific experience [144]. Neurons have an axon and up to 100,000 dendrites that connect to other neurons. The intertwining of dendrites make up the connections that largely guide behaviour [145]. When learning new tasks we can see through fMRI the area of neural networks swelling as a skill or behaviour is mastered,

and, once mastered, shrinking as the behaviour or skill moves to an automatic function which takes place in subcortical regions of the brain. Moving behaviour outside of the cerebral cortex frees up neurons to learn new tasks. Behind the scenes of our awareness we have two other brain regions responsible for various automatic and autonomic functions. The hindbrain houses the Spinal Cord, the Medulla Oblongata, the Pons, and the Cerebellum, which is where primary sensation occurs and is what drives motor functions, including movement of facial muscles and the throat [144]. The Midbrain contains the central nervous system associated with vision, hearing, motor control, sleep-/wake, arousal (alertness), and temperature regulation [144]. When tasks/behaviours are mastered at the cerebral cortex level, they become 'pushed' down or 'encoded' into these two subcortical areas, allowing us to initiate the behaviour/skill without cognitive effort. This is what happens when we learn to ride a bike or play a musical instrument. For an improviser, this involves learning to recognise the social dynamics at play in a wide range of communication tasks. Keith Johnstone describes these dynamics as 'status transactions' where each person in a social experience is consciously or unconsciously in constant negotiation of their given status which manifests in not just words but the entire communicating body. Improvisers learn to instantly recognise the offer of status that is being presented by the partner and can act in appropriate relation to the offer, without needing to fully register the specific content of the message. He explains, "every inflection and movement implies a status, and that no action is due to chance, or really 'motiveless' [134]."

2.8.4 Bypassing Normal Cognitive Functioning

According to Johnstone, utterances in a communication act are an offer of submission or dominance that can be intuited from the tone of voice, physicality, and gestures from a scene partner. In real life, we pick up on these offers subconsciously at a subcortical level which means we can immediately assess if there is a threat or opportunity, triggering a particular cognitive state that matches the perception [145]. This is how an insulting remark from an authority figure can instantly trigger anger, while the same remark from a friend might result in laughter. For improvisers to creatively respond in context to the offers they are receiving, they must be able to bypass normal executive cognitive functioning that looks for threats and opportunities and instead operate in an open learning state. The basal ganglia sits at the bottom of the cerebral cortex and acts as a kind of governor for 'action selection,' helping to decide which of several possible behaviours to execute at any given time. Neuroscientists have identified that the basal ganglia 'exerts an inhibitory influence' or in other words is responsible for keeping certain motor functions offline, and that impulses from other parts of the brain can signal the

basal ganglia to turn off and on various motor systems [145]. This activity is essentially the 'behaviour switching' that takes place within the basal ganglia when it gets signals from the other parts of the brain, including the prefrontal cortex, which determines the level of threat of an opportunity in a given situation.

2.8.5   Accepting Offers

Improvisational theatre training essentially involves learning how to dynamically shift between learned schemas to maximise collaborative storytelling effort. Theatrical improvisation has many different forms and approaches but there are basic tenets that guide the ability to shift out of executive cognitive functioning. The first technique learned by improvisers is to train themselves to automatically accept the 'truth' and reality of anything said by another improviser. The essential idea that makes this practice significant is that the improviser has to shift from judgement to acceptance. Practically speaking, this allows scene partners to collaborate together to construct a scene rather than fighting over control of it. One improviser might suggest they are the captain of the ship and that you are their subordinate. A natural response would be to challenge the authority just exerted, or even dismiss the offer all together: "You're not a captain, we are just in a nautical museum!" While perhaps natural, this response kills the offer of the partner and creates a kind of tension, not just within the scene, but within the improvisers. Training to say 'Yes' and to accept the offer means that the focus is on understanding and connecting with the creative offers being made, simply trying to build up a reality based exclusively on each subsequent offer.

2.8.6   Adaptive Learning

On a cognitive level, this is the first step to directing the brain of the individual improviser from 'predictive heuristic' thinking to an 'adaptive' learning mode. Social experience in life teaches most of us to be sceptical of offers being made from anyone we don't already know and trust, and generally to avoid getting trapped in a tacit agreement of reciprocity based on accepting a gift we never asked for. Such defensive behavioural schema become particularly triggered during times of stress or anxiety, like when performing on stage (or perhaps when video conferencing with a large mirror facing us.) Improvisation theatre scholar Rhonda Blair explains the way such modes of behaviour and awareness are triggered which are relevant to performing, by citing cognitive scientist Elizabeth Wilson who defines schemas as 'a postural model of ourselves that is dynamic and which determines the psychological parameters of bodily posture

and movement [146].' These schemas operate invisibly and inform what kinds of information from the environment are available to consciousness. Harvard psychiatrist John Ratey notes that "perception is more than simply sensing stimuli from the environment, but more accurately sensations (qualia) are fitted into constructions that we have (already) learned. We essentially 'prime' our perceptions to match the world to what we expect" [144]. And in stressful situations, like performing in front of an audience, we often expect the worst. But what we learn by practising to accept all offers during an improvisation is that by shifting to a mindset of saying 'Yes and', we begin to expect - and therefore 'sense' new things. The visual environment of remote collaboration, however, likely plays a role in which schemas get triggered on a subconscious level, with mirrors generally triggering the critically self-aware states already described. To build a tool for remote performers to collaborate, it is therefore crucial to bear in mind how the visual environment can facilitate entering into collaborative flow and a learning mindset and what features to avoid that might interrupt that flow.

2.8.7   Attunement and Making Your Partner Look Good

A second tenet of improvisational pedagogy is to 'make your partner look good'. In addition to accepting offers, Keith Johnstone emphasises the critical importance of the psychic priming to believe whatever your partner says and encourage and amplify their offers by reacting appropriately to their behaviour. This means, if they enter a scene as a cruel and demanding boss, to make them look good, we cower in fear and jump to the commands in order to help justify their behaviour. He writes that "The improvisor has to understand that her first skill lies in releasing her partner's imagination. [134]" When one focuses on making their partner look good, we activate schemas of collaboration experienced as attunement, formulated from previous experiences of trust, cooperation, and creative flow. 'Attunement' is a term that shows up in psychology and neuroscience in studies involving how well people are able to connect with each other while engaging in a shared task. In the field of psychology, attunement is described as part of the 'social plasticity hypothesis' put forward by Cousijn et al and which operates as 'the degree to which one adapts to and harmonises with one's social environment [147]. Harmonising with the social environment implies an acute awareness of or presence with the offers being made available in the social environment. The cognitive effort to 'make my partner look good' is an effort an improviser can make to be attuned to the socially developing narrative, as opposed to the exclusively private narrative that may be forming. Neuroscientist Vittoria Gallese explains how attunement is 'a form of experiential understanding of others that is achieved by modelling

their behaviour as intentional experiences on the basis of the activation of shared neural systems underpinning what the others do and feel and what we do and feel.' The activation of this shared neural system, according to Gallese, rests on the 'constitution of a shared meaningful interpersonal space' [64]. The hyper focus on justifying and supporting a scene partner's efforts would therefore seem to be a potential constituting agent for a 'shared meaningful interpersonal space.' Several studies related to musical improvisation make use of the term 'attunement' to explain the mutual feelings of awareness that correlate with successful improvisations [7, 148, 149]. A study on jazz musicians for instance, through extensive video analysis of physical behaviour between the musicians, observed the emergence of a 'non-verbal collaborative mode' that 'displayed empathic attunement' through synchronous and reciprocal gestures and physical affect [149]. Definitions of attunement used in social science are particularly useful for extrapolating the mechanisms underpinning the special kind of collaboration implied by improvisation. For a study on the relationship between adult mentors and adolescent mentees, attunement is defined as 'the capacity to respond flexibly to verbal and non-verbal cues by taking into account the others' needs and desires' [150]. This definition fits neatly with Johnstone's notion of making the partner look good as an act in service of releasing their imagination. Connecting these terms opens the door for a way to potentially evaluate improvisational performance using validated survey instruments from psychology and social science, which will be critical for examining the efficacy of a given tele-conferencing tool for supporting improvisational activity. Results from Pryce's early study led to expanding on the concept of attunement to create a model for 'Facilitating Attuned Interactions' (FAN) built around how 'the experience of feeling connected and understood...opens up space for trying new ways of relating' [150]. The FAN model in particular provides a potentially useful lens to understand the generalisable social mechanism at play that is engaged with theatrical improvisation. This will be discussed in more detail in the chapter reviewing methods for evaluating tele-immersive systems.

2.8.8 Picking up Verbal and Nonverbal Cues

With the cognitive effort to support a partner and the subsequent encouragement of social attunement, our sensing is primed for picking up on cues from our partners that fit this model. This allows the improviser to literally see their partner as making offers to them, or improvisational 'gifts' that reward collaboration. Psychologist Robert Caldini's research into persuasion provides insight into how this technique works with the seemingly obvious observation that 'as a rule we most prefer to say yes to the requests of someone we know and like.' What's less obvious however, is how our liking of others can be influenced by simply declaring that 'Once we have made a choice or taken

a stand, we will encounter personal and interpersonal pressures to behave consistently with that commitment' [151]. Cialdini goes on to explain how environmental factors inform how we behave as a condition of social pressure to conform to what is expected. When an improviser puts her arm around her partner, both are confronted with the internalised as well as the stage picture of 'friendship' that is presented, and that picture likely informs and triggers attunement schemas of friendship which can be tapped into in order to perform convincingly as 'friends' - even if they are meeting for the first time on stage. The power of the stage picture presents an interesting opportunity for exploiting tele-immersive perspectives to trigger various schemas visually that on the traditional improvisational 'empty' stage happen almost exclusively through language. A tele-immersive system might for instance place partners in extreme close proximity as if in an embrace, or alternatively very far apart, or as different sizes triggering the relative schemas of intimacy, estrangement, and power imbalances.

2.8.9 Make Offers and Receive Gifts

A third tenet of improvisation is to 'make offers and receive gifts.' Johnstone describes how the impulse to be interesting usually results in less collaborative scenes: "When the actor concentrates on making the thing he gives interesting, each actor seems in competition, and feels it. When they concentrate on making the gift they receive interesting, then they generate warmth between them." The tendency of 'receiving' interesting meaningful gifts to foster better listening and cohesion with others, corresponds to the reward system of learning that takes place in the basal ganglia. Cambridge neuroscientist Wolfram Schultz explains that: Rewards are involved in learning (positive reinforcement), approach behavior, economic choices and positive emotions. The response of dopamine neurons to rewards consists of an early detection component and a subsequent reward component that reflects a prediction error in economic utility. [152]. The basal ganglia, he explains, operates as a kind of gate that opens awareness to different aspects of the environment and suitable responses. When a reward is detected, such as this person gave me a gift, dopamine is released, signalling to the basal ganglia to trigger the reward-seeking schema. The schema, as a prediction error utility, continues to release dopamine as if the rewarding experience is happening - not simply as a response to what is happening. In other words the mind is primed to look for any behaviours that will continue to provide similar rewards in expectation of more rewards - until a significant error triggers a threat. When an improviser shifts to a schema associated with 'making the partner look good', it seems that sensory motor mechanisms become engaged which allow the improviser to pay attention to more prosocial behaviour. As an improviser responds to her partner and is rewarded with offers, dopamine is likely released in the

basal ganglia, signalling to the neurons currently engaged in the particular activity to pay attention, that 'there might be more rewards'. The basal ganglia then attempts to anticipate the reward by sending dopamine to the neurons before the cerebral cortex can 'sense' the behaviour. When there is a match between the prediction and the actually sensed phenomenon, the neural pathways are strengthened and with enough stimulation become 'pushed down' into the subcortical regions of automatic behaviour. In this way, the improviser 'learns' how to pay attention to the behaviours of their scene partner that produce the greatest rewards of evolving and a cohesive shared narrative that delights the audience. Any distraction that triggers a different cognitive state, such as an audience member walking out, or possibly the self-awareness triggered by the video mirror of a video conferencing interface, can interrupt the flow and cause the improviser to become threat aware and defensive, pulling them out of the scene.

2.8.10 Noticing Emotions

Recent research by Charles Limb and Malinda McPherson sought to further nuance our understanding of how emotion may affect the ability to shift into and remain in the relaxed cognitive state associated with improvisation. To explore how specifically positive and negative feelings might play a role in the phenomenon, they primed musicians with happy and sad faces and asked them to create music associated with the mood: The results were somewhat surprising. McPherson's team predicted the creativity-related DLPFC deactivation from the previous study would be found equally in the negative and positive improvisations, but it was much more pronounced during the happy trial. The researchers also found that the negative-photo improvisations showed greater activity in certain brain regions connected to cognitive control and reward; specifically, there was increased connectivity between the insula, an area that controls visceral awareness, and the substantia nigra, an area responsible for reward and pleasure [30]. The arousal of particular emotional states evidently seems to have a profound impact on what kind of cognitive state gets engaged when completing a task. Lamb and McPherson's findings support the need for an improv environment to be relaxed and playful to foster cooperative play that initiates the experience of a flow state, while negative markers in the environment can disrupt the ability to enter into flow. Such negative markers might include the mirror-induced self awareness from traditional conferencing environments that have been associated with negative self comparisons. Emotions play a significant role in learning and affect 'our ability to form vivid memories of even trivial events' [30]. Learned content appears to get encoded along with emotional states which become the basis for how learned information is recalled. Studies of emotion and learning report that positive emotions directly facilitate learning and contribute to academic achievement,

being mediated by the levels of self-motivation and satisfaction with learning materials [**?**]. Designing platforms for rehearsing and performing improvisational theatre therefore should take care to consider not just how to minimise distractions and maximise the amount of information remote partners can receive about each other, but also the playfulness of the user experience. 'Fun' however, does not appear to be a design focus or metric of success for most remote communication platforms.

2.8.11 Ludic Engagement

As the playful environments of improvisational theatre activity have been shown to lead to the disengagement of judgement and to foster accelerated learning, designing remote communication platforms that encourage playfulness may also be beneficial to remote collaborative activities beyond just the practice of improvisation itself. Improvisational theatre pedagogies here emerge as a potential practice for training remote partners in creative cooperation itself. As Johnstone summarises about the impact of regular improvisational activity, the long practising improvisor 'awakens' to how their 'normal' procedures not only destroy an other's talent, but also their own talent. Normal procedures here refer to the regular offers of dominance and submission that take place as a consequence of our automatic and learned responses to difficult situations. Shifting into playful states allows us to learn new ways of handling rejection and threats, and instead of offering our own rejections and defences, search for and be open to opportunities for collaboration that may also still be available in the situation. As noted earlier, the video mirror of most remote communication platforms presents a potential obstacle for improvisers who must be as attentive to the behavior and offers of their scene partners as possible. The symptoms of Zoom Fatigue are not only inconveniences to the improviser, but would seem to directly challenge the ability to enter into flow with partners, deactivate dorsolateral lateral prefrontal cortex (DLPF) activity, and therefore be able to draw from their learned skills to manufacture rapid creative narrative solutions in real time. So what might a mirrored tele-immersive platform provide the improviser?

Chapter 3

Methodology

And further, when walking, the monk discerns, 'I am walking.' When standing, he discerns, 'I am standing.' When sitting, he discerns, 'I am sitting.' When lying down, he discerns, 'I am lying down.' Or however his body is disposed, that is how he discerns it. (Satipatthana Sutta)

3.1 Methodological Lens

A qualitative methodology focused on developing grounded theories is the primary lens adopted for this thesis to evaluate, measure and understand the various features of tele-immersion for rehearsing and performing theatre. A grounded theory approach focuses on collecting qualitative data through close observation of user behaviour, interviews, and surveys. Adopting this type of methodological lens is informed by the insights of Sarker et al. who argue that the study of virtual teams should begin 'inductively, based on the collaborative experiences of virtual team members and the meanings they attribute to the virtual experiences'. This approach keeps the focus on what the user experience can tell us about the experimental variables that would otherwise be lost by focusing on measuring a particular outcome alone. The grounded theory approach is ideal when 'organisational forms are so novel' from other forms they 'cannot be easily translated or directly extended to understand or explain phenomena pertaining to the new forms' [153]. Performing tele-immersively is different from physically co-located performance on a number of levels, making grounded theory the most appropriate methodology for examining the impact of mirror-based tele-immersion on rehearsal and performance. Performing online, however, also provides a unique opportunity to examine theories related to improvisational performance that are more difficult to measure in traditional environments. Several studies related to immersive communication in the past have

already demonstrated that tele-immersive experiences can provide a significant sense of presence and connection with remote partners [154]. Many improvisational theatre pedagogy's in turn argue that live performance is dependent on an immediate sense of co-presence. While the main research focus of this thesis is to develop theories related to tele-immersive improvisational performance as the data emerges, it is important to be mindful of the potential connection between these existing theories and the participants' experience. The general experimental design for each study is subsequently aimed at the discovery of theories that, when possible, can be informed by validated survey questions from related fields. By qualitatively examining and organising the data generated by these field studies and generating theories based on the recurring themes and insights, it is the aim to 'guard against imposing a theory' related to how a particular feature of tele-immersion might have salience which 'may not actually match the patterns in the data' [155]). To support the qualitative data from video and audio analysis of behaviour, user feedback, and open discussions about the experience of using tele-immersion for improvisation, there are few validated instruments designed to measure specific aspects of collaborative experience that are potentially useful for further grounding emergent theories.

3.1.1 Measuring and Evaluating Presence

As different video collaboration tools have emerged over the years with increasingly more immersive capacity, a number of instruments have been developed to evaluate various features of the user experience. The degree of 'presence' one feels with the virtual environment and remote partner is a popular benchmark for evaluating the success of an immersive system [2, 12, 89, 156], however in this section I will argue that conventional methods for evaluating presence using digital media systems are insufficient for evaluating communications systems that are not aimed at mimicking natural conversation, and therefore evidence for this type of presence is not informative. The concept of presence itself remains useful for examining and evaluating the experience of mirror-based tele-immersion, but the purposefully artificial nature of a mirror-based tele-immersive system (as will be argued below?) does not conform to the ethos driving most validated instruments for studying presence in immersive systems, as will be explained below. For this reason, a differently nuanced measure of presence is needed that can be related to not just what users are present with, but what they are attuned with via the platform. The following section will give a brief overview of presence as a way to measure the efficacy of a given immersive digital media environment, and then demonstrate how the concept of attunement from social psychology provides a more useful way to examine the features of a mirror-based tele-immersive system for rehearsing and performing theatre.

Presence was first put forward to the Human Computer Interaction (HCI) community as a possible measurable experience by researchers Mathew Lombard and Theresa Ditton in their essay for the Journal of Computer-Mediated Communication called 'At the Heart of it All: The Concept of Presence.' They describe how "the feeling of presence in a technologically-mediated environment is a function of the possibilities for interaction" [6]. This argument suggests that one can feel present inside of a virtual environment (VE) to varying degrees that can be measured by sampling from user experience what they are paying attention to. The reasoning is compelling, as it appears measuring presence will allow the researchers to evaluate 'potential' generally, and avoid the need to account for the specific experience a user may have in the context of their interaction. When a user feels more 'there' in the virtual environment than the 'here' of the natural environment, it is inferred that the possibilities inherent in the natural environment are now subsumed by the virtual one. With this reasoning, feeling present to virtual objects, further implies the virtual environment is providing sufficient stimulation for engagement. In principle, this makes the degree of presence one feels a useful quality measure to provide a benchmark of a system's general utility as a communication platform that is not dependent on the type of collaboration taking place. Several researchers have attempted to design survey instruments capable of doing just that [157, 158]. For many HCI researchers designing immersive experiences, this has generally equated to examining how aware the subject is of the presence of the medium as medium as opposed to a feeling of presence directly with the reality presented by the medium, or in other words the 'perceptual illusion of non-mediation' [6]. These survey instruments for evaluating presence with tele-present and tele-immersive tools involve soliciting feedback before, throughout, and after using the given technology with questions to elicit the degree of awareness with the artificiality of the technology and where attention was most often directed during the experience. The ITC-Sense of Presence Inventory (ITCSOPI) is one of the most popular peer reviewed and validated instruments for measuring presence generally when using technology to communicate [159?–162]. Questions from the inventory centre around to what degree the awareness of the technology as technology disappeared with questions like 'I felt that the displayed environment was part of the real world' and 'I sensed that the temperature changed to match the scenes in the displayed environment.' These questions are designed specifically to measure a 'user's experience of media, with no reference to objective system parameters' [160]. Lessiter and her team who developed the ITC-SOPI argue that 'presence is a more useful concept when it is limited to the study of a user's experience of media presentations', as opposed to a concept for 'describing people's everyday experience' [160]. Their instrument subsequently focuses almost exclusively on measuring how the 'illusion' of mediated experience stands in for the 'real.' This allows the researcher to concentrate attention on 'media characteristics' which influence the sense of presence in various immersive media systems. This and

other HCI presence-focused instruments are useful tools, in particular, for media systems that are indeed designed with the purpose of illusion and encouraging the user to believe the mediated environment is real (or forgetting that it's not). This narrowing of focus, however, limits the utility of the instrument for examining the larger phenomenon of presence initially put forward by Riva et al. who describe it more generally as a concept that in effect accounts for 'how we behave, what we pay attention to, and how we understand and remember events' when using media systems to communicate and collaborate [89]. The feeling and experience of presence moreover is part of communication acts that operate in a complex ecosystem of intention and action that cannot be reduced to any particular feeling about what is happening while we communicate. Riva et al. describe that presence itself is 'an intuitive metacognitive process that allows us to control our actions through the comparison between intentions and perceptions' [89]. They continue to describe how intentions and perceptions are a result of several conscious and unconscious cognitive processes that all turn in relation to both the real and imagined capacity for presence. We perceive selectively from our environment the phenomenon that we can meaningfully act upon, or in other words, we are present to the phenomenon in the environment we judge to be most relevant for meaningful acts. Our intentions are, accordingly, bound up with what are perceived as well as imagined to be things we can meaningfully change. So presence is not restricted to actual phenomenon, but a spectrum of experience that stretches between real physical objects and speculative ones. The immediate physical environment does not inherently take precedence over the imagined, but they both are subject to perception. Therefore, it is reasoned that one can sample from a subject's awareness of the things in a given environment that they can feel present with (or aware of), to infer how meaningful those things are in relation to the things available in their environment that they are not aware of. For example, when tele-conferencing with a screen in a room, one can lose awareness of the things in the physical room as the subject becomes more attuned to the remote partner. Instruments like the ITC-SOPI, do not necessarily tell us how feeling present (as a result of being less aware of technology as technology) affects the particular aspects of collaboration that may be most relevant for the given collaboration. In other words, forgetting that the virtual environment one is conversing in is not real does not necessarily have any impact on the quality of the conversation taking place. In fact there are instances where remembering that it is artificial might benefit the collaboration, for instance in a design meeting where participants are actively changing the environment to demonstrate how a design choice is affecting the experience of the space. This demonstrates how there are specific nuances to the experience of presence that are more general which uniquely code to different qualities of engagement beyond the binary of real/not real. The theatre and film actor, for instance, does not need to delude themselves into thinking the set they are on is a real WWII bunker in order to effectively perform and experience the

act of being in a WWII bunker. The film actor in particular must always perform with a high degree of artificiality as a camera and a crowd of technicians are usually present from every vantage point. Perhaps even more importantly, the actor actually learns how to use the presence of the camera and the artificiality of the stage properties to more profoundly communicate with their partners and audiences. The camera, for example, magnifies and isolates parts of the actor, allowing them to exploit the selective focus to engender a greater sense of intimacy when close, or remoteness when far away for not only the audience, but also the scene partners reacting to them. The actor's sense of presence in the moment of the scene is therefore directly impacted by the technology and arguably enhanced by virtue of its unavoidable presence rather than as a result of being able to forget it. The drive to generalise is what motivates the development of survey instruments to indicate measurable structures for evaluating presence, but there are many problems introduced by such generalisations that can arbitrarily limit how such systems get designed, as described in the background chapter on telepresence systems. The generalisations of the ITC-SOPI assumes the ideal communication system is one that is indistinguishable from natural face to face communication. This line of reasoning as we have seen in the case of the actor, goes too far in assuming what is and what can be meaningful in a communication act, assuming the experience of non-mediated communication is inherently more meaningful than mediated. This type of measurement is therefore not useful for evaluating tele-immersive communication systems that deliberately provide extra-realistic interfaces in service of non-standard collaborations, such as theatrical improvisation. The initial arguments for the usefulness of studying presence put forward by Riva et al. even warn against the reduction of presence studies to 'the degree of technological immersion', instead instructing researchers to look at technological immersion as having a 'potential role in understanding the experience of presence.' Instead of evaluating how present users are within a tele-immersive system as a measure of technological awareness, evaluating presence in relation to social attunement may be more instructive. While such instruments designed around the technology of digital immersion appear less useful, instruments from the social sciences which are aimed at evaluating human sociality and connection provide more instructive feedback related to collaboration that can be used to inform the development of theories that can support broader innovation in design that moves beyond replicating a given ideal, and instead drives toward discovering what's possible.

3.1.2 Measuring and Evaluating Attunement

Besides looking at presence as a measure of how indistinguishable the technology is from reality, of particular interest for the improviser is to what degree the visual environment

affects how much they feel seen and heard by their partner, otherwise known as attunement. Measuring and evaluating this effect is inherently a qualitative question, however there are some potentially common shared values for improvisational performers that overlap with other sociological instruments that have been used to measure attunement in dynamic social situations that are instructive for learning what can be generalised about the features of a mirror-based tele-immersive system. As described in the section on improvisational theory, attunement is a term used in social science, psychology, and neuroscience studies involving how attuned individuals are to each other while engaging in shared tasks including therapy, mentoring, teaching, and patient care [163]. Attunement emerged as a concept for conceptualising the neural basis for an intersubjective process that begins early in life and is expressed in mutually coordinated activities during which the movements, facial expressions, and voice interactions of infant and mother synchronise in time [163]. The same neurological mechanisms driving synchronicity between mother and child were later theorised to account for attunement between adults and have become a subject of particular interest for therapists and doctors treating patients [64]. The mechanism at play is theorised by neuroscientist Vittoria Gallese as an automatic response system where 'perceiving the other's behaviour automatically activates in the observer the same motor program that underlies the behaviour being observed' [64]. Improvising successfully with a partner likely functions in relation to how well the improviser can take in the behaviour of their partner and not only empathise but attune to them to generate an appropriate response. Psychotherapy researchers Snyder and Silberschatz describe how attunement goes beyond empathy as it involves not only being able 'to connect with another person's experience/sensations' but utilises the empathetic response in service of 'the communication of that connection to the other person' [164]. Successful improvisation is not just the degree to which an individual is able to be spontaneous and expressive, but is more about the co-creation of a narrative that assumes being in tune or attuned to the needs of the other. Snyder et al. write about attunement in the context of developing the [164]. Their findings show 'significant correlation' between perceived attunement and general outcomes, and the scale they developed potentially provides a useful tool for examining the correlation between attunement and other collaborative acts, such as theatrical improvisation. The questions on the instrument are focused on 'the patient's experience of the therapist's degree of attunement and responsiveness during a therapy session', that were validated and based on 'previous studies conducted by the San Francisco Psychotherapy Research Group, and [164]. Many of the questions are naturally focused on a therapy context and would not be appropriate for evaluating attunement between improvisers. The questions were subsequently reviewed by three improvisational specialists to find a small subset of questions that could be adapted for the study of improvisational theatre.

3.1.3 Adapted Scale for Improvisation

Questions from the PEAR were reviewed by a panel of improv specialists and selected based on how well they correlated with accepted improvisational best practices defined by Keith Johnstone and Viola Spolin that have been described in the background chapters. The core practice of improvisational theatre is the spontaneous offer of suggestions and simultaneous acceptance of suggestions from a partner. To achieve this, a certain degree of listening and feeling listened to is vital. Specialists selected to review the questions each have over 10 years professional experience both teaching and performing improvisation internationally. The following table lists the 20 questions provided by the PEAR scale and the selected and adapted questions that were deemed the most relevant for measuring the degree to which an improviser felt fully capable of applying the core tenets of good improvisational practice:

Adapted PEAR Scale		
Original PEAR Scale	Adapted PEAR Scale	Improv Application
1. My therapist provided valuable insight and helped me achieve greater self-understanding.	Not used. 'Greater self understanding' is not a traditional aim of improv.	NA
2. I felt able to take the lead in bringing up whatever I wished to talk about today.	Not used. Improvisers speak to contribute to a scene rather than for self-expression.	NA
3. My therapist seemed to enjoy working with me today.	My improv partner seemed to enjoy working with me today.	Enjoyment is a key experience to determine the quality of the experience.
4. I got help in being able to talk about what was really important or troubling to me today.	Not used. The goal of improv is to build story together not express what was troubling.	NA
5. My therapist's comments enabled me to see my motives and behaviours in a more positive light today.	My improv partner's comments enabled me to be creative today.	Creative inspiration from partner is important and relates to 'Accepting offers.'
6. I made progress in dealing with the problems for which I sought therapy today.	Not used. Improvisers are generally instructed to leave their problems outside of the scene.	NA

7. My therapist understood me (i.e., my thoughts, feelings, goals) today.	My improv partner understood me.	Being understood and feeling in synch is vital for improv
8. What my therapist did and said was helpful today.	What my improv partner did and said was helpful today	Feeling supported is vital for improv.
9. My therapist seemed comfortable with all of my reactions today.	Not used. Sometimes it is appropriate to appear 'uncomfortable' in a scene.	NA
10. I felt relief from the tension I was experiencing today.	Not used, tension relief is not a focus of improv.	NA
11. My therapist acknowledged my strengths and my progress today.	Not used. Strengths and progress are out of context for the study. (NA)	NA
12. I was able to experience my feelings deeply, to feel moved today.	Not used. Sometimes improv scenes are light and fun. (NA)	NA
13. I felt accepted by my therapist today.	I felt accepted by my improv partner	Feeling accepted or uninhibited is part of tapping in to the unconscious.
14. I felt reassured and encouraged about how I am doing today.	Not used. The study context was not one of coaching.	NA
15. I was able to feel my feelings, to be who I really am today.	Not used. Improvisers don't usually play themselves.	NA
16. I felt that my therapist really cared about me today.	Not used. Scene partners may appear to 'not care' in the context of a scene.	NA
17. I got ideas for new or better way for dealing with people today.	Not used. This is not a goal of improv.	NA
18. I felt a sense of having an honest person-to-person relationship with my therapist today.	I felt a sense of having a meaningful person-to-person relationship with my improv partner.	Sense of meaning connects with the flow state needed to improvise.
19. My therapist had accurate empathy for my needs and feelings today.	My improv partner had accurate empathy for my needs and feelings today	Empathetic response is a core improv tenant.

20. I made progress in developing better self-control over my moods and behaviour today.	Not used. Self-control over moods is not a priority of improv.	NA

With the adjusted attunement scale, a measure is in place that can capture how the tele-immersive experience might impact the ability to be attuned to a partner. This is particularly important for evaluating the utility of a mirror-based tele-immersive experience as opposed to first person perspectives. If social attunement does indeed rely on access to the behaviour of the partner, then the presence of a separate video mirror in the interface would possibly reduce access to the behaviour of the other, as focus is split and a self-focus cognitive state is engaged. Alternatively, the absence of the mirror could prevent the user from feeling fully present with the partner in the context of a shared scene or the given virtual environment. The attunement scale thus provides a potentially useful metric to examine how different visual environments might impact the ability to feel attuned to not just the partner, but the environment as well.

3.1.4 Measuring and Evaluating Flow

Connected to presence and flow, improvising also involves engaging in the cognitive state called flow described by psychologist Mihaly Csikszentmihalyi as 'an almost automatic, effortless, yet highly focused state of consciousness' [131]. Improvising and entering into flow in performance require collaboration that is supported by a deep awareness of the presence of others [132]. Improvisers rely on constant verbal and visual feedback from scene partners and audience members to construct a shared reality. It is through this feedback that improvisers can synchronise around invented relationships that appear so cohesive they 'lose their fictitiousness of time and place' [133]. Csikszentmihaly''s definition of flow compliments the cognitive process described by improv theatre's first major theorist, Viola Spolin, who describes improvisation as an act where 'in present time a path is opened to your intuition, closing the gap between thinking and doing' [135]. Here Spolin speaks to the way improvisation functions as a distinct mental process, later identified in neuroscience by a shift of neural activity within the prefrontal cortex [137]. One way to understand the experience of this cognitive shift is Csikszentmihalyi's 'nine dimensions of flow' [5]. In the early 1990's, Csikszentmihalyi set out to understand the conditions that accompanied 'optimal' performance from elites in their respective fields. Over several years of listening to people describe their optimal experiences he noticed recurring patterns across the different domains of experience which he and his colleagues

formulated into a theory of flow and the nine dimensional scale [131]. Theatrical improvisation, as an artform of spontaneity, naturally has a lot in common with flow as they both require a cognitive shift from the prefrontal cortex activity of 'executive' functioning or what neuroscientist Daniel Khaneman describes as 'system 2' slow thinking to the faster more automatic 'system 1' thinking that is engaged when we are being spontaneous [165]. One can of course perform an improvisation without entering into flow, and one can experience flow while engaging in 'bad' improv (improv that is more of a solo scene with another improviser standing by as witness), so it is important to clarify that one experience does not automatically imply the other. Nevertheless, the nine dimensions of flow have been used as a qualitative measure for evaluating improvisational performance by a number of researchers in the past [139, 166, 167]. Examining the 9 dimensions demonstrates which may be applied to improvisational performance and how they can be used to help measure the impact of a given tele-conferencing platform's design on the ability to improvise. The experience of flow however, is an entirely subjective experience, rendering it inherently difficult to quantify and measure [168]. There are nevertheless several survey instruments that have been developed and successfully validated for measuring flow in many different fields[169–172]. While these instruments have been validated for some specific activities, there remains debate about the ability of these instruments to meaningfully capture the broad range of the flow dimensions themselves as conceived by Csikszentmihalyi. For instance, Seifert and Hedderson, in exploring more deeply the nature of an 'autotelic' or 'intrinsically rewarding' activity, argues that 'studies utilising self-report measures...do not readily provide a compelling account of what it means to be intrinsically motivated'. [173]. Intrinsic motivation is an important aspect of the autotelic experience but is a complex phenomenon to capture, especially in an experimental setting that is further complicated by the activity of improvisation itself. One can feel joy or pleasure related to any number of aspects of the improv experience. One can feel intrinsically motivated to share an experience with another or to be able to express themself, or to even be entertained by those around them. In evaluating how a given video conferencing interface affects improvisation, it will be valuable to be able to capture what parts of the experience contribute to or detract from the feeling of joy or pleasure instead of just a blanket measure of enjoyment overall. Earlier researchers looking into flow and improvisation also describe how improvisation involves several different levels of motivation related to being a social flow experience, resulting in slightly different qualities to a private flow experience [174]. There is the motivation to improvise itself, which inherently involves an intrinsic desire, but becomes further nuanced once the improvising begins, and then can change. One can be motivated to contribute more to the scene, and experience pleasant emotions in the offers they make, as well as in the way they are received and added to by the partner. The 'reward' of performing can therefore emerge from extrinsic circumstances that may

be experienced as intrinsic. A self-reported measure of different flow dimensions alone therefore will not necessarily correlate with the specific improvisational activity being measured. As Deci and Ryan note in their study of perceived causality, 'flow represents a descriptive dimension that may signify some of the purer instances of intrinsic motivation' [175]. Rather than exclusively relying on a particular validated instrument for measuring flow generally, a mixed method approach is preferred that captures some self-reported data related to optimally performing improvisation with survey questions along with observational data of the scenes performed, and responses to open ended questions about the experience. By having a set of fixed survey questions, we can look to see if there are any specific trends or correlations associated with the visual environment being tested that can be further nuanced with open ended feedback. In this way, a theory can be developed that is not unnecessarily tied to a given hypothesis that inspired the research (ie. tele-immersion enhances the experience of flow), but rather something more nuanced about the features of tele-immersion might emerge from the data to inspire better design practice for future iterations of a conferencing platform for rehearsing and performing theatre. As this thesis is exploring multiple aspects of experience, a short survey instrument is needed for each category to avoid survey fatigue in the participant. Several flow scales were reviewed for this study, and eventually the Core Flow instrument developed by Andrew Martin and Susan Jackson was selected for both its brevity and focus on capturing the 'phenomenology of the subjective flow experience' rather than the 'aggregate or global measure(s) drawn from the 'long' multi-item multi-factor flow instrument(s)' that other instruments measure' . The Core Flow instrument was developed specifically to support 'projects that include many measures' where 'brief forms may be preferable' [176]. The prior long form and short form flow scales were designed to 'assess the factors that comprise and/or lead to flow' whereas the 'the core flow scale captures the central subjective optimal experience.' As we will be assessing specific factors beyond the experience of flow in the same survey, the specificity of the short flow scale would create potential confusion with similarity to questions related to attunement and presence. The Core Flow instrument is therefore the better choice as it provides a metric to evaluate the overall phenomenological experience of flow as a measure of the whole improvised experience. The following table lists the Core Flow items and how they were adapted by the same panel of improv specialists who helped form the Improv Attunement scale for the subsequent case studies that form the major contribution of this thesis. Four of the original items were eliminated to further assist in avoiding survey fatigue, and potential confusion with other questions.

Core Flow Scale	
Core Flow Items	Adapted
1. I am 'totally involved'	I was 'totally involved.'
2. It feels like 'everything clicks.'	It felt 'everything clicked'
3. I am 'tuned in' to what I am doing.	I was 'tuned in' to what I was doing
4. I am 'in the zone'	I was 'in the zone'
5. I feel 'in control'	I felt 'in control'
6. I am 'switched on'	Not Used/redundant
7. It feels like I am 'in the flow' of things	Not Used/redundant
8. It feels like 'nothing else matters'	Not used/Not applicable
9. I am 'in the groove'	Not used/ redundant
10. I am 'totally focused' on what I am doing	I felt completely immersed in the activities

3.1.5 Mixed Methods

The data from listed survey questions related to flow, attunement, and presence are to be captured alongside the emergent data from performance and open discussion to both inspire new design practice, and inform future research. For the following case studies, questions related to flow in combination with a selection of attunement based questions (as a function of presence) provide a framework of survey questions to support a grounded theory approach to understanding how the experience of tele-immersion affects rehearsal and performance. The subsequent studies will pull from this framework to measure and evaluate different uses of the system in service of developing a larger theory about the experience of tele-immersion for the improvising performer.

Chapter 4

Virtual Director: Building a tele-immersive tool

A growing use of video conferencing tools for remote collaboration in the performing arts presents a compelling opportunity to explore how theatre pedagogies and performance can be meaningfully practised remotely - a need amplified by the Covid-19 pandemic which caused national lockdowns around the world between 2020-2022 [177]. Popular video conferencing tools being used by performers, however, have been generally designed to meet the needs of remote business and education which do not take into consideration the unique collaboration demands of teaching, developing, and performing theatre when each actor is isolated from the others [178]. While there have been many experiments over the last few decades into the potential of remote collaboration tools for building performance [179] including tele-immersive experiences by various artists, no one had developed a generally available platform for working tele-immersively to use outside of the given productions.

4.0.1 Rehearsing and Performing Online

Rehearsing and performing theatre online entails the use and incorporation of a broad range of technologies developed for various independent industries. Foundational to all online performance is the question of how remote users are networked together. There are many different technical protocols for networking and sharing data across systems that utilise different compression formats for optimising distribution and rely on various hardware and software systems. Conventional video conferencing over the internet is subject to many variables that can cause significant latency between users which can interrupt performance. For professional live to digital theatrical performances specialist

hardware and fibre-based networking systems are often employed to minimise latency. These systems are not generally accessible for remote theatre artists to take advantage of from home. On top of the networking, platforms must be able to work with and incorporate live camera footage and video data streams from users. By definition, video conferencing platforms work with webcams connected to a user's computer, but for the performing artist, other cameras must often be incorporated. In addition to live cameras, digital assets for scenery and props must be able to be incorporated as well. Sound can also be important, both the live audio of performers, and also the playing back of audio files or even generating music and sound during performances. Different platforms have different ways for incorporating these elements, but most existing conferencing platforms, as will be seen, are quite limited for the artist.

4.0.2 Controlling Realtime Assets

Having access to audiovisual data is the first part of a system, but equally important is how those assets can be controlled and manipulated in realtime in the context of performance. A tele-immersive system must be able to layer assets on top of each other in order to provide the illusion of performers being integrated into a cohesive and comprehensible scene. Realtime manipulation of such assets is traditionally the domain of broadcast television related technology. The broadcasting industry has a large range of hardware and software systems for switching between video feeds, performing background segmentation, compositing, and transitioning between scenes. Most of these systems are designed for use in studios purpose built for live editing of sporting and live performance events. There are some platforms designed around the needs of the home broadcaster that can be used for creating remote digital theatre, but no commercially available tools at the time of writing this thesis are purpose built for tele-immersive performance. Instead the focus of these tools is generally sharing footage of remote users to a general audience. Finally, the actual live control and real time editing of a live performance is the domain of live event control systems used in the live entertainment industry. Generally these systems are built around the needs of a localised event like a theatre performance for the playback of media projected onto a set or distributed to screens. Like broadcast tools, these platforms are generally designed around the needs of artists to display and present video assets that are part of a given live event, rather than for incorporating all of the assets into a single scene. These systems are also generally inaccessible to the home user. Modularity

VirtualDirector is a platform that draws from all of these domains to provide a unique modular system that can take a large variety of 2D and 3D assets and allow a remote technician/director to control and arrange them in realtime for a cinematic tele-immersive

experience. It is set up both for remote users who can participate from home using a mid-range laptop or pc and conventional webcam, and for working with co-located performers in a 'virtual production' environment. The system also implements a variety of computer vision tools and graphics processing techniques that allow novel incorporation of animations and cinematic perspectives unavailable in any other system. The platform's unique modularity means it can be easily customised for researchers to experiment with various layouts and configurations to explore how different aspects of the interface and visual environment affect performance as well as to add novel functionalities based on the needs of the performers. Virtual Director operates as a server that can be run from a single gaming level PC at home or hosted in the cloud allowing remote performers and audience to connect without any need for downloading specialised software. Participants can connect via traditional video conferencing software like Zoom, through webRTC protocols, or even directly through cameras connected to the serving computer. The specific features of Virtual Director will be further examined below, but to understand the novelty of the platform, it is important to examine some of the existing tools on the market, as well as a brief history of technology developed for tele-immersive experiences that directly or indirectly influenced the design choices around Virtual Director.

4.1 Tele-presence and Telematic Art

Virtual Director as a software platform is related to two trajectories of telepresence study and research. One trajectory tracks along the field of tele-communications tracing from Marvin Minskey forward, investigating how technology can allow remote people to better collaborate generally, and another trajectory from the field of 'telematic art' that explores how networking technology can allow remote performers to create together. The main difference between these trajectories until quite recently has been that in telematic art the focus has been to bring together remote stages of performance where for instance a dancer on a stage in Paris can appear to dance alongside another performer on a stage in Tokyo. Tele-matic art has traditionally relied upon complex hardware and software configurations of tele-communications technology that was not necessarily designed for the performing arts. Often the technology involved is focused on the audience experience, with performers being expected to perform for the camera, but not necessarily experiencing themselves in the tele-immersive environment. Tele-presence technology, on the other hand, has been focused on allowing remote participants to collaborate and see themselves together. In recent years there have been some attempts to create tele-communications platforms for artists generally to collaborate, but none

have the features of tele-immersion that are the subject of this thesis Virtual Director subsequently sits in the middle of these two fields, and is built on findings from both.

4.1.1 A note on Accessibility

Virtual Director sets itself apart from early attempts at tele-immersive communications platforms both in its general accessibility to users from home, and its incorporation of a highly customisable 3D environment for generating not only a tele-immersive, but a cinematic view of users. The EVL workshop described in the earlier section on tele-immersive technology marked the beginning of research activities into tele-immersion systems that led to the development of virtual reality 'cave' environments and a drafting table display system call 'ImmersaDesk' [114]. These systems and subsequent systems developed until relatively recently have been used for various performing arts activities including aspects of tele-immersive theatrical performance [180]. These systems, however, have depended on hardware, computing resources, and network bandwidth inaccessible to the general public. EVL's offerings including ImmersaDesks and CAVES were enterprise level tele-communcations devices only available to large organisations able to invest in the hardware and maintenance. At the height of their sales, they were only installed at eight universities, five US government labs, and ten different international business organisations [80]. Many presence studies nevertheless, have continued to demonstrate the potential and demand for more immersive communication capabilities on home and mobile devices to facilitate the growing needs of remote workers [181].

4.1.2 The Legacy of Nam Jun Paik

In 1973, Nam Jun Paik was the first to explore telepresence as an artistic medium using satellite broadcast technology to co-locate performers from Germany, Korea, and the U.S. [182]. During the broadcast, Paik extracted blue screen backgrounds in realtime of performers like Merce Cunningham, placing his body next to a live Salvador Dali reading poetry. This early example allowed the audience to experience the co-location, however the performers were not necessarily experiencing the co-location themselves. Paik's system nevertheless was designed around the needs of a live broadcaster who could improvise along with the remote performers, and provides a conceptual frame that became one of the inspirations for designing Virtual Director. Paik, considered 'the father of video art', developed his video synthesizers for various broadcast applications [183]. Paik's system involved feeding live video into his custom synthesizer to not only mix feeds together, but to generate various kinds of distortions and effects in realtime by turning knobs and switches [184]. Paik was one of the very first artists to examine

broadcast television as a novel artistic medium and set the groundwork for exploring presence, liveness, and performance within the televisual medium, as opposed to treating television simply as a way to capture a physical performance and place it in closer proximity to the remote viewer.

4.1.3 The first Social Tele-Immersive Event

Around the same time, artists Kit Galloway and Sherrie Rabinowitz created the first documented exploration of the tele-immersive experience in a performance setting with Satellite Arts Project: A Space with No Geographical Boundaries in 1977. Working with NASA and using the US-Canadian Hermes CTS satellite, "people 3000 miles apart were electronically composited into a single image that was displayed on monitors at each location, creating a 'space with no geographical boundaries'" [185]. In these early works, the artists laid down the foundation for all subsequent tele-immersive artworks, proposing a 'virtual telespace' as a "new environment for the performing arts and a new model for live multi-site televisual collaborations' [185]. To accomplish their tele-immersive artworks, they had to rely on proprietary space technology from the U.S. government, meaning that it would be quite some time before the technology would advance to the point that tele-immersive experiences could be accessible to all. There does not appear to be any documentation of the performers' actual experience working tele-immersively, but in interviews Galloway and Rabinowitz describe interesting effects of performing in that space that are the subject of the research questions motivating this thesis. They describe how when performing tele-immersively, 'you give priority to your image as a kind of ambassador in virtual space', and how 'even though you're separate from your body, it's incredibly sensual'. They even speak directly to the powerful effect of the virtual that allows one to "'own your image' so completely in real time that it's like having phantom limbs." These anecdotal observations speak to the great potential of a tele-immersive platform for performing artists to explore, but have not been available to all but a very few performers over the subsequent decades.

4.1.4 Telematic Art Today

Since Paik and Galloway and Rabinowitz, networked tele-visual technology has continued to be in use in a wide range of performing arts-related activities that has informed divergent practices ranging from the early work of Adrien Jenik and Lisa Brennies's Desktop Theatre in the 1990s of 'avatar-based improvisations' which let remote performers move 2D avatars around different digital environments [186], to the contemporary work of Paul Sermon who has been placing performers into shared digital spaces

since his 'Telematic Dreaming' project around the same time [187]. Jenik's desktop theatre's avatar-based system allowed users to control 2D avatars together on top of a virtual backdrop in a 'shared cartoon arena' [188]. Unlike traditional business minded tele-communications platforms, Jenik sought to answer how with a virtual stage, 'drama might be expressed when separated from the body, the voice, and shared space' [188]. While not a tele-immersive environment with video, it did demonstrate how allowing performers to see the avatars they were controlling inside a shared space could powerfully foster collective creativity particularly in the way users would identify with their virtual selves: 'we enter a psychic space in which we become our masks' [188].

4.1.5 Virtual Masking

Masks have long been part of theatre training and performance and have a demonstrated ability to shape and influence the behaviour of the performer [189]. This observation echoes what Galloway and Rabinowitz reported with their early experiments. Most tele-immersive platforms however, have been designed around a 1st person perspective, inadvertently preventing a creative and playful use of such environments for theatrical performance for the wider population. Drawing from the success of Desktop Theatre to foster avatar identification and a creative improvisational environment, Virtual Director as a platform is set up to explore qualitatively how the video mirror of the performer might function as a kind of 'mask' or avatar for performance that extends their expressive capacity when placed inside the shared virtual environment.

4.1.6 Paul Sermon

Paul Sermon more directly picked up the baton from Galloway and Rabinowitz as he began experimenting with tele-immersive projection in the early 1990s to explore what happens when remote people see themselves inhabiting identical physical spaces connected in virtual space. His work Telematic Dreaming [187] was an art installation where visitors would enter a room with a bed and be able to see another visitor projected live onto that bed, while simultaneously having their own image projected onto the bed of the other visitor. Each room was configured with monitors so visitors could see each other as if sharing the same bed. Sermon has continued this work over the last three decades, culminating in the development of 'A Telepresence Stage' where he invited performing artists from around the world to work with him and his team to create tele-immersive performances. The Telepresence Stage does not offer a specific platform for creating tele-immersive experiences; instead Sermon and his team explore how existing video-conferencing tools and digital media software can be connected together to

allow for tele-immersive performance. Virtual Director was actually used as part of the project as an example of a new platform purpose-built for tele-immersive performance.

4.1.7 Designing for Performance vs Designing for Rehearsal

Leading up to the development of Virtual Director, the majority of documented practice and research related to tele-immersive performance however has almost exclusively focused on the engineering and design of novel systems that connect existing communications technology together for a particular production, dramaturgy, or the audience experience [179]. These systems have not been designed with the purpose of allowing performers to rehearse and experiment with tele-immersion, and instead are designed around a particular artistic concept. Furthermore, publications related to these works, to the best knowledge of the researcher, tend to focus on the first person experience of the creators and do not investigate formally the experience of actually performing inside of a tele-immersive space. The nearest example of research involving the experience of performing in a tele-immersive space comes from dance and tele-immersion, with a study investigating how the time delay between dancers interacting tele-immersively impacted synchronicity [83]. Most recently, researchers in theatre have carried out a study on the rehearsal process and performance of a theatrical production between two remote groups. This study however focused on the use of life size projections of remote partners and the telepresent collaboration between two physically co-located groups [190]. In each of these cases, the technology used for the productions does not allow the average remote user to participate, they do not incorporate a 'mirror' perspective, nor are they modular in nature to allow for iterative design and exploration of various features of tele-immersion.

4.1.8 The Need for a Mirror Based Tele-Immersive Platform

There are a few publicly available technological platforms and tools that provide opportunities for some accessible tele-immersive experimentation, and a small number designed around performance needs. Generally however, they all fall short of being able to provide a flexible mirror-based tele-immersive experience suitable for the needs of improvisational theatre rehearsal. A brief overview of some of these systems and how they are configured and have been attempted to be used for performance will demonstrate why a new tool needed to be built for this study, and furthermore developed around the specific needs of improvisational rehearsal.

Currently the most popular tools for remote performers to rehearse and present work together are video conferencing platforms designed initially around business needs but

which have begun providing tele-immersive options as well. The most popular video communication tools enabling theatre at the onset of the 2020 pandemic included Zoom and similarly functioning business conferencing tools like Skype, WebEx, Microsoft Teams, and Google Hangouts [191]. These tools allowed anyone connected to the internet with a computer or mobile device to transmit video to remote partners in various arrangements from grids to 'speaker view' layouts that highlight individual video feeds [192]. Microsoft was one of the first mainstream video conferencing tools that began providing an immersed view for Skype and Teams users called 'Together Mode', soon followed by Zoom which provided 'Immersive View'. With both of these platforms, the users can see themselves arranged in front of various backgrounds as if they were all in the same space. Default views involve appearing as if all seated in an auditorium or around a large coffee table. They each also allow you to upload an original background, and the host can manually place users around the image with a certain degree of freedom. With each platform there appears to be some limitations on exactly where a user can be placed, and users cannot be overlapping.

4.1.9 Realtime Dynamic Scene Manipulation

With these basic functionalities, a variety of tele-immersive improvisational activities can be carried out, but the interfaces have several limitations. It is not quick to change background environments, as each change resets the arrangements and there is a noticeable interruption involving freezing video feeds and blank screens. It is not possible to dynamically arrange users during a scene, so performers become essentially 'stuck' in place once a scene starts. The inability to overlay video means there is limited capacity for simulating touch. The entire environment is actually a 2D environment, so any illusion of depth is difficult to create. There are also no options for placing foreground elements to create more naturalistic arrangements, nor any way to resize users so that they can be arranged to appear the correct dimensions for a scene. Ultimately, the inability to work with actual 3D geometry limits a lot of the visual design capacity of these interfaces, making them unsuitable for regular rehearsal needs. It is also important to note that at the time of the first case study reviewed below, none of these tools were actually available. They were actually released close to the time of the first publication related to my initial findings on tele-immersive performance.

4.1.10 Existing tools

There are very few online platforms designed specifically for live performance artists to rehearse and perform, and none to date offer a rich tele-immersive live video experience

for desktop experiences [193, 194]. UpStage is an interesting platform originally conceived and produced by Helen Varley Jamieson and developed by Paul Rohrlach that operates as a kind of live puppet theatre that can be remotely operated by performers [195]. The platform is designed around uploading graphics and animations that can be manipulated in realtime on a virtual stage. The system is not built for compositing live video of performers, so falls short of providing a tele-immersive experience for actors, nor is it designed for live video performance. It does however, offer a range of notable features useful for the specific needs of live performance that provide insight for what a tele-immersive theatrical platform might need. UpStage features a 'backstage' area where users can design a scene by uploading a background and attach various audio/video files. Multiple stages can be saved, allowing one to build a performance with multiple locations that can be transitioned between during performance. There are functions for virtual curtains to come down and up on performances, allowing clean transitions between scenes, and digital 'props' in the form of graphics with transparencies can be loaded as foreground or background elements to facilitate the appearance of an avatar holding or carrying an object. The platform is run from a remote server, meaning users do not need to download software to use it, making it quite accessible. There is a general 1MB limit for graphic and audio media uploads, and 300MB for video uploads, and backdrop graphics cannot be scaled, making it somewhat limited for robust graphic experiences. It is also limited to 2D video assets.

4.1.11 Virtual Puppetry

Another notable contribution to digital platforms for live performance in the realm of virtual puppetry comes from researcher and developer Maneesh Agrawala out of UC Berkeley who began developing video puppetry software that allows a user to create physical 2D puppet 'cut outs' that could be manipulated by hand in front of a camera and be automatically recognized by scanned versions of the puppet and controlled digitally [196]. Argawala and his team employed various computer vision algorithms for recognizing the physical puppets and translating them into movements of the digital counterparts. Later, Argawala and team applied the same techniques for recognising and controlling 3D objects using a Kinect depth sensor, allowing the realtime animation of complex 3 dimensional scenes. Their work demonstrates how similar principles could be employed for manipulating live video feeds of performers that can be arranged in more complex 3 dimensional scenes.

4.1.12   Broadcast Tools

There are a variety of online broadcasting or 'live streaming' tools that in principle can allow for tele-immersive experiences, though they are not specifically designed for them. It is beyond the scope of this chapter to review all of the different platforms available and their functionality, but one platform in particular is worth examining in detail that comes the closest to offering theatre makers some opportunities for performing tele-immersively. Open Broadcaster Software (OBS) is an open source live streaming tool with a robust feature set and several available plugins that can be utilised for rehearsing and performing dynamic digital theatre experiences. OBS allows a user to bring in video from remote users in a variety of ways, including directly from webRTC streams to screen capturing video from a 3rd party video conferencing sessions and compositing them into OBS's video stage. OBS allows multiple 'scenes' to be set up that have different kinds of arrangements of media assets. The functionality of the platform is largely focused on a kind of broadcast talkshow paradigm where a producer may want to switch between various speakers, show video or image clips as well as screen titles and play sound. As an open source software, there are hundreds of plugins that add to the basic functionality, including the ability to remove chroma backgrounds from users, arrange users who have had their backgrounds removed into tele-immersive style scenes, and layer foreground objects so that a tele-immersive cinematic view is possible. The main drawback of this approach is that it takes a considerable amount of time to set up and 'design' each environment, making it cumbersome for a rehearsal setting, particularly an improvisational theatre rehearsal. It is not possible to quickly cycle through a folder of video environments for instance for quick scene changes and performers must be staged into scenes ahead of time, meaning it is more of a tool for rehearsing a scripted performance than for an open rehearsal. The final limitation is that the platform is locked into a two-dimensional graphical environment so there are limitations on design and aesthetics.

4.1.13   The Urgent Need for Rehearsing and Performing Online

In 2019, when the Covid-19 pandemic began, there were few tools available for online collaboration other than video conferencing tools designed around the needs of traditional conferencing. As described in the earlier chapter on tele-immersion and video conferencing systems, these systems prioritise verbal communication, with the video component designed to support dialogue between remote participants and the presentations. At this time, none of the commercially available tools including Zoom, Skype, Teams, and Cisco WebEx included any tele-immersive options for display. A few VR
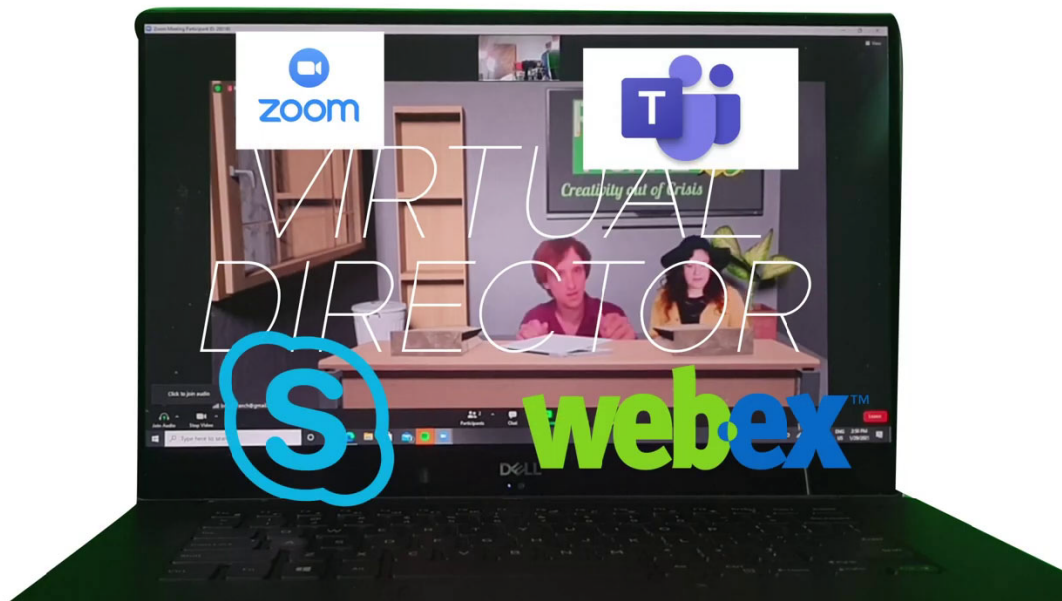
FIGURE 4.1: Virtual Director works with existing virtual conferencing tools to add tele-immersive functionality to the meeting.

platforms allowed for immersive social interaction between remote participants, but of course these depended on specific hardware and software to run that most consumers did not have access to. Moreover, these systems were (and largely remain) avatar-based, meaning participants could only interact via 3D models of characters which at best could only vaguely resemble the real features of collaborators. Avatars currently lack significant expressivity compared to our physical faces, which reduces the amount of physical information that can be shared with others that performers rely on to collaboratively tell stories. None of the generally available VR platforms facilitated an easy way to both interact and perform with scene partners and also maintain a sense of the stage picture being created for audiences. Finally, as mentioned before, none of these systems, whether for video conferencing or VR social interaction, provided a mirror-based tele-immersive experience, which is the major focus of this thesis. For these reasons, a tool needed to be developed that not only provided a tele-immersive experience, but could also be accessed by remote users with the most basic hardware and software. This was particularly important, as the first studies were being carried out during periods of national lockdowns which prevented physical assembly.

4.1.14 Problem Solving Design

Virtual Director was subsequently developed to address not just the question of how mirror-based tele-immersion impacted performance, but how to meaningfully provide opportunities for remote isolated performers to rehearse and perform in general. A

FIGURE 4.2: Improvisational actors rehearsing with Virtual Director, 2019

number of tools are available for designing video collaboration tools that each come with a variety of costs and benefits. In developing the platform, the ability to rapidly prototype and iterate was vital as I was developing it for an audience with needs that could not be easily intuited. Touch Designer is a software package designed as a kind of sandbox platform to quickly prototype realtime video experiences. It features a rich library of tools for routing live video through computational processes that can be tailored to take advantage of a variety of hardware configurations. The platform is a node-based programming environment that is visual in nature, making it easy for visually-inclined artists to be aware of each component of the system. Besides a robust native library of nodes for processing video and data, every node can be modified and iterated upon with Python scripting, meaning new tools can be easily developed and added to the platform. Finally, the platform has easy-to-access customisable generic-use interface objects that can be programmed for limitless applications.

4.2 Designing and Building Virtual Director

This finally brings us to Virtual Director and how it was designed and built to meet the specific needs of improvisational theatre. As described in the section on improvisation, the visual environment of the improviser plays an integral role in the ability to perform. Improvisers must be attuned to not only their scene partners, but the entire environment of the stage, including the props or set that might be there as well as the audience. As has been demonstrated, some software exists for specialists to design immersive digital

experiences for a particular production, but there are no immersive communication tools generally available for the isolated actor to re- hearse and build performances themselves [1, 51]. The video conferencing systems designed for business and education nevertheless have been the most accessible instruments for socially-distant performers. It is therefore important and timely to explore the potential of augmenting these tools with more immersive, dynamic, and flexible visual environments that can address the unique demands of improvisation and analyse how these design features affect performance. Tele-immersion facilitated by Virtual Director addresses this need with a field study of professional actors rehearsing and performing improvisational theatre in isolation, using this novel system. The following section presents Virtual Director, a program developed for this study that augments video conferencing services such as Zoom or Skype by extracting individual videos and compositing them into a shared virtual space. Virtual Director is compositing and video switching software I began developing for this thesis to explore how existing video conferencing tools could be generically enhanced with tele-immersive features to facilitate rehearsing and performing theatre. I developed the main features of the software and interface leading up to the first study of tele-immersive improvisational theatre, after which I recruited an AI and computer vision specialist to help build out new features for automating various functions and implementing novel AI image and speech generation tools to further experiment with. The tele-immersive environment is generated by running scripts that isolate individual video feeds and perform chromakey background segmentation from each participant's video. These isolated video feeds can then be positioned as 2D planes inside a 3D environment arranged by an operator in relation to selectable scenic elements in the space. Each object (including the performers) can be dynamically displaced, scaled, and rotated to simulate an appropriate sense of scale and depth between performers and the environment, whether they are seated or standing or positioned in different proximity to their cameras. Scenic elements can be dynamically replaced or changed with other objects available from a library of stored graphical elements

4.2.1 TouchDesigner

Virtual Director was built inside of TouchDesigner[1], *'a node based visual programming language for real time interactive multimedia content'*. TouchDesigner natively supports capturing and streaming ®NDI[2] video feeds which allows us to seamlessly work with various video conferencing tools. We designed the program to remotely supplement the existing conferencing tools our subjects had available *(Fig. 6.1a)*, avoiding the need for participants to download or install additional software. Since many of our subjects

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[1] https://derivative.ca/
[2] https://ndi.tv/tools/

FIGURE 4.3: Virtual Director System Overview: *(a) GUI, (b) MIDI Controller, (c) Player Crop, (d) 3D Environment, (e) GLSL Style Macros*

participated from work laptops, they were often locked in to using their company's chosen video conferencing tool and we wanted to make our study as accessible as possible. The program captures and separates video from conferencing tools like Skype[3] which provide ®NDI feeds for each participant *(Fig. 6.1d)*. With conferencing tools that do not provide discrete ®NDI video channels for participants, macros are launched to perform a screen-capture using ®NDI Tool's 'Scan Converter' of the video conferencing interface that Virtual Director automatically crops and separates into individual performer video feeds *(Fig. 4.3c)*. Each feed has its own chromakey functions that can be adjusted in real time for fine-tuning background segmentation. The user interface presents an operator with a grid of players and controls to dynamically select, switch, and manipulate the segmented performer videos inside a three-dimensional space *(Fig. 6)*. The interface also provides the user with interactive menus to load folders of images, videos, or 3D meshes to populate the virtual environment of the performers *(Fig. 6b,1d)*. Virtual Director stores up to sixteen scenes that are updated synchronously during performance or in the background asynchronously to support dynamic scene transitions. To facilitate real time interaction and response to the spontaneous behavior of the improvisers, the software is controllable via any attached musical instrument digital interface (MIDI) devices so that knobs, sliders, and buttons manipulate scenery and performers *(Fig. 4.3b)*. Virtual Director therefore allows the operator to improvise along with the performers by altering backgrounds, foreground elements, and positions of the performers based on their suggestions. Six custom OpenGL[4] shaders are available for real time color grading

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[3] https://www.skype.com/en/content-creators/
[4] https://www.khronos.org/opengl/

FIGURE 4.4: Actors being composited into virtual environment.

and visual effects that style performers into 'cartoon-like' renderings *(Fig. 4.3e)*. Virtual lighting and camera positions can also be freely adjusted for each scene.

4.2.2 Screen Capture

Screen capturing the grid layouts from other conferencing tools meant that resolution of individual participants was always relatively low, and was highly sensitive to any changes in the grid layout of the video conferencing software. This meant that if a participant entered or left the video call, the grid of players would rearrange, requiring the need to re-crop and arrange the grid, resulting in player feeds getting re-positioned within the Virtual Director scenes. Any change to the incoming grid from the 3rd party software meant that the entire rehearsal would need to be paused while the facilitator re-programmed the scenes. To solve this issue I began looking at how to bring in remote users' camera feeds directly through webRTC protocols and discovered a service created by Steve Seguin called at the time 'OBS Ninja' (now VDO.Ninja) which was initially designed to allow broadcasters to 'bring live video from a smartphone, tablet, or remote computer, directly into OBS Studio or other browser-enabled software' through webRTC's peer-to-peer streaming technology (VDO Ninja, 2022). Seguin's service allows hosts and clients to connect webcams directly through a web browser with robust controls for bandwidth, resolution, and a host of other features including an automatic virtual green screen. With this service, anyone with a web browser and connected webcam could directly join a Virtual Director session.

4.2.3 Background Segmentation

Each performer feed, whether coming from a screen capture or directly via NDO.Ninja has its own automatic background segmentation functions that run open-cv scripts for removing subjects from the background pixels from an image that can be run with a button click and then can be adjusted manually in real time for fine tuning the edges and

FIGURE 4.5: Diagram of background segmentation and compositing framework.

colours of the background segmentation. The user interface presents an operator with a grid of players and controls to dynamically select, switch, and manipulate the segmented performer videos inside a three-dimensional space . The interface also provides the user with interactive menus to load folders of images, videos, or 3D meshes to populate the virtual environment of the performers . Virtual Director stores up to sixteen scenes that are updated synchronously during performance or in the background asynchronously to support dynamic scene transitions.

4.2.4 Storing Scenes

The Virtual Director operator can program the 16 different scenes prior to the rehearsal by selecting background and foreground elements, virtual camera positions, and placement of the performers; or during a rehearsal or performance new scenes can be programmed behind the scenes during a performance that can be updated when ready. For improvisational theatre, this is the preferred method of working which allows the scenic arrangements to be inspired by the previous improvisations. For example, if a scene starts out in a modern kitchen, and the players reference going out on the town for a date, the operator might find an appropriate 'date' environment such as a bowling alley or pub to place the performers inside of in the next scene. A 'realtime' mode can also be toggled on, allowing the performers and audience to see changes to the environment
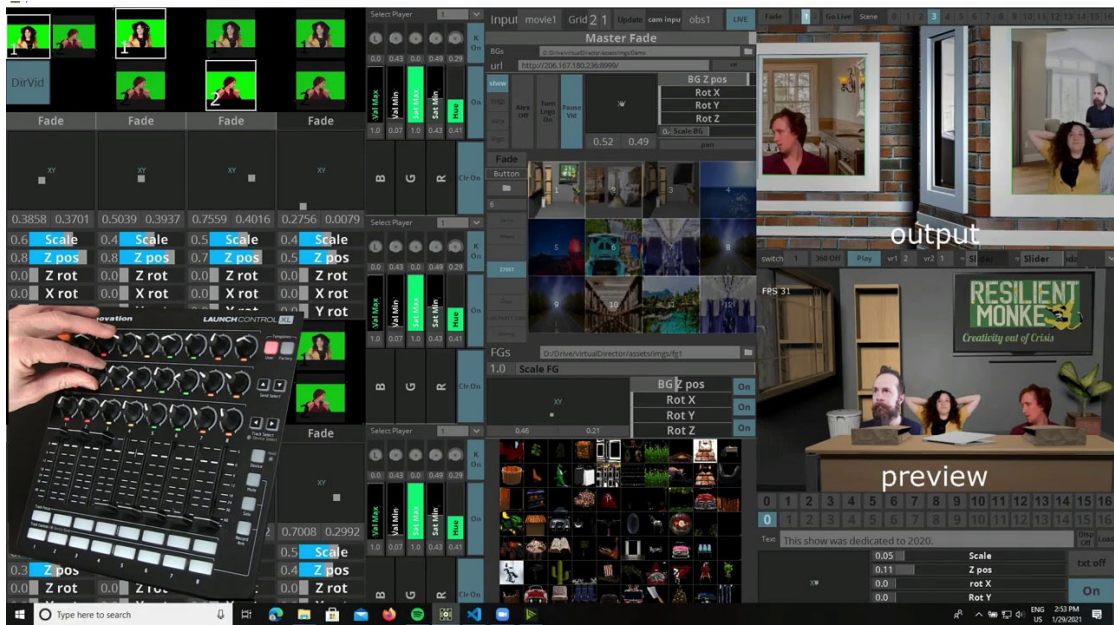
FIGURE 4.6: Midi controller used to manipulate characters and scene elements on the fly.

happen in realtime. This can be utilised for facilitating characters entering and exiting a given scene without needing to transition, a kind of 'realtime' animation of characters and objects floating, spinning, or moving around the scene, changes in speed and direction of video backgrounds, and many other novel ways of interacting.

4.2.5 MIDI Control

The initial designs and subsequent iterations of Virtual Director studied in this thesis revolve around a human 'director' who dynamically selects and controls who performs and all of the scenic elements placed into each scene. To further facilitate real time interaction and response to the spontaneous behaviour of the improvisers, the software is controllable via an attached musical instrument digital interface (MIDI) device so that knobs, sliders, and buttons manipulate scenery and performers (Fig. 3b). This allows a user to more intuitively perform with the improvisers and the development of tactile skill in manipulating the environment that is similar to the experience of playing a musical instrument. Virtual Director therefore allows the operator to improvise along with the performers by altering backgrounds, foreground elements, and changing virtual camera positions as well as those of the performers, based on their suggestions.
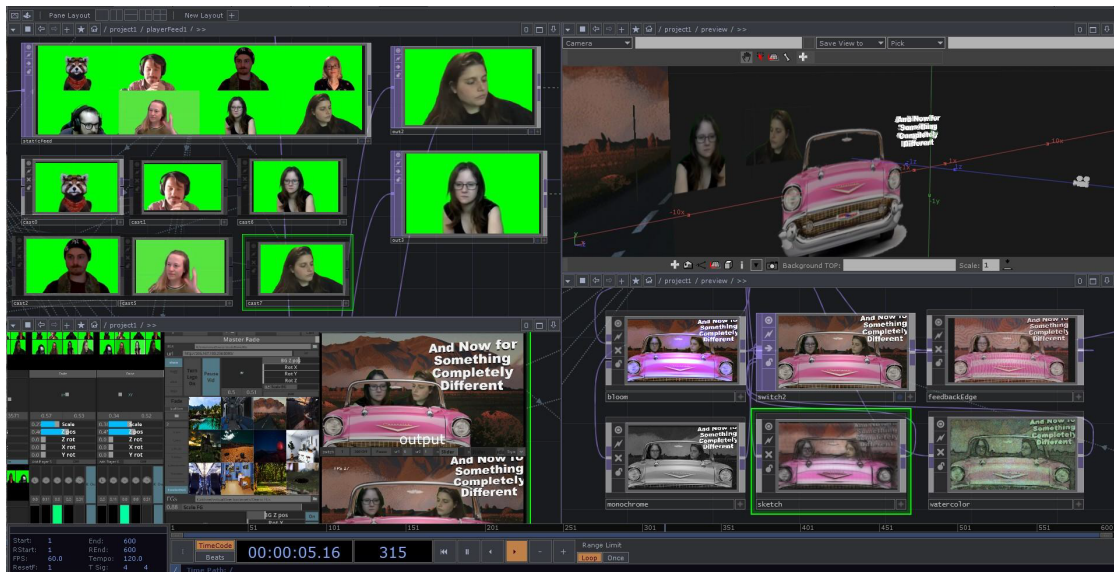
FIGURE 4.7: Various GLSL shaders styling video in real-time

4.2.6 OpenGL Shaders

Six custom OpenGL6 shaders are currently programmed into the system for real time colour grading and visual effects that style performers into 'cartoon-like' renderings . Novel shaders can be written or copied from open source shader libraries and easily added to the program, allowing for further experimentation with visual style. The current shaders have been used to simulate a film noir style of environments as well as several 'live animation' styles for different rehearsals and performances. A particularly useful and novel feature of Virtual Director is the ability to dynamically adjust lighting and camera positions for each scene. This means cameras can dolly, truck, pan, and zoom around the scene into close ups of performers, long shots, and medium shots, effectively providing the interface with a cinematic vocabulary.

4.2.7 AI Integration

As a modular program, the base environment of Virtual Director can be augmented with Python-based scripts for a wide range of enhancements. Many of these features go beyond answering the specific mirror-based tele-immersion questions driving this thesis, but are nonetheless relevant for understanding the novelty of the Virtual Director platform for facilitating further experimentation and study of how immersive performance spaces and new technologies might affect performance. Currently there are iterations of Virtual Director that perform AI-assisted background removal, a novel user navigation setting that allows a user to move around the screen by pointing the direction they want to go or moving their head in a particular direction. We have also begun incorporating

FIGURE 4.8: Improbotics cast performing with AI chatbot and image generator, 2021

FIGURE 4.9: Improvisers practicing AI painting with Virtual Director, 2021

AI image generation tools that allow the users to type a description of an environment that the AI will generate in 1-3 minutes time. Additionally we have implemented realtime-translation tools that allow performers to speak in different languages and be automatically subtitled with English translations, as well as implementation of an AI chatbot trained to improvise with performers.

4.2.8   Limitations and Future Work

There are features for playing back music files for underscoring and scene transitions, as well as settings for programming specific animations within a scene. Virtual Director is not only for working with physically remote performers, but is also set up to capture a group of performers on stage using a Kinect depth sensor to isolate each player from their background and allow them to be placed into the virtual environment along with players in remote locations. This effectively facilitates a kind of 'virtual production' workflow where performers can see themselves inside the virtual world as if they were performing in front of a large LED wall, mimicking the filming of a movie scene in the studio. Besides implementing Virtual Director for studying the effects of mirror-based tele-immersion on improvisation in the following case studies.

Chapter 5

Case Study: Platforms for Multilingual Tele-Immersive Storytelling and Improvisation

The results of the following case study were published in the Electronic Literature Organisation's conference proceedings in 2021. Excerpts from that publication are presented below as well as additional information related to the larger thesis that did not make it into the publication. Note, as the primary author, the text is included as a contribution in support of the thesis. The original publication is available to read in the appendix. My original contributions are noted and distinguished from the contributions of my co-authors.

5.1 Iterative Design

Various iterations of VirtualDirector have been employed for seven international theatre festivals, five applied improv theatre workshops, three dedicated online performances, and two scripted performances. The following chapter begins with excerpts from a paper published by the Electronic Literature Organisation in 2021 as part of the Platform (Post?) Pandemic conference of that year. The original paper was co-authored by Kory Mathweson and Piotr Mirowksi and details how VirtualDirector was used for three different performances with Improbotics, an improv theatre company that works with artificial intelligence to create improvisational theatre. The paper included reports from audience surveys about watching tele-immersive performance as well as the integration of artificial intelligence into the VirtualDirector interface to allow for real-time translation of performers improvising in different languages. As the primary author of the paper,

I include relevant excerpts here as part of this thesis examining the impact of tele-immersion on the rehearsal and performance of live theatre. See Appendix A for a full list of applications of VirtualDirector for festivals, workshops, and other performances.

5.2   Abstract

In 2020-2021, a pandemic caused a global shut down of the performance of live theatre. This led to many artists being left without creative outlets, companies having to modify their programming, and, in an unfortunately large number of cases, the complete shutdown of performing arts organisations. This circumscription led to a burst of technological innovation to support new ways to connect performers and audiences. In this work, we present two such innovations: Rosetta Code and Virtual Director. Rosetta Code is a tool for improvisation, live or online, which allows for simultaneous translation, enabled by artificial intelligence. Virtual Director is a platform for tele-immersive performance. In the hands of multilingual cast members, VirtualDirector augments Rosetta Code to create online multilingual improv shows. We describe these platforms and provide descriptions and reflections on two performances of Improbotics Online which used Virtual Director to bring together audience members and performers from around the world. These performances were part of the 2020 Paris Fringe where Improbotics Online received positive reviews and an award for the Most Innovative Show of the festival. We conclude this work by discussing the potential for mixed-presence international shows as we emerge from physical and social distancing requirements and how our tools will continue to support online and on-site performances. We have sparked a creative ratcheting effect: performers are enabled to tell new and interesting stories, and are inspired to suggest innovations which improve the tools with which they perform. These innovations are deployed in future performances. This positive feedback loop is a metaphor for the fundamental theory of improvisation: Accept and Expand.

5.3   Introduction

Live theatre is a casualty of the current COVID-19 pandemic. Social and physical distancing requirements preclude assemblies necessary for participatory theatre. These restrictions have significantly reduced public performances, pressured many performing arts institutions to modify their programming, and in many cases forced the complete shut-down of arts organizations. Many of the world's most popular stages, including all Broadway theatres in New York, USA and West End theatres in London, United

Kingdom, have plans to remain closed until at least the middle of 2021.[1] Early studies on the impact of social distancing restrictions on live arts professionals report substantial reductions in income for artists and increases in anxiety, depression and overall mental health [197]. The long term impact of shuttering theatres and the effects of social isolation on creativity in the performing arts industry remains to be seen. While some performing artists have been able to shift to digital mediums to somewhat mitigate the impact on their creativity, artists that rely heavily on the live presence of not only an audience, but their fellow performers have had little recourse to maintain their craft. Improvisational art forms in particular have struggled to find footing in digital mediums.

Theatrical improvisation relies on performers and audiences gathering in the same space and using that shared physical proximity to collaboratively build stories. The pandemic caused a global creative constipation through social and physical distancing requirements. Virtual gatherings using video-conferencing platforms are, at best, an ersatz solution for audiences longing for connection in an ever more disconnected world. These technologies have been linked to a phenomenon labelled 'Zoom-gloom' or 'Zoom fatigue', which has been studied in several recent works [23, 198]. Some improvisational theatre groups have embraced tele-conferencing and streaming for workshops, practice, and performance. But, due to how demanding it is to set these sorts of systems up, and the aforementioned Zoom-gloom which both performers and audiences are all too accustomed to, many are preferring to temporarily pause while waiting for the conditions of performance to resume [199]. The live performance limitation is a global issue; the world-wide community has been brought together online to share stories of adversity and challenge. A list of 'Improv Theatres That Shut Down in 2020' has been circulated and updated over the last year has over 60 theatres that have closed in the United States and Canada alone [200].[2] We believe that live theatre cannot wait for the pandemic to wane. Instead of re-streaming previously recorded live performances, we advocate for embracing technology, and specifically innovative platforms for tele-immersive storytelling and improvisation.

5.4 Virtual Director in Action

Many live performers struggle with the desire to be as live and in the moment as possible while dealing with the physical impossibilities introduced by virtual improvisation. The laws of physics, that is, the speed of light, defines a theoretical maximum for the speed of information transfer. This is the maximum rate at which information from one performer

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[1]https://broadway.com/announcement/covid-19-update/
[2]Thank you to Noah Johnson & Levity Theatre (https://levitytheatre.com/) for compiling this grim list.

can reach another performer or an audience observer. When audience and performer are co-located in a theatre, this information can happen at the speed of sound for jokes, laughter, and applause, and at the speed of light for body language and scenic painting. When performers are not co-located with audience members, it takes a non-insignificant amount of time for the information round trip to occur. While this is generally under a half-second, it can feel like a lifetime. Thus, platforms must be designed in such a way to handle issues of latency and lag introduced by these delays. And, as the number one rule in comedy is timing, handling these issues effectively is paramount for translating the comedy from the performers to the observers.

Theatres around the world have tried countless ways to incorporate live and prerecorded content for performance, hosting, and audience interaction. But, the platforms often stand in the way rather than uplift. These tools need to be easy enough for performers to use and improve audience enjoyment.

To handle these requirements, Branch built a platform for online performance. Our system, called the *Virtual Director*[3], enables actors to simulate feelings of presence with stage partners while performing and storytelling remotely [201]. Our research combines cinematic and video communication technologies with the theatrical practice of improvisational and scripted theatre, and aims at recreating presence, virtually. Virtual Director relies on commodity software (i.e. TouchDesigner[4] and web browsers such as Google Chrome), widely adopted video conferencing tools (e.g. Zoom, Microsoft Teams), and popular streaming platforms (e.g. YouTube, Twitch). Our solution 'piggy-backs' on these digital platforms for streaming and video conferencing for participatory online performances. This makes using the tools as easy as using common consumer software. These technologies have evolved significantly with a year of development and global dependence for tele-work and remote education. Software such as Open Broadcaster Software (OBS), OBS.Ninja[5], and even Zoom's and Google Meet's capabilities have improved significantly through 2020 and 2021.

While a full system description is out of the scope for this particular work, we encourage readers to see [201] for complete details. Next, we discuss how the Virtual Director system was tested with 2 small 'live' public performances featuring a variety of improvisational teams and 2 performances with Improbotics Online at the 2020 Paris Fringe festival.

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[3]'Tele-Immersive Improv': https://youtube.com/watch?v=LkqfRWH3iKU
[4]https://derivative.ca/
[5]https://obsproject.com/, https://obs.ninja/

FIGURE 5.1: Examples of the immersive multi-performer virtual stage. In these images, one can see multiple performers–who are not physically co-located, and who are connecting from different countries–composed together in a virtual scene. The real-time masking and composition is done by the Virtual Director software.

5.4.1 Early public trials

While developing Virtual Director Branch led two trials of the platform in front of live audiences with short performances from four different improv theatre teams. The teams were solicited from an open call for two-person improv teams who had been working together for at least a year and were interested in trying out new tools for streaming performance. Each team trained with the software for two weeks prior to performing for small audiences who watched the live shows from within a Zoom conference call. Twinprov [6] and the Jess's's's [7] performed for the show Double Incidentally May 31, 2020 for 15 audience members. Sudden Knot and Assimilate performed for Digital Improv Presents June 14th the following month for 21 audience members. Each team performed for approximately 20 minutes. We conducted surveys after each performance and received 13 responses. Twelve of the thirteen respondents 'agreed' or 'strongly agreed' to feeling present with the performers as well as agreeing they could 'easily visualize the world created by the performers,' demonstrating that the platform was successful in bringing a sense of cohesion and shared presence between remote participants. Answers to our open ended questions yielded a more nuanced appreciation of the impact

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[6] https://www.facebook.com/twinprovimprov
[7] https://www.facebook.com/jesssssimprov

of the technology on the potential of live streamed performance. We include the following quotes from audience members (A1-A7) for discussion answering 'How did you feel about the presence of the technology in the show?':

> *It was certainly interesting, and the visuals helped to create an extra dimension for us as the audience.* (A1)

> *Really engaging, and the connections between performers particularly stood out!* (A2)

> *It was terrific, the second part with the filter was super cool and I loved seeing them on green screen as well as in the virtual environment - it was distracting but not detracting if that makes sense (and really the distraction pulled me in deeper).* (A3)

> *I felt I was a part of it - especially at the top and end, there is something powerful for an audience member to share the screen with the performers.* (A4)

> *Felt great - would be awesome to have ongoing cues or coordination where artists knew the bounds of the technology and explored it more.* (A5)

> *I would like to see actors working more in different levels of the virtual space. Playing with their size inside the screen could be really engaging for the audience and both challenging and exciting for actors.* (A6)

> *It was something I was aware of, but it added to the feel and vibe of the show - even when things didn't work as well as you might have hoped, it all just added to the fun.* (A7)

The range of responses we share capture both the sense of pleasure audience members expressed in being part of a visually co-located performance, as well how the presence of technology stimulated their imaginations about what might be possible with a platform that could immerse audiences and performers inside a shared visual space.

5.4.2 Performances at the Paris Fringe Festival

We deployed Virtual Director within the context of an Improbotics Online show as part of the community-based performances at the 2020 online Paris Fringe festival. Improbotics[8] started as a research and performance project exploring Turing's imitation game using machine intelligence in improvised theatre [202–204]. To ensure that the audience understood the context for the performance, the description of the show was as follows: *Improbotics Online is a fully online, live improvised performance in an immersive virtual reality stage where human improvisers interact with artificial intelligence.*

We performed the show twice, on the 6th and 21st of June 2020. The show won a 'Ballsy Award', and was also awarded the 'Most Innovative Show' at the 2020 Paris Fringe.[9] The performance received a four-out-of-five star review on June 7, 2020 and the complete text of the review is included for context as an appendix to this work. We include a quote from the review here for discussion:

> The translation of the stage show into an online performance was not entirely seamless – however I do not feel it is important to mark **Improbotics Online** down for this, as a lot of the witty and interesting moments occurred during the slight awkward panic of being live and online. –Jake Mace

This review acknowledges that even the unique moments when the performance was not seamless were still interesting. This balance between 'everything is under control' and 'potential panic' contributes to special quality of live performance that is always somewhat dangerous with the opportunity for things to go 'wrong'. In a way, this risk is analogous to the 'ring-of-fire' that a trapezist would leap through in the big tent at a circus [134].

To see the show, we have posted a short trailer and a full performance, accessible at https://improbotics.org/online/. In the next section, we briefly describe several interesting qualitative observations that we synthesized from the audience members and performers during and after these performances.

5.4.3 Performer-Audience Interaction

We now examine the perception of the performance by audiences and their participation in collective storytelling. Our audience was interested in the new interaction formats

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[8] https://improbotics.org
[9] https://twitter.com/leparisfringe/status/1279062282723622915

and performance modalities presented as part of Improbotics Online. Our streamed performances redefined the nature of live performance, and we identified 4 levels of participation: (1) **participating as a performer**, (2) **privileged audience member**, (3) **general audience member**, (4) **onlookers watching the show recording, post-performance**.

We briefly summarize each of these modes of participation, comparing and contrasting the qualitative experiences. First, our tool enabled visual collocation and presence among performers. These are the professional improvisors who perform the show, they represent the cast of performers. Second, Virtual Director enabled visual collocation and audio interaction between selected privileged audience member and the performers, or recreated visual presence if we placed them in a virtual "amphitheatre". Third, general audience members audiences could interact indirectly via synchronous chat. Finally, onlookers can watch, or re-watch the performance, as we post the recording of the performance to the internet for asynchronous enjoyment.

Our initial study on the impact of visual co-location on remote improvised demonstrated how being visually co-located enhanced the sense of presence with remote scene partners in a way that traditional 'grid' arrangements of popular conference tools did not. Subjects of the study reported how this sense of presence with each other contributed to their ability to enter into a state of 'flow' during performance that in turn led to enhanced feelings of creativity and the idea that online improvisation could be an entirely new medium distinct from physically staged improvisation.

We noted a similar idea emerging from our audience feedback about how online performance could be considered a new medium with different rules and expectations from physically staged performance. The 'extra dimension' of a shared visual environment for one audience member that added to their enjoyment was the same dimension leading another to imagine how the addition of dynamic visual environments could be better exploited with actors 'working more in different levels of the virtual space.' Traditional improvisation is bound by physical laws that digital improvisers are not inherently bound to meaning 'space' now has additional expressive potential as performers can appear bigger or smaller taking up space in new ways that impact storytelling.

During our initial audience study we experimented with keeping the audience visually present throughout different moments of the show by instructing them to keep their cameras and microphones on. The feeling that 'there is something powerful for an audience member to share the screen with the performers' was echoed by another who reported 'My attention felt more present and necessary'. Co-locating all audience members with performers during shows streamed to larger audiences on social media platforms such as

Youtube however cannot take advantage of webcams the way video conferencing tools can, so require different methods for engaging with audiences.

For our Paris Fringe shows we instead explored how live chat could be incorporated into performances. We added functionality to Virtual Director that could display the results from a web-server that audience members could send suggestions to in addition to commenting with each other during performances via the built in chat functions of Youtube. Curated suggestions from both sources would then appear inside the virtual environment inhabited by the performers between scenes.

These different modes of interaction are all complimentary to the performance experience. They all contributed to a sense of collaborative collective storytelling in a shared 'space'. As a performer, you need to consider the performance from each of these perspectives, and understand how to engage with these perspectives in the moment. Additional analyses of the performers' experience of presence in tele-immersive virtual spaces is covered in work by Branch et al. (2021).

Having tools such as the Virtual Director accessible to us, and rehearsing and performing with them led to a creative ratcheting effect. The more that we shared these tools with brilliant performers and professional improvisors, the more interesting and innovative ideas they had to tune and modify them and use them in interesting ways. For instance, the shared virtual environments of online rehearsals and performances with Virtual Director resemble cinema much more than theatre and led to the novel adoption of cinematic techniques for improvised storytelling. During rehearsals improvisers began exploring how they could move props on and off screen, make their heads disappear by placing green fabric in front of their faces, and composite their bodies onto each other by overlapping their images on screen.

With Virtual Director performers can not only enter and exit the playing space by moving off camera, but they can also reference and incorporate physical props and costumes dynamically into scenes as they develop. Our platform also provided the addition of a 'virtual camera' as another scene partner that could interact with the performance. The environments of Virtual Director are built inside a 3D environment where performers are placed on transparent digital planes sandwiched between foreground and background elements which can subsequently be viewed from different angles. This allowed us to incorporate virtual camera controls to our platform so that an operator could 'pan' and 'zoom' into different areas of the screen like a sitcom or movie.

In addition to new cinematic techniques, virtual performance also led to novel incorporation of communication tools that bridged not only physical distance, but language barriers. Prior to the pandemic, Improbotics had long been adapting technology from

state-of-the-art language models, to digital avatars, to translation systems to explore how humans can improvise with technology [130]. In physically co-located shows, the role of these technologies could often be difficult for audiences to distinguish. With online performances however, we discovered not only how we could make these novel tools more visually present, but how we could incorporate them more meaningfully into performance.

5.5 Multilingual Performance and Actor Interaction
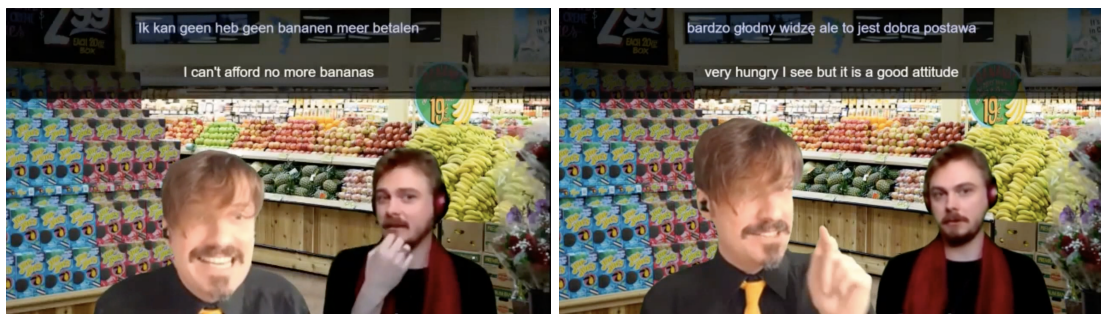
FIGURE 5.2: Examples of the immersive multi-performer virtual stage combined with real-time translation for two performers who are not physically co-located and who are speaking in two different languages (Dutch and Polish) with live transation into English. The real-time masking and composition is done by the Virtual Director software, combined with the Google Speech Recognition and Translation APIs.

As an international theatre troupe, Improbotics has cast members representing multiple nationalities and languages. In 2019 we began exploring novel multilingual improvisational formats by exploiting live translation and speech recognition technology in a show called Rosetta Code.

Using Google's API for speech recognition, for real-time translation, and for text-to-speech generation, Branch built a program to listen to improvisers speaking in a language foreign to their scene partner's and to send them the near real-time translation via headset, as well as to display the result of speech recognition and of real-time translation on a screen. In this way we enabled actors to improvise in multiple languages while being understood by cast members and audiences. The show was performed on stage in November 2019 at the Rich Mix Theatre[10] in London, as part of the Voila Festival of European Theatre [205].

While we had some successes with this format it could at times be difficult for audiences to track how the translations were taking place as we relied on projections that did not always sync smoothly with the performance. Moreover, capturing the speech of

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[10]https://richmix.org.uk/events/rosetta-code/

individual performers, without cross-talk from their stage partners, proved challenging and required them to hold a dynamic microphone with an on-off switch in their hand. Moving to an online platform with Virtual Director not only began to solve many of these challenges (for example, speech recognition could be run independently on each performer's computer), but also introduced new ways to incorporate translations into the show.

Our original system which enabled a low-latency, multilingual experience for performers and audiences alike, challenged contemporary theatre which is often performed and enjoyed in a single language. Building up on an existing multilingual improv stage show [205], we combined tele-immersion with translation to create a multilingual performance that transcends typical physical limitations of the stage. As the performers spoke in different languages, real-time translation of their lines was displayed on the screen, like the subtitles in a foreign film. The cohesive environment of the virtual stage enabled us to use subtitling more effectively so that audiences could see the translations and the performance simultaneously, in a way that projections alone could not do.

Moreover, the addition of virtual environments meant we could provide a more cohesive narrative experience and context for multilingual improv with performers appearing to be in the same physical location. When performing in physically co-located shows, the stage is empty and requires improvisers to not only spontaneously generate meaningful dialogue, but also verbally 'paint' the visual environment of the scene through that dialogue. With multilingual performance it there is a significant cognitive demand on both performers and audiences to keep track of physical details being described throughout the scene, and there is subsequently little agreement about the physical reality of the space. Performing tele-presently with Virtual Director meant performers and audiences could immediately understand where the scene was taking place, alleviating much of that cognitive burden.

5.6   Discussion and Conclusions

One consideration is that our system de-centers the place of the actors on the digital stage. No longer is there a human front-and-center, but rather, there is a window (sometimes quite literally a digital window) within which performers are co-located. This has a potential to shift the audiences focus from the acting and emotion of the live performer to the technological choices that are supporting the experience. While this risk is real, we have found that the balance enables us to explore mixed human-machine storytelling in a way that would otherwise not be possible. That is, we are able to have humans and machines perform scenes together and it 'looks and feels' similar to having

two humans perform together. This delicate balance on the cusp of the uncanny valley is a fun and playful experience for performers, and it allows us to tell stories that are otherwise more demanding on the audiences' suspension of disbelief.

Once we assemble again in a post-pandemic world, we will keep the tele-immersion and translation tools to create mixed-presence connected international shows. What we aimed to do with our Virtual Director work was not to repeat or replicate the experience the interactive and embodied experience in a shared theatre setting. Rather, we aimed to augment the creativity and storytelling capabilities of human performers with technology that can be used in multiple settings [204].

These tools will enable the next generation of on-site improvisational theatre as well. Performers will be able to build immersive lighting, visual, and audio experiences in the moment, and from the stage. Audiences will be empowered to immerse themselves in the collective creation of the show through textual interaction, through their voices, or even by moving around the space. These platforms are built in such a way that they can easily be adopted by improvisational theatres anywhere on earth. We are already sharing this technology with other performers around the world. These groups have engaged with out platforms to enable their shows. This global impact is a testament to the impact of platform development. Finally, as we slowly and cautiously migrate back into the theatres, our technologies will continue to enable live theatre experiences in novel and immersive ways.

Chapter 6

Experiment I: Effects of Tele-Immersive Improv

The results of the following experiment were published in the ACM SIGGCHI conference proceedings in 2020. Excerpts from that publication are presented below as well as additional information related to the larger thesis that did not make it into the publication. Note, as the primary author, the text is included as a significant contribution in support of the thesis. The original publication is available to read in the appendix.
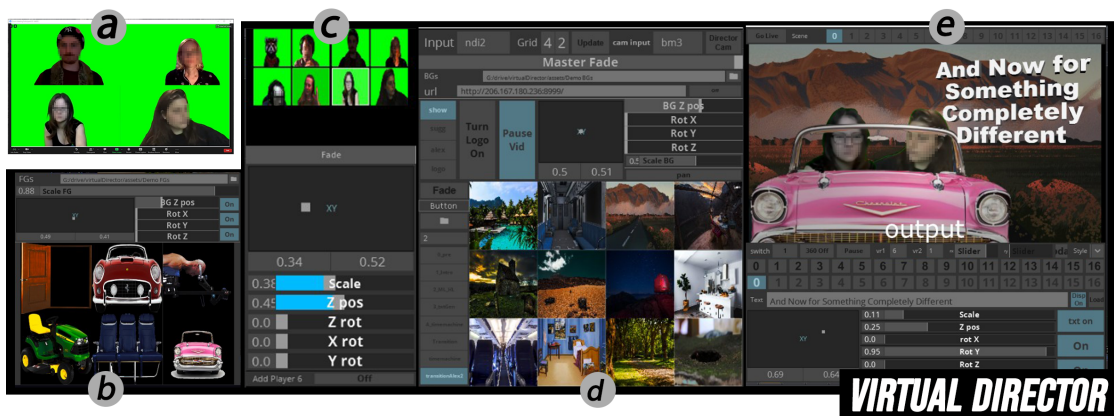
User interface of Virtual Director, developed with TouchDesigner. Image (a) in the top right shows a screen captured Zoom screen with participants displayed on a green background. Image (b) shows graphics which can be selected as foreground elements. Image (c) in the middle left shows the participants that can be selected for display in the Virtual Director. Image (d) in the middle shows the background elements and control interface. Image (e) shows the output screen of the final composited image.

6.1 Introduction

A growing use of video conferencing tools for remote collaboration in the performing arts presents a compelling opportunity to explore how theatre pedagogies and performance can be meaningfully practised remotely — a need amplified by the current Covid-19 pandemic [177]. Popular video conferencing tools being used by performers, however, have been generally designed to meet the needs of remote business and education which do not take into consideration the unique collaboration demands of teaching, developing, and performing theatre when each actor is isolated from the others [178]. While there have been many experiments over the last few decades into the potential of remote collaboration tools for building performance [179], few have directly examined how specific types of remote video collaboration affect an isolated actor's experience of rehearsing and performing with others. Our study is the first step towards filling this gap in existing research on immersive communication for live performance.

'Live-to-Digital' is the U.K. entertainment industry's term for a 'live performance, event or experience captured and distributed digitally, through television, cinema, or online' [206]. Prior to the pandemic, the term 'Live-to-Digital' generally implied that stage productions would be captured and broadcast live for digital spaces. There are for instance, no examples of theatre involving remote actors collectively performing together for digital spaces in any of the biennial reports by the the Arts Council that began analysing the industry in 2016 [206, 207]. To rehearse and perform exclusively through screens is a different experience altogether from adapting stage productions for streaming digital experiences. Improvisational theatre is particularly affected by the technical limitations of remote performance, as performances rely exclusively on an improviser's ability to react in real-time to the behavior of others [208].

Improvisation in theatre is a rehearsal tool, a process for creating new work, and a genre of performance [126]. As a genre, *'it is a form of live theatre where artists perform real-time, dynamic problem solving to collaboratively generate interesting narratives'* [127–129, 209]. Improvising involves engaging a cognitive state called *flow* described by psychologist Mihaly Csikszentmihaly as *'an almost automatic, effortless, yet highly focused state of consciousness'* [210]. Improvising and entering into flow in performance require collaboration that is supported by a deep awareness of the presence of others [132]. Improvisers rely on constant verbal and visual feedback from scene partners and audience members to construct a shared reality. It is through this feedback that improvisers can synchronize around invented relationships that appear so cohesive they *'lose their* fictitiousness *of time and place'* [133]. The visual environment of the improviser therefore plays an integral role in the ability to perform.

Currently the most popular video communication tools enabling theatre during the 2020 pandemic include Zoom and similarly functioning business conferencing tools like Skype, WebEx, Microsoft Teams, and Google Hangouts [191]. These tools allow anyone connected to the internet with a computer or mobile device to transmit video to remote partners in various arrangements from grids to 'speaker view' layouts that highlight individual video feeds [192]. 'Zoom Fatigue' is a popular term referring to how the *'inability to read body language'* when video conferencing, time-lags, and a split focus across screens *'interfere with our normal, instinctual and finely-tuned way of communicating'* [211]. Zoom fatigue is particularly disruptive to improvisers who rely so heavily on body language and a shared sense of presence. With the very recent exception of Microsoft Teams which released 'Together Mode' [212] in July 2020, there have been few opportunities for isolated performers to improvise through an immersive visual environment.

While software exists for specialists to design immersive digital experiences for a particular production, there are no immersive communication tools generally available for the isolated actor to *rehearse and build* performances themselves [193, 194]. Even Microsoft's new 'Together Mode' falls short of enabling immersive theatre collaboration, as it restricts users from relocating position, customizing or changing backgrounds, and locks them into lecture hall or conference table environments. These video conferencing systems designed for business and education nevertheless have been the most accessible instruments for socially-distant performers. It is therefore important and timely to explore the potential of augmenting these tools with more immersive, dynamic, and flexible visual environments that can address the unique demands of improvisation and analyse how these design features affect performance.

We address this need with a field study of professional actors rehearsing and performing improvisational theatre in isolation using a novel system for tele-immersion. We present Virtual Director, a program developed by the researchers for this study that augments video conferencing services such as Zoom or Skype by extracting individual videos and compositing them into a shared virtual space. We validate this system through extensive qualitative analysis with 16 domain experts. We present details of the analysis including a diverse set of quotes from the performers regarding components they embrace and found friction in. We synthesize qualitative feedback into 3 clear and actionable design recommendations to future theatre. We conclude by proposing how the future of tele-immersive theatre might proceed to benefit performers, audiences, the environment, and society as a whole.

FIGURE 6.1: System overview, Virtual Director 2020: *(a) Isolated performer connects via client software, (b) Background segmentation is performed by client software, (c) Performer sees a video of themselves co-located with partners in virtual space, (d) NDI macros supply client video to Virtual Director, (e) Automatic separation of video call participants, (f,g) Virtual Director selects background and foreground assets for compositing, (h) Each asset appears as a 3D object that can be rotated, scaled, faded, and positioned dynamically.*
Graphics demonstrating how video feeds are captured from a video conferencing application and processed by Virtual Director

6.2 Related Work

Our research is related to previous studies on user experience of collaborating inside a shared virtual environment, as well as studies of immersive communication for theatrical performance. While many different forms of remote collaboration have been researched in the past [154, 213–216], user experience of 'tele-immersive' systems that feature the ability for performers to remotely collaborate and perform inside a shared virtual environment from their individual homes has not been studied. Most research related to theatrical performance inside shared virtual environments in particular, have relied on the use of virtual reality headsets or large scale immersive display systems [154, 217]. Subsequently most of these studies have been carried out in studios and laboratory settings dependent on having the performers still physically co-located to some degree. Studies of productions featuring telepresent theatre have been largely focused on audience experiences or dramaturgy [179, 218]. Recently however, performers in unprecedented numbers have been engaging in remote rehearsal and performances outside of studios and laboratories [219]. Our study appears to be the first to examine actor experiences of performing remotely with other actors from their homes.

6.2.1 Tele-Immersion

Our study builds on research that has analysed user experiences of collaboration in virtual environments [154, 220] and studies of presence in virtual worlds[217]. An early experiment in 1991 demonstrated the immersive potential of mixing live captured video with 3 dimensional environments reporting that out of 160 participants using a system placing chromakey extracted video of their bodies into a virtual world, *"71% of those who tried the demos considered the 'being on the screen' to be their real self."* The study went on to report that respondents described feeling both physical and emotional responses when they touched animated graphical objects in these worlds [221]. In 1996 the term 'Tele-Immersion' was born when researchers at the Electronic Visualization Laboratory (EVL) used it as the title for a workshop on 'networking, virtual reality, and collaboration' [222]. Most of the developments in tele-immersion have been related to 'expanding the boundaries of computer vision, tracking, display, and rendering technologies' for computationally expensive displays of complex 3-dimensional geometry [223–225]. The experience of feeling present in a virtual space however is not dependent on accurate 3-dimensional representations of physical space as the early experiments with background segmentation and projection have shown. Instead, chromakey background removal was all that was required to provide a convincing illusion of being in a shared space [221]. Advances in computer-vision have allowed popular video-conferencing platforms to perform real-time adaptive background segmentation without the need for users to have access to complex studio lighting and chromakey environments [124]. This feature makes a 2D form of tele-immersion in a virtually 3D space a possibility for any video conferencing platform. Microsoft Teams, however, is the only service currently providing some tele-immersive functionality publicly and this service was released after our study [212]. Without the accessibility of tele-immersive platforms for the public, there have been few opportunities to explore how a shared virtual environment affects remote collaboration in real-world environments generally, let alone how it might affect actors rehearsing and performing online. The decades of research of tele-immersion systems nevertheless clearly demonstrates that when users have been able to see themselves co-located, they have experienced an enhanced sense of presence over dislocated video interfaces, as well as increased productivity [125, 222, 226].

6.2.2 Performing Telepresently

In the digital and performing arts, there has been some research into performing telepresently, but most of this research has focused on the development of technology, dramaturgy, or the audience experience [179, 227]. There has been some research involving

dance and tele-immersion, investigating how the time delay between dancers interacting tele-immersively impacted synchronicity [228–230]. Most recently, researchers in theatre have carried out a study on the rehearsal process and performance of a theatrical production between two remote groups. This study however focused on the use of life size projections of remote partners and the telepresent collaboration between two physically co-located groups [231]. To the knowledge of the researchers, no study has ever explored the impact of virtually co-locating performers who each performed remotely from home.

6.2.3   Improvisation and Flow

Improvising for the theatre is a cognitive process where *'in present time a path is opened to your intuition, closing the gap between thinking and doing'* [135]. This definition, laid down by one of improvisational theatre's early theorists, Viola Spolin, has been further nuanced by psychologists and cognitive scientists as a distinct mental process identified by the shift of neural activity within the prefrontal cortex [137]. Key to understanding the experience of this cognitive shift is psychologist Mihaly Csikszentmihaly's 'nine dimensions of flow' [210]. In designing our study we considered his nine dimensions of flow to help us evaluate the experience of our participants. The nine dimensions of flow have been used as a tool for evaluating improvisational performance by a number of researchers in the past [139, 166, 167]. The dimensions are summarised as (1) an equal balance between challenge and skill level, (2) a merging of 'action-awareness' or being fully absorbed in the moment, (3) a clear sense of purpose, (4) direct and immediate feedback meaningful to the task, (5) the ability to concentrate on the task, (6) a sense of control, (7) a loss of self-consciousness, (8) a distorted sense of time, (9) being an *autotelic* or intrinsically rewarding activity. [1] These dimensions became meaningful as we analysed the experience of the improvisers engaged in remote performance and were useful touchstones for our qualitative study.

6.3   Experimental Design

6.3.1   Research Questions

The focus of our qualitative study was to capture a broad range of experiences related to performing within a dynamic tele-immersive environment actors could easily access from their homes. For the purposes of this study we defined the core design features enabling a tele-immersive environment as those facilitating: *1) The placement of participants in*

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[1] https://theflowcentre.com/9-dimensions-to-flow/

a shared virtual environment. 2) The ability to dynamically replace objects in the virtual environment in real time. 3) The ability to re position participants and objects inside the 3D environment in real time. We posed several questions related to core improvisational concepts that we theorized would be directly affected by the visual environment of the collaboration tool:

- *Does performing in isolation with others tele-presently help them feel connected to remote partners?*

- *Do tele-immersive environments affect actors' abilities to enter flow states while improvising?*

- *To what extent do virtual environments contribute to the creative experience of improvsing?*

This theoretical framing served as a guide for designing the features of our software, as well as developing activities we thought would be conducive to engaging in the unique collaborative experience of improvisation.

6.3.2 Methodology

In designing our study, we adopted a grounded theory approach focused on collecting qualitative data through close observation of user behavior, interviews, and surveys. Our experimental methodology was informed by the insights of Sarker et al.(2000) who argue that the study of virtual teams should begin *'inductively, based on the collaborative experiences of virtual team members and the meanings they attribute to the virtual experiences'* [232]. The grounded theory approach is ideal when *'organizational forms are so novel'* from other forms they *'cannot be easily translated or directly extended to understand or explain phenomena pertaining to the new forms'* [232]. Performing tele-immersively is different from physically co-located performance on a number of levels, making grounded theory the most appropriate methodology for this study.

Performing online, however, also provides a unique opportunity to examine theories related to improvisational performance that are more difficult to measure in traditional environments. Several studies related to immersive communication in the past have already demonstrated that tele-immersive experiences can provide a significant sense of presence and connection with remote partners [154]. Many improvisational theatre pedagogies in turn argue that live performance is dependent on an immediate sense of co-presence. While our main research focus was to develop theories related to tele-immersive improvisational performance as the data emerged, we remained mindful of the potential connection between these existing theories and the participants' experience.

Our experimental design was therefore aimed primarily at the discovery of theories that could be tested with follow up research. By immersing ourselves in the data generated by this field study and generating theories based on the re-occurring themes and insights, we hoped to 'guard against imposing a theory' related to how a particular feature of tele-immersion might have salience which 'may not actually match the patterns in the data' [155].

6.3.3 Field Studies During a Pandemic

As a field study our research was focused on tele-immersion that could be accessed by individuals at home who may have limited access to various types of hardware and software configurations and inconsistent access to internet services. The study was conducted during national lock-downs across Europe while strict social distancing measures were in place [233]. Due to these variables, the researchers made efforts to adapt the study to meet the emergent needs of the participants by being flexible with study duration and frequency. Subsequently rehearsal periods and frequency of meetings were highly variable. Additionally participants were encouraged to explore the possibilities of tele-immersion by adapting their existing skill set as improvisers to the virtual environment. As a result there was a high degree of variability in the types of exercises and formats explored by individuals and groups. Nevertheless, the results can be generalized as each participant effectively used the system in the same way: in isolation from other partners and observing themselves in the virtual environments. Our findings therefore are generalized to the broad experience of improvising tele-immersively and not directed at the performance of any particular activity.

6.3.4 Data Collection

The Research Ethics & Governance Board at the University of Kent granted approval for the collection of audio-visual and survey data proposed by our study. Consent was solicited from participants for use of their data during the study. Data was recorded of participants during remote rehearsals and performance in the co-located virtual space. Additionally online surveys were conducted after each session and semi-structured interviews were held with participants after the study. Interviews were conducted through Virtual Director and consisted of a series of general open-ended questions regarding their experience of the software and their experience improvising. Rehearsal periods lasted between 90 and 120 minutes. Initial rehearsal periods focused on configuring hardware and software remotely and finding the best environment for interaction. Participants were instructed to wear brightly colored clothing that contrasted with colors

in the background, position lighting to optimally expose the face and body, and arrange the perspective of the camera to facilitate capturing as much of the body as possible. Rehearsals began with a variable series of games and activities commonly used in improvisational theatre training that were adapted for the constraints of the tele-immersive environment.

6.3.5 Translating physical exercises for virtual experiences

Theatrical improvisation is guided by a few basic techniques that must be learned and regularly practiced for partners to spontaneously and convincingly construct stories and relationships. The entire enterprise is based on the ability of performers to immediately agree to an emerging reality between them. The given circumstances of real life that are generally taken for granted (where we are, what time it is, who we are, who are we with) have to be made up on the spot in improvisational theatre. There is a natural tendency however, for actors to reject contradictions to their perceptions of reality, instinctively blocking the 'creative' ideas of others that may interfere with that reality [134]. Therefore improvisers usually 'warm up' before performing by practising the acceptance of offers, and in turn building upon those offers (popularly referred to as 'saying yes and'). Secondly improvisers must engage an altered cognitive state that is distinct from ordinary rational cognition [234]. Improvisers learn to bypass confusion and avoid disagreement by playing games that require automatic agreement and rapid responses to the behavior of others. Lastly, improvisational theatre is ultimately dependent on tight collaboration, so performers must become acutely aware of the nuances in behavior of their partners as well being able to make verbal, physical, and gestural offers that will contribute to the veracity of the relationships and story. The tele-immersive environment limits the kind of games and activities that can be performed together, but it also adds features to the collaboration not typically possible in traditional environments including dynamically changing backgrounds and the possibility of a broader range of physical relationships (through the scaling and re-positioning of the video feeds). We therefore designed games and activities inspired by traditional improvisational training and adapted to the virtual space. Our primary aim with the initial activities was to see to what extent we could help the improvisers feel fully embodied in the virtual space and be responsive to the physical and verbal behavior of their partners.

6.3.6 Facilitation

Improvisational theatre is generally rehearsed with a facilitator or director who takes responsibility for warming up the players, guiding the various games and activities decided

upon, and standing in as a proxy for the audience providing feedback to the performers when they practice scene work. In order to maintain consistency in instruction as well as technical execution of the virtual environment, each session was facilitated by the same improvisation specialist who is also a lead developer of the software. Facilitation required both technical proficiency with the experimental digital interface as well as an understanding of the traditional rehearsal practices of professional improvisers. Having both technical knowledge of the software and improvisational expertise meant the facilitator could quickly adapt the visual environment to match the spontaneous narratives being generated by the performers.

6.3.7 Activities

While our system was capable of interfacing with any video conferencing tool, Zoom[2] was selected for conducting the study based on its accessibility and widespread use amongst our participants. Each study began inside a Zoom conferencing interface with the facilitator helping the participants optimize their hardware for background segmentation and ensuring participants could safely move around the space. Participants were instructed that they could stand or sit based on their available space, hardware limitations, and comfort levels. All participants experimented with standing and sitting, and generally preferred to stand when their physical environment allowed.

Once the participants arranged their performance environment, they were instructed to select the facilitator's video feed and maximize it on their screen. The participants then saw themselves composited into a shared virtual environment and were invited to spend a few moments exploring the space. After a period of 5-10 minutes the participants were invited to engage in a series of games and activities (*Fig.6.2*) they were told would help them acclimate to the virtual space and explore the possibilities for improvisation.

The order of games and activities sometimes changed with different groups and based on how many times they had previously engaged with the tele-immersive space, however they generally followed a progressive order beginning with different kinds of virtual physical engagement, and then proceeding to games of spontaneity and active listening. The games were structured around fostering awareness of their own bodies in virtual space, awareness of their partners bodies, exploring three dimensions of a two-dimensional screen, responding to the backgrounds, and finding flow and rhythm with each other.

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[2]https://zoom.us/
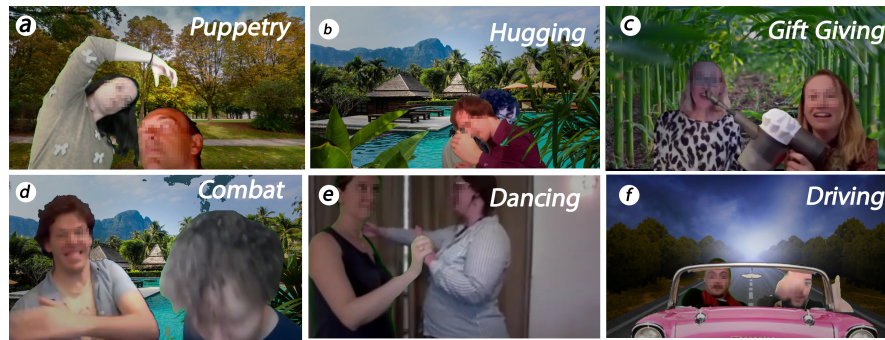
FIGURE 6.2: Examples of tele-immersive improv training: *(a) p3 'controls' p4 movements, (b) p5 and p6 practice hugging, (c) p1 and p2 give each other gifts, (d) p7 and p8 practice combat, p9 and p10 virtually dance, (f) p11 and p12 simulate driving.* Composited screen captures of Zoom and Virtual Director feeds demonstrating user interaction. Background graphic: Freepik.com

6.3.8 Performing

After each period of warming up with the adapted games and activities, the participants were instructed they would be practising a *long-form* [3] format with dynamically shifting backgrounds. For initial rehearsals, participants were invited to perform a popular format called *'montage'* [235] consisting of six or seven short scenes inside different virtual environments connected loosely by a theme. The montage format is a popular training tool in theatrical improvisation that tests the basic skills of any improviser. Participants were instructed they were free to perform a 'montage' or adapt their own format for a public audience at the end of the study. We note however, that performing publicly introduces several variables including whether performance is streamed or presented in a video conferencing environment, audience integration and feedback during performance, and how multiple performances are structured together as part of an event. Therefore the scope of this initial study is limited to the experience of practicing and rehearsing in the tele-immersive environment without an audience.

6.3.9 Coding the Data

Audio from rehearsals, performances, and interviews were transcribed using Google's transcription service and then corrected by hand against the original recordings. These transcriptions were coded along with open text responses input online by participants after each session. Initial codes were assigned based on our guiding research questions regarding 'flow', 'presence', and 'embodiment'. Subsequent codes were added based on frequency of sentiments shared by multiple participants. The following seven categories emerged as salient for the broadest range of participants and useful for guiding future

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[3]Long-form improv is a continuous series of scenes inspired by a word or phrase.

research and practice: *Enjoyment, Creativity and Collaboration, Immersion, Presence and Flow, Embodied Performance, Distractions, and Scenic Inspiration.*

6.3.10 Participants

A total of 16 professional improvisers participated in the study. The study included five volunteering 'duo' teams (p1-p10) and one ensemble group of six players (p11-p16). Volunteers for the study were solicited through advertisements posted on social media sites and European improv forums. Improv teams were required to have been performing publicly together for at least one year and have access to a mobile device or computer that was capable of video conferencing. The five duo teams were selected from 24 applicants based on schedule availability and diversity of experience improvising. The ensemble team is directed by two of the authors and had been solicited previously by the researchers during the initial testing of the software. Due to the small sample size of only one ensemble group, this study is not focused on the differences between group sizes. Instead we focused on the generalisable experience across all participants.

Participants were located across cities in Europe and the U.S. including Belfast, Antwerp, New York, Montreal, London, Brighton, and Canterbury. 9 of the participants identified as female, and 7 as male. All participants identified as white. The average age of participants was 30 with the youngest 25 and the oldest 37. Participants had been performing improvisational theatre professionally for the public on average for 6 years, with their experience ranging from minimum of 2 years and maximum of 10 years of public performance.

6.4 Results

"I hope your experimental design is just they spend the whole time laughing at how much fun it is (p3)."

6.4.1 Enjoyment

Performing just through video conferencing tools appears to have presented cognitive barriers to enjoyment that were resolvable through tele-immersion. Throughout the study, participants reported on their general enjoyment of performing inside the shared virtual space. In between warm up activities as well as between improvisational performances, in survey responses, and during interviews, all 16 participants described

interacting in the tele-immersive space positively. Enjoyment was inferred with descriptions of the experience as being *'fun (16)'*, *'enjoyed (13)'*, *'exciting (11)'* , and *'amazing (10)'* – where the number in brackets shows the number of participants that made relevant references. The addition of a shared virtual environment to the existing conferencing platform they had been using for performance earlier translated for five participants as a *"new medium"* entirely. Additionally, a sense of joy was described by seven participants in the context of earlier attempts at performing with the same tools but without a tele-immersive environment. One noted, *"it's been a lot of fun to play virtually in a way that I was really struggling with before,"* explaining that with Zoom, *"it is difficult to fabricate a world that you're all supposed to be in when you're limited by the background of individual homes (p4)."* This idea was echoed by other participants, describing *"there's a freedom of play that exists in being visually in the same location that unfortunately is hard to create when you don't have access to (shared) backgrounds (p3)."* Being co-located in the same virtual space appears to not only have contributed to a joyful interaction between participants, but also contributed to the emergence of flow states and creative inspiration as described in the following sections.

6.4.2 Creativity and Collaboration

The experience of creativity in improvisation often has less to do with having interesting ideas than it does with being able to discover interesting contexts for what your partners are doing and saying. The feelings of being creative described by five participants were associated with the enhanced feeling of connection with their scene partners: *"It was really joyful and fun, in a way that online improv hasn't been for me yet- I felt really together with my partner even though we were only together on the screen (p11)."* Connecting creativity with collaboration makes sense as the creative outputs of improvisation are uniquely collaborative in nature as opposed to scripted and solo-performance. The feeling of having a restored connection with remote partners was cited by twelve of the sixteen participants throughout the study and appeared to translate back into their improvisational work. Four participants identified how the environment specifically facilitated narrative cohesion: *"The ability to be in the same virtual space as my partner allowed us to fully agree where we were (p12)"* and *" I find the scenic view, seeing the whole picture, helpful in making choices within the scene and also in using my body and physicality to enhance the feeling of connection and presence (p13)."* Rather than seeing performing online as a concession, some began to see it a distinct medium with fresh possibilities: *"We're getting to do stuff that actually wouldn't be possible in this same way in a normal improv show (p3),"* and *"the technology brings something different to an improvised scene, which you couldn't normally do in real life (p6)."* The ability to be

different sizes on screen and in dynamically changing physical relationships was particularly salient for many in thinking about tele-immesive improv as a new medium. Three participants described feeling like they were in a cartoon or fantasy movie: *" you can be a sponge that lives under the sea, you can be a mouse who lives in a castle (p5)."* Others described how the feeling of creativity experienced during the sessions carried over the following day: *"I'm still processing...I woke up this morning feeling creatively invigorated with loads of ideas... seeing my scene partner next to me and with virtual physical contact had an impact on me psychologically (p14)."* The deep feeling of immersion and co-presence experienced by participants confirms earlier studies of immersive communication [236] but has particular relevance for live performance that benefits from actors entering into flow states with each other.

6.4.3 Immersion, Presence, and Flow

Of note is how participants connected the immersive space with an enhanced ability to improvise and perform. The connections between feeling immersed and performing better improv correlates with many of the nine dimensions of flow described by Mihaly Csikszentmihalyi [168]. The experience of immersion was particularly acute for some: *"everything expanded into my space because I felt like there was some kind of relationship between me moving into the screen and the screen moving out to me- and there was some kind of middle ground that was found between those two things (p6)."* The immediacy of this described 'middle ground' bringing awareness into the current moment speaks to the merging of action-awareness essential for flow. *"The ability to be in the same virtual same as my partner allowed us to fully agree where we were- then we quickly got into the flow (p12)."* The joy and sense of presence described earlier also speaks to the autotelic experience performers felt improvising as well as the merging of action-awareness. Three participants made direct observations related to warping or losing sense of time and space. *"There were a lot of times I forgot other things were going on around me, what the time is or you know, where we are- how long we tended to be in this for (p5)."* Some of the features of the experience that performers credited for enhanced flow included the ability to focus on a single environment for all the action, noting that *"the backgrounds helped me be less distracted, focusing on the "physical" location of the scene. I worried less about my partner's background and my set up, and I truly felt closer and more connected with my partner (p15)."*

FIGURE 6.3: Players interact with virtual environment and each other. ***Dialogue excerpt (a):*** *p1: You can see for miles around. p2: Yes, you can see that there are no more humans, that's a bit sad. p1: You want that? You want some more Moss? p2: It's my favorite.*

6.4.4 Embodied Performance (getting physical)

"We haven't improvised or seen each other in the real world for 3 months now (p3)."

The image of oneself in Virtual Director is not quite a mirror, as there inevitably is a slight delay in the movement, but perhaps more significantly the body is often placed larger or smaller than would be natural, or inverted, turned upside down, and freely moved about the screen *(Fig.6.3c)*. Rather than feeling abstracted from their image nine participants referred to feeling a greater sense of their body. Video analysis of performances showed that all sixteen performers consistently reflected what they were seeing on screen back into their physical experience. Many described how the virtual reality directed their physical reality. *"We were passing objects, changing our view so that it looks like we're looking at each other, touching each other's heads (p8)."* In these moments, audio/visual recordings show the participants were actively reaching and grabbing objects, contorting their bodies and heads to animate their virtual selves *(Fig.6.3b)*. The ability to virtually interact with each other appears to have created a feedback loop where the visual reality caused a change in the physical reality, which led to a new virtual relationship that fed back into the loop. The simulation of touch provoked a visceral response in many; for example, *"the ability to simulate physical contact appeals very much to me. It allows us to be in contact with the other player and allows for more intense scenes (p16)."* The initial experience of seeing themselves co-located immediately inspired physical explorations; one participant described, *"I think I found myself to be a lot more physical in the virtual director. When it's in real life, we*

don't tend to be too physical (p6)" In designing the study, we anticipated there would be some physical engagement between performers, however it was surprising to hear the experience led some to feel like they were more physically active than they typically felt during co-located performances. Besides a sense of relief from social-distancing, the increased sense of physical engagement might be related to how performing virtually gave them a safe space to practice intimacy that would be uncomfortable on a physical stage, *" We wouldn't usually kiss like this in real life, we just, we've never done that. So we've done it now in virtual space and that's fine (p5)."* The visceral experiences of the performers when virtually touching one another seems to support the idea that when visual reality is cohesive, cognition will engage to supply a supporting sensual experience to make sense from it.

6.4.5 Distractions

Though most identified a strong sense of immersion and presence during the study, those feelings could get interrupted. Three participants described moments of being overwhelmed and confused by the environment. *"Sorry, it's just it's not really sticking in my head I think because there's so much going on actually with like all the different scenes and all of this (p1)."* Improvisers often describe falling out of improvisational rhythms as being 'in their head' as opposed to just responding to the moment, and two reported struggled initially with that feeling. For many sessions, reduced bandwidth meant there was a small time delay or 'lag' in the video (60-190 msec). Such lags were described during the initial sessions as *"frustrating"* or *"difficult"* by seven participants, however after more experience with the system five participants similarly observed *"you get a little used to the time lag -like it's weird at first but then it gets to be less weird (p3)."* One participant who struggled initially with his focus in the environment found the more abstracted his video was, the easier it was to connect, *"I am still experiencing some disconnect, and notice I focus on myself a lot still, but stylised filters are helping with that and I am reminding myself to shift focus to my scene partner more often (p11)."* Four participants echoed a feeling of frustration *" when I need to like turn and I can't see the screen any longer (p6)."* Of note, is that this study was carried out with participants utilizing personal media devices with displays ranging from 13 inch laptops to 27 inch screens. The observation that participants felt any immersion even with small displays is nevertheless noteworthy, and demonstrates there are opportunities for further research into how particular training practices can be adapted to the available hardware of the remote performers to minimize distractions.

6.4.6 Scenic Inspiration From Virtual Environments

The experience of improvising based on visual cues was novel as improvisational theatre is typically performed on a bare stage. In lieu of scenery, improvisers spend the first moments of a scene describing the visual environment either directly or through inference in a practice called 'scene painting.' For the study we designed dozens of various scenic environments ranging from beach resorts to cramped living rooms filled with furniture and knitted blankets. Performing inside virtual environments meant the performers no longer needed to 'paint' the scene verbally. Eleven participants described how tele-immersion not only helped restore the feelings of connection and embodiment otherwise lost in virtual performance, but that it offered something new. *"We're getting to do stuff that actually wouldn't be possible in this same way in an normal improv show (p3)."* A standard trope in improvisational theatre is to solicit suggestions from the audience to inspire the scene. This serves multiple purposes, including to demonstrate that scenes are genuinely being created on the spot, as well as helping improvisers enter the flow dimension of 'merging action and awareness' as they incorporate suggestions into the scenes in real time. The dynamic environments appeared to not only remove the cognitive load of 'scene painting' but also kept participants more directly in the moment as their awareness was being actively stimulated by the environment. The environments were furthermore a significant source of creativity as participants described not feeling as bound to their physical form. Participants took inspiration not only from the designed visual environments, but also from the visual constraints of the system, such as when poor lighting resulted in an inaccurate background segmentation. *"I'm edged with green. I look vaguely like an alien copy of myself, I'm also, like you have normal hands, I have like green mitts. It's it's okay I can use it (p4)."* This acceptance of intentional and unintentional visual cues is an extension of the improviser's primary practise of accepting and amplifying what are traditionally given in live improvisation as verbal offers (saying "yes and"). In figure *6.3* are some examples of participants interacting with the virtual environments. The scenes demonstrate the wide range of responses to environments and how performers used the environments to infer relationships and dramatic tension.

6.5 Discussion

Our observations are grounded by a theoretical framework that connects the cognitive effort of improvising with the affective experience of co-presence and social connection through tele-immersion. Our participants reported that seeing themselves virtually next to their remote partners inside a shared digital environment was effective in helping them rehearse and perform remotely. Some participants described how seeing themselves

together led to a strong emotional sense of togetherness that made virtual improvisation more enjoyable. Others described how the visually cohesive performance space was less distracting than traditional video conferencing interfaces, and therefore allowed them to focus more on performing. Many participants described getting creative stimulation from the dynamic backgrounds. Participants associated these effects of tele-immersion with the ability to enter into flow states while improvising remotely. In designing our study we initially focused on how the visual environment would affect improvisational activity, theorizing about the potential of 2D compositing of live video feeds inside 3D environments that could be delivered inside existing video conferencing tools on home computers. Our form of tele-immersion appears to have been effective in providing a more immersive and physically engaged experience for users than they otherwise had experienced before; however, after reviewing data collected from the study, we were struck by how improvisational activities in turn might be affecting user experience of the technology and influencing the feelings of connection and immersion. This led us to consider which essential features of Virtual Director could be generalised for others interested in developing their own rehearsal and performance platforms. What follows is a discussion of three design recommendations based on our observations for further developing remote conferencing tools tailored to the unique needs of performing artists.

Recommendation 1: Design platforms that prioritise real time feedback between participants. Virtually co-locating remote performers appears to help them feel more connected to each other while rehearsing, *particularly when they can immediately see how their actions affect their partner.* Our participants described how seeing themselves in the same space led them to feel immersed and connected; however, seeing themselves next to their partners was almost always followed with an unprompted simulation of physical interaction, and expressions of delight in seeing their partners react as if being poked, shoved, hugged, or kissed. As partners engaged in physical interactions they reported losing sense of the 'real' world and in effect identified more strongly with the virtual one. Simulating touch visually is a result of user-driven action that happens both in the real and virtual world. The feeling of being connected with a remote partner appears to be associated with the act of virtual touching among participants, which in turn appears to have stimulated an enhanced feeling of immersion and connection when that touch takes place. Rather than focusing on the quality of graphics or physical accuracy of the environment, live performers appear to benefit the most from the real time physical interactions they can have not only with each other, but also the environment. Of note is that while many participants identified strongly with the virtual reality, virtually none of the participants identified the quality of the graphics as a factor in either feeling more or less immersed. This observation presents an opportunity for further study into how various kinds of simulated touch (or lack of touch) might impact

how they perceive the quality of the visual environment, as well as how they perceive the quality of the collaboration.

Recommendation 2: Design interfaces for performers that eliminate the need to split focus between areas of the screen to help foster flow. Improvisers and other live arts performers rely on their ability to be aware of both direct and indirect messages being communicated by others through verbal and nonverbal cues. Developing cohesive and relatable scenes spontaneously requires that improvisers be exceptionally attentive to the physical behavior of their remote partners in order to enter into flow with them. Describing their experience performing with popular video conferencing tools, participants in our study reported a tendency to shift focus regularly between their scene partners and their own videos which meant they often would lose a sense of flow. Removing visual barriers between performers by placing them in visually co-located environments allows them to simultaneously observe themselves, and how they are affecting their partner as one action. In improvisational training, improvisers are taught to heighten focus on scene partners and rely on intuitive, automatic, and subconscious impulses for their expressive acts. In improvisation there is therefore a need for visual feedback, and so cognitive effort is concentrated on the visual environment that can give the most data about the exchange of information, and visual information outside of that domain is more likely to be discarded. This idea is supported by our observations of participants who specifically described losing sense of the world outside of the screen, and feeling disoriented when looking away, or when their video feed became corrupted from reduced bandwidth. Designing platforms that can minimize visual distractions for performers is therefore crucial in order to allow them to develop cohesive scenes.

Recommendation 3: Design interfaces that can dynamically respond to the actions of participants. The experience of joy, feelings of playfulness, and declarations of fun participants expressed were another phenomenon that appeared to be co-dependent on the ability to see themselves in a cohesive shared virtual space as well as the the nature of the improvisational activities. Theatrical improvisation is an inherently autotelic experience for practitioners who experience joy from the act of collaborative story telling. That joy, however, is dependent on having sensory feedback that is stimulating the collaboration. The tele-immersive platform provided rich sensory data not only from the behavior of the remote partners, but also from the dynamically changing environment, *"if anything the ease of changing the scenery makes for easier immersion in the fictional world we created (p12)."* During the study, participants were aware that the facilitator was closely listening to them because they often found the environment dynamically changing in response to the unfolding scene. For instance, during a driving scene an improviser would indicate they wanted to pick up a hitch-hiker, and they suddenly found the on-screen image of the car had pulled over, or they could express

wanting to leave, and they would find themselves being moved off screen only to appear again in another location. The joyful experience of improvising generally emerges when an improviser's expressive act resonates not only with their partner, but also with the audience who is contributing to the emergent stories with their suggestions and laughter. However, feelings of humiliation, awkwardness, and shame are also not infrequently experienced by improvisers when stories do not appear to resonate with partners or audiences appear bored. As several participants expressed in the study, using popular video conferencing tools without Virtual Director had made improvising considerably less enjoyable, likely a result in no small part from the relative sensory deprivation of video conferencing platforms compartmentalized user interfaces. The phenomenon of 'Zoom fatigue,' as described in the introduction, resulting from the inability to read body language, latency, and distracted focus all make it nearly impossible for an improviser to know if what they are doing is resonating with others. In turn the participants in this project took advantage of the visually rich and dynamically changing environments *"You put us somewhere, and that's an enormous suggestion, an audience suggestion really, evident from the director (p3)."* When the visual 'suggestions' from the virtual environment responded to the choices the improvisers made, they were rewarded with a sensation of resonance with the 'virtual director' that became associated with feelings of 'fun' and 'joy'.

Our examination of how improvisational activities affected the experience of immersion leads us to believe that improvisational activities, in turn, might be designed into other remote collaboration experiences beyond the performing arts. We find the visceral reactions our participants described from virtual touch particularly salient while social-distancing mandates are still in place and physical touch is restricted. We believe our findings will be useful for researchers, designers, as well as communication specialists for further exploring how to effectively develop tools to facilitate not only other creative collaborations, but to enhance feelings of social connection in business and educational settings as well. As outlined in the introduction, the immediacy of our need for finding ways to rehearse and perform theatre through remote communication tools is amplified in the wake of the current pandemic, but our results show that tele-immersive theatre presents an opportunity to explore new dimensions of creative expression that can only be experienced through virtual environments.

6.6   Limitations and Future Work

As this study was conducted during a national lockdown our focus was to examine how tele-immersive features might be accessible to performers in a broad range of conditions.

We therefore focused our findings on the most generalisable observations of our participants regarding the experience of rehearsing in a visually co-located virtual space. Many variables we could not control for in this initial study likely contributed to the overall experience that we plan to examine in follow up studies. In particular the role of the facilitator operating the software likely influenced how participants engaged with the virtual environments. The various hardware specifications and performance spaces also likely influenced participant experience. In future studies we plan to control specifically for various performance conditions including standing versus seated performance, display size, lighting conditions, and audio interfaces as well as studying how other facilitators would use Virtual Director, and how various features of Virtual Director could be automated. In this study we did not observe any significant correlations between improvisational experience or group size and our results. We believe with larger study sizes however, we may find interesting correlations between these factors that would be useful for guiding development and practice with tele-immersive environments for performance.

During this initial study we had the opportunity to collect some preliminary data on using Virtual Director for live public performance. These observations have highlighted that performing publicly in a tele-immersive environment can introduce several new variables including how the audience becomes integrated into the experience, frequent switching between tele-immersive environments and traditional conferencing environments, and various ways of distributing performance for streaming versus inside a closed video conferencing environment. We aim to investigate the specific aspects of public performance through tele-imersive environments as one of our future research directions.

6.7   Conclusion

We observed in our study that the tele-immersion provided by Virtual Director was a highly effective solution for rehearsing improvisational performance while performers could not meet physically. The features of tele-immersive environments appear to support the findings of Heeter el al (1992) who also observed that users generally identified more strongly with their virtual selves than their real selves [221]. Our form of tele-immersion also appears to address many of the shortcomings of traditional video conferencing tools that make it difficult to keep track of other performers' nonverbal reactions, requires focus to be split between different windows, and disembodies the user. Furthermore, our results showed that the platform facilitated entering into flow states and had considerable impact on feelings of excitement, joy, fun and playfulness. Of note is the immersive effectiveness of placing two-dimensional live video feeds of performers

inside 3-dimensional scenic layers rather than capturing and displaying 3-dimensional images of performers, eliminating the need for special hardware or resource intensive computing. These observations support the notion put forward by the 'father of telepresence' Marvin Minsky that telecommunication research should be focused primarily on the experience of the user rather than just the mechanical reproduction of physical experience [237]. By focusing on experience we are motivated to consider the psychological factors that generate social behavior in the context of the available technology for remote communication. There is opportunity for further research into how improvisational tools can be incorporated into designing immersive communication experiences and improvisational games and activities can be applied to virtual collaborations as a means of priming participants to have more immersive, socially present, creative, and emotionally positive experiences remotely.

Chapter 7

Experiment II: Mirror Placement Matters in Remote Collaboration

The results of the following experiment were published in the ACM SIGGCHI conference proceedings in 2023. Excerpts from that publication are presented below as well as additional information related to the larger thesis that did not make it into the publication. Note, as the primary author, the text is included as a significant contribution in support of the thesis. The original publication is available to read in the appendix.

7.1 Abstract

Video Feedback (VF) in tele-conferences is reported to contribute to 'Zoom Fatigue' (ZF). However, such feedback is important for many remote collaborative tasks where users must be aware of their relationship to the camera. Tele-immersion (TI) is presented as an alternative to traditional interfaces that can mitigate symptoms of ZF while maintaining the benefit of VF. The effects of TI on behaviour are understudied. Therefore, we present the findings of a novel field study of 14 domain experts performing a remote collaborative task—improvisational theatre—under all three conditions: 1) with video feedback (VF) in an isolated window, 2) within a tele-immersive environment, and 3) without video feedback at all. A qualitative study was conducted using surveys measuring improv performance metrics. 'Physical engagement' and 'presence' were perceived highest with tele-immersion, while 'attunement' and 'flow' between performers were comparable between tele-immersion and no mirror. Isolated VF was perceived worse for most conditions.

FIGURE 7.1: Comparison of 3 different user interfaces for tele-conferencing. Left: Single View without a video feedback mirror, Middle: a tele-immersed video feedback view, Right: isolated video feedback mirror, 2022.

7.2 Introduction

There are non-trivial drawbacks to virtual meetings that continue to undermine user health, well-being, and enjoyment, many of which have been linked to the presence of video feedback (VF) mirrors. Recent studies on the phenomenon of 'Zoom Fatigue' [110] credit VF for increased negative self evaluation from staring at video of oneself [37, 67] and anxiety about appearance [22, 37, 61, 238, 239]. Others, however have demonstrated that removing VF from conferencing actually increased social anxiety [44]. Furthermore, VF plays an important role in many remote collaborative activities, including improvisational theatre where users must be aware of how they appear to each other on screen to inform a performance. For this purpose, we differentiate the traditional VF mirror of tele-conferencing—that allows one to see how they appear *to others*—from the *tele-immersive mirror* (TI), as defined by Galloway and Rabinowitz [240]—that allows one to see how they appear *with others*. We build on previous studies of Tele-Immersion which suggest TI might mitigate other factors related to Zoom Fatigue such as reduced mobility [37] and sense of social presence [241], where participants using TI mirrors reported feeling more physically active and 'there' in a shared virtual space than in the 'here' of their physical environment [242].

This study contributes insights related to how 1) viewing oneself isolated from remote collaborators (typical mirror VF) compares with 2) viewing the self fully immersed in a virtual environment with a TI mirror or 3) not viewing the self at all. We evaluate these three conditions while participants engage in a collaborative task of improvisational theatre (an inherently *ludic* social activity [243]) in a custom-built virtual environment. We study the ludic response to video-conferencing layouts as it is an effective way to evaluate usability and engagement [244–247]. It is the first study of its kind to comparatively measure mirror-based tele-immersion against traditional video conferencing

layouts for their impact on the sense of *flow* [1], social *attunement* [2], physical engagement, sense of physical presence, and semantic choice between remote performers.

Specifically, we investigate whether tele-immersive 'mirror' configurations enhance: a) the sense of presence with the shared virtual environment, b) the experience of *flow*, c) the *attunement* between participants, d) the sense of playfulness and e) the improvisational choices of participants. Findings of this field study with fourteen improvisers indicate that the tele-immersive environment contributed to increased physical activity while performing, to a sense of physical connection with their partner, and to a sense of being transported into the same virtual space as their remote partner. Small differences were found in self-reports of flow or attunement between the three platforms; however, trends are identified for further research with larger sample sizes.

Semantic analysis of improvisational dialogue found a significant increase in the frequency of utterances referring to the 'present' moment between improvisers for tele-immersive environments over the other two conditions, as well as references to the given virtual environment of the scene. A qualitative analysis assisted with automated tools for text categorization found that interfaces affected the content and style of performance. When no mirrors were present, improvisers tended to speak in slightly longer sentences and included slightly more monologues on subjects related to imagined pasts or expected future events. When a small video mirror was present at the side, the scenes generally involved slightly more conflict with each other. Results are discussed to explain how tele-immersive environments encourage users to incorporate more feedback from the environment and remote partners during creative activities. Applicability of findings to the design of new tele-conferencing platforms that incorporate tele-immersive features are further discussed, as well as how they might mitigate some Zoom Fatigue symptoms, but can exacerbate others.

7.3 Methodology

Measuring success of improvisation performance is highly subjective. The experimental methodology for previous studies [242] was informed by the insights of Sarker et al. who argue that the study of virtual teams should begin *'inductively, based on the collaborative experiences of virtual team members and the meanings they attribute to*

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[1] "a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it" [248]

[2] "attunement is a process that includes two parts: (1) the ability to connect with another person's experience/sensations(i.e., cognitive and affective empathy); and (2) the communication of that connection to the other person" [131]

FIGURE 7.2: Participants simulating touch while 'tele-immersed'.
Two sets of drivers appear to be leaning on each other and giving a high-five while driving.'

the virtual experiences' [153]. The results of that research provided the basis for designing survey instruments to empirically support nuanced theories related to how tele-immersion provides greater opportunities for flow, physical engagement, and optimal performance of improvisations between remote partners. We subsequently conducted a cross-disciplinary literature review of linguistics, social psychology, creativity, and improvisational theatre. We used this review to inform a mixed method approach to this follow up study from our previous investigation of improv theatre and tele-immersion [242], in order to account for a complete picture of actual behaviour during the improvisational theatre activity [249, 250, 250, 251], analysing how tele-immersion impacts the collaboration itself.

7.3.1 Study Design

The collection of audio-visual and survey data in our study was approved by a Research Ethics and Governance Board at the University of Kent. Consent was solicited from participants for use of their data during the study. Data was recorded of participants during remote rehearsals and performance in the co-located virtual space. Fourteen volunteers with varying levels of improvisational experience (1 non-binary, 5 female, 8 male, age between 18-55) were solicited to take part in a 60 minute study of 'digital tools for improv'. Study participants engaged in three 5-minute improvisational collaborative storytelling sessions with remote partners in the context of a 'road trip' using traditional video conferencing interfaces as well as 'mirror tele-immersed' interfaces. The loose goal of the improvised scenes was for the participants to engage in a dialogue building towards a creative, collaborative, and cohesive narrative. Participants were introduced to the 'road trip' improv format before beginning the study and given 10 minutes to become familiar with the interface and environment, become acquainted with their partner, and ask any questions. Following the induction, the participants were given a randomly selected thematic prompt to inspire a 5 minute 'road trip scene'. After each 5-minute scene, participants were instructed to immediately fill out a survey of questions related

FIGURE 7.3: Layout1: Isolated (Participants' webcam feeds appear adjacent to window of remote partner.

to flow, attunement, presence, the quality of the improvisational experience, and an open ended question where they could describe their general experience. After completing all three 'drives' participants were invited to share their impressions of each interface and overall experience. During the open ended interviews, 5 minute 'sandboxing' time as well as the 5 minute 'road trip' sessions audio and video was recorded for post-study qualitative analysis.

In order to maintain consistency across experiences and minimise interaction and influence by the facilitator, subjects were prompted by a text caption informing them about the upcoming activity. When the subjects started the first study, the prompt said: 'We will start the road trip soon. Please take a minute to get to know your partner :)' After 5 minutes of open exploration with the interface, the prompt told them to 'Get ready for your 5 minute road trip!' They were then given a prompt they could use or discard to motivate the scene (i.e. 'Chewing Gum'). At the end of 5 minutes, another prompt appeared: 'End Scene. Fantastic!', followed by 'Please fill out the survey and return after you have finished'. Participants were assigned a random partner at the start of the study and performed all three scenes with that partner.

Completing a Latin square of combinations would require a cohort of 12 participants (to have 6 pairs). However, as our recruitment campaign managed to attract more participants, we decided to relax that requirement in order to avoid reducing our overall number of participants. This in practice meant that one of the combinations was over represented in our dataset. We did not observe that the specific over-representation of one combination introduced any observable bias in our results.

The three conditions were organised as: *A: Isolated* (with participants webcam feeds appearing adjacent to each other, each with the same background), *B: Tele-immersed* (with the background of both participants' video replaced with a virtual 'driving' environment where they appear seated next to each other as if driving a car) and *C: Single view* (where participants only see their remote partner with the option to toggle a small video mirror on or off). The three layouts were presented in the following orders: *(P)1-4:*

FIGURE 7.4: Layout2: Tele-Immersed (Participants appear tele-immersed with one another).

FIGURE 7.5: Layout3: Solo (Participants only see partner, without video feedback.

ABC, (P)3-4: ACB, (P)5-6: BCA.(P)7-8: BAC.(P)9-10: CAB, (P)11-12, (P) 13-14 CBA.

7.3.2   Tele-Immersive Environment

The three tele-immersive environments were built inside of Touchdesigner[3], and the VDO.Ninja[4] WebRTC service was used to connect and to route participant audio and video from their webcams and microphones into the Touchdesigner platform. The webRTC video feed of two participants was fed to background segmentation then superimposed onto a driving video backplate. A simple user interface was built for the facilitator to switch between scenes and direct participants through video text that would appear on their screens. A function was built to record video of each session as well as separate

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[3]https://derivative.ca/
[4]https://vdo.ninja/

FIGURE 7.6: Operator UI.

FIGURE 7.7: Touchdesigner network.

FIGURE 7.8: Overview of Touchdesigner interface.

audio from each participant captured directly from their microphone; both audio and video data were stored and catalogued on a private server.

7.3.3 Surveys

After all three drives had taken place, participants for the given session were invited to fill out a survey and share their general thoughts and impressions about their experience. The survey questions were adapted from the *Core Flow Scale* designed by Martin and Jackson based on Csikszentmihalyi's nine dimensions of flow [131, 176], *The Patient's Experience of Attunement Scale* [164], and improvisational theatre related performance language, and areas of future study recommended by the outcomes of previous studies on tele-immersive theatre [242].

Flow refers to 'an almost automatic, effortless, yet highly focused state of consciousness' [131] that would correlate with 'feeling immersed and performing better improv'. *Attunement* refers to what degree people feel seen and heard by each other in a given social exchange [252].

Questions were presented with a 5 point Likert scale with the following categories: strongly agree, somewhat agree, neutral, somewhat disagree, and strongly disagree. The questions have been formed around the unique experience of performing improvisational theatre online, of which there is no existing validated instrument. Instead an original instrument was formed out of the related instruments for flow, attunement, observations related to physical presence from our previous study, as well as literature related to improvisational studies.

7.3.4 Dialogue Analysis and Lingustic Measures of Improvisational Technique

Audio from each session (drives and interviews) was transcribed using the Google speech transcription service, reviewed independently by three different members of the research team and subsequently coded qualitatively for emerging patterns. We identified 9 aspects of performances[5] related to the quality and style of performance that differed across the three platforms. First we noticed a difference in the amount of dialogue in different sessions, particularly as tele-immersive scenes appeared to have more silences and physical interactions than others. Furthermore sessions without a mirror featured more monologues (uninterrupted speech) from individuals than other sessions. We also noticed that some scenes referred more frequently to the given virtual environment, while others did not. In reviewing the footage we also noticed that we could identify when improvisers 'accepted' or 'agreed' to the offers of their partners and added to them (ie *P(1) 'You kept the mix tape!'/ P(2) 'Yes, I play it every day')* , and when they 'rejected' offers in the from of suggesting 'new topics' (ie *P(3)'Pepsi is better than Coke'/ P(4) 'This is a nice view'.* The 'tense' of the conversations also appeared to change across conditions with many scenes almost exclusively referring to fictional 'past' or 'anticipated' events, while other scenes appeared to involve more 'real-time' problem solving in the moment, i.e. trying to get 'gum from the glove compartment' (p2). Ultimately, we analysed the semantic choices from the transcripts quantitatively to measure the frequency of each of these 9 features:

1) **Word Count**: Subjective review of transcripts suggested there was more silent 'physical interaction' in tele-immersive environments, further suggesting these scenes might have a lower word count than others. However, when word count was calculated, no statistically significant differences in word count were noticed between environments.

2) **Pronoun Usage**: Casual observation of transcripts indicated participants might use more intrinsically motivated language in some scenes, and more extrinsically motivated language in others. To capture the nature of referential language, we tabulated the usage of pronouns into: "I, me, mine, I've, I'd", "You, your, you're, yours", and "we, us, our(s)".

3) **Acceptance of offers**: A standard improvisational trope is that an improviser should 'accept the offers' of their partner. To determine the frequency of offer acceptance, transcripts were annotated for how frequently subsequent lines of dialogue incorporated previous statements from a partner.

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[5]These 9 categories refer to various factors known to affect performance and often discussed in improvisational training scenarios.

4) **Adding to offer**: In addition to accepting the offers of scene partners, improvisers are encouraged to 'add' ("yes, and") to the suggestion. We counted the addition of information related to previous offers in each line of dialogue.

5) **Conflict**: Generally improvisers are encouraged to establish a common ground and encourage playful co-creation of narratives. Dialogue was annotated for lines which appeared to introduce a 'conflict' related to the previous statement.

We also annotated 6) **references to the visual environment** and to 7) **past**, 8) **present**, and 9) **future events**.

Some features relied on word count and word frequency, which could be counted with Python scripts and Microsoft Excel. Others required manual semantic annotation. To facilitate the annotation, we employed the generative pre-trained transformer (GPT-3) language model [253]. GPT-3 has been shown to have a few-shot learning capability for simple natural language processing tasks such as translation, part-of-speech tagging, etc. and thus we used it to qualify whether each individual line of dialogue was referring to "past", "present", "future" events, or whether a pair of consecutive lines of dialogue corresponded to an agreement or disagreement. Note that these preliminary annotations suffer from the lack of reliability of automated NLP methods, hence their results were reviewed and corrected by hand[6].

7.4 Results

The data results are divided into three categories: *Survey Results* (Section 7.4.1), *Quantitative Analysis of Improvisational Dialogue* (Section 7.4.2) and *Qualitative Analysis of Interviews* (Section 7.4.3). Where appropriate, survey data is compiled and presented alongside observations from the participants about their experience, as well as observations by the researchers of audio and video data from the performances. We performed a Kruskal-Wallis one-way analysis of variance to determine if there was statistical significance[7] for any of the survey results or any of the 9 features identified in improvisational dialogue (see Section 7.3.4).

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[6]The inclusion of language model-based annotation for this study is presented for later discussion on how language models might be used to allow the study of larger improvisational theatre sample sizes.

[7]The Kruskal-Wallis test 'is a non-parametric method for testing whether samples originate from the same distribution'. It is used to indicate if 'at least one sample stochastically dominates one other sample' [254]. It assumes a null hypothesis that the medians of all groups are equal, and indicates when that hypothesis can be rejected as a result of a significant variance in one of the samples from the others. The results do not indicate which group is significantly different, only that there is one or more samples with a significantly different mean ranking between groups.
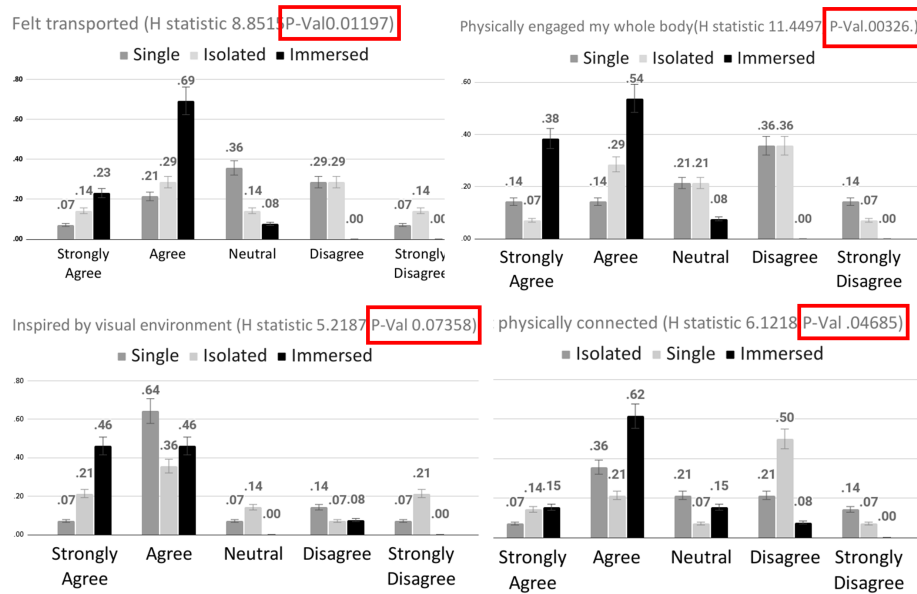
FIGURE 7.9: Survey responses with significant (p¡.05) and near significant (p¡.08) results. Participants reported physical engagement, sense of physical connection with partner, and feeling transported into the scene as highest with tele-immersion. Taking inspiration from the visual environment was nearly signficantly associated with tele-immersion, 2022.

7.4.1 Survey Results

A rank based non parametric Kruskal-Wallis H test indicated statistically significant differences between tele-immersion and video-feedback in participant self-reporting ($p < 0.05$): *"I found myself physically engaging with my whole body"*, *"I felt physically connected with my partner"*, and *"I felt transported in the driving scenes"*. A near statistical significance ($p < 0.08$) was reported for *"I was creatively inspired by the visual environment of the drive"*.

The remaining survey results did not yield statistically significant results, however charts on Figure 7.9 indicate small trends in user experience relevant for discussion and point to areas for further research with larger sample sizes.

7.4.2 Analysis of Improvisational Dialogue

A rank based non parametric Kruskal-Wallis H test indicated statistically significant ($p < 0.05$) differences between tele-immersive views and video-feedback, in the frequency of the following measures: 'Present tense' verb usage and semantic context of the 'present moment', and references to the virtual environment during the scene. Charts on Figure 7.10 indicate that 'tele-immersion' was the significantly correlated interface for both categories.

Reference to Past (p-val: .216), Present (p-val: .005), & Future(p-val: .186)
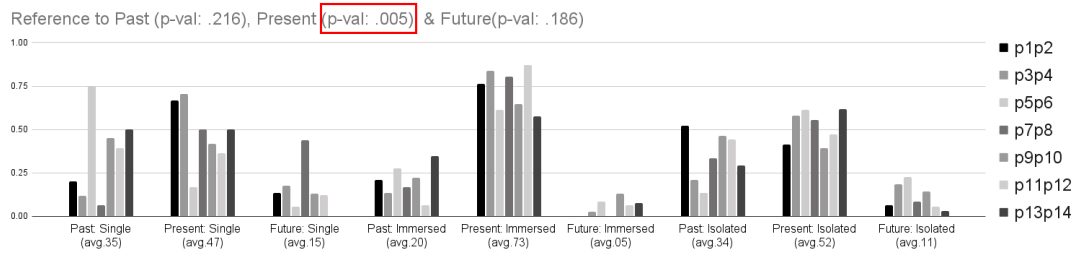
FIGURE 7.10: Significant (p¡.05) results of dialogue analysis. Participants referred to virtual environment and the present moment significantly more often while tele-immersed, 2022.

Black and white bar charts with the tallest black bars labeled 'Immersed' clearly distinguished from the lower grey bars associated with 'Single' and 'Isolated' conditions.

FIGURE 7.11: Ludic engagement: Participants reported significant enjoyment while Tele-immersed over other scenarios.

7.4.3 Interviews

Qualitative analysis of participant feedback after each drive and from post-study interviews supported findings from survey responses. 12/14 participants commented similarly that tele-immersion *"was a lot more enjoyable"* (p6) than the other two interfaces. 9 participants reported variations of the feeling that with tele-immersion *"it was easier to physically respond and to see both myself and my partner"* (p1). 8 indicated taking the most inspiration from the tele-immersed virtual environment, commenting how it was *"great being in the same car, and the scenery helped with context and information"* (p12). The feeling of connection and attunement was most frequently commented on with both the tele-immersed environment (6/14) as well as no-mirror (5/14), but for different reasons. With tele-immersion, participants commented how *"being able to play physically... felt more natural and I was a lot more focused on and able to respond to my partner"* (p11). Without a mirror other participants shared how *"not being able to see myself meant I was more focused on what my scene partner was doing"* (p1). Few commented directly on their experience of flow, however 6/14 indirectly described how the presence of an isolated mirror negatively affected their focus and how they *"felt quite disconnected because I was unable to see my body in the car"* (p13). A strong sense of

presence with the scene was reported for tele-immersion by 4 participants who described similar sentiments to being *"very drawn into the space of the car journey"* (p4), and 1 describing how they *"felt the car movement"* (p3). For 3 participants, not having a mirror however also appeared to be beneficial in fostering a sense of presence, *"because you can sometimes find that you check your own appearance instead of focusing on your partner"* (p2).

7.5 Discussion

This study set out to answer whether tele-immersive 'mirror' configurations provide advantages over traditional video conferencing platforms to mitigate some symptoms of 'Zoom Fatigue' for improvisers, by enhancing the sense of presence between performers, the experience of flow, the quality of attunement as well as the physical engagement while improvising. Furthermore, we asked if the presence or absence of the video feedback mirror in the different configurations had a measurable impact on improvisational focus and storytelling subject matter and style.

7.5.1 Designing Tele-Conference Platforms for Performance and Mitigating Symptoms of 'Zoom Fatigue'

7.5.1.1 Physical Engagement

While being tele-immersed, participants were able to overcome the inclination to be stationary credited for contributing to ZF associated with traditional conferencing environments. Observing the drives, it appeared that participants were visually motivated to physically engage with the virtual scenery and to simulate naturalistic poses and postures as well as physical contact with their partners. This interaction correlated with a ludic response as participants described the enjoyment and fun they experienced by playfully interacting with each other. Interestingly, the playfulness and physical engagement did not necessarily translate to the sensation of performing better improvisation as some reported that physical engagement came at the cost of being focused more directly on their partner and developing the improvised scene. These observations suggest that tele-immersion while, potentially mitigating some ZF symptoms may not be ideal for all types of remote collaboration, but instead may be best used for specific tasks, with the ability to easily switch to other layouts more appropriate for the given activity. For instance, tele-immersion might be useful for rehearsing scripted theatre before a performance to discover types of physical engagement that can unlock different behaviours,

FIGURE 7.12: Performers 'physically' moving thier bodies to create physical relationship on screen.

before switching to a no VF interface for rehearsing dialogue. For general remote collaboration, meetings might be structured with short breaks that include tele-immersion as a way to energise participants, and trigger playful engagement before returning to the main collaborative task.

7.5.1.2 Referencing the Visual Environment and the Now

A significant finding of the study was that during the sessions, participants intuitively made more references to not only the visual environment, but also the dialogue itself stayed in the present moment. Whereas in the other two scenarios, participants started scenes referencing a past event or a character outside of the scene (i.e. comparing who received more Christmas gifts when they were children), the tele-immersed participants tended to generate dialogue around being together in the car in that moment (i.e. searching the car for tarpaulin). For improvisational theatre, this is interesting as it demonstrates tele-immersion is drawing the focus of the improviser externally, which is important for maintaining a more collaborative approach to scene building. These initial findings along with previous observations related to tele-immersive improv [242] point to opportunities for more research into how platforms can be designed specifically for improvisational training that encourages improvisers to learn how to better incorporate external offers into their spontaneous storytelling.

7.5.1.3 Tele-Immersion for Designers

Beyond improvisational theatre, the finding that tele-immersion encourages an external focus on the visual environment may present opportunities for other fields or practices that are interested in getting feedback from clients or focus groups about their product, such as interior designers or architects. Some possible applications include designing new social spaces for a building where there is an interest to explore how the colours or shapes of a space or even the artwork on a wall might influence behaviour and how people engage. Potential users of the space could be tele-immersed in the environments

and encouraged to have conversations that are later analysed for emergent themes the way the improvisational dialogue was analysed.

7.5.1.4 Psychosocial Applications of Tele-Immersion

Outside of theatrical applications, this finding has potential relevance for remote collaborations that have a goal of responding in realtime to the behaviour and given environment. Psychosocial experiences might also benefit from exploring this feature of tele-immersion, where it is important that participants stay in the present moment. Couples therapy, conflict resolution, or public debates might each find interesting applications of a tele-immersive environment that encourages participants to stay focused on what is happening right now, rather than focusing on past or future events.

7.5.2 Limitations and Future Work

Given the small sample size, it was interesting that we observed significant results in many areas. However these observations should not be used to make too general an argument about the effects of tele-immersion, since participants only engaged with the environments for relatively short periods. Instead, the findings provide support for future research into the features of tele-immersion for larger and more diverse groups. Moreover, these results add some empirical weight to previous anecdotal reports on the power of tele-immersion to make people feel like they are really 'there' in the virtual world. The findings further provide an impetus for conducting longer studies of people working in tele-immersed environments, as well as other possible configurations to examine how social interactions and dialogue might be affected. It is also important to note, that users relied on their own internet speeds to connect, and there was variable quality of connection and experience of 'lag' during the trials. In future studies, we plan to control for variability in hardware and connection speed by performing tests in a laboratory setting, as well as comparing tele-immersion experienced on a screen to tele-immersion experienced with a virtual reality headset.

7.6 Conclusion

In this paper we compared the effects of video feedback (VF) presented as an isolated window, within a tele-immersive environment, and no video feedback at all, on a remote collaboration task. Our novel field study of 14 domain experts performing improvisational theatre under all three conditions produced significant results from our mixed

method study. Results from surveys, participant interviews, and quantitative analytics of the dialogue produced during improvisational scenes, found that tele-immersion significantly impacted five different domains of performance. 'Physical engagement' and 'presence' were perceived highest with tele-immersion, while 'attunement' and 'flow' between performers were comparable between tele-immersion and no mirror. Isolated VF was perceived worse for most conditions. Analysis of improvisation dialogue indicated TI significantly impacted verb tense and direct references to a given scenic environment.

Chapter 8

Discussion

The preceding chapters and case studies have now laid the groundwork for a nuanced discussion not only of tele-immersion, but also the value and importance of a grounded theory and mixed method research approach to designing communication technology. The results and discussion of the case study in chapter 5 outlined the emergent unique affordances and limitations of tele-immersion that informed the following experiments. The discussion used observations from audience members and performers to ground a theory regarding the de-centralisation of the performing improviser, and how the visual environment became an equal creative partner. This phenomenon was further explicated with experiment 1 in chapter 6 with observations from the multiple users about the way tele-immersive improv felt like a distinct genre from performing on stage. This case study further situates tele-immersion in the context of problem-solving for an immediate problem, and demonstrates how more generalisable observations can emerge from focusing on local problems.

Experiment 1 in chapter 6 draws from extensive in depth qualitative review of survey responses, interviews, discussions, and direct observation of rehearsal and performance in tele-immersive environments to provide three grounded design recommendations for developing communications software specifically for remote theatre makers. With recommendation 1, the importance of immediate feedback re-enforces the special needs of domain specific design for collaborative story-telling. Improvisers are used to suspending disbelief and imagining the details of a scene, they don't need photo-realism to make believe- they need immediate feedback from their partners. In recommendation 2 the advantage of single screen interfaces in made explicit, and recommendation 3 I lay the groundwork for developing a communication system that does not try to be invisible,

but rather becomes a relevant visual player in the performance. Together these recommendations, grounded by observations provide important contributions specifically to the field of HCI.

With experiment 2, a comparative study helps further disambiguate what design considerations are contributing the postive experience, and what might simply be the nature of the improvisational collaboration. Having data to support the theories of greater engagement reported in the case study and initial experiment provides important empirical weight to the discussion.

The work of this collective thesis has demonstrated how practice based research can both feed and be fed by qualitative and quantitative measures that help the research evolve with the subjects of experience. The contributions of this thesis track down two paths simultaneously that could be examined independently, but when viewed together locate a powerful twin engine for HCI design that guides new experience while it follows . As practice based research, the development and deployment of VirtualDirector could have stood alone as a study in user led design. The initial case study of chapter 5 describes the iterative development of VirtualDirector and examples of the tool being used in rehearsal and performance, with observations about the utility of specific features, and the need for the development of new ones. The case study specifically addresses the iterative design practice that involved talking with the members of Improbotics about what might make rehearsals more fun, and then trying those things out. The subject of Tele-Immersion emerged subsequently as a solution from practice, not from research or scholarship. But when I learned there was a history of exploring tele-immersion during the early days of computing, new questions formed about why no version of tele-immersion had ever made it into a commercial platform.

In particular, the question burned: why despite the surprising amount of 'telematic' artists who had in fact demonstrated much of the value tele-immersion could add to the wider tele-conferencing industry, was their work relatively unknown in the tele-communications design field? This question introduced the other path of research and the subsequent two qualitative studies designed to measure more formally (ground) the experiences of tele-immersion that appeared to be salient. Grounding theory in observation, and then testing those theories is vital to both deeply understanding and being able to demonstrate more formally the special experience it affords. As a designer and artist, I had looked at the tele-immersive part of the platform as simply a 'good enough' solution to the problem of how to feel more like we are all together. There were many other aspects of designing software for remote theatre that became interesting to explore, and a traditional iterative design process likely would have led to eventually abandoning mirror based tele-immersion in favour of trying new things out for remote collaboration.

During the early tests with Virtual Director, the improvisers were modestly interested and curious about tele-immersion, but were equally interested in exploring different ways to exploit the 'windowed' nature of tele-conferencing and making up new games and practices around the more readily available tool of traditional video conferencing. Latching on to the relatively obscure history of tele-immersion as a concept of HCI kept the research grounded in exploring that essential experience even without direct user feedback about the usefulness of the feature for improv.

Mirror based tele-immersion was essentially an answer to a question no one was asking. The research for this thesis began before any known commercially available tele-conferencing package had the feature. Prior to developing Virtual Director there were only a handful of published papers on the subject, and the last commercial attempt to realise it ended in the early 2000's when Bell Labs promised but never realised 'Immersive Communication' platform. The result is that while technology over the last decade made tele-immersion possible on a large scale, there was not an intuitive reason to implement it. Even now as the feature has become available, there is little public information available about how often the feature is used and what for. The results of this thesis are not only some of the first published examples of how people actually experience tele-immersion, based on both quantitative and qualitative data, but also presents tele-immersion itself as a potential solution to a real world problem. The discussion that follows draws interchangeably from all three studies- the case study of Virtual Director in Chapter 5 for multilingual Tele-Immersive Storytelling, the formal qualitative study of tele-immersion in chapter 6, and the comparative study of tele-immersion against more traditional interfaces in chapter 7. Together the results speak to the value of user based design, as well as the validity of mixed methods to examine both how the specific data that emerged from the case studies might be used with any tele-immersive platform, as well as how VirtualDirector itself as a modular and adaptive tool might further evolve the possibilities of tele-immersion focused exclusively on training and performing live arts.

8.1   More Fun

The optimal experience studies led by Csikszentmihalyi that developed into his theory of flow which have guided much of the research focus of this thesis, in many ways circle around the experience of 'fun.' Fun might even be considered the agent of autotelic experiences which is the cornerstone of a flow. All three studies described in this thesis overwhelmingly demonstrate that tele-immersion inclines users toward ludic activity and playfulness. All interviewed subjects reported on the fun and enjoyment

FIGURE 8.1: Cast of Improbotics celebrating at the end of a tele-immersed performance.

they experienced seeing themselves co-located in virtual environments. The novelty of the experience itself might of course be playing a role in that enjoyment, however participant feedback and observations of participants engaging in tele-immersive communication indicate there are specific features of tele-immersion that are uniquely in place to encourage playfulness.

8.2 Familiar Bodies in Unfamiliar Spaces

Tele-immersion, as explored in this thesis, involves employing the photographed body as avatar for interacting in the virtual space, which is quite different from many other experiences of virtual environments which employ some version of a 3D model to represent the user. Traditional video conferencing also employs the photographed face/body as a kind of avatar, but without the shared virtual environment. For the participants in the various studies, the tele-immersive space was unique in the way it blended the real and virtual together. The juxtaposition of the two worlds, according to participants, invited a different kind of engagement than both traditional tele-conferencing. During the first case study with duo groups, one participant described as she was noticing green artefacts resulting from an underlit greenscreen, "I'm edged with green; I look vaguely like an alien copy of myself, I'm also, like you have normal hands, I have like green mitts. It's it's okay, I can use it." The subject here is experiencing a failure of the system to correctly remove her background, which in another setting would perhaps lead to a pause in activity to 'correct' the problem. In the tele-immersive space, the 'bug'

was playfully transformed into a feature "I'm an alien" and "I can use this." With the mixture of the photographed 'real body' in the virtual space, it is difficult to know what the actual rules of engagement might be. There is no existing protocol, and so it seems a 'playful' behavioural schema becomes employed that turns problems into opportunities for playful engagement. This also follows the improviser's creed of 'accepting offers' and so the actor's training is likely also at play in this scenario, so we must be careful not to assume too much about what the aesthetic experience of tele-immersion itself is responsible for. The interesting observation is less whether tele-immersion by itself always leads to playful interaction, and more that playful interactions can be encouraged through design. Rather than focusing exclusively on developing technology that allows us to communicate, we are served by being mindful of how the interfaces will necessarily encourage different types of communication. Playful engagement is not necessarily ideal for what people want generally in a video conferencing platform. The boardroom of most face to face conferences was also not designed with ludic engagement in mind. But unlike the physical boardroom, conferencing software can dynamically change between environments and interfaces to encourage different types of engagement. As described in the background, tele-immersive features have become available for most of the popular platforms during the writing of this thesis. While Zoom, MS Teams, and Skype all have some form of a tele-immersive view there appears to be little understanding of how or when to use the feature. The user studies that help form this thesis are some of the first to explore and test for how a tele-immersive platform affects the quality and nature of collaboration. The findings about playfulness and fun point to how the familiar body, in an unfamiliar space appears to encourage playfulness, and familiar bodies together in unfamiliar spaces encourage playfulness together. Tele-conferencing platforms have had the ability for users to replace their own backgrounds with virtual backgrounds for several years and their use and adoption by individuals indicates that while they are fun and useful for the individual, they have little impact on other viewers (Hwang 2021). In other words a user may select a virtual background to appear more 'fun' or 'approachable' but when viewed by others the backgrounds have little measurable influence on reception. Placing all participants in the same virtual environment, however seems to have an effect on behaviour of the group. The significant impact of the virtual environments in affecting how frequently improvisers referred to them during scenes points to an opportunity for more study of how different backgrounds themselves might affect group behaviour.

8.3   Applications for 'fun' in other collaborative tasks

Improvisational theatre is by design a kind of ludic activity. The goal is to entertain, delight, discover, and be creative. So a tele-immersive environment that encourages play is well suited for such an activity. But what about other types of remote collaboration? The typical business meeting is likely not the ideal place for encouraging participants to 'virtually hug,' or pretend they are driving a car if the goal is to quickly and efficiently disseminate information. If however the goal is to get the full attention of the participants, to get them tuned into the room, and aware of the other participants, tele-immersion might be just the right tool. Tele-immersion accordingly, might be well employed at the start or close of remote meetings with a focus on community building before diving into the topics to be discussed. The findings related to physicality and sense of physical connection extend beyond the specific platform developed for the study. As described in the background, most popular conferencing platforms now have tele-immersive features, users just do not necessarily know what to use them for. The design of tele-immersive features of popular platforms might be contributing to a misunderstanding of their utility. Currently they consist of the ability to select from given virtual backgrounds, most of which resemble traditional environments for meeting, such as board rooms, lecture halls, or cafes. Understanding that a tele-immersive environment is better equipped to foster play, more playful backgrounds and environments might be appropriate. In the first case study, without prompting, participants automatically worked to justify the environments they found themselves in. Appearing as if on a spaceship, participants adopted roles of captain, engineer, or alien and if appearing black and white in front of a ranch they took on the swagger of cowboys, miming lassos and pretending to ride horses. The perceptual studies examined in the background explain how our behaviour automatically adjusts to the environment we are in, without necessarily any conscious thought. While the improv training and improvisational focus of the main studies played a significant role in the participants willingness to react to the environment, a similar kind of playfulness emerged with non improvisers when Virtual Director was employed for workshops in science communication and leadership training. The PhD students that were part of the Ciencia workshop mentioned in the chapter on Virtual Director in Action changed the way they pitched their research when they saw themselves presenting at a grand podium for a prestigious conference. For almost all of the initial experiences with Virtual Director, participants saw themselves as if swimming in a beautiful resort pool. Improvisers and non improvisers immediately began to pretend they were swimming and mimed splashing each other. These informal results were re-enforced by the second case study where there was a significant increase in physical engagement and interaction with the environment when tele-immersed.

8.4   Referencing the Visual Environment and the Now

A significant finding of the second study was that during the sessions, the participants intuitively made more references to not only the visual environment, but also the dialogue itself stayed in the present moment. Whereas in the other two scenarios, participants started scenes referencing a past event or a character outside of the scene (i.e. comparing who received more Christmas gifts when they were children), the tele-immersed the participants tended to generate dialogue around being together in the car in that moment (i.e. searching the car for tarpaulin). For improvisational theatre, this is interesting as it demonstrates tele-immersion is drawing the focus of the improviser externally, which is important for maintaining a more collaborative approach to scene building. The initial findings from the two case studies point to opportunities for more research into how platforms can be designed specifically for improvisational training that encourages improvisers to learn how to better incorporate external offers into their spontaneous storytelling. A part of the fun and excitement of improvisational theatre is the way one can surprise themselves with the ability of the mind to rapidly take in information that is being introduced in the moment and fabricate intricate plots and storylines with coherence. Traditional training occurs in a black box or non-descript stage so the improviser is usually just focused on incorporating things that are said, however being able to incorporate what is seen only adds to the experience. Tele-immersion presents an ideal environment for training to draw from the visual as well as the aural information of the environment. Beyond improvisational theatre, the finding that tele-immersion encourages an external focus on the visual environment may present opportunities for other fields or practices that are interested in getting feedback from clients or focus groups about their product, such as interior designers or architects. Some possible applications include designing new social spaces for a building where there is an interest to explore how the colours or shapes of a space or even the artwork on a wall might influence behaviour and how people engage. Potential users of the space could be tele-immersed in the environments and encouraged to have conversations that are later analysed for emergent themes the way the improvisational dialogue was analysed. While generally rehearsing and performing online has been considered a 'second best' alternative to performing co-located, the digital nature of tele-immersion means that performances can be easily played back and studied to discover what choices are leading to better collaborative storytelling and which ones are not. One of the most exciting things about remote communication platforms is that because the entire collaboration occurs in a digital space, data becomes available for researchers to use to better understand various aspects and features of the collaboration. AI powered voice/speech analytics are becoming quite sophisticated and can perform many operations in realtime. Tele-immersion adds visual data to every conversation, meaning it is possible to design and train AI on

models that integrate voice and gesture to test and evaluate performance metrics that historically could only be done subjectively with a trained professional. While there are already emerging services that offer generic analytics, there are currently few resources for analysing the specifics of theatrical and cinematic performance. One of the next steps for Virtual Director will be to begin including functions for such analytics, allowing the platform to more deeply assist people developing improvisational skills.

8.5   Novel Form of Improvisational Theatre?

Throughout both case studies and the dozens of public performances carried out as part of this thesis, participants and audiences have asked if what we are doing is a novel form of improvisational theatre. Since the pandemic there have been a flood of new kinds of digital media infused performance practices that also have included some form of tele-immersion. Paul Sermon has been carrying out experiments and public installations of tele-immersive improvisations since the 1990's, so it would be hard to make a case that VirtualDirector has introduced a novel form of improvising altogether. What does appear to be noteworthy, is that this work has specifically focused on trained improvisers, rather than just looking at how people improvise within tele-immersive spaces generally. Sermon's work is often situated in public spaces where he encourages play between strangers. Improvisational theatre as a discipline has been mainly focused on storytelling on an empty stage, but there are of course many companies who have explored projections and digital scenery before. There are increasingly more VR-based improv troupes emerging since the 2019 pandemic which allow improvisers to engage with dynamic scenic environments. The focus of this thesis has not been to break new ground in performance with digital environments, but rather to understand the experience of performing inside digital environments, and the impact of the digital mirror in particular on performance. Inadvertently the work introduced a wider audience to the possibilities of digital performance who otherwise would not have had access. The experiments and work of tele-immersive performance have historically relied on hardware and software systems custom built for a particular show or company. VirtualDirector is one of the first examples of a platform that is essentially accessible to anyone with a laptop and internet connection. So the novelty at best is in the form of accessibility and presenting a tool rather than a new discipline or form. It is only when a medium is ubiquitous that artists generally can discover what to do with it artistically. The work of the thesis demonstrates the need for more developers and designers to start building generic tools with immersive technology that performers can easily experiment with and test and innovate around.

With the tool of VirtualDirector, however, some novel games and practices have emerged that might be of use for other artists and developers to explore. Below is a list of some of the games and activities that were developed or discovered in the process of performing tele-immersive. Like most improv activities, it is difficult if not impossible to trace authorship or originality, so the following list is not meant as a contribution of authorship, rather an attempt to share and inspire others.

8.5.1 Pass the Spoon

In this game each participant grabs a spoon from home and hides it off camera. Participants are all arranged on screen so that the edges of their cameras line up with each other. One player starts by slowly moving their spoon from off camera to the opposite end of their screen. The player next to them holds their spoon off camera and attempts to time presenting their spoon so that it appears as if they are simply grabbing the same spoon from their neighbour and then begin moving it across their screen. The spoon must be handed to each participant. The game helps players pay more attention to each other, and get used to the little lags of timing that occur. They learn how to be aware of the breaks where the camera edge cuts them off, and how to use that edge strategically. Variation: Instead of a spoon, participants grab any object they can find and attempt to make it look like the object is being stretched or pulled into a new shape with each new person.

8.5.2 Digital Hypnosis

This is essentially a variation on Augusto Boal's 'Colombian Hypnosis' where participants get into pairs and person has 'hypnotic' power to control the other by moving their hand and making the partner try to follow the movement. In the classic version, the person being hypnotised has too keep their nose six inches from the hand. In the tele-immersed version it is the same, except that you have the added difficulty of trying to watch the screen and make it look like you are following the hand. This game is great for getting people used to moving with their whole bodies during tele-immersion and understanding the need to keep both a sense of the screen, and also the correct perspective for the audience.

8.5.3 Virtual Slapstick/ Intimacy

To explore the range of possible physical interactions I would often have the players practice various forms of fighting and intimacy such as hugging or dancing. We would

start with 'slapping' each other where they slowly practice the movement of slapping and getting slapped and get used to any lags or timing issues. I instruct them to give subtle signals for when a slap will happen so that the recipient can prepare and react at the right time. Similar to a 'stage slap,' the person being slapped claps their hands off screen to make the sound. Participants learn the camera angles for making the slaps the most convincing. We carry on with punching and headbutting as well, and then move on to shaking hands and hugging, and then finally dancing. Watching remote people appear to be physically in touch was a powerful thing to watch as an audience member, and was reported to have a strong impact on the players as well. Later in the discussion the power of virtual touch will be explored in more depth. If there is lag of more than one second, much of this work becomes frustrating for the performers at first, but interestingly if asked to see if they could find humour in the lag, will often begin to find the activities enjoyable.

8.5.4 Magic Morphing Gifts

Similar to pass the spoon, instead of trying to make it look like the object is being handed to the partner, one player 'offers' a gift off camera by gesturing their hands as if handing something off, while the recipient places their hands off camera in a way that it looks like they have grabbed the object and then they reveal it to the audience. Variation: Player one shows an object on screen, then pushes it down off screen, while player to at the same time grabs off screen from another location to pull a new object onto screen. If the timing is right, it has the effect of a 'mail tube' or dumb waiter where an object humoursly transforms while not see as the other player receives it.

8.5.5 Speed Dating

Speed dating as a concept has been used for many improvisational games and activities, and it is not known who first introduced the concept or when. With VirtualDirector, because players can be moved around the screen with midi controller buttons or just a mouse quite easily, it is possible to rapidly move improvisers on and off 'stage' which is ideal for a speed dating game. In our version with Improbotics, the game is played with an improviser who is receiving lines from an artificial intelligence that has been prompted to try and make a romantic connection. Human improvisers rapidly jump in at intervals as if 'speed dating' to talk with the AI. Being tele-immersed and having dynamic control of where the improvisers appear in the scene means one can play with the visual humour of the scene. In some instances the facilitator controlling the scenic environment will place the date very close to the 'AI' performer or very far away, or as

unusually larger or smaller. These visual cues encourage the players to try and justify the unusual visual environments creating opportunities for absurdist humour. The game of course can be played without an AI. The main novelty is the physical arrangements that can be set up.

FIGURE 8.2: Actors appearing to be on a dinner date. One actor is instantly replaced with a new actor when the date appears to go too 'wrong' or sometimes event 'too right.'

8.5.6   My Drive with Andre (Road Trip)

The basic details of this game are already explained in the second case study, Self as Avatar: Mirror Placement Matters in Remote Collaboration. For the case study the version described is a simple scene of a car and a video of a long drive in the background. The nature of the road trip seems to provide a lot of creative inspiration for collaborative storytelling. The drive though, can also be on a tractor, a motorcycle, bicycle, or even flying in a helicopter or plane. For one version I used a 3D model of Central Park in NYC and rendered several bike rides to use as background plates. During different 'stops' on the route I would place another improviser behind the main rider as if they picked up someone new. The improvisers needed to justify why they were doubled up on a bicycle which provided a lot of creative inspiration.

FIGURE 8.3: Actors appearing to drive a car together.

8.5.7 Blind Date with Sentiment Analysis

This game is a tele-immersive take on the classic 'Blind Date' reality show where a contestant has to pick a date from three candidates after asking them a series of silly questions. In our version, we add an AI tool that listens for 'agreement' between sentences in realtime that is displayed on a digital dial while the candidate talks. The candidates try to say things that boost the reading while staying in character. The game demonstrates further potential of AI assisted language analysis not only for analysing dialogue, but as part of the improvisational games.

8.5.8 AI Painting

Piotr Mirowski who developed all of the AI features utilised with VirtualDirector scripted in early 2021 an image generation tool based on Big GAN (Generative Adversarial Networks) + CLIP (Contrastive Language-Image Pretraining, Radford et al 2021) that was slowly generating an image based on textual prompts, and that I was able to use to texture a 3D model of an easel that could be moved on and off the screen with a button as well as flipped around so the audience can see either the back of the easel or the painting. This allowed us to develop several different games around 'painting' things that would surprise the improvisers and the audience. The basic form of the game involved a painter in a studio with a new client wanting a portrait. The subject would describe things they wanted and the artist would suggest what was inspiring them and how they were applying everything being said. While the scene is being played, the

FIGURE 8.4: Experimental performance with a co-located cast appearing tele-immersed for an audience. AI painting is used to amke it appear as if the performers are actually painting.

AI is being fed the lines from the improvisers in an attempt to depict what is being described. The image is revealed halfway through the scene (usually looking nothing like what is expected) and the improvisers need to justify and react. Many variations of this game can be played including having the painter be a street caricature artist that the couple randomly encounters, to a 'new age' art therapist who paints a person's trauma while they describe their problems. The game and technology are constantly developing as the technology develops. In early 2022 we implemented a version based on Vector Quantized Generative Adversarial Networks (VQGAN, Esser et al, 2021) + CLIP and CLIP-guided Diffusion Networks (Dhariwal and Nichol, 2021) that generated much more realistic imagery that could be prompted to resemble a specific artistic "style". The painting is slowly built up over time and rendered using "brush strokes", allowing it to look like the improviser is applying brush strokes while they speak. This game demonstrates some of the most exciting new areas for live performance with co-creative AI that is setting the stage for entirely new types of performance experience.

8.5.9 Spin the Wheel of Time

The ability to rapidly change environments and store scenes, means it is quite easy to incorporate audience feedback into rather intricate visual performances. There are numerous types of improv games that involve time travel where the improvisers are given a time period to be in that they need to justify and make sense of. With tele-immersion the time travelling can be made more concrete for both the audience and the improvisers as they can be put into cinematic environments that depict the actual locations of time travel. VirtualDirector employs custom shaders that allow scenes to appear in various 'filmic' styles that replicate old film stock, adding to the experience of performing during different time periods. From black and white westerns, to overly saturated colours that mimic old kodachrome depictions of medieval Europe, the effect of seeing yourself as if on a movie set can be a powerful source of creative inspiration. Versions of this can be done with the tele-immersive features of the popular platforms to a lesser degree by just having backgrounds ready to shift between scenes. With Virtual Director, there are tools built in to allow a fully cinematic experience to take place with virtual camera moves, close ups, and cutaways. For some games I would assemble a series of 'B-Roll' footage to set the tone of the upcoming scene, such as a rolling tumbleweed, or a car chase. Performing tele-immersively opens up a new vocabulary of cinematic devices that can significantly assist in the creative storytelling.

8.5.10 Why are you upside down?

[h!] Another fun feature of VirtualDirector is the ability to place performers in unusual physical arrangements. One game we found that was quite fun involved starting a scene with a player appearing as if they were hanging upside down from a tree or the ceiling of a building. The improvisers would need to come up with reasons for the unusual arrangement. The experience of seeing oneself upside down was reported to be an unusual experience of itself that could induce feelings of actually being upside down. This feature was never formally tested for feedback, so there are opportunities for exploring how seeing oneself in such physical arrangements affects the performer.

8.5.11 What's in your kitchen?

Inspired by the work of miniature artist, such as Tatsuya Tanaka (Brown, 2005) who use close up photography to make everyday objects like a toothbrush appear as a swimming pool or field of grass, I experimented with a few improv troupes to see if they could make fun and unusual environments with things they found in their kitchen or around

FIGURE 8.5: Performers playing the game 'why are you upside down.'

FIGURE 8.6: Performers playing 'What's in your kitchen.'

their house and a close up camera. In this game each player in the improv session is invited to prepare an environment that can become the background for their fellow performers. This introduces a whole different level of improvisational creativity for a group. In addition to providing the shared environment for the cast, the designer can also interact with the environment, moving objects on and off screen, marching their fingers in close up across the scene to simulate an army crossing by or something more abstract. The game opens up many different levels of creativity and new ways for improvisers to interact.

8.5.12   Bad Makeup Artist

In this game one player is 'applying' makeup to another player virtually in the tele-immersive environment. The player receiving makeup is turned away from the camera, and the player applying the makeup is arranged so they are behind the other player and we can see them appear to be applying something to the face of the other. The scene involves getting ready for a big important event like a wedding or an interview. While the scene plays out, the player who is to be receiving the makeup is actually applying the makeup to themselves, usually in a comically bad way, so that when they turn to reveal the make-over the other partner has to try and justify their decisions.

Chapter 9

Conclusion

This thesis has carved winding dual paths of practice based as well as theory led research to present a wide range of contributions to the fields of human computer interaction, theatre studies, improvisational theatre practice, and digital art. The work presented in this thesis demonstrated the design, development, field testing, and professional application of novel software called VirtualDirector for tele-immersive improvisational rehearsal and performance. The impact of the software has been wide ranging with Virtual Director, demonstrated by the case study in chapter 5, being employed for seven international theatre festivals, five professional workshops, and three dedicated online performances. This work has garnered awards in innovation from the Paris Fringe Festival, and commissions for performances from the international Art AI Festival in the UK, Fliegenden Funken festival in Germany, International Theatre Festival in Iasi, Romania. The workshops have been commissioned from far ranging institutions including Yale University, Mt Sinai Hospital in NYC, The New York Academy of Sciences, the UK Arts Council funded Telepresent Stage Project in Brighton, UK, and the Art AI Festival in Leicester, UK. The use of VirtualDirector as a solution for live theatre artists during the Covid-19 pandemic and as a modular platform for incorporating artificial intelligence based language translation models for multi-lingual improvisation has been presented for and published by the Electronic Literature Organisation. The iterative and user based design process was complemented with theory led research inquiries that presented a novel way for improvisers to create theatre remotely, and drew from their experience to discover both better designs to fit users needs, but also better research questions to generate new experiences for the field. VirtualDirector was used not only to create tele-immersive rehearsal and performance opportunities, but to also conduct the first formal user studies of performers using tele-immersive software. Two novel case studies on tele-immersion and performance were carried out resulting in significant contributions to the field of Human Computer Interaction with a publication of my initial findings with The

Special Interest Group on Computer–Human Interaction (SIGCHI). Both experiments provided novel findings for the field including qualitative data that underscored indicate that tele-immersive environments uniquely provide performers with a strong sense of co-presence, feelings of physical connection, and an increased ability to enter the social-flow states required for improvisational theatre. Findings of the case study and two experiments indicate that tele-immersion significantly leads to increased physical movement during remote rehearsal and performance, heightened awareness and engagement with the present moment and given circumstances of a scene, incorporation of virtual scenery into performance, and sense of physical presence with remote partners. The second experiment specifically presented novel findings that indicate tele-immersion significantly leads to increased physical movement during remote rehearsal and performance, heightened awareness and engagement with the present moment and given circumstances of a scene, incorporation of virtual scenery into performance, and sense of physical presence with remote partners. My work presents original insights in understanding how traditional computing display environments can be utilised to enhance co-creatively a sense of physical presence between remote partners, and how presenting virtual bodies in co-located space can provide sufficient aesthetic feedback for performers to restore the physical aspect of social flow for improvisation that is otherwise lost with existing telepresence technologies.

Appendix A

REVIEW: Improbotics Online, Paris Fringe 2020, 4/5 Stars

This review was posted to BingeFringe.com June 7, 2020 and is authored by Jake Mace.[1]

In events reminiscent of a mix between a Franz Kafka novel and an episode of Black Mirror written on an acid trip, Alex the Artificially Intelligent Avatar has joined an improv troupe. Alex's automatically generated lines are slotted into the architecture of stories created by audience suggestions through a website. These suggestions are then beamed back to YouTube in the style of a Raoul Hausmann collage as the bodies of the improvisers are inserted into different backgrounds by virtual director Boyd Branch.

Improbotics Online was split into 3 sections. In the first, Alex is inserted directly into the scene, creating some incredibly surreal interaction between a photorealistic AI cat and a man who just wants to swim. In the second section two-hander scenes are played out by the improvisers but one's body is inhabited by Alex, becoming a "Cyborg" and only speaking lines generated by the robot.

Possibly the most entertaining section of the show took the form of a narrative across many scenes where one of the improvisers was a "Cyborg" and the audience has to guess which. This led to a hysterical moment where in the middle of an intense scene about a woman who suspects her boyfriend has been cheating on her while he's at the gym, improviser Harry Turnbull (seemingly inhabited by Alex) blurts out the line "The number of troops in Afghanistan in the past three years has risen directly in tandem with President Obama's strategy."

Other standout lines from the AI include "I'm your Mum, you're my Brother, what do you think of my Dad?" and "I'm an alcoholic, so I don't mind." Alex, either intentionally

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[1] https://bingefringe.com/2020/06/07/review-improbotics-online-paris-fringe-2020/

or unintentionally, seems hellbent on disrupting any scene that they are dropped into the middle of.

The translation of the stage show into an online performance was not entirely seamless – however I do not feel it is important to mark Improbotics Online down for this, as a lot of the witty and interesting moments occurred during the slight awkward panic of being live and online. If anything, the online show seemed to thrive on the anarchy that the format provided. All of the performers showed excellent form to carry the show through despite being scattered all over the world.

Live suggestions from the audience were integrated into the show's last segment and the performers seem to feed perfectly off of these as well as bouncing around Alex's chaos-bringing presence. The narrative of this final segment took many surprising turns. It eventually landed on the story of a grunt being sent by a wizard to find him a Scandinavian wife as he had turned his previous girlfriend into a Pumpkin Spiced Latte while in the Starbucks queue.

His quest leads us to a woman who still bathes with her forty one year old adult son. On their first date, the wizard gets cold feet and turns himself into a cat, before through a number of tangential encounters lead us back to some sort of conclusion.

The implementation of the AI into these traditional Improv troupe games is genius and the pace of the event doesn't skip a beat, even in between the monumental technical efforts undertaken to splice each player into a scene. This is exactly the kind of response that the creative world will have to look towards as we continue to learn to live with the current tricky situation regarding lockdowns and restrictions on how readily artists can perform together and in front of live audiences.

Overall, the show was raucous fun, pure anarchy and a dystopian vision of an Artificially Intelligent future where the Turing Test might be decided by how readily you can hold back your views about the deployment of US troops into the Middle East.

Improbotics Online is not to be missed this Paris Fringe. A second performance will be held on the Paris Fringe Youtube Channel on the 21st June 2020 at 21.30 Paris Time, for absolutely free. You can read more about future Improbotics performances on their website.

Appendix B

Survey Questions from 'Mirror Placement Matters' Experiment

B.0.1 Survey Questions

- I was 'totally involved'.

- I was 'tuned in' to what I was doing.

- I was 'in the zone'.

- I felt completely immersed in the activities.

- I enjoyed performing with my scene partners.

- My driving companion seemed to enjoy working with me today.

- My driving companion's comments enabled me to be creative today.

- My driving companion understood me.

- What my driving companion did and said was helpful today

- My driving companion seemed comfortable with all of my reactions today

- I felt accepted by my driving companion today

- I felt a sense of having a meaningful person-to-person relationship with my driving companion today

- I felt fully present with my partner.

- I found myself physically engaging with my body.

- I was very aware of my partner's body.

- I was often making extra effort to think of interesting things to say.

- I become so immersed in the scene that I forget my physical surroundings.

- I was distracted by my physical surroundings.

- It was easy for me to add to and participate in the conversation.

- I was often making effort to be funny.

- I relied significantly on my partner's reactions to inform my performance.

- I was very aware of my partners reactions.

- I felt physically connected with my partner.

- I was inspired creatively by the visual environment of the drive.

- I was distracted by the visual environment of the drive.

- I felt transported into the driving scene.

- My ability to feel connected was limited by the technology used.

- Please describe your general experience of DriveTogether during this most recent session.

B.0.2   Tele-Immersive Environment Design

Figure 5: Screenshot of TouchDesigner network developed for the study and the GUI for controlling drives, 2022.

FIGURE B.1: Screen shot of GUI for controlling tele-immersive drives for Mirror Placement Matters study.

Appendix C

List of international festivals, workshops, and other performance with Virtual Director

C.1 Paris Fringe 2019

FIGURE C.1: Paris Fringe 2019

Date: August 2019

Event: Paris Fringe Festival

Name of Show: Improbotics Online

Show Description:

Improbotics Online is a revolutionary artificial intelligence and communications technology-powered online improv comedy show. Performed live by an international troupe of humans and robots, located in four different countries, the show happens live in a shared online space and is coordinated by the Virtual Director. Our company, Improbotics, includes professional actors and a small robot running artificial intelligence chatbot software. We conduct an arts-meet-science interdisciplinary exploration of how physically distant actors can communicate and seamlessly perform while controlled by a machine and thrust into a shared virtual space. Our impossible (and hilarious) challenge relies on absurdism, misunderstanding and human connection.

C.2 Robots vs Humans Comedy Show 2019

FIGURE C.2: Robots Vs Humans Comedy Show 2019

Date: October 2019

Event: Maryland STEM Festival

Name of Show: Robots vs Humans

Show Description:

Robots are taking over jobs in manufacturing, security, but what about comedy? Find out on October 3rd when joke-telling robots take the virtual stage in a show like you have never seen before. Pesky humans will also be performing. This show will feature robotics researchers, joke-telling robots, human stand-up comedians, and a live Turing test with an improv troupe! Audience members will have the opportunity to ask questions about the performances after the show.This show will take place on Zoom. Performers Naomi Fitter is an engineering professor at Oregon State University, who also does stand-up comedy. Her soothing midwestern voice has been described as "sexy," "librarian-like," and "nearly inaudible." She has opened for Bil Dwyer, Laurie Kilmartin, and Whitney Cummings and performed in the All Jane Comedy Festival. When she's not telling jokes, she spends time creating our future robot overlords. Jon the Robot is Naomi's autonomous joke-telling machine. He has not learned to pass captcha challenges, but he hopes to captcha your heart. Improbotics is an artificial intelligence and communications technology-powered improv comedy show, performed live by an international troupe. Some improvisers are controlled by robots running artificial intelligence chatbots: will they pass the Turing Test? We explore how physically distant actors can communicate and seamlessly perform while controlled by a machine. Our impossible (and hilarious) challenge relies on absurdism, misunderstanding and human connection.

C.3 Bingoing Crazy by Loosely Woven Theatre, 2020

Date: October 2020

Event: Electric Medway Festival

Name of Show: Bingoing Crazy

Show Description:

A surreal comedy with super playful bingo themed participation and mind-blowing virtual effects *Bingoing Crazy is a surreal comedy by Sarah Davies (Loosely Woven Theatre) complete with super playful bingo themed participation, courtesy of mind-blowing online wizardry from our Virtual Director! Bingo Caller and all round loser Raymond lives in a dream, convinced that e the show, and will be able to interact with the story at key points, to play along with Raymond in real time!*

Date: October 2020

Event: Improbotics Online Holiday Show

FIGURE C.3: Bingoing Crazy by Loosely Woven Theatre, 2020

FIGURE C.4: Bingoing Crazy by Loosely Woven Theatre, 2020

Name of Show: Winter Cyberland
Show Description:

Join us for Winter Cyberland! Our final 2020 Improbotics show will feature friendly humans and chatbots/robots improvising together virtually in the cloud. Using the combined magic of artificial intelligence, of Boyd Branch's Virtual Director and of our human creativity, we will transport you to a magic wonderland, making everything up, based on

your suggestions.

FIGURE C.5: Winter Cyberland, 2020

FIGURE C.6: Winter Cyberland, 2020

C.4   Online eXtreme Improv, 2020

Date: August 2020

Event: Online eXtreme Improv

Name of Show: Improbotics Online

Link: https://www.extremeimprov.co.uk/improbotics.html **Show Description:**
*Improbotics Online is an artificial intelligence and communications technology-powered
online improv comedy show, performed live by an international troupe, coordinated by a
Virtual Director built and operated by Boyd Branch. Improvisers connecting on the internet will perform for you in a shared virtual space. Some of us are controlled by robots
running artificial intelligence chatbots: will they pass the Turing Test? We explore how
physically distant actors can communicate and seamlessly perform while controlled by a
machine. Our impossible (and hilarious) challenge relies on absurdism, misunderstanding and human connection.*

FIGURE C.7: Online eXtreme Improv, 2020

C.5 Camden Fringe 2021

Date: July 2021
Event: Camden Fringe Festival
Name of Show: Rosetta Code Online

Show Description:

*Human improvisers connect across borders on stage via technology: AI, live translation and augmented reality at Camden Fringe 2021 "High-tech improv show Rosetta
Code connects actors across borders, with a cast performing in multiple languages, using
live translation, remote connection and augmented reality. The show will take place at*

The Cockpit Theatre on 18th and 19th August 2021 as part of Camden Fringe 2021. When the pandemic struck, Improbotics stayed connected by rehearsing and performing online in a virtual reality environment. Using tele-immersive improv, performers were brought together in shared virtual worlds. Their show, Improbotics Online, won the Most Innovative Show Award at the Online Paris Fringe 2020 and a 'Ballsy Award' from Binge Fringe. Rosetta Code builds on this work; this modern Tower of Babel is made possible through human connection... and by state-of-the-art technology including real-time speech recognition and machine translation, artificial intelligence (GPT-3), and telecommunications. Will the wonders of AI enable human communication and mutual understanding? Misunderstandings and deception will make for a completely improvised "Comedy of Speech Recognition Errors" (as an audience member so beautifully put it!).

Quotes:

"It was very funny. And when it did not work, it was even funnier." (Neil Delamere, Irish comedian, London 2017).

"This could be revolutionary" (Broadway Baby, Brighton Fringe 2018).

"If I was Introduced to a show like this as a kid I would have paid more attention to science class" (5 stars, Phoenix Remix, Brighton Fringe 2019).

The show creators and developers are Dr. Piotr Mirowski, Dr. Kory Mathewson, and Boyd Branch, award-winning professional improvisers who explore the use of AI for creativity in improv and in human-machine interaction. Mirowski and Mathewson moonlight as research scientists in AI at DeepMind. Branch is a former Fulbright fellow and directs the Improvisational Media and Performance Lab at the University of Kent."

C.6 Telepresence Stage Guttersnipe, 2021

Date: July 2021
Event: Tele-Presence Stage Project
Name of Show: Shuggafix vs the Illuminati
Description:
Case study produced by the Telepresence Stage documenting how VirtualDirector was used: https://www.telepresencestage.org/residencies/guttersnipe-theatre https://www.telepresencestag study-pdfs/Guttersnipe-Theatre-Case-Study.pdf

Show summary "The Guttersnipe Theatre residency was facilitated by project guest researcher Boyd Branch, utilising his online 3D compositing software Virtual Director, a particularly suitable telepresence solution for Guttersnipe's unique cabaret style of

FIGURE C.8: Telepresence Stage Guttersnipe, 2021

FIGURE C.9: Telepresence Stage Guttersnipe, 2021

theatre. Boyd Branch, Lecturer in the School of Media and Performing Arts at Coventry University, developed and built Virtual Director to explore the effects of immersive visualisations on rehearsing and performing theatre online as part of his PhD at the University of Kent. By the time Boyd joined the project he had already undertaken research on improvisation techniques for telepresence performance and was able to provide a unique set of bespoke 3D solutions for Guttersnipe Theatre." (Sermon, 2021)

C.7 Yale Ciencia Academy SciCom Improv Training, 2021

Date: July 2021
Event: Yale Ciencia STEM Academy
Name of Show: Tele-Immersive workshop: Applied Improv
Link: https://medicine.yale.edu/news-article/yale-ciencia-academy-new-class-young-science-leaders/ **Description:**
"During the initial workshops, fellows developed trust and built community through improv games led by theater expert Boyd Branch. They also learned how to craft an effective personal narrative to communicate their scientific and personal identities to a variety of audiences with the guidance of science communicator and trainer, Liz Neeley. Over the upcoming year, fellows will gather for online conversations and workshops with role models and experts who will help them with career planning, mentoring, and scientific and interpersonal communication skills" (Guerrero-Medina, 2021).

C.8 International Theatre Festival in Lasi, Romania, 2021

Date: July 2021
Event: Theatre FestivalLasi
Name of Show: Improbotics Online
Description:
Could an AI make up a story? Our group of improvisers will find out, as they collaborate with artificial intelligence. Improbotics is an immersive improv comedy show that combines robots, virtual reality and an international troupe of theatre actors, comedians and technologists. Some improvisers are controlled by artificial intelligence chatbots: will they pass the Turing Test? The actors are connecting remotely and immersed into a shared online stage controlled by a Virtual Director: will they overcome the Zoom Gloom? Improbotics invites audiences to explore how physically distant actors can communicate and seamlessly perform while controlled by a machine. Our impossible and hilarious challenge relies on absurdism, resourcefulness and human connection.

C.9 Art AI Festival, 2021

Date: September 2021
Event: Art AI Festival
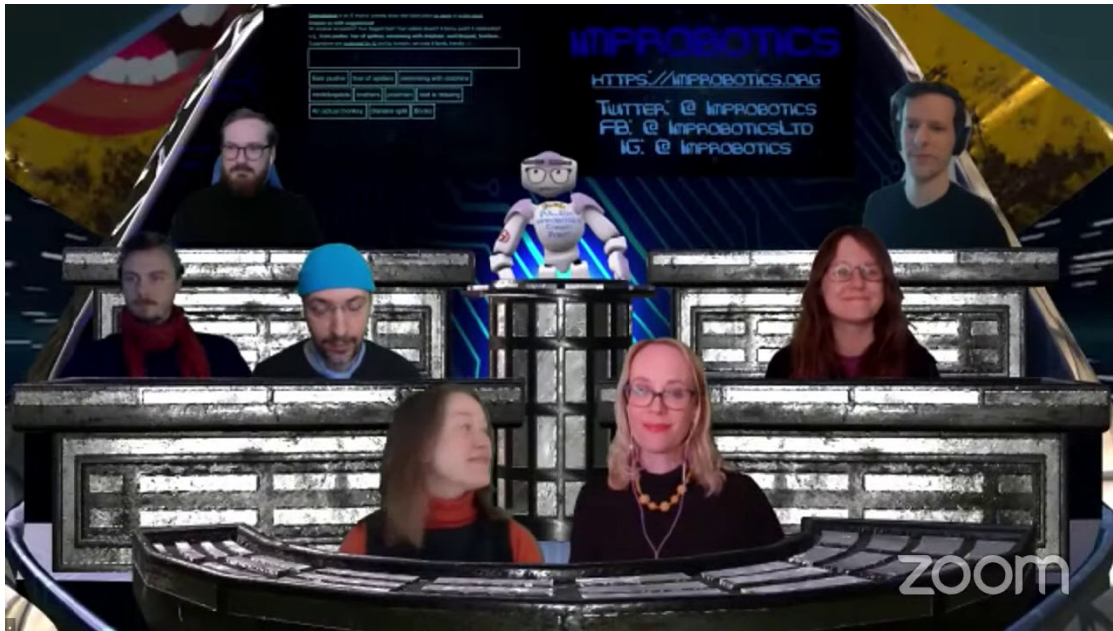**Name of Show:** Improbotics Online
Description:

FIGURE C.10: International Theatre Festival in Lasi, Romania, 2021

"Could an AI make up a story? Our group of improvisers will find out, as they collaborate with artificial intelligence. Improbotics is an immersive improv comedy show that combines robots, virtual reality and an international troupe of theatre actors, comedians and technologists. Some improvisers are controlled by artificial intelligence chatbots: will they pass the Turing Test? The actors are connecting remotely and immersed into a shared online stage controlled by a Virtual Director: will they overcome the Zoom Gloom? Improbotics invites audiences to explore how physically distant actors can communicate and seamlessly perform while controlled by a machine. Our impossible and hilarious challenge relies on absurdism, resourcefulness and human connection."

C.10   Queen City Virtual Improv, 2021

Date: September 2021
Event: Queen City Virtual Improv
Name of Show: Improbotics Online
Description:
Deep in the cyberspace, where our video conferences are taking place, humans and robots live in harmony. They improvise. Artificial intelligence, virtual reality, human performers. Improbotics is using the Virtual Director technology developed by Boyd Branch (https://boydbranch.com), Director of the Improvisational Media and Performance Lab (http://www.improvmedialab.com) and the AI improv technology developed by Piotr

FIGURE C.11: Art AI Festival, 2021

Mirowski (https://piotrmirowski.com) and Kory Mathewson (https://korymathewson.com), cofounders of Improbotics (https://improbotics.org) and of HumanMachine (https://humanmachine.live

FIGURE C.12: Queen City Virtual Improv, 2021

C.11 New York Academy of Sciences SciCom Improv Training, 2022

"The next generation of scientists, engineers and STEM professionals need to diversify their skill sets to effectively communicate across cultures, be innovative, nurture future STEM professionals and build learning communities to drive the challenges of society. The Science Alliance program and the Academy partner with a consortium of universities, teaching hospitals and independent research facilities to drive excellence and cultivate a diverse STEM ecosystem." (Lyer, 2021)

Leadership and Critical Communication **Date:** September 2021
Event: New York Academy of Sciences SciCom Improv Training
Name of Show: Applied Improv Training with Virtual Director
Description:

This workshop, led by Boyd Branch, serves as a communication laboratory in which scientists utilize performance and improvisation tools to develop personal, dynamic, data driven techniques to build consensus, encourage excellence in teammates, and make outcome independent requests of stakeholders. Participants will practice proven improvisation forms together in a fun and fast-paced environment that empowers individuals in leadership positions to flexibly adapt to unpredictable situations. These techniques and forms are applied to leadership and critical communication scenarios drawn from participants' experiences and rehearsed through theatrical improvisations.

C.12 Art AI Tele-Immersive Workshop 2022

Date: March 2022
Event: Art AI Festival
Name of Show: Improbotics Online
Description:
Taking place on Saturday 12 March between 2-5pm, this FREE 3-hour workshop introduces you to working with an artificial intelligence and robot as a co-performer. The workshop will be led by Piotr Mirowski and Boyd Branch of the internationally recognized Improbotics troupe. Piotr and Boyd will guide you through developing some ideas for performance, giving you an opportunity to practice your ideas along with other workshop

FIGURE C.13: Art AI Tele-Immersive Workshop 2022

participants. Their creative ethos is about risk, challenge, and cooperation. Their approach embodies how improvisers take on seemingly impossible tasks, and through their skill and open mind, surprise themselves.

C.13   Fliegende Funken Festival, 2022

Date: September 2021
Event: Fliegende Funken Festival
Name of Show: Dancing with Pixels
Description:

A film crew, a virtual film and an invisible wall Improbotics and Improtheater Bremen (UK and Germany). As the door to the world opens, a cold wind also blows in. We can communicate with everyone, but we can't get together with anyone. Long-distance relationships eat up souls and zoom sex is only limited fun. But two people desire each other and desire against each other. They have a lot to overcome: cultural differences, class differences, technology. "Tired of technology" yet dependent on it, they dance on the razor's edge of forbidden and impossible love. This show takes place hybrid: While Improtheater Bremen plays the festival stage, Improbotics from London telematically

FIGURE C.14: Enter Caption

joins in, using its immense technical skills to juggle the video streams. The result is a collage-like, magical teleportation" (Loes, 2022).

FIGURE C.15: Enter Caption

Appendix D

Telepresence Stage Case Study of Virtual Director

Guttersnipe Theatre

Contents

Introduction

Guttersnipe Theatre
July – September 2021

Company Summary

Guttersnipe Theatre are a London based company, who describe their aims and productions as "Theatre with womxn [sic] front and centre, both onstage and off it. We are a femxle-led collaborative collective who make bold original theatre that celebrates womxn everywhere. Sometimes we write scripts, sometimes we devise, sometimes we see what happens in the rehearsal room". The core Team are Grace Church and Molly McGeachin. Their current show 'SHUGA FIXX vs The Illuminati' is a collaboration with writer and performer Poppy Pedder. Guttersnipe's previous productions include: Trip (Winner at One Act Festival 2018 and Brighton Fringe 2019), BITS (Forest Fringe 2018) and Moonface (Park Theatre, Edinburgh Fringe 2016, "Devised with precision and intelligence, and performed with honesty and joy. Not to be missed." Broadway Baby).

Grace Church is a Lecoq-trained theatre-maker and performer from Brighton whose shows are performed at venues and festivals Including Wilderness Festival, Edinburgh Fringe, Camden People's Theatre, The Wardrobe Theatre Bristol and VAULT Festival. Molly McGeachin is a theatre-maker and actor who has performed at venues such as Park Theatre, Tristan Bates Theatre and features in the Kingsman film The Great Game (February 2020). Poppy Pedder is an actor, writer and workshop leader. She trained at the University of East Anglia and Bristol Old Vic Theatre School where she worked with Sally Cookson, Tom Morris and was Cordelia to Timothy West's King Lear.

https://www.guttersnipetheatre.co.uk

GUTTERSNIPE THEATRE

Guttersnipe Theatre
July – September 2021

Residency Summary

The Guttersnipe Theatre residency was facilitated by project guest researcher Boyd Branch, utilising his online 3D compositing software Virtual Director, a particularly suitable telepresence solution for Guttersnipe's unique cabaret style of theatre. Boyd Branch, Lecturer in the School of Media and Performing Arts at Coventry University, developed and built Virtual Director to explore the effects of immersive visualisations on rehearsing and performing theatre online as part of his PhD at the University of Kent. By the time Boyd joined the project he had already undertaken research on improvisation techniques for telepresence performance and was able to provide a unique set of bespoke 3D solutions for Guttersnipe Theatre.

As part of their ongoing production of SHUGA FIXX vs The Illuminati, Guttersnipe Theatre explored and produced a telepresence staging of the Triple Threat Teen Awards, a 'behind the scenes' talent show parody of television's X Factor and Britain's Got Talent. The show took the form of a satirical black comedy that explores the dark absurdity of conspiracy theories, the poor treatment of young talent and the rise of fear culture through the eyes of SHUGA FIXX, a tween pop-band who have become prime targets of the ultimate inner circle. The three Guttersnipe Theatre performers, Grace Church, Molly McGeachin and Poppy Pedder played multiple parts that follow SHUGA FIXX, from nervous backstage preparations to their final performance, their humiliation by the judges and their success over fellow finalists The Muftiday Boys. They thought this would lead to fame and stardom, but finally it explodes to become the dark controlling world of the Illuminati.

Guttersnipe Theatre
July – September 2021

Company Engagement

Guttersnipe Theatre were already engaged in rehearsals for their new production SHUGA FIXX vs The Illuminati in February 2020. Having just received Arts Council England funding, they were all set to go into production and secure venues and tour dates. But when lockdown struck in March 2020, like many performing arts companies, they were forced to put the show on hold. Whilst the company had previously worked on music video productions for the promotion of their live shows, as well as writing and producing their own music, their experience and preparedness to create alternative online performances was limited. Working with Zoom between the performers' homes and bedrooms provided very few options to realise the production they had envisaged.

Guttersnipe Theatre's founding member Grace Church attended a presentation by the Telepresence Stage research team in February 2021 for the WhatNext platform **https://www.whatnextculture.co.uk**, a UK-wide cultural and creative industries network. Following the presentation Grace approached the team, eager to explore the Telepresence Stage possibilities. Together with company co-founder Molly McGeachin and collaborator Poppy Pedder, the company were looking for a solution to develop and present an online episode of their delayed production of SHUGA FIXX vs The Illuminati. They also wanted to expand their ideas and experience of online theatre, and reach their audience and network through an alternative composited telepresence approach – in keeping with their particular unique *femxle-led* approach.

> **"We are so excited to be working with the Telepresence Stage team on this exciting venture into uncharted digital performance territory. Our company had received Arts Council funding for our show 'SHUGA FIXX vs The Illuminati' in February 2020, thus due to COVID-19 our rehearsals and performances were cancelled. We managed to make videos, do live sharing and make scenes, dances and music from our bedrooms. However, this certainly doesn't compare to our experience of being composited in the virtual space all together."**

Grace Church, Guttersnipe Theatre co-founder and performer

Ideas and Experiments

Following their first introduction session on the principles of the Telepresence Stage, Guttersnipe Theatre produced a concept/mood-board for the project team, drawn from their ongoing production SHUGA FIXX vs The Illuminati. The concept document provided costume and set design suggestions and script ideas, based on a fictitious talent show, the Triple Threat Teen Awards. Having established the theme and direction they wanted to explore, the research team were able to provide feedback and suggestions, delivering a more tailored residency. Six practical sessions took place between July and September 2021, facilitated by Boyd Branch, using Virtual Director as the main compositing solution for the residency.

For their first practical session, the company explored a range of telepresence interaction exercises, which they went on to use in their final performance. Using their preview monitors positioned stage right and stage left (so the performers could view themselves whilst appearing to look directly at the other remote performer in profile) they practiced 'high-fiving' (Image 1; pg.8), including a jolting 'tuck' of the hand mime technique to emphasise the point of contact. They perfected 'virtual hugging' and learned to position their arms according to the layered composition of their video images, performing a convincing group hug. They learnt how to perform 'virtual slaps' (Image 2; pg.8) by refining their coordination and timing, accompanied by a simultaneous, hidden slap to the thigh to provide a convincing sound effect. They practised a sleight of hand 'gift-giving' exercise, where both performers have identical props – one performer reveals the prop and then presents it just outside the camera's view to the other performer, who gestures to receive it and then reveals the same prop in view again. In order to develop their reaction and improvisation techniques they responded to objects and shapes (Image 3; pg.9) and explored tactile sensitivity using the 'Colombian Hypnosis' technique, developed by Brazilian drama theorist Augusto Boal. As if in a hypnotised state one performer faced and followed the hand of another (Image 4; pg.9), whilst maintaining a 20cm distance from it to develop and perfect their telepresence control and response for future practical sessions.

Guttersnipe Theatre
July – September 2021

Image 1
Molly McGeachin (left) and Grace Church (centre) perfect a virtual 'high-five' and Poppy Pedder (right) prepares for another.

Image 2
Molly (left) attempts to 'virtual slap' Grace (centre) whilst Poppy (right) provides the sound effect.
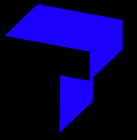
Guttersnipe Theatre
July – September 2021

Image 3
Playing and responding to shapes: Molly (left) and Poppy (right) apply pressure from the sides and Grace (centre) pushes from within.

Image 4
Exploring the 'Colombian Hypnosis' technique: Poppy (centre) leads with her hands as Molly (left) and Grace (right) follow.

Performance

Technical Approaches

Virtual Director is a compositing and video switching open-source software tool **https://github.com/Geitenkaas/VirtualDirector/** built by Boyd Branch to explore how existing video conferencing tools can be enhanced with telepresence features to facilitate rehearsing and performing online theatre (Diagram 1). The telepresence environment is generated by isolating separate video feeds from a video chat meeting such as Zoom or receiving individual video feeds directly via OBS Ninja **https://vdo.ninja**. Green-screen backgrounds are extracted from the participants' video feeds, who are then positioned as 2D planes inside a 3D environment. This is arranged by an operator in relation to selectable scenic elements in the space. Each object (including the performers) can be moved around, scaled, and rotated to simulate an appropriate sense of scale and depth between performers and the environment, whether they are seated or standing. The scenic elements can be dynamically replaced or changed with other objects available from a library of stored virtual elements and sets.

Virtual Director's graphical user interface (Diagram 2) presents an operator with a grid of players and controls to dynamically select, switch, and manipulate the individual performers' video feeds inside a three-dimensional space. The interface also provides the user with interactive menus to load images, videos, or 3D objects that fill the virtual environment in which the performers are positioned. Virtual Director stores up to sixteen scenes that can be immediately updated to provide seamless scene transitions during the performance. To facilitate real time interaction and response to the spontaneous behaviour of the performers, the software can be controlled via any attached 'musical instrument digital interface' (MIDI) devices, so that knobs, sliders, and buttons can manipulate the scenery and performers on the fly. The functionality of Virtual Director allows the operator to work with the performers by altering backgrounds, foreground elements, and positions of the performers based on their suggestions.

Branch, Boyd (2021) Tele-Immersive Improv: Effects of Immersive Visualisations on Rehearsing and Performing Theatre Online. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. May 2021 Article No.: 458, Pages 1–13 **https://doi.org/10.1145/3411764.3445310**

For the Guttersnipe Theatre residency (Diagram 3) Virtual Director was used in combination with OBS Ninja to receive individual high-resolution green-screen video feeds directly from the performers. Virtual Director composited the performers' video feeds within the 3D virtual environments and scenes and streamed the whole performance live into a Zoom meeting, along with music and sound effects. The performance was viewed by audience members in the Zoom meeting.

Technical Approaches

Video Conferencing Software (Zoom, Skype, MS Teams, OBS Ninja etc.)
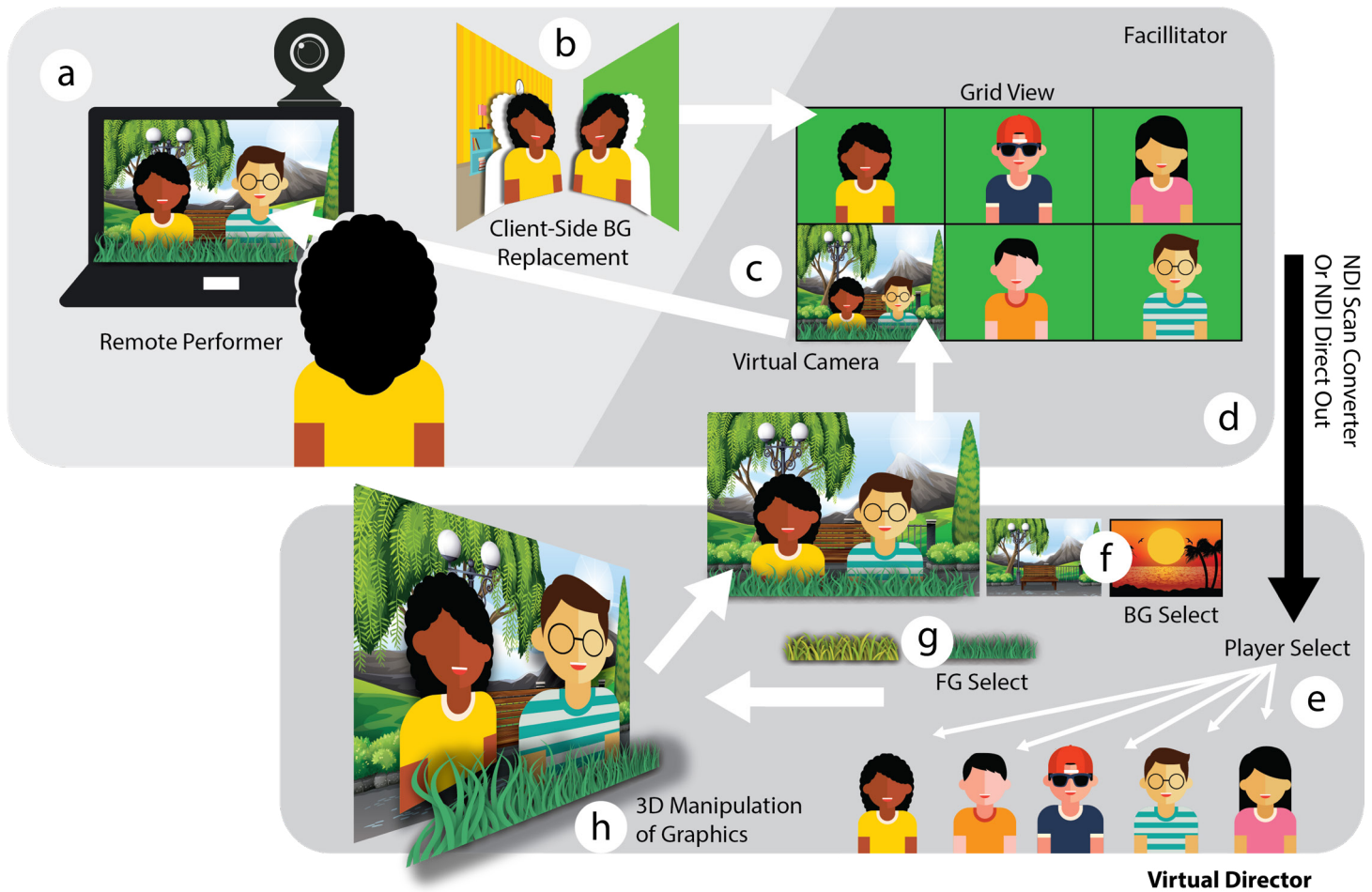
Diagram 1: System overview, Virtual Director 2020: (a) Remote performer connects via videoconference (e.g. Zoom) software, (b) Background green-screen is performed by videoconference software, (c) Performer sees a video of themselves co-located with partners in virtual space, (d) NDI sends videoconference video to Virtual Director, (e) Automatic separation of videoconference call participants, (f) Virtual Director selects background and (g) foreground elements for compositing, (h) Each element appears as a 3D object that can be rotated, scaled, faded, and positioned dynamically.

Technical Approaches

Diagram 2: Graphical user interface, Virtual Director 2020: (a) Zoom screen capture, (b) Foreground select, (c) Player select, (d) Background select, (e) Preview.

Diagram 3: Telepresence Stage system overview: Video communications via OBS Ninja, audio communication via Zoom, video and 3D set design compositing with Virtual Director, streamed on Zoom.

Participants' Technical Setup

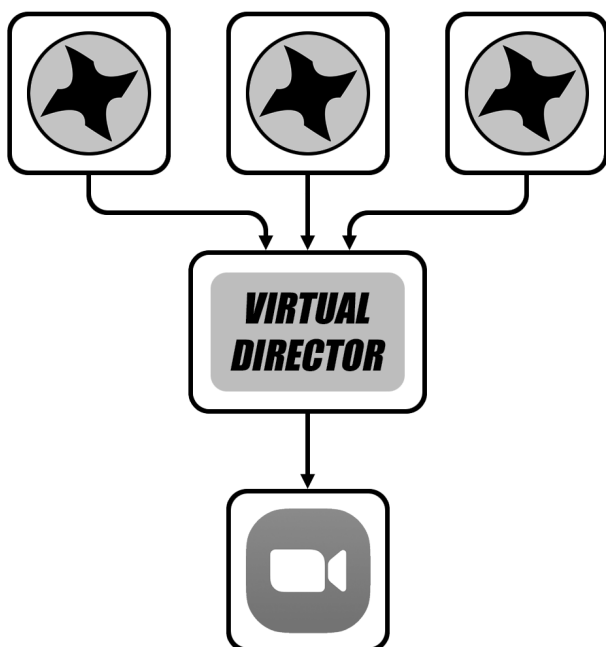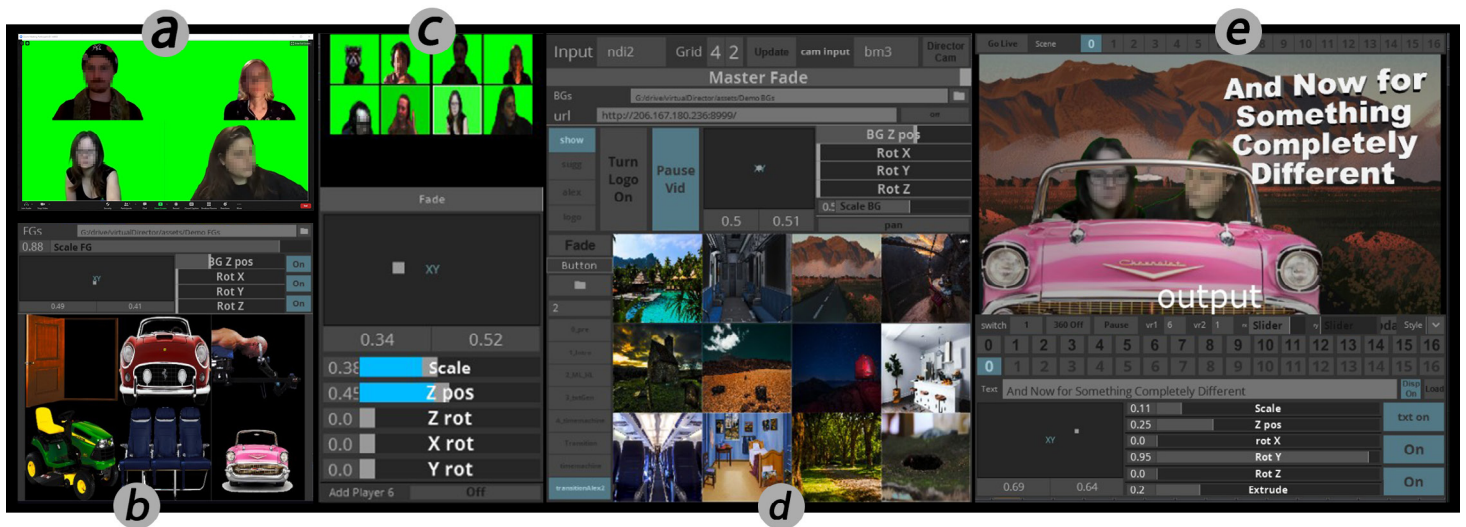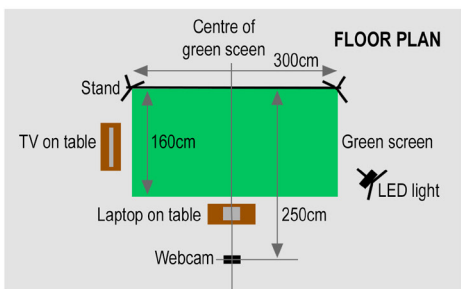**Diagram 4:** Green-screen studio setup instructions for each remote performer: Green-screen backdrop and stand, LED video light, webcam, laptop, ethernet connection and TV screen.

FLOOR PLAN

Centre of green sceen
300cm
Stand
TV on table
160cm
Green screen
LED light
Laptop on table
250cm
Webcam

Use the SmallRig to mount your camera 1.8 meters high, using a shelf or door (or stand if you have one). Position it directly central to the green-screen, 2.5 meters away from it. Point the camera downward to get a full picture of the figure. See floor plan detail for info

If you have a TV screen its very helpful to use as a larger 2nd monitor to the left or the right of the green screen, position it on a table as high to your eye level as possible and connect it to your monitor out on your laptop with an HDMI cable

Green-Screen (provided)

300 cm

200 cm

160cm

LED Light (provided)

Make sure your lights are not too close and causing, hot spots and shadows, sometimes pointing it up and bouncing the light off the ceiling helps defuse it in smaller rooms

TV Screen

USB webcam cable

HDMI cable

Webcam and mount (provided)
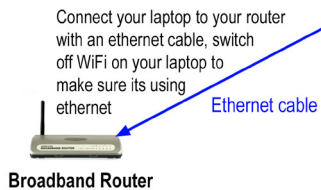
Connect your laptop to your router with an ethernet cable, switch off WiFi on your laptop to make sure its using ethernet

Ethernet cable

Position laptop on a table directly in front of green screen at a central position as high to your eye level as possible

Fix green-screen to floor with duct tape

Broadband Router

Equipment and Materials

Video studio resources supplied to each performer:

1 x Green-Screen Backdrop: Neewer 10 x 12ft / 3 x 3.6m PRO Photo Studio 100% Pure Muslin.
1 x Backdrop Stand: Fotga 2.1 x 3m Background Support System Kit.
1 x Video Lights: Neewer Advanced 2.4G 660 LED Video Light, Dimmable Bi-Colour LED Panel with LCD Screen.
1 x Webcam: Logitech C930e USB 1080p Full HD Webcam.
1 x Camera mount: SMALLRIG Cool Ballhead Clamp Mount with Mini Magic Arm.

Hardware and software used by each performer:

1 x MacBook Pro / Laptop Windows 10 Broadband Internet (ethernet connected).
1 x 24" LCD HD TV.
1 x Google Chrome Browser: **https://obs.ninja**
1 x Zoom Videoconference application: **https://zoom.us**

Hardware and software used by the central compositing node:

1 x Desktop PC: Windows 10, AMD Ryzen 7 5800X CPU, Nvidia RTX Quadro 4000 GPU.
1 x 24" Computer Monitor.
1 x Virtual Director software: **https://github.com/Geitenkaas/VirtualDirector/**
1 x Zoom Videoconference application: **https://zoom.us**

Description and Analysis

Image 5
The spinning SHUGA FIXX ident used between scenes and costume changes.

Image 6
Introducing SHUGA FIXX on stage: 'Jude' (left) played by Molly McGeachin, 'Brooke' (centre) played by Grace Church and 'Gemma' (right) played by Poppy Pedder.

Description and Analysis

Image 7
A heated argument breaks out between Jude (left) and Brooke (centre) in the dressing room, to Gemma's (right) horror.

Image 8
Realising they need to pull together, SHUGA FIXX make up with a 'virtual [group] hug'.

Description and Analysis

Image 9
Left on her own in the dressing room, Gemma (right) has a strange sensation of being watched.

Image 10
SHUGA FIX take the stage for their Triple Threat Teen Award performance, complete with pre-recorded videos insets of the band.

Description and Analysis

Image 11
Jude (left), Brooke (centre) and Gemma (right) drive through a techno landscape during their performance routine.

Image 12
Cool and confident, Jude (left), Brooke (centre) and Gemma (right) get behind the wheel of a car for their performance routine.

Description and Analysis

Image 13
The Triple Threat Teen Award Judges include the archetypal harsh judge (left) played by Poppy Pedder and the overly enthusiastic judge (right) played by Grace Church.

Image 14
SHUGA FIXX on stage with pre-recorded Muftiday Boys, played by (from left to right) Poppy Pedder, Grace Church and Molly McGeachin for the announcement of the winners.

Description and Analysis

Image 15
SHUGA FIXX's celebrations turn to shock as the stage abruptly explodes!

Image 16
Jude (left) and Brooke (centre) attempt to pull Gemma (right) from the rubble as they find themselves in a hellish landscape.

Description and Analysis

Image 17
A demonic pre-recorded Lizard King steps out from a mirror to menacingly welcome SHUGA FIXX to the Illuminates' lair.

Image 18
Dressed in Illuminati cloaks, SHUGA FIXX hail the Lizard King and succumb to his power and control.

Description and Analysis

For their final Telepresence Stage performance Guttersnipe Theatre portray the trials and tribulations of Triple Threat Teen Award finalists SHUGA FIXX. The online performance shifts between theatre and television, from backstage fly-on-the-wall drama to prime-time TV talent show, complete with graphic idents between scenes and costume changes (Image 5; pg.16). The performance commences with SHUGA FIXX on stage to introduce themselves, in a confident group plea for viewers' votes (Image 6; pg.16).

The action then moves backstage to the dressing room to reveal ongoing tensions between Brooke, played Grace Church and Jude, played by Molly McGeachin (Image 7; pg.17). Brooke snatches Jude's phone, using the 'gift-giving' technique, which escalates into 'virtual slaps'. The third [wheel] member of SHUGA FIXX, Gemma, played by Poppy Pedder insists they need to make up and 'virtual [group] hug' before going on stage (Image 8; pg.17). Agreeing, Brooke and Jude race off, leaving Gemma behind to encounter a (pre-recorded) visitation from SHUGA FIXX's demon, the Lizard King (Image 9; pg.18). The scene changes as Gemma catches up with Brooke and Jude on stage for their final performance routine (Image 10; pg.18). Through a rapid succession of 3D scene changes, including inset pre-recordings of SHUGA FIXX in the 3D stage set, they perform behind the wheel of a car as they drive through psychedelic landscapes (Image 11 and 12; pg.19). The performance routine ends to rapacious applause followed by a brief ident interlude and costume change. In the next scene the three archetypal judges, played by Grace, Molly and Poppy, give their feedback (Image 13; pg.20).

In the closing scenes, SHUGA FIXX are back on stage with fellow (pre-recorded) finalists The Muftiday Boys, also played by Grace, Molly and Poppy for the concluding announcement… "and the winners are… SHUGA FIXX!" (Image 14; pg.20). As the synchronised and disgruntled 'boy band' leaves and SHUGA FIXX thank their fans, the stage explodes (Image 15; pg.21). As the dust settles a hellish landscape is revealed as Brooke and Jude grapple to help Gemma back on her feet (Image 16; pg.21). Brooke tragically cries out "this isn't what I thought fame would look like!" just as a pre-recorded Lizard King appears from a mirror, laughing menacingly "you're mine now SHUGA FIXX" (Image 17; pg.22), satirically echoing a dark world of coercion and control. In the final scene SHUGA FIXX have accepted their fate and appear in ceremonial occult cloaks trapped in the Illuminates' lair, possessed by the Lizard King (Image 18; pg.22).

Video Recordings

SHUGA FIXX vs The Illuminati – Trailer
4 minutes mp4
Watch here

SHUGA FIXX vs The Illuminati – Performance
12 minutes mp4
Watch here

Guttersnipe Theatre – Residency PLAYLIST
Watch here

Evaluation

Evaluation

Company Reflections

This was unlike anything Guttersnipe Theatre had done before, presenting some fun challenges and providing opportunities for more ambitious ideas and staging configurations. As they progressed through the residency, they became more comfortable and natural working in telepresence space. Grace Church spoke about the difference between her work with physical theatre and the empty space of mime, which was in complete contrast to working with the limitless possibilities of telepresence. Poppy Pedder, who comes from a more classical theatre background was more familiar with having props and sets around her, and so had to rely on her imagination to place herself within the space, becoming less aware of her immediate surroundings. Molly McGeachin, similarly didn't think of herself at home, but rather considered herself as physically transported into telepresence space.

> **"Whenever I was thinking about what we had to do for the show I was always thinking of us within that space, I was never thinking of my body in my living room standing on a green bit of material."**

Molly McGeachin, Guttersnipe Theatre co-founder and performer

Grace was surprised by the effects of 'virtual hugging', describing "a level of solace, it's a weird feeling … a sense of closeness I wasn't expecting". All three concurred, noting how they suddenly felt very alone on their green-screen after shutting down the laptop screen at the end of a session.

They also spoke about the ritual of setting up and preparing to enter the space, which they perfected as the residency progressed. Poppy spoke about how the experience was more like theatre than film, feeling the adrenalin of being live and present, "because in [her] head the screen was like a mini stage".

Poppy also talked about being at ease with observing her own image. She thought this was partly due to her cartoon-like character and wondered how it might feel if she had a more emotional and vulnerable role to play. All three spoke about the future post pandemic possibilities of the Telepresence Stage, for script read-throughs, casting, preparing sets and reducing production costs, as well as new hybrid theatre forms, slipping between stage and screen.

Evaluation

Research Team Reflections

Guttersnipe Theatre were extremely ambitious and embraced the Telepresence Stage opportunities from the outset. Their decision to create a mood-board/ script early on was very effective in setting out their aims for the residency. Unlike previous groups, the performers chose to be in costume for every session, which aided them to get into character. It was particularly helpful from a telepresence point of view, allowing them to observe, experience and further embody 'Brooke', 'Jude' and 'Gemma' as members of SHUGA FIXX, rather than themselves. They played multiple roles including live and pre-recorded characters and they perfected quick costume changes, very convincingly switching characters, from naive 'tween pop-band' to egotistical judges. All three were particularly interested in performing with pre-recorded characters and especially enjoyed playing the 'Muftiday Boys'.

Aided by Boyd Branch's control with Virtual Director, they negotiated the latency and synchronised their interactions seamlessly with the pre-recoded boy band. They were particularly committed to rehearsing and learning a routine, repeatedly trying something out again and again until they had perfected a sequence of interactions and could reproduce them reliably. Sometimes, whole sessions concentrated on just one particular scene. Some actions proved easier to reproduce than others. The virtual group hug was particularly effective, while the fast face slap could be impacted by even the tiniest amounts of lag. However, the performers developed cues to help them manage the timing on most occasions. It was agreed that a small amount of time-slippage highlighted the liveness of the event without detracting from the ongoing narrative. The audience is accustomed to a certain amount of suspension of disbelief in live staged theatre, and the telepresence stage is no different in that respect, although the particular points of suspension differ slightly.

Before the residency Boyd had mainly used Virtual Director for improvisation, and this was the first time he had to follow a script and prepare specific scene changes in advance. In this capacity he had to work in partnership with the performers, rather than choose their scenography for them. Boyd had a complete view of all the performers' video feeds, even when off screen/stage, 'waiting in the wings' which he could use to cue scenes, so he had oversight of the entire production, both on stage and backstage simultaneously. Towards the end of the residency in September 2021, Guttersnipe were also starting physical rehearsals for a staged version of SHUGA FIXX vs The Illuminati, which included routines they had learnt and developed during the residency. But some scenes were just not possible to replicate on a physical stage. The two different performances represented a trans-media storytelling of the same production, but they were ultimately interested in how the two shows could perhaps converge in the future.

Evaluation

Key Takeaway Points

Commencing the first practical session with a series of telepresence interaction exercises introduces the performers to the space very effectively. They quickly learn how to orientate themselves, react and respond to virtual interactions, through techniques such as 'high-fiving', 'virtual hugging', 'virtual combat' and 'gift-giving'. The performers learn how to negotiate latency and develop a telepresence sense of proprioception in relation to themselves and other performers in the space.

Wearing a costume helps the performer get into character and further embody the role they are playing on screen in front of them. When the performer is dressed according to the scenography they are placed within, the experience becomes more intuitive, they immediately feel in context and a sense of freedom in performing in character.

Using video clips or 'idents' between scenes provides an opportunity for costume changes and scene setting interludes, as well as for the preparation of props or physical objects. Video clips of pre-recorded performers can be used to integrate additional characters. By rehearsing and synchronising interactions with a pre-recorded video it is possible to create convincing interactions between live and pre-recorded performers.

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Appendix E

Publication: Platforms for Multilingual Tele-Immersive Storytelling and Improvisation, ICCC 2021.

Platforms for Multilingual Tele-Immersive Storytelling and Improvisation

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Abstract

In 2020-2021, a pandemic caused a global shut down of the performance of live theatre. This led to many artists without creative outlets, many companies having to modify their programming, and, in an unfortunately large number of cases, the complete shutdown of theatres and companies. This circumscription led to a burst of technological innovation to support new ways to connect performers and audiences. In this work, we present two such innovations: *Rosetta Code* and *Virtual Director*. *Rosetta Code* is a tool for improvisation, live or online, which allows for simultaneous translation, enabled by artificial intelligence. The *Virtual Director* is a platform for tele-immersive performance. In the hands of multilingual cast members, the Virtual Director augments Rosetta Code to create online multilingual improv shows. We describe these platforms and provide descriptions and reflections on two performances of Improbotics Online which used the Virtual Director to bring together audience members and performers from around the world. These performances were part of the 2020 Paris Fringe and Improbotics Online received positive reviews and an award for the Most Innovative Show of the festival. We conclude this work by discussing the potential for mixed-presence international shows as we emerge from physical and social distancing requirements and how our tools will continue to support online and on-site performances. We have sparked a creative ratcheting effect: performers are enabled to tell new and interesting stories, and are inspired to suggest innovations which improve the tools with which they perform. These innovations are deployed in future performances. This positive feedback loop is a metaphor for the fundamental theory of improvisational: Accept and Expand.

Keywords: theatre, improvisation, immersive, multilingual, interactive, performance

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[*]Equal contribution, alphabetic order of authors.

1 Introduction

Live theatre is a casualty of the current COVID-19 pandemic. Social and physical distancing requirements preclude assemblies necessary for participatory theatre. These restrictions have significantly reduced public performances, pressured many performing arts institutions to modify their programming, and in many cases forced the complete shut-down of arts organizations. Many of the world's most popular stages, including all Broadway theatres in New York, USA and West End theatres in London, United Kingdom, have plans to remain closed until at least the middle of 2021.[1] Early studies on the impact of social distancing restrictions on live arts professionals report substantial reductions in income for artists and increases in anxiety, depression and overall mental health (Spiro et al. 2020). The long term impact of shuttering theatres and the effects of social isolation on creativity in the performing arts industry remains to be seen. While some performing artists have been able to shift to digital mediums to somewhat mitigate the impact on their creativity, artists that rely heavily on the live presence of not only an audience, but their fellow performers have had little recourse to maintain their craft. Improvisational art forms in particular have struggled to find footing in digital mediums.

Theatrical improvisation relies on performers and audiences gathering in the same space and using that shared physical proximity to collaboratively build stories. The pandemic caused a global creative constipation through social and physical distancing requirements. Virtual gatherings using video-conferencing platforms are, at best, an ersatz solution for audiences longing for connection in an ever more disconnected world. These technologies have been linked to a phenomenon labelled 'Zoom-gloom' or 'Zoom fatigue', which has been studied in several recent works (Bailenson 2021; Fauville et al. 2021). Some improvisational theatre groups have embraced tele-conferencing and streaming for workshops, practice, and performance. But, due to how demanding it is to set these sorts of systems up, and the aforementioned Zoom-gloom which both performers and audiences are all too accustomed to, many are preferring to temporarily pause while waiting for the conditions of performance to resume (Berger 2020). The live performance limitation is a global issue; the world-wide community has been brought together online to share stories of adversity and challenge. A list of 'Improv Theatres That Shut Down in 2020' has been circulated and updated over the last year has over 60 theatres that have closed in the United States and Canada alone (Johnson 2020).[2] We believe that live theatre cannot wait for the pandemic to wane. Instead of re-streaming previously recorded live performances, we advocate for embracing technology, and specifically innovative platforms for tele-immersive storytelling and improvisation.

2 Virtual Director

Many live performers struggle with the desire to be as live and in the moment as possible while dealing with the physical impossibilities introduced by virtual improvisation. The laws of physics, that is, the speed of light, defines a theoretical maximum for the speed of information transfer. This is the maximum rate at which information from one performer can reach another performer or an audience observer. When audience and performer are co-located in a theatre, this information can happen at the speed of sound for jokes, laughter, and applause, and at the speed of light for body language and scenic painting. When performers are not co-located with audience members, it takes a non-insignificant amount of time for the information round trip to occur. While this is generally under a half-second, it can feel like a lifetime. Thus, platforms must be designed in such a way to handle issues of latency and lag introduced by these delays. And, as the number one rule in comedy is timing, handling these issues effectively is paramount for translating the comedy from the performers to the observers.

Theatres around the world have tried countless ways to incorporate live and prerecorded content for performance, hosting, and audience interaction. But, the platforms often stand in the way rather than uplift. These tools need to be easy enough for performers to use and improve audience enjoyment.

To handle these requirements, we built a platform for online performance. Our system, called the *Virtual Director*[3], enables actors to simulate feelings of presence with stage partners while performing and storytelling remotely (Branch et al. 2021). Our research combines cinematic and video communication technologies with the theatrical practice of improvisational and scripted theatre, and aims at recreating presence, virtually. Virtual Director relies on commodity software (i.e. TouchDesigner[4] and web browsers such as Google Chrome), widely adopted video conferencing tools (e.g. Zoom, Microsoft Teams), and popular streaming platforms (e.g. YouTube, Twitch). Our solution 'piggy-backs' on these digital platforms for streaming and video conferencing for participatory online performances. This makes using the tools as easy as using common consumer software. These technologies have evolved significantly with a year of development and global dependence for tele-work and remote education. Software such as Open Broadcaster Software (OBS), OBS.Ninja[5], and even Zoom's and Google Meet's capabilities have improved significantly through 2020 and 2021.

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[1] https://broadway.com/announcement/covid-19-update/

[2] Thank you to Noah Johnson & Levity Theatre (https://levitytheatre.com/) for compiling this grim list.

[3]'Tele-Immersive Improv': https://youtube.com/watch?v=LkqfRWH3iKU

[4] https://derivative.ca/

[5] https://obsproject.com/, https://obs.ninja/

Figure 1: Examples of the immersive multi-performer virtual stage. In these images, one can see multiple performers–who are not physically co-located, and who are connecting from different countries–composed together in a virtual scene. The real-time masking and composition is done by the Virtual Director software.

While a full system description is out of the scope for this particular work, we encourage readers to see (Branch et al. 2021) for complete details. Next, we discuss how the Virtual Director system was tested with 2 small 'live' public performances featuring a variety of improvisational teams and 2 performances with Improbotics Online at the 2020 Paris Fringe festival.

2.1 Early public trials

While developing Virtual Director we conducted two trials of the platform in front of live audiences with short performances from four different improv theatre teams. The teams were solicited from an open call for two-person improv teams who had been working together for at least a year and were interested in trying out new tools for streaming performance. Each team trained with the software for two weeks prior to performing for small audiences who watched the live shows from within a Zoom conference call. Twinprov [6] and the Jess's's's [7] performed for the show Double Incidentally May 31, 2020 for 15 audience members. Sudden Knot and Assimilate performed for Digital Improv Presents June 14th the following month for 21 audience members. Each team performed for approximately 20 minutes. We conducted surveys after each performance and received 13 responses. Twelve of the thirteen respondents 'agreed' or 'strongly agreed' to feeling present with the performers as well as agreeing they could 'easily visualize the world created by the performers,' demonstrating that the platform was successful in bringing a sense of cohesion and shared presence between remote participants. Answers to our open ended questions yielded a more nuanced appreciation of the impact of the technology on the potential of live streamed performance. We include the following quotes from audience members (A1-A7) for discussion answering 'How did you feel about the presence of the technology in the show?':

> *It was certainly interesting, and the visuals helped to create an extra dimension for us as the audience.* (A1)

> *Really engaging, and the connections between performers particularly stood out!* (A2)

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[6] https://www.facebook.com/twinprovimprov
[7] https://www.facebook.com/jessssssimprov

It was terrific, the second part with the filter was super cool and I loved seeing them on green screen as well as in the virtual environment - it was distracting but not detracting if that makes sense (and really the distraction pulled me in deeper).(A3)

I felt I was a part of it - especially at the top and end, there is something powerful for an audience member to share the screen with the performers. (A4)

Felt great - would be awesome to have ongoing cues or coordination where artists knew the bounds of the technology and explored it more. (A5)

I would like to see actors working more in different levels of the virtual space. Playing with their size inside the screen could be really engaging for the audience and both challenging and exciting for actors. (A6)

It was something I was aware of, but it added to the feel and vibe of the show - even when things didn't work as well as you might have hoped, it all just added to the fun. (A7)

The range of responses we share capture both the sense of pleasure audience members expressed in being part of a visually co-located performance, as well how the presence of technology stimulated their imaginations about what might be possible with a platform that could immerse audiences and performers inside a shared visual space.

2.2 Performances at the Paris Fringe Festival

We deployed Virtual Director within the context of an Improbotics Online show as part of the community-based performances at the 2020 online Paris Fringe festival. Improbotics[8] started as a research and performance project exploring Turing's imitation game using machine intelligence in improvised theatre (Turing 2009; Mathewson and Mirowski 2018; Mirowski and Mathewson 2019). To ensure that the audience understood the context for the performance, the description of the show was as follows: *Improbotics Online is a fully online, live improvised performance in an immersive virtual reality stage where human improvisers interact with artificial intelligence.*

We performed the show twice, on the 6th and 21st of June 2020. The show won a 'Ballsy Award', and was also awarded the 'Most Innovative Show' at the 2020 Paris Fringe.[9] The performance received a four-out-of-five star review on June 7, 2020 and the complete text of the review is included for context as an appendix to this work. We include a quote from the review here for discussion:

> The translation of the stage show into an online performance was not entirely seamless – however I do not feel it is important to mark **Improbotics Online** down for this, as a lot of the witty and interesting moments occurred during the slight awkward panic of being live and online. –Jake Mace

This review acknowledges that even the unique moments when the performance was not seamless were still interesting. This balance between 'everything is under control' and 'potential panic' contributes to special quality of live performance that is always somewhat dangerous with the opportunity for things to go 'wrong'. In a way, this risk is analogous to the 'ring-of-fire' that a trapezist would leap through in the big tent at a circus (Johnstone 2012).

To see the show, we have posted a short trailer and a full performance, accessible at `https://improbotics.org/online/`. In the next section, we briefly describe several interesting qualitative observations that we synthesized from the audience members and performers during and after these performances.

2.3 Performer-Audience Interaction

We now examine the perception of the performance by audiences and their participation in collective storytelling. Our audience was interested in the new interaction formats and performance modalities presented as part of Improbotics Online. Our streamed performances redefined the nature of live performance, and we identified 4 levels of participation: (1) **participating as a performer**, (2) **privileged audience member**, (3) **general audience member**, (4) **onlookers watching the show recording, post-performance**.

We briefly summarize each of these modes of participation, comparing and contrasting the qualitative experiences. First, our tool enabled visual collocation and presence among performers. These are the professional improvisors who perform the show, they represent the cast of performers. Second, Virtual Director enabled visual collocation and audio interaction between selected privileged audience member and the performers, or recreated visual presence if we placed them in a virtual "amphitheatre". Third, general audience members audiences could interact indirectly via synchronous chat.

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[8]`https://improbotics.org`
[9]`https://twitter.com/leparisfringe/status/1279062282723622915`

Finally, onlookers can watch, or re-watch the performance, as we post the recording of the performance to the internet for asynchronous enjoyment.

Our initial study on the impact of visual co-location on remote improvised demonstrated how being visually co-located enhanced the sense of presence with remote scene partners in a way that traditional 'grid' arrangements of popular conference tools did not. Subjects of the study reported how this sense of presence with each other contributed to their ability to enter into a state of 'flow' during performance that in turn led to enhanced feelings of creativity and the idea that online improvisation could be an entirely new medium distinct from physically staged improvisation.

We noted a similar idea emerging from our audience feedback about how online performance could be considered a new medium with different rules and expectations from physically staged performance. The 'extra dimension' of a shared visual environment for one audience member that added to their enjoyment was the same dimension leading another to imagine how the addition of dynamic visual environments could be better exploited with actors 'working more in different levels of the virtual space.' Traditional improvisation is bound by physical laws that digital improvisers are not inherently bound to meaning 'space' now has additional expressive potential as performers can appear bigger or smaller taking up space in new ways that impact storytelling.

During our initial audience study we experimented with keeping the audience visually present throughout different moments of the show by instructing them to keep their cameras and microphones on. The feeling that 'there is something powerful for an audience member to share the screen with the performers' was echoed by another who reported 'My attention felt more present and necessary'. Co-locating all audience members with performers during shows streamed to larger audiences on social media platforms such as Youtube however cannot take advantage of webcams the way video conferencing tools can, so require different methods for engaging with audiences.

For our Paris Fringe shows we instead explored how live chat could be incorporated into performances. We added functionality to Virtual Director that could display the results from a web-server that audience members could send suggestions to in addition to commenting with each other during performances via the built in chat functions of Youtube. Curated suggestions from both sources would then appear inside the virtual environment inhabited by the performers between scenes.

These different modes of interaction are all complimentary to the performance experience. They all contributed to a sense of collaborative collective storytelling in a shared 'space'. As a performer, you need to consider the performance from each of these perspectives, and understand how to engage with these perspectives in the moment. Additional analyses of the performers' experience of presence in tele-immersive virtual spaces is covered in work by Branch et al. (2021).

Having tools such as the Virtual Director accessible to us, and rehearsing and performing with them led to a creative ratcheting effect. The more that we shared these tools with brilliant performers and professional improvisors, the more interesting and innovative ideas they had to tune and modify them and use them in interesting ways. For instance, the shared virtual environments of online rehearsals and performances with Virtual Director resemble cinema much more than theatre and led to the novel adoption of cinematic techniques for improvised storytelling. During rehearsals improvisers began exploring how they could move props on and off screen, make their heads disappear by placing green fabric in front of their faces, and composite their bodies onto each other by overlapping their images on screen.

With Virtual Director performers can not only enter and exit the playing space by moving off camera, but they can also reference and incorporate physical props and costumes dynamically into scenes as they develop. Our platform also provided the addition of a 'virtual camera' as another scene partner that could interact with the performance. The environments of Virtual Director are built inside a 3D environment where performers are placed on transparent digital planes sandwiched between foreground and background elements which can subsequently be viewed from different angles. This allowed us to incorporate virtual camera controls to our platform so that an operator could 'pan' and 'zoom' into different areas of the screen like a sitcom or movie.

In addition to new cinematic techniques, virtual performance also led to novel incorporation of communication tools that bridged not only physical distance, but language barriers. Prior to the pandemic, Improbotics had long been adapting technology from state-of-the-art language models, to digital avatars, to translation systems to explore how humans can improvise with technology (Mathewson and Mirowski 2017). In physically co-located shows, the role of these technologies could often be difficult for audiences to distinguish. With online performances however, we discovered not only how we could make these novel tools more visually present, but how we could incorporate them more meaningfully into performance.

3   Multilingual Performance and Actor Interaction

As an international theatre troupe, Improbotics has cast members representing multiple nationalities and languages. In 2019 we began exploring novel multilingual improvisational formats by exploiting live translation and speech recognition technology in a show called Rosetta Code.
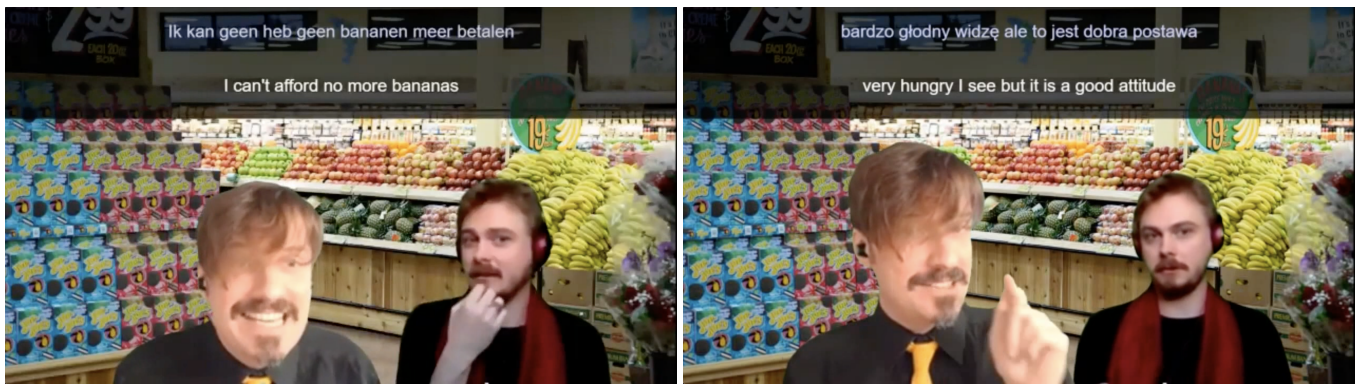
Figure 2: Examples of the immersive multi-performer virtual stage combined with real-time translation for two performers who are not physically co-located and who are speaking in two different languages (Dutch and Polish) with live transation into English. The real-time masking and composition is done by the Virtual Director software, combined with the Google Speech Recognition and Translation APIs.

Using Google's API for speech recognition, for real-time translation, and for text-to-speech generation, we built a program to listen to improvisers speaking in a language foreign to their scene partner's and to send them the near real-time translation via headset, as well as to display the result of speech recognition and of real-time translation on a screen. In this way we enabled actors to improvise in multiple languages while being understood by cast members and audiences. The show was performed on stage in November 2019 at the Rich Mix Theatre[10] in London, as part of the Voila Festival of European Theatre (Mirowski, Mathewson, et al. 2020).

While we had some successes with this format it could at times be difficult for audiences to track how the translations were taking place as we relied on projections that did not always sync smoothly with the performance. Moreover, capturing the speech of individual performers, without cross-talk from their stage partners, proved challenging and required them to hold a dynamic microphone with an on-off switch in their hand. Moving to an online platform with Virtual Director not only began to solve many of these challenges (for example, speech recognition could be run independently on each performer's computer), but also introduced new ways to incorporate translations into the show.

Our original system which enabled a low-latency, multilingual experience for performers and audiences alike, challenged contemporary theatre which is often performed and enjoyed in a single language. Building up on an existing multilingual improv stage show (Mirowski, Mathewson, et al. 2020), we combined tele-immersion with translation to create a multilingual performance that transcends typical physical limitations of the stage. As the performers spoke in different languages, real-time translation of their lines was displayed on the screen, like the subtitles in a foreign film. The cohesive environment of the virtual stage enabled us to use subtitling more effectively so that audiences could see the translations and the performance simultaneously, in a way that projections alone could not do.

Moreover, the addition of virtual environments meant we could provide a more cohesive narrative experience and context for multilingual improv with performers appearing to be in the same physical location. When performing in physically co-located shows, the stage is empty and requires improvisers to not only spontaneously generate meaningful dialogue, but also verbally 'paint' the visual environment of the scene through that dialogue. With multilingual performance it there is a significant cognitive demand on both performers and audiences to keep track of physical details being described throughout the scene, and there is subsequently little agreement about the physical reality of the space. Performing tele-presently with Virtual Director meant performers and audiences could immediately understand where the scene was taking place, alleviating much of that cognitive burden.

4 Discussion and Conclusions

One consideration is that our system de-centers the place of the actors on the digital stage. No longer is there a human front-and-center, but rather, there is a window (sometimes quite literally a digital window) within which performers are co-located. This has a potential to shift the audiences focus from the acting and emotion of the live performer to the technological choices that are supporting the experience. While this risk is real, we have found that the balance enables us to explore mixed human-machine storytelling in a way that would otherwise not be possible. That is, we are able to have humans and machines perform scenes together and it 'looks and feels' similar to having two humans perform

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[10]https://richmix.org.uk/events/rosetta-code/

together. This delicate balance on the cusp of the uncanny valley is a fun and playful experience for performers, and it allows us to tell stories that are otherwise more demanding on the audiences' suspension of disbelief.

Once we assemble again in a post-pandemic world, we will keep the tele-immersion and translation tools to create mixed-presence connected international shows. What we aimed to do with our Virtual Director work was not to repeat or replicate the experience the interactive and embodied experience in a shared theatre setting. Rather, we aimed to augment the creativity and storytelling capabilities of human performers with technology that can be used in multiple settings (Mirowski and Mathewson 2019).

These tools will enable the next generation of on-site improvisational theatre as well. Performers will be able to build immersive lighting, visual, and audio experiences in the moment, and from the stage. Audiences will be empowered to immerse themselves in the collective creation of the show through textual interaction, through their voices, or even by moving around the space. These platforms are built in such a way that they can easily be adopted by improvisational theatres anywhere on earth. We are already sharing this technology with other performers around the world. These groups have engaged with out platforms to enable their shows. This global impact is a testament to the impact of platform development. Finally, as we slowly and cautiously migrate back into the theatres, our technologies will continue to enable live theatre experiences in novel and immersive ways.

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5 Appendix 1: REVIEW: Improbotics Online, Paris Fringe 2020, 4/5 Stars

This review was posted to BingeFringe.com June 7, 2020 and is authored by Jake Mace.[11]

In events reminiscent of a mix between a Franz Kafka novel and an episode of Black Mirror written on an acid trip, Alex the Artificially Intelligent Avatar has joined an improv troupe. Alex's automatically generated lines are slotted into the architecture of stories created by audience suggestions through a website. These suggestions are then beamed back to YouTube in the style of a Raoul Hausmann collage as the bodies of the improvisers are inserted into different backgrounds by virtual director Boyd Branch.

Improbotics Online was split into 3 sections. In the first, Alex is inserted directly into the scene, creating some incredibly surreal interaction between a photorealistic AI cat and a man who just wants to swim. In the second section two-hander scenes are played out by the improvisers but one's body is inhabited by Alex, becoming a "Cyborg" and only speaking lines generated by the robot.

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[11]https://bingefringe.com/2020/06/07/review-improbotics-online-paris-fringe-2020/

Possibly the most entertaining section of the show took the form of a narrative across many scenes where one of the improvisers was a "Cyborg" and the audience has to guess which. This led to a hysterical moment where in the middle of an intense scene about a woman who suspects her boyfriend has been cheating on her while he's at the gym, improviser Harry Turnbull (seemingly inhabited by Alex) blurts out the line "The number of troops in Afghanistan in the past three years has risen directly in tandem with President Obama's strategy."

Other standout lines from the AI include "I'm your Mum, you're my Brother, what do you think of my Dad?" and "I'm an alcoholic, so I don't mind." Alex, either intentionally or unintentionally, seems hellbent on disrupting any scene that they are dropped into the middle of.

The translation of the stage show into an online performance was not entirely seamless – however I do not feel it is important to mark Improbotics Online down for this, as a lot of the witty and interesting moments occurred during the slight awkward panic of being live and online. If anything, the online show seemed to thrive on the anarchy that the format provided. All of the performers showed excellent form to carry the show through despite being scattered all over the world.

Live suggestions from the audience were integrated into the show's last segment and the performers seem to feed perfectly off of these as well as bouncing around Alex's chaos-bringing presence. The narrative of this final segment took many surprising turns. It eventually landed on the story of a grunt being sent by a wizard to find him a Scandinavian wife as he had turned his previous girlfriend into a Pumpkin Spiced Latte while in the Starbucks queue.

His quest leads us to a woman who still bathes with her forty one year old adult son. On their first date, the wizard gets cold feet and turns himself into a cat, before through a number of tangential encounters lead us back to some sort of conclusion.

The implementation of the AI into these traditional Improv troupe games is genius and the pace of the event doesn't skip a beat, even in between the monumental technical efforts undertaken to splice each player into a scene. This is exactly the kind of response that the creative world will have to look towards as we continue to learn to live with the current tricky situation regarding lockdowns and restrictions on how readily artists can perform together and in front of live audiences.

Overall, the show was raucous fun, pure anarchy and a dystopian vision of an Artificially Intelligent future where the Turing Test might be decided by how readily you can hold back your views about the deployment of US troops into the Middle East.

Improbotics Online is not to be missed this Paris Fringe. A second performance will be held on the Paris Fringe Youtube Channel on the 21st June 2020 at 21.30 Paris Time, for absolutely free. You can read more about future Improbotics performances on their website.

Appendix F

Publication: Tele-Immersive Improv: Effect of Immersive Visualisation on Rehearsing and Performing Theatre, ACM SIGCHI 2021.

Tele-Immersive Improv

Effects of Immersive Visualisations on Rehearsing and Performing Theatre Online

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CHRISTOS EFSTRATIOU, University of Kent, United Kingdom

PIOTR MIROWSKI, Improbotics, United Kingdom

KORY MATHEWSON, Improbotics, Canada
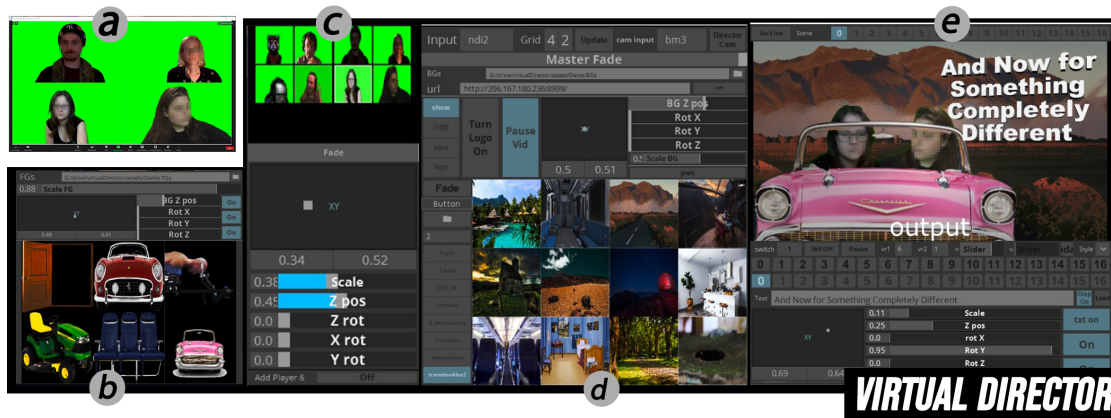
PAUL ALLAIN, University of Kent, United Kingdom

Fig. 1. Virtual Director GUI, 2020: *(a) Zoom screen capture, (b) FG select, (c) Player select, (d) BG select, (e) Preview*

Performers acutely need but lack tools to remotely rehearse and create live theatre, particularly due to global restrictions on social interactions during the Covid-19 pandemic. No studies, however, have heretofore examined how remote video-collaboration affects performance. This paper presents the findings of a field study with 16 domain experts over six weeks investigating how tele-immersion affects the rehearsal and performance of improvisational theatre. To conduct the study, an original media server was developed for co-locating remote performers into shared virtual 3D environments which were accessed through popular video conferencing software. The results of this qualitative study indicate that tele-immersive environments uniquely provide performers with a strong sense of co-presence, feelings of physical connection, and an increased ability to enter the social-flow states required for improvisational theatre. Based on our observations, we put forward design recommendations for video collaboration tools tailored to the unique demands of live performance.

CCS Concepts: • **Human-centered computing** → **Computer supported cooperative work**; **Collaborative and social computing theory, concepts and paradigms**; **Interactive systems and tools**.

1 INTRODUCTION

A growing use of video conferencing tools for remote collaboration in the performing arts presents a compelling opportunity to explore how theatre pedagogies and performance can be meaningfully practised remotely — a need amplified by the current Covid-19 pandemic [Painter and Qiu 2020]. Popular video conferencing tools being used by performers, however, have been generally designed to meet the needs of remote business and education which do not take into consideration the unique collaboration demands of teaching, developing, and performing theatre when each actor is isolated from the others [Lewis 2020]. While there have been many experiments over the last few decades into the potential of remote collaboration tools for building performance [Wake 2018], few have directly examined how specific types of remote video collaboration affect an isolated actor's experience of rehearsing and performing with others. Our study is the first step towards filling this gap in existing research on immersive communication for live performance.

'Live-to-Digital' is the U.K. entertainment industry's term for a 'live performance, event or experience captured and distributed digitally, through television, cinema, or online' [Reidy et al. 2016]. Prior to the pandemic, the term 'Live-to-Digital' generally implied that stage productions would be captured and broadcast live for digital spaces. There are for instance, no examples of theatre involving remote actors collectively performing together for digital spaces in any of the biennial reports by the the Arts Council that began analysing the industry in 2016 [England 2018; Reidy et al. 2016]. To rehearse and perform exclusively through screens is a different experience altogether from adapting stage productions for streaming digital experiences. Improvisational theatre is particularly affected by the technical limitations of remote performance, as performances rely exclusively on an improviser's ability to react in real-time to the behavior of others [Pressing 1984].

Improvisation in theatre is a rehearsal tool, a process for creating new work, and a genre of performance [Frost and Yarrow 2015]. As a genre, *'it is a form of live theatre where artists perform real-time, dynamic problem solving to collaboratively generate interesting narratives'* [Bruce et al. 2000; Johnson-Laird 2002; Magerko et al. 2009; Mathewson 2019]. Improvising involves engaging a cognitive state called *flow* described by psychologist Mihaly Csikszentmihaly as *'an almost automatic, effortless, yet highly focused state of consciousness'* [Csikszentmihalyi and Csikzentmihaly 1990]. Improvising and entering into flow in performance require collaboration that is supported by a deep awareness of the presence of others [Zaporah 1995]. Improvisers rely on constant verbal and visual feedback from scene partners and audience members to construct a shared reality. It is through this feedback that improvisers can synchronize around invented relationships that appear so cohesive they *'lose their* fictitiousness *of time and place'* [Cynkutis et al. 2014]. The visual environment of the improviser therefore plays an integral role in the ability to perform.

Currently the most popular video communication tools enabling theatre during the 2020 pandemic include Zoom and similarly functioning business conferencing tools like Skype, WebEx, Microsoft Teams, and Google Hangouts [Melendez and Melendez 2020]. These tools allow anyone connected to the internet with a computer or mobile device to transmit video to remote partners in various arrangements from grids to 'speaker view' layouts that highlight individual video
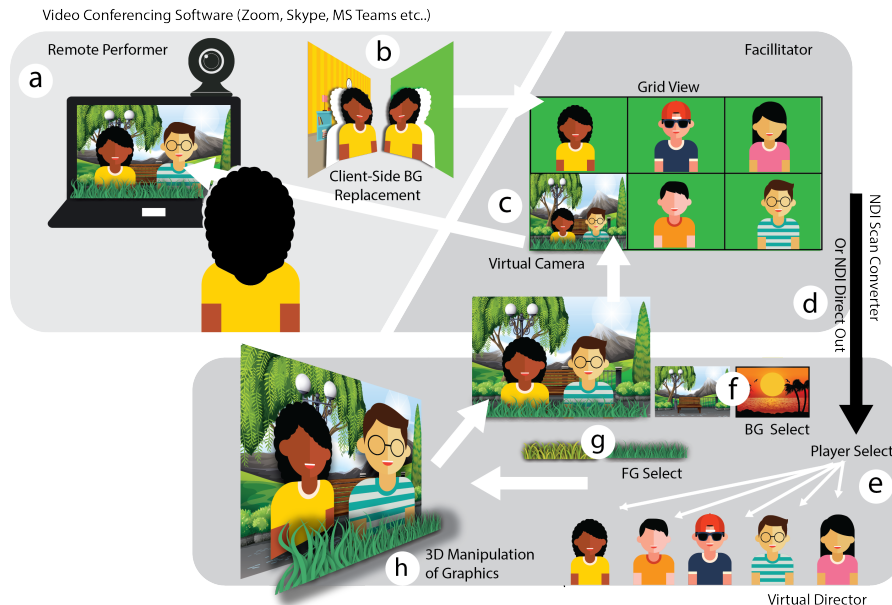
Fig. 2. System overview, Virtual Director 2020: *(a) Isolated performer connects via client software, (b) Background segmentation is performed by client software, (c) Performer sees a video of themselves co-located with partners in virtual space, (d) NDI macros supply client video to Virtual Director, (e) Automatic separation of video call participants, (f,g) Virtual Director selects background and foreground assets for compositing, (h) Each asset appears as a 3D object that can be rotated, scaled, faded, and positioned dynamically.*

feeds [Singh and Awasthi 2020]. 'Zoom Fatigue' is a popular term referring to how the *'inability to read body language'* when video conferencing, time-lags, and a split focus across screens *'interfere with our normal, instinctual and finely-tuned way of communicating'* [Morris 2020]. Zoom fatigue is particularly disruptive to improvisers who rely so heavily on body language and a shared sense of presence. With the very recent exception of Microsoft Teams which released 'Together Mode' [Rae 2020] in July 2020, there have been few opportunities for isolated performers to improvise through an immersive visual environment.

While software exists for specialists to design immersive digital experiences for a particular production, there are no immersive communication tools generally available for the isolated actor to *rehearse and build* performances themselves [Allain 2019; University 2020]. Even Microsoft's new 'Together Mode' falls short of enabling immersive theatre collaboration, as it restricts users from relocating position, customizing or changing backgrounds, and locks them into lecture hall or conference table environments. These video conferencing systems designed for business and education nevertheless have been the most accessible instruments for socially-distant performers. It is therefore important and timely to explore the potential of augmenting these tools with more immersive, dynamic, and flexible visual environments that can address the unique demands of improvisation and analyse how these design features affect performance.

We address this need with a field study of professional actors rehearsing and performing improvisational theatre in isolation using a novel system for tele-immersion. We present Virtual Director, a program developed by the researchers for this study that augments video conferencing services such as Zoom or Skype by extracting individual videos and

compositing them into a shared virtual space. We validate this system through extensive qualitative analysis with 16 domain experts. We present details of the analysis including a diverse set of quotes from the performers regarding components they embrace and found friction in. We synthesize qualitative feedback into 3 clear and actionable design recommendations to future theatre. We conclude by proposing how the future of tele-immersive theatre might proceed to benefit performers, audiences, the environment, and society as a whole.

2 RELATED WORK

Our research is related to previous studies on user experience of collaborating inside a shared virtual environment, as well as studies of immersive communication for theatrical performance. While many different forms of remote collaboration have been researched in the past [Balakrishnan et al. 2008; Furness 1995; Heldal et al. 2007a; Tanner and Shah 2010; Teo et al. 2019], user experience of 'tele-immersive' systems that feature the ability for performers to remotely collaborate and perform inside a shared virtual environment from their individual homes has not been studied. Most research related to theatrical performance inside shared virtual environments in particular, have relied on the use of virtual reality headsets or large scale immersive display systems [Hartmann and Fox 2020; Heldal et al. 2007a]. Subsequently most of these studies have been carried out in studios and laboratory settings dependent on having the performers still physically co-located to some degree. Studies of productions featuring telepresent theatre have been largely focused on audience experiences or dramaturgy [Wake 2018; Webb et al. 2016]. Recently however, performers in unprecedented numbers have been engaging in remote rehearsal and performances outside of studios and laboratories [Soloski 2020]. Our study appears to be the first to examine actor experiences of performing remotely with other actors from their homes.

2.1 Tele-Immersion

Our study builds on research that has analysed user experiences of collaboration in virtual environments [Earnshaw et al. 2001; Heldal et al. 2007a] and studies of presence in virtual worlds[Hartmann and Fox 2020]. An early experiment in 1991 demonstrated the immersive potential of mixing live captured video with 3 dimensional environments reporting that out of 160 participants using a system placing chromakey extracted video of their bodies into a virtual world, *"71% of those who tried the demos considered the 'being on the screen' to be their real self."* The study went on to report that respondents described feeling both physical and emotional responses when they touched animated graphical objects in these worlds [Heeter 1992]. In 1996 the term 'Tele-Immersion' was born when researchers at the Electronic Visualization Laboratory (EVL) used it as the title for a workshop on 'networking, virtual reality, and collaboration' [Leigh et al. 1997]. Most of the developments in tele-immersion have been related to 'expanding the boundaries of computer vision, tracking, display, and rendering technologies' for computationally expensive displays of complex 3-dimensional geometry [Glasenhardt et al. 2003; Park et al. 2000; Sidelnik et al. 2009]. The experience of feeling present in a virtual space however is not dependent on accurate 3-dimensional representations of physical space as the early experiments with background segmentation and projection have shown. Instead, chromakey background removal was all that was required to provide a convincing illusion of being in a shared space [Heeter 1992]. Advances in computer-vision have allowed popular video-conferencing platforms to perform real-time adaptive background segmentation without the need for users to have access to complex studio lighting and chromakey environments [Kauff and Schreer 2002]. This feature makes a 2D form of tele-immersion in a virtually 3D space a possibility for any video conferencing platform. Microsoft Teams, however, is the only service currently providing some tele-immersive functionality publicly and this service was released after our study [Rae 2020]. Without the accessibility of tele-immersive platforms for the

public, there have been few opportunities to explore how a shared virtual environment affects remote collaboration in real-world environments generally, let alone how it might affect actors rehearsing and performing online. The decades of research of tele-immersion systems nevertheless clearly demonstrates that when users have been able to see themselves co-located, they have experienced an enhanced sense of presence over dislocated video interfaces, as well as increased productivity [Curry 1999; Kuksa and Childs 2014; Leigh et al. 1997].

2.2 Performing Telepresently

In the digital and performing arts, there has been some research into performing telepresently, but most of this research has focused on the development of technology, dramaturgy, or the audience experience [Dixon and Smith 2007; Wake 2018]. There has been some research involving dance and tele-immersion, investigating how the time delay between dancers interacting tele-immersively impacted synchronicity [Kurillo et al. 2008; Yang et al. 2006a,b]. Most recently, researchers in theatre have carried out a study on the rehearsal process and performance of a theatrical production between two remote groups. This study however focused on the use of life size projections of remote partners and the telepresent collaboration between two physically co-located groups [Gorman et al. 1910]. To the knowledge of the researchers, no study has ever explored the impact of virtually co-locating performers who each performed remotely from home.

2.3 Improvisation and Flow

Improvising for the theatre is a cognitive process where *'in present time a path is opened to your intuition, closing the gap between thinking and doing'* [Spolin 1963]. This definition, laid down by one of improvisational theatre's early theorists, Viola Spolin, has been further nuanced by psychologists and cognitive scientists as a distinct mental process identified by the shift of neural activity within the prefrontal cortex [Limb and Braun 2008]. Key to understanding the experience of this cognitive shift is psychologist Mihaly Csikszentmihaly's 'nine dimensions of flow' [Csikszentmihalyi and Csikzentmihaly 1990]. In designing our study we considered his nine dimensions of flow to help us evaluate the experience of our participants. The nine dimensions of flow have been used as a tool for evaluating improvisational performance by a number of researchers in the past [Douse 2013; Gruzelier et al. 2010; Keeler et al. 2015]. The dimensions are summarised as (1) an equal balance between challenge and skill level, (2) a merging of 'action-awareness' or being fully absorbed in the moment, (3) a clear sense of purpose, (4) direct and immediate feedback meaningful to the task, (5) the ability to concentrate on the task, (6) a sense of control, (7) a loss of self-consciousness, (8) a distorted sense of time, (9) being an *autotelic* or intrinsically rewarding activity. [1] These dimensions became meaningful as we analysed the experience of the improvisers engaged in remote performance and were useful touchstones for our qualitative study.

3 EXPERIMENTAL DESIGN

3.1 Research Questions

The focus of our qualitative study was to capture a broad range of experiences related to performing within a dynamic tele-immersive environment actors could easily access from their homes. For the purposes of this study we defined the core design features enabling a tele-immersive environment as those facilitating: *1) The placement of participants in a shared virtual environment. 2) The ability to dynamically replace objects in the virtual environment in real time. 3) The ability to re position participants and objects inside the 3D environment in real time.* We posed several questions

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[1]https://theflowcentre.com/9-dimensions-to-flow/

Fig. 3. Virtual Director System Overview: *(a) GUI, (b) MIDI Controller, (c) Player Crop, (d) 3D Environment, (e) GLSL Style Macros*

related to core improvisational concepts that we theorized would be directly affected by the visual environment of the collaboration tool:

- *Does performing in isolation with others tele-presently help them feel connected to remote partners?*
- *Do tele-immersive environments affect actors' abilities to enter flow states while improvising?*
- *To what extent do virtual environments contribute to the creative experience of improvsing?*

This theoretical framing served as a guide for designing the features of our software, as well as developing activities we thought would be conducive to engaging in the unique collaborative experience of improvisation.

3.2 Virtual Director

Virtual Director[2] is compositing and video switching software we built to explore how existing video conferencing tools could be generically enhanced with tele-immersive features to facilitate rehearsing and performing theatre. The tele-immersive environment is generated by running scripts that isolate individual video feeds and perform chromakey background segmentation from each participant's video. These isolated video feeds can then be positioned as 2D planes inside a 3D environment arranged by an operator in relation to selectable scenic elements in the space. Each object (including the performers) can be dynamically displaced, scaled, and rotated to simulate an appropriate sense of scale and depth between performers and the environment whether they are seated or standing or positioned in different proximity to their cameras. Scenic elements can be dynamically replaced or changed with other objects available from a library of stored graphical elements.

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[2]To broaden the scope of our research we have released an open source version of Virtual Director which we hope others interested in tele-immersive performance can use and adapt to further explore the potential of this platform. The software can be accessed at: https://github.com/Geitenkaas/VirtualDirector_app.

Virtual Director was built inside of TouchDesigner[3], *'a node based visual programming language for real time interactive multimedia content'*. TouchDesigner natively supports capturing and streaming ®NDI[4] video feeds which allows us to seamlessly work with various video conferencing tools. We designed the program to remotely supplement the existing conferencing tools our subjects had available *(Fig. 2a)*, avoiding the need for participants to download or install additional software. Since many of our subjects participated from work laptops, they were often locked in to using their company's chosen video conferencing tool and we wanted to make our study as accessible as possible. The program captures and separates video from conferencing tools like Skype[5] which provide ®NDI feeds for each participant *(Fig. 2d)*. With conferencing tools that do not provide discrete ®NDI video channels for participants, macros are launched to perform a screen-capture using ®NDI Tool's 'Scan Converter' of the video conferencing interface that Virtual Director automatically crops and separates into individual performer video feeds *(Fig. 3c)*. Each feed has its own chromakey functions that can be adjusted in real time for fine-tuning background segmentation. The user interface presents an operator with a grid of players and controls to dynamically select, switch, and manipulate the segmented performer videos inside a three-dimensional space *(Fig. 1)*. The interface also provides the user with interactive menus to load folders of images, videos, or 3D meshes to populate the virtual environment of the performers *(Fig. 1b,1d)*. Virtual Director stores up to sixteen scenes that are updated synchronously during performance or in the background asynchronously to support dynamic scene transitions. To facilitate real time interaction and response to the spontaneous behavior of the improvisers, the software is controllable via any attached musical instrument digital interface (MIDI) devices so that knobs, sliders, and buttons manipulate scenery and performers *(Fig. 3b)*. Virtual Director therefore allows the operator to improvise along with the performers by altering backgrounds, foreground elements, and positions of the performers based on their suggestions. Six custom OpenGL[6] shaders are available for real time color grading and visual effects that style performers into 'cartoon-like' renderings *(Fig. 3e)*. Virtual lighting and camera positions can also be freely adjusted for each scene.

3.3 Methodology

In designing our study, we adopted a grounded theory approach focused on collecting qualitative data through close observation of user behavior, interviews, and surveys. Our experimental methodology was informed by the insights of Sarker et al.(2000) who argue that the study of virtual teams should begin *'inductively, based on the collaborative experiences of virtual team members and the meanings they attribute to the virtual experiences'* [Sarker et al. 2000]. The grounded theory approach is ideal when *'organizational forms are so novel'* from other forms they *'cannot be easily translated or directly extended to understand or explain phenomena pertaining to the new forms'* [Sarker et al. 2000]. Performing tele-immersively is different from physically co-located performance on a number of levels, making grounded theory the most appropriate methodology for this study.

Performing online, however, also provides a unique opportunity to examine theories related to improvisational performance that are more difficult to measure in traditional environments. Several studies related to immersive communication in the past have already demonstrated that tele-immersive experiences can provide a significant sense of presence and connection with remote partners [Heldal et al. 2007a]. Many improvisational theatre pedagogies in turn argue that live performance is dependent on an immediate sense of co-presence. While our main research focus was to

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[3]https://derivative.ca/
[4]https://ndi.tv/tools/
[5]https://www.skype.com/en/content-creators/
[6]https://www.khronos.org/opengl/

develop theories related to tele-immersive improvisational performance as the data emerged, we remained mindful of the potential connection between these existing theories and the participants' experience.

Our experimental design was therefore aimed primarily at the discovery of theories that could be tested with follow up research. By immersing ourselves in the data generated by this field study and generating theories based on the re-occurring themes and insights, we hoped to 'guard against imposing a theory' related to how a particular feature of tele-immersion might have salience which 'may not actually match the patterns in the data' [Glaser and Strauss 2017].

3.4 Field Studies During a Pandemic

As a field study our research was focused on tele-immersion that could be accessed by individuals at home who may have limited access to various types of hardware and software configurations and inconsistent access to internet services. The study was conducted during national lock-downs across Europe while strict social distancing measures were in place [Office [n.d.]]. Due to these variables, the researchers made efforts to adapt the study to meet the emergent needs of the participants by being flexible with study duration and frequency. Subsequently rehearsal periods and frequency of meetings were highly variable. Additionally participants were encouraged to explore the possibilities of tele-immersion by adapting their existing skill set as improvisers to the virtual environment. As a result there was a high degree of variability in the types of exercises and formats explored by individuals and groups. Nevertheless, the results can be generalized as each participant effectively used the system in the same way: in isolation from other partners and observing themselves in the virtual environments. Our findings therefore are generalized to the broad experience of improvising tele-immersively and not directed at the performance of any particular activity.

3.5 Data Collection

The Research Ethics & Governance Board at the University of Kent granted approval for the collection of audio-visual and survey data proposed by our study. Consent was solicited from participants for use of their data during the study. Data was recorded of participants during remote rehearsals and performance in the co-located virtual space. Additionally online surveys were conducted after each session and semi-structured interviews were held with participants after the study. Interviews were conducted through Virtual Director and consisted of a series of general open-ended questions regarding their experience of the software and their experience improvising. Rehearsal periods lasted between 90 and 120 minutes. Initial rehearsal periods focused on configuring hardware and software remotely and finding the best environment for interaction. Participants were instructed to wear brightly colored clothing that contrasted with colors in the background, position lighting to optimally expose the face and body, and arrange the perspective of the camera to facilitate capturing as much of the body as possible. Rehearsals began with a variable series of games and activities commonly used in improvisational theatre training that were adapted for the constraints of the tele-immersive environment.

3.6 Translating physical exercises for virtual experiences

Theatrical improvisation is guided by a few basic techniques that must be learned and regularly practiced for partners to spontaneously and convincingly construct stories and relationships. The entire enterprise is based on the ability of performers to immediately agree to an emerging reality between them. The given circumstances of real life that are generally taken for granted (where we are, what time it is, who we are, who are we with) have to be made up on the spot in improvisational theatre. There is a natural tendency however, for actors to reject contradictions to their perceptions of reality, instinctively blocking the 'creative' ideas of others that may interfere with that reality [Johnstone

2012]. Therefore improvisers usually 'warm up' before performing by practising the acceptance of offers, and in turn building upon those offers (popularly referred to as 'saying yes and'). Secondly improvisers must engage an altered cognitive state that is distinct from ordinary rational cognition [Scheiffele 2001]. Improvisers learn to bypass confusion and avoid disagreement by playing games that require automatic agreement and rapid responses to the behavior of others. Lastly, improvisational theatre is ultimately dependent on tight collaboration, so performers must become acutely aware of the nuances in behavior of their partners as well being able to make verbal, physical, and gestural offers that will contribute to the veracity of the relationships and story. The tele-immersive environment limits the kind of games and activities that can be performed together, but it also adds features to the collaboration not typically possible in traditional environments including dynamically changing backgrounds and the possibility of a broader range of physical relationships (through the scaling and re-positioning of the video feeds). We therefore designed games and activities inspired by traditional improvisational training and adapted to the virtual space. Our primary aim with the initial activities was to see to what extent we could help the improvisers feel fully embodied in the virtual space and be responsive to the physical and verbal behavior of their partners.

3.7 Facilitation

Improvisational theatre is generally rehearsed with a facilitator or director who takes responsibility for warming up the players, guiding the various games and activities decided upon, and standing in as a proxy for the audience providing feedback to the performers when they practice scene work. In order to maintain consistency in instruction as well as technical execution of the virtual environment, each session was facilitated by the same improvisation specialist who is also a lead developer of the software. Facilitation required both technical proficiency with the experimental digital interface as well as an understanding of the traditional rehearsal practices of professional improvisers. Having both technical knowledge of the software and improvisational expertise meant the facilitator could quickly adapt the visual environment to match the spontaneous narratives being generated by the performers.

3.8 Activities

While our system was capable of interfacing with any video conferencing tool, Zoom[7] was selected for conducting the study based on its accessibility and widespread use amongst our participants. Each study began inside a Zoom conferencing interface with the facilitator helping the participants optimize their hardware for background segmentation and ensuring participants could safely move around the space. Participants were instructed that they could stand or sit based on their available space, hardware limitations, and comfort levels. All participants experimented with standing and sitting, and generally preferred to stand when their physical environment allowed.

Once the participants arranged their performance environment, they were instructed to select the facilitator's video feed and maximize it on their screen. The participants then saw themselves composited into a shared virtual environment and were invited to spend a few moments exploring the space. After a period of 5-10 minutes the participants were invited to engage in a series of games and activities (*Fig.4*) they were told would help them acclimate to the virtual space and explore the possibilities for improvisation.

The order of games and activities sometimes changed with different groups and based on how many times they had previously engaged with the tele-immersive space, however they generally followed a progressive order beginning with different kinds of virtual physical engagement, and then proceeding to games of spontaneity and active listening. The
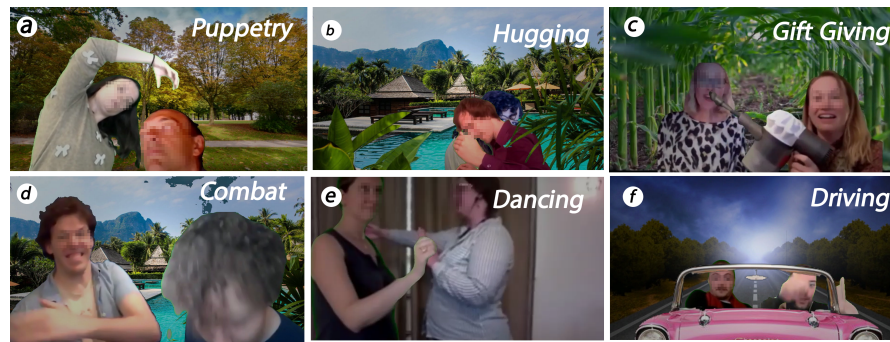
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[7]https://zoom.us/

Fig. 4. Examples of tele-immersive improv training: *(a) p3 'controls' p4 movements, (b) p5 and p6 practice hugging, (c) p1 and p2 give each other gifts, (d) p7 and p8 practice combat, p9 and p10 virtually dance, (f) p11 and p12 simulate driving.*

games were structured around fostering awareness of their own bodies in virtual space, awareness of their partners bodies, exploring three dimensions of a two-dimensional screen, responding to the backgrounds, and finding flow and rhythm with each other.

3.9 Performing

After each period of warming up with the adapted games and activities, the participants were instructed they would be practising a *long-form* [8] format with dynamically shifting backgrounds. For initial rehearsals, participants were invited to perform a popular format called *'montage'* [Center 2017] consisting of six or seven short scenes inside different virtual environments connected loosely by a theme. The montage format is a popular training tool in theatrical improvisation that tests the basic skills of any improviser. Participants were instructed they were free to perform a 'montage' or adapt their own format for a public audience at the end of the study. We note however, that performing publicly introduces several variables including whether performance is streamed or presented in a video conferencing environment, audience integration and feedback during performance, and how multiple performances are structured together as part of an event. Therefore the scope of this initial study is limited to the experience of practicing and rehearsing in the tele-immersive environment without an audience.

3.10 Coding the Data

Audio from rehearsals, performances, and interviews were transcribed using Google's transcription service and then corrected by hand against the original recordings. These transcriptions were coded along with open text responses input online by participants after each session. Initial codes were assigned based on our guiding research questions regarding 'flow', 'presence', and 'embodiment'. Subsequent codes were added based on frequency of sentiments shared by multiple participants. The following seven categories emerged as salient for the broadest range of participants and useful for guiding future research and practice: *Enjoyment, Creativity and Collaboration, Immersion, Presence and Flow, Embodied Performance, Distractions, and Scenic Inspiration.*

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[8]Long-form improv is a continuous series of scenes inspired by a word or phrase.

3.11 Participants

A total of 16 professional improvisers participated in the study. The study included five volunteering 'duo' teams (p1-p10) and one ensemble group of six players (p11-p16). Volunteers for the study were solicited through advertisements posted on social media sites and European improv forums. Improv teams were required to have been performing publicly together for at least one year and have access to a mobile device or computer that was capable of video conferencing. The five duo teams were selected from 24 applicants based on schedule availability and diversity of experience improvising. The ensemble team is directed by two of the authors and had been solicited previously by the researchers during the initial testing of the software. Due to the small sample size of only one ensemble group, this study is not focused on the differences between group sizes. Instead we focused on the generalisable experience across all participants.

Participants were located across cities in Europe and the U.S. including Belfast, Antwerp, New York, Montreal, London, Brighton, and Canterbury. 9 of the participants identified as female, and 7 as male. All participants identified as white. The average age of participants was 30 with the youngest 25 and the oldest 37. Participants had been performing improvisational theatre professionally for the public on average for 6 years, with their experience ranging from minimum of 2 years and maximum of 10 years of public performance.

4   RESULTS

"I hope your experimental design is just they spend the whole time laughing at how much fun it is (p3)."

4.1 Enjoyment

Performing just through video conferencing tools appears to have presented cognitive barriers to enjoyment that were resolvable through tele-immersion. Throughout the study, participants reported on their general enjoyment of performing inside the shared virtual space. In between warm up activities as well as between improvisational performances, in survey responses, and during interviews, all 16 participants described interacting in the tele-immersive space positively. Enjoyment was inferred with descriptions of the experience as being *'fun (16)', 'enjoyed (13)', 'exciting (11)'* , and *'amazing (10)'* – where the number in brackets shows the number of participants that made relevant references. The addition of a shared virtual environment to the existing conferencing platform they had been using for performance earlier translated for five participants as a *"new medium"* entirely. Additionally, a sense of joy was described by seven participants in the context of earlier attempts at performing with the same tools but without a tele-immersive environment. One noted, *"it's been a lot of fun to play virtually in a way that I was really struggling with before,"* explaining that with Zoom, *"it is difficult to fabricate a world that you're all supposed to be in when you're limited by the background of individual homes (p4)."* This idea was echoed by other participants, describing *"there's a freedom of play that exists in being visually in the same location that unfortunately is hard to create when you don't have access to (shared) backgrounds (p3)."* Being co-located in the same virtual space appears to not only have contributed to a joyful interaction between participants, but also contributed to the emergence of flow states and creative inspiration as described in the following sections.

4.2 Creativity and Collaboration

The experience of creativity in improvisation often has less to do with having interesting ideas than it does with being able to discover interesting contexts for what your partners are doing and saying. The feelings of being creative described by five participants were associated with the enhanced feeling of connection with their scene partners: *"It*

was really joyful and fun, in a way that online improv hasn't been for me yet- I felt really together with my partner even though we were only together on the screen (p11)." Connecting creativity with collaboration makes sense as the creative outputs of improvisation are uniquely collaborative in nature as opposed to scripted and solo-performance. The feeling of having a restored connection with remote partners was cited by twelve of the sixteen participants throughout the study and appeared to translate back into their improvisational work. Four participants identified how the environment specifically facilitated narrative cohesion: *"The ability to be in the same virtual space as my partner allowed us to fully agree where we were (p12)"* and *"I find the scenic view, seeing the whole picture, helpful in making choices within the scene and also in using my body and physicality to enhance the feeling of connection and presence (p13)."* Rather than seeing performing online as a concession, some began to see it a distinct medium with fresh possibilities: *"We're getting to do stuff that actually wouldn't be possible in this same way in a normal improv show (p3),"* and *"the technology brings something different to an improvised scene, which you couldn't normally do in real life (p6)."* The ability to be different sizes on screen and in dynamically changing physical relationships was particularly salient for many in thinking about tele-immesive improv as a new medium. Three participants described feeling like they were in a cartoon or fantasy movie: *"you can be a sponge that lives under the sea, you can be a mouse who lives in a castle (p5)."* Others described how the feeling of creativity experienced during the sessions carried over the following day: *"I'm still processing...I woke up this morning feeling creatively invigorated with loads of ideas... seeing my scene partner next to me and with virtual physical contact had an impact on me psychologically (p14)."* The deep feeling of immersion and co-presence experienced by participants confirms earlier studies of immersive communication [Heldal et al. 2007b] but has particular relevance for live performance that benefits from actors entering into flow states with each other.

4.3 Immersion, Presence, and Flow

Of note is how participants connected the immersive space with an enhanced ability to improvise and perform. The connections between feeling immersed and performing better improv correlates with many of the nine dimensions of flow described by Mihaly Csikszentmihalyi [Jackson and Eklund 2002]. The experience of immersion was particularly acute for some: *"everything expanded into my space because I felt like there was some kind of relationship between me moving into the screen and the screen moving out to me- and there was some kind of middle ground that was found between those two things (p6)."* The immediacy of this described 'middle ground' bringing awareness into the current moment speaks to the merging of action-awareness essential for flow. *"The ability to be in the same virtual same as my partner allowed us to fully agree where we were- then we quickly got into the flow (p12)."* The joy and sense of presence described earlier also speaks to the autotelic experience performers felt improvising as well as the merging of action-awareness. Three participants made direct observations related to warping or losing sense of time and space. *"There were a lot of times I forgot other things were going on around me, what the time is or you know, where we are- how long we tended to be in this for (p5)."* Some of the features of the experience that performers credited for enhanced flow included the ability to focus on a single environment for all the action, noting that *"the backgrounds helped me be less distracted, focusing on the "physical" location of the scene. I worried less about my partner's background and my set up, and I truly felt closer and more connected with my partner (p15)."*

4.4 Embodied Performance (getting physical)

"We haven't improvised or seen each other in the real world for 3 months now (p3)."
    The image of oneself in Virtual Director is not quite a mirror, as there inevitably is a slight delay in the movement, but perhaps more significantly the body is often placed larger or smaller than would be natural, or inverted, turned upside
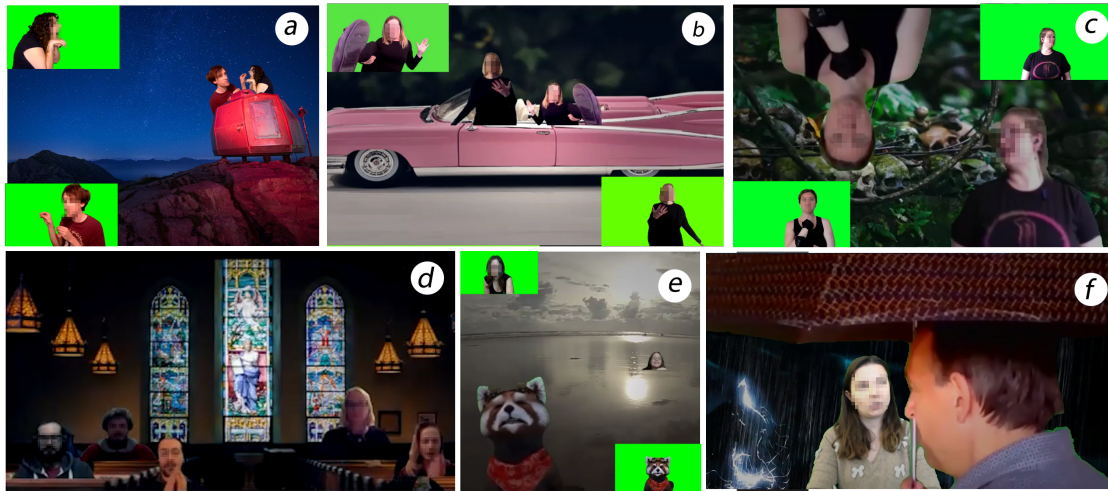
Fig. 5. Players interact with virtual environment and each other. ***Dialogue excerpt (a):*** *p1: You can see for miles around. p2: Yes, you can see that there are no more humans, that's a bit sad. p1: You want that? You want some more Moss? p2: It's my favorite.*

down, and freely moved about the screen *(Fig.5c)*. Rather than feeling abstracted from their image nine participants referred to feeling a greater sense of their body. Video analysis of performances showed that all sixteen performers consistently reflected what they were seeing on screen back into their physical experience. Many described how the virtual reality directed their physical reality. *"We were passing objects, changing our view so that it looks like we're looking at each other, touching each other's heads (p8)."* In these moments, audio/visual recordings show the participants were actively reaching and grabbing objects, contorting their bodies and heads to animate their virtual selves *(Fig.5b)*. The ability to virtually interact with each other appears to have created a feedback loop where the visual reality caused a change in the physical reality, which led to a new virtual relationship that fed back into the loop. The simulation of touch provoked a visceral response in many; for example, *"the ability to simulate physical contact appeals very much to me. It allows us to be in contact with the other player and allows for more intense scenes (p16)."* The initial experience of seeing themselves co-located immediately inspired physical explorations; one participant described, *"I think I found myself to be a lot more physical in the virtual director. When it's in real life, we don't tend to be too physical (p6)"* In designing the study, we anticipated there would be some physical engagement between performers, however it was surprising to hear the experience led some to feel like they were more physically active than they typically felt during co-located performances. Besides a sense of relief from social-distancing, the increased sense of physical engagement might be related to how performing virtually gave them a safe space to practice intimacy that would be uncomfortable on a physical stage, *" We wouldn't usually kiss like this in real life, we just, we've never done that. So we've done it now in virtual space and that's fine (p5)."* The visceral experiences of the performers when virtually touching one another seems to support the idea that when visual reality is cohesive, cognition will engage to supply a supporting sensual experience to make sense from it.

4.5 Distractions

Though most identified a strong sense of immersion and presence during the study, those feelings could get interrupted. Three participants described moments of being overwhelmed and confused by the environment. *"Sorry, it's just it's not really sticking in my head I think because there's so much going on actually with like all the different scenes and all of this (p1)."* Improvisers often describe falling out of improvisational rhythms as being 'in their head' as opposed to just responding to the moment, and two reported struggled initially with that feeling. For many sessions, reduced bandwidth meant there was a small time delay or 'lag' in the video (60-190 msec). Such lags were described during the initial sessions as *"frustrating"* or *"difficult"* by seven participants, however after more experience with the system five participants similarly observed *"you get a little used to the time lag -like it's weird at first but then it gets to be less weird (p3)."* One participant who struggled initially with his focus in the environment found the more abstracted his video was, the easier it was to connect, *"I am still experiencing some disconnect, and notice I focus on myself a lot still, but stylised filters are helping with that and I am reminding myself to shift focus to my scene partner more often (p11)."* Four participants echoed a feeling of frustration *" when I need to like turn and I can't see the screen any longer (p6)."* Of note, is that this study was carried out with participants utilizing personal media devices with displays ranging from 13 inch laptops to 27 inch screens. The observation that participants felt any immersion even with small displays is nevertheless noteworthy, and demonstrates there are opportunities for further research into how particular training practices can be adapted to the available hardware of the remote performers to minimize distractions.

4.6 Scenic Inspiration From Virtual Environments

The experience of improvising based on visual cues was novel as improvisational theatre is typically performed on a bare stage. In lieu of scenery, improvisers spend the first moments of a scene describing the visual environment either directly or through inference in a practice called 'scene painting.' For the study we designed dozens of various scenic environments ranging from beach resorts to cramped living rooms filled with furniture and knitted blankets. Performing inside virtual environments meant the performers no longer needed to 'paint' the scene verbally. Eleven participants described how tele-immersion not only helped restore the feelings of connection and embodiment otherwise lost in virtual performance, but that it offered something new. *"We're getting to do stuff that actually wouldn't be possible in this same way in an normal improv show (p3)."* A standard trope in improvisational theatre is to solicit suggestions from the audience to inspire the scene. This serves multiple purposes, including to demonstrate that scenes are genuinely being created on the spot, as well as helping improvisers enter the flow dimension of 'merging action and awareness' as they incorporate suggestions into the scenes in real time. The dynamic environments appeared to not only remove the cognitive load of 'scene painting' but also kept participants more directly in the moment as their awareness was being actively stimulated by the environment. The environments were furthermore a significant source of creativity as participants described not feeling as bound to their physical form. Participants took inspiration not only from the designed visual environments, but also from the visual constraints of the system, such as when poor lighting resulted in an inaccurate background segmentation. *"I'm edged with green. I look vaguely like an alien copy of myself, I'm also, like you have normal hands, I have like green mitts. It's it's okay I can use it (p4)."* This acceptance of intentional and unintentional visual cues is an extension of the improviser's primary practise of accepting and amplifying what are traditionally given in live improvisation as verbal offers (saying "yes and"). In figure *5* are some examples of participants interacting with the virtual environments. The scenes demonstrate the wide range of responses to environments and how performers used the environments to infer relationships and dramatic tension.

5 DISCUSSION

Our observations are grounded by a theoretical framework that connects the cognitive effort of improvising with the affective experience of co-presence and social connection through tele-immersion. Our participants reported that seeing themselves virtually next to their remote partners inside a shared digital environment was effective in helping them rehearse and perform remotely. Some participants described how seeing themselves together led to a strong emotional sense of togetherness that made virtual improvisation more enjoyable. Others described how the visually cohesive performance space was less distracting than traditional video conferencing interfaces, and therefore allowed them to focus more on performing. Many participants described getting creative stimulation from the dynamic backgrounds. Participants associated these effects of tele-immersion with the ability to enter into flow states while improvising remotely. In designing our study we initially focused on how the visual environment would affect improvisational activity, theorizing about the potential of 2D compositing of live video feeds inside 3D environments that could be delivered inside existing video conferencing tools on home computers. Our form of tele-immersion appears to have been effective in providing a more immersive and physically engaged experience for users than they otherwise had experienced before; however, after reviewing data collected from the study, we were struck by how improvisational activities in turn might be affecting user experience of the technology and influencing the feelings of connection and immersion. This led us to consider which essential features of Virtual Director could be generalised for others interested in developing their own rehearsal and performance platforms. What follows is a discussion of three design recommendations based on our observations for further developing remote conferencing tools tailored to the unique needs of performing artists.

Recommendation 1: Design platforms that prioritise real time feedback between participants. Virtually co-locating remote performers appears to help them feel more connected to each other while rehearsing, *particularly when they can immediately see how their actions affect their partner.* Our participants described how seeing themselves in the same space led them to feel immersed and connected; however, seeing themselves next to their partners was almost always followed with an unprompted simulation of physical interaction, and expressions of delight in seeing their partners react as if being poked, shoved, hugged, or kissed. As partners engaged in physical interactions they reported losing sense of the 'real' world and in effect identified more strongly with the virtual one. Simulating touch visually is a result of user-driven action that happens both in the real and virtual world. The feeling of being connected with a remote partner appears to be associated with the act of virtual touching among participants, which in turn appears to have stimulated an enhanced feeling of immersion and connection when that touch takes place. Rather than focusing on the quality of graphics or physical accuracy of the environment, live performers appear to benefit the most from the real time physical interactions they can have not only with each other, but also the environment. Of note is that while many participants identified strongly with the virtual reality, virtually none of the participants identified the quality of the graphics as a factor in either feeling more or less immersed. This observation presents an opportunity for further study into how various kinds of simulated touch (or lack of touch) might impact how they perceive the quality of the visual environment, as well as how they perceive the quality of the collaboration.

Recommendation 2: Design interfaces for performers that eliminate the need to split focus between areas of the screen to help foster flow. Improvisers and other live arts performers rely on their ability to be aware of both direct and indirect messages being communicated by others through verbal and nonverbal cues. Developing cohesive and relatable scenes spontaneously requires that improvisers be exceptionally attentive to the physical behavior of their remote partners in order to enter into flow with them. Describing their experience performing with popular video

conferencing tools, participants in our study reported a tendency to shift focus regularly between their scene partners and their own videos which meant they often would lose a sense of flow. Removing visual barriers between performers by placing them in visually co-located environments allows them to simultaneously observe themselves, and how they are affecting their partner as one action. In improvisational training, improvisers are taught to heighten focus on scene partners and rely on intuitive, automatic, and subconscious impulses for their expressive acts. In improvisation there is therefore a need for visual feedback, and so cognitive effort is concentrated on the visual environment that can give the most data about the exchange of information, and visual information outside of that domain is more likely to be discarded. This idea is supported by our observations of participants who specifically described losing sense of the world outside of the screen, and feeling disoriented when looking away, or when their video feed became corrupted from reduced bandwidth. Designing platforms that can minimize visual distractions for performers is therefore crucial in order to allow them to develop cohesive scenes.

Recommendation 3: Design interfaces that can dynamically respond to the actions of participants. The experience of joy, feelings of playfulness, and declarations of fun participants expressed were another phenomenon that appeared to be co-dependent on the ability to see themselves in a cohesive shared virtual space as well as the the nature of the improvisational activities. Theatrical improvisation is an inherently autotelic experience for practitioners who experience joy from the act of collaborative story telling. That joy, however, is dependent on having sensory feedback that is stimulating the collaboration. The tele-immersive platform provided rich sensory data not only from the behavior of the remote partners, but also from the dynamically changing environment, *"if anything the ease of changing the scenery makes for easier immersion in the fictional world we created (p12)."* During the study, participants were aware that the facilitator was closely listening to them because they often found the environment dynamically changing in response to the unfolding scene. For instance, during a driving scene an improviser would indicate they wanted to pick up a hitch-hiker, and they suddenly found the on-screen image of the car had pulled over, or they could express wanting to leave, and they would find themselves being moved off screen only to appear again in another location. The joyful experience of improvising generally emerges when an improviser's expressive act resonates not only with their partner, but also with the audience who is contributing to the emergent stories with their suggestions and laughter. However, feelings of humiliation, awkwardness, and shame are also not infrequently experienced by improvisers when stories do not appear to resonate with partners or audiences appear bored. As several participants expressed in the study, using popular video conferencing tools without Virtual Director had made improvising considerably less enjoyable, likely a result in no small part from the relative sensory deprivation of video conferencing platforms compartmentalized user interfaces. The phenomenon of 'Zoom fatigue,' as described in the introduction, resulting from the inability to read body language, latency, and distracted focus all make it nearly impossible for an improviser to know if what they are doing is resonating with others. In turn the participants in this project took advantage of the visually rich and dynamically changing environments *"You put us somewhere, and that's an enormous suggestion, an audience suggestion really, evident from the director (p3)."* When the visual 'suggestions' from the virtual environment responded to the choices the improvisers made, they were rewarded with a sensation of resonance with the 'virtual director' that became associated with feelings of 'fun' and 'joy'.

Our examination of how improvisational activities affected the experience of immersion leads us to believe that improvisational activities, in turn, might be designed into other remote collaboration experiences beyond the performing arts. We find the visceral reactions our participants described from virtual touch particularly salient while social-distancing mandates are still in place and physical touch is restricted. We believe our findings will be useful for researchers, designers, as well as communication specialists for further exploring how to effectively develop tools to

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facilitate not only other creative collaborations, but to enhance feelings of social connection in business and educational settings as well. As outlined in the introduction, the immediacy of our need for finding ways to rehearse and perform theatre through remote communication tools is amplified in the wake of the current pandemic, but our results show that tele-immersive theatre presents an opportunity to explore new dimensions of creative expression that can only be experienced through virtual environments.

6 LIMITATIONS AND FUTURE WORK

As this study was conducted during a national lockdown our focus was to examine how tele-immersive features might be accessible to performers in a broad range of conditions. We therefore focused our findings on the most generalisable observations of our participants regarding the experience of rehearsing in a visually co-located virtual space. Many variables we could not control for in this initial study likely contributed to the overall experience that we plan to examine in follow up studies. In particular the role of the facilitator operating the software likely influenced how participants engaged with the virtual environments. The various hardware specifications and performance spaces also likely influenced participant experience. In future studies we plan to control specifically for various performance conditions including standing versus seated performance, display size, lighting conditions, and audio interfaces as well as studying how other facilitators would use Virtual Director, and how various features of Virtual Director could be automated. In this study we did not observe any significant correlations between improvisational experience or group size and our results. We believe with larger study sizes however, we may find interesting correlations between these factors that would be useful for guiding development and practice with tele-immersive environments for performance.

During this initial study we had the opportunity to collect some preliminary data on using Virtual Director for live public performance. These observations have highlighted that performing publicly in a tele-immersive environment can introduce several new variables including how the audience becomes integrated into the experience, frequent switching between tele-immersive environments and traditional conferencing environments, and various ways of distributing performance for streaming versus inside a closed video conferencing environment. We aim to investigate the specific aspects of public performance through tele-imersive environments as one of our future research directions.

7 CONCLUSION

We observed in our study that the tele-immersion provided by Virtual Director was a highly effective solution for rehearsing improvisational performance while performers could not meet physically. The features of tele-immersive environments appear to support the findings of Heeter el al (1992) who also observed that users generally identified more strongly with their virtual selves than their real selves [Heeter 1992]. Our form of tele-immersion also appears to address many of the shortcomings of traditional video conferencing tools that make it difficult to keep track of other performers' nonverbal reactions, requires focus to be split between different windows, and disembodies the user. Furthermore, our results showed that the platform facilitated entering into flow states and had considerable impact on feelings of excitement, joy, fun and playfulness. Of note is the immersive effectiveness of placing two-dimensional live video feeds of performers inside 3-dimensional scenic layers rather than capturing and displaying 3-dimensional images of performers, eliminating the need for special hardware or resource intensive computing. These observations support the notion put forward by the 'father of telepresence' Marvin Minsky that telecommunication research should be focused primarily on the experience of the user rather than just the mechanical reproduction of physical experience [Minsky 1980]. By focusing on experience we are motivated to consider the psychological factors that generate social behavior in the context of the available technology for remote communication. There is opportunity for further research into how

improvisational tools can be incorporated into designing immersive communication experiences and improvisational games and activities can be applied to virtual collaborations as a means of priming participants to have more immersive, socially present, creative, and emotionally positive experiences remotely.

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Appendix G

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Mirror Placement Matters in Remote Collaboration

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SINGLE VIEW (NO VIDEO FEEDBACK) **TELE-IMMERSED VIDEO FEEDBACK** **ISOLATED VIDEO FEEDBACK**

Figure 1: Comparison of 3 different user interfaces for tele-conferencing. Left: Single View without a video feedback mirror, Middle: a tele-immersed video feedback view, Right: isolated video feedback mirror, 2022.

ABSTRACT

Video Feedback (VF) in tele-conferences is reported to contribute to 'Zoom Fatigue' (ZF). However, such feedback is important for many remote collaborative tasks where users must be aware of their relationship to the camera. Tele-immersion (TI) is presented as an alternative to traditional interfaces that can mitigate symptoms of ZF while maintaining the benefit of VF. The effects of TI on behaviour are understudied. Therefore, we present the findings of a novel field study of 14 domain experts performing a remote collaborative task—improvisational theatre—under all three conditions: 1) with video feedback (VF) in an isolated window, 2) within a tele-immersive environment, and 3) without video feedback at all. A qualitative study was conducted using surveys measuring improv performance metrics. 'Physical engagement' and 'presence' were perceived highest with tele-immersion, while 'attunement' and 'flow' between performers were comparable between tele-immersion and no mirror. Isolated VF was perceived worse for most conditions.

CCS CONCEPTS

• **Human computer interaction** ; • **Interaction design**; • **Collaborative and social computing**; • **Visualisation**;

KEYWORDS

tele-immersion, video feedback mirrors, tele-conferencing

1 INTRODUCTION

There are non-trivial drawbacks to virtual meetings that continue to undermine user health, well-being, and enjoyment, many of which have been linked to the presence of video feedback (VF) mirrors. Recent studies on the phenomenon of 'Zoom Fatigue' [21] credit VF for increased negative self evaluation from staring at video of oneself [1, 24] and anxiety about appearance [1, 7, 12, 14, 20]. Others, however have demonstrated that removing VF from conferencing actually increased social anxiety [17]. Furthermore, VF plays an important role in many remote collaborative activities, including improvisational theatre where users must be aware of how they appear to each other on screen to inform a performance. For this purpose, we differentiate the traditional VF mirror of tele-conferencing—that allows one to see how they appear *to others*—from the *tele-immersive mirror* (TI), as defined by Galloway and Rabinowitz [6]—that allows one to see how they appear *with others*. We build on previous studies of Tele-Immersion which suggest TI might mitigate other factors related to Zoom Fatigue such as reduced mobility [1] and sense of social presence [22], where participants using TI mirrors reported feeling more physically active and

'there' in a shared virtual space than in the 'here' of their physical environment [3].

This study contributes insights related to how 1) viewing oneself isolated from remote collaborators (typical mirror VF) compares with 2) viewing the self fully immersed in a virtual environment with a TI mirror or 3) not viewing the self at all. We evaluate these three conditions while participants engage in a collaborative task of improvisational theatre (an inherently *ludic* social activity [5]) in a custom-built virtual environment. We study the ludic response to video-conferencing layouts as it is an effective way to evaluate usability and engagement [2, 8, 18, 27]. It is the first study of its kind to comparatively measure mirror-based tele-immersion against traditional video conferencing layouts for their impact on the sense of *flow* [1], social *attunement* [2], physical engagement, sense of physical presence, and semantic choice between remote performers.

Specifically, we investigate whether tele-immersive 'mirror' configurations enhance: a) the sense of presence with the shared virtual environment, b) the experience of *flow*, c) the *attunement* between participants, d) the sense of playfulness and e) the improvisational choices of participants. Findings of this field study with fourteen improvisers indicate that the tele-immersive environment contributed to increased physical activity while performing, to a sense of physical connection with their partner, and to a sense of being transported into the same virtual space as their remote partner. Small differences were found in self-reports of flow or attunement between the three platforms; however, trends are identified for further research with larger sample sizes.

Semantic analysis of improvisational dialogue found a significant increase in the frequency of utterances referring to the 'present' moment between improvisers for tele-immersive environments over the other two conditions, as well as references to the given virtual environment of the scene. A qualitative analysis assisted with automated tools for text categorization found that interfaces affected the content and style of performance. When no mirrors were present, improvisers tended to speak in slightly longer sentences and included slightly more monologues on subjects related to imagined pasts or expected future events. When a small video mirror was present at the side, the scenes generally involved slightly more conflict with each other. Results are discussed to explain how tele-immersive environments encourage users to incorporate more feedback from the environment and remote partners during creative activities. Applicability of findings to the design of new tele-conferencing platforms that incorporate tele-immersive features are further discussed, as well as how they might mitigate some Zoom Fatigue symptoms, but can exacerbate others.

2 METHODOLOGY

Measuring success of improvisation performance is highly subjective. The experimental methodology for previous studies [3] was informed by the insights of Sarker et al. who argue that the

study of virtual teams should begin *'inductively, based on the collaborative experiences of virtual team members and the meanings they attribute to the virtual experiences'* [23]. The results of that research provided the basis for designing survey instruments to empirically support nuanced theories related to how tele-immersion provides greater opportunities for flow, physical engagement, and optimal performance of improvisations between remote partners. We subsequently conducted a cross-disciplinary literature review of linguistics, social psychology, creativity, and improvisational theatre. We used this review to inform a mixed method approach to this follow up study from our previous investigation of improv theatre and tele-immersion [3], in order to account for a complete picture of actual behaviour during the improvisational theatre activity [9, 10, 25, 25], analysing how tele-immersion impacts the collaboration itself.

2.1 Study Design

The collection of audio-visual and survey data in our study was approved by a Research Ethics and Governance Board at the University of Kent. Consent was solicited from participants for use of their data during the study. Data was recorded of participants during remote rehearsals and performance in the co-located virtual space. Fourteen volunteers with varying levels of improvisational experience (1 non-binary, 5 female, 8 male, age between 18-55) were solicited to take part in a 60 minute study of 'digital tools for improv'. Study participants engaged in three 5-minute improvisational collaborative storytelling sessions with remote partners in the context of a 'road trip' using traditional video conferencing interfaces as well as 'mirror tele-immersed' interfaces. The loose goal of the improvised scenes was for the participants to engage in a dialogue building towards a creative, collaborative, and cohesive narrative. Participants were introduced to the 'road trip' improv format before beginning the study and given 10 minutes to become familiar with the interface and environment, become acquainted with their partner, and ask any questions. Following the induction, the participants were given a randomly selected thematic prompt to inspire a 5 minute 'road trip scene'. After each 5-minute scene, participants were instructed to immediately fill out a survey of questions related to flow, attunement, presence, the quality of the improvisational experience, and an open ended question where they could describe their general experience. After completing all three 'drives' participants were invited to share their impressions of each interface and overall experience. During the open ended interviews, 5 minute 'sandboxing' time as well as the 5 minute 'road trip' sessions audio and video was recorded for post-study qualitative analysis.

In order to maintain consistency across experiences and minimise interaction and influence by the facilitator, subjects were prompted by a text caption informing them about the upcoming activity. When the subjects started the first study, the prompt said: 'We will start the road trip soon. Please take a minute to get to know your partner :)' After 5 minutes of open exploration with the interface, the prompt told them to 'Get ready for your 5 minute road trip!' They were then given a prompt they could use or discard to motivate the scene (i.e. 'Chewing Gum'). At the end of 5 minutes, another prompt appeared: 'End Scene. Fantastic!', followed

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[1] "a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it" [19]

[2] "attunement is a process that includes two parts: (1) the ability to connect with another person's experience/sensations(i.e., cognitive and affective empathy); and (2) the communication of that connection to the other person" [11]

Figure 2: Participants simulating touch while 'tele-immersed'.

by 'Please fill out the survey and return after you have finished'. Participants were assigned a random partner at the start of the study and performed all three scenes with that partner.

Completing a Latin square of combinations would require a cohort of 12 participants (to have 6 pairs). However, as our recruitment campaign managed to attract more participants, we decided to relax that requirement in order to avoid reducing our overall number of participants. This in practice meant that one of the combinations was over represented in our dataset. We did not observe that the specific over-representation of one combination introduced any observable bias in our results.

The three conditions were organised as: *A: Isolated* (with participants webcam feeds appearing adjacent to each other, each with the same background), *B: Tele-immersed* (with the background of both participants' video replaced with a virtual 'driving' environment where they appear seated next to each other as if driving a car) and *C: Single view* (where participants only see their remote partner with the option to toggle a small video mirror on or off). The three layouts were presented in the following orders: *(P)1-4: ABC, (P)3-4: ACB, (P)5-6: BCA.(P)7-8: BAC.(P)9-10: CAB, (P)11-12, (P) 13-14 CBA.*

2.2 Tele-Immersive Environment

The three tele-immersive environments were built inside of Touchdesigner[3], and the VDO.Ninja[4] WebRTC service was used to connect and to route participant audio and video from their webcams and microphones into the Touchdesigner platform. The webRTC video feed of two participants was fed to background segmentation then superimposed onto a driving video backplate. A simple user interface was built for the facilitator to switch between scenes and direct participants through video text that would appear on their screens. A function was built to record video of each session as well as separate audio from each participant captured directly from their microphone; both audio and video data were stored and catalogued on a private server.

2.3 Surveys

After all three drives had taken place, participants for the given session were invited to fill out a survey and share their general

thoughts and impressions about their experience. The survey questions were adapted from the *Core Flow Scale* designed by Martin and Jackson based on Csikszentmihalyi's nine dimensions of flow [11, 15], *The Patient's Experience of Attunement Scale* [26], and improvisational theatre related performance language, and areas of future study recommended by the outcomes of previous studies on tele-immersive theatre [3].

Flow refers to 'an almost automatic, effortless, yet highly focused state of consciousness' [11] that would correlate with 'feeling immersed and performing better improv'. *Attunement* refers to what degree people feel seen and heard by each other in a given social exchange [13].

Questions were presented with a 5 point Likert scale with the following categories: strongly agree, somewhat agree, neutral, somewhat disagree, and strongly disagree. The questions have been formed around the unique experience of performing improvisational theatre online, of which there is no existing validated instrument. Instead an original instrument was formed out of the related instruments for flow, attunement, observations related to physical presence from our previous study, as well as literature related to improvisational studies.

2.4 Dialogue Analysis and Linguistic Measures of Improvisational Technique

Audio from each session (drives and interviews) was transcribed using the Google speech transcription service, reviewed independently by three different members of the research team and subsequently coded qualitatively for emerging patterns. We identified 9 aspects of performances[5] related to the quality and style of performance that differed across the three platforms. First we noticed a difference in the amount of dialogue in different sessions, particularly as tele-immersive scenes appeared to have more silences and physical interactions than others. Furthermore sessions without a mirror featured more monologues (uninterrupted speech) from individuals than other sessions. We also noticed that some scenes referred more frequently to the given virtual environment, while others did not. In reviewing the footage we also noticed that we could identify when improvisers 'accepted' or 'agreed' to the offers of their partners and added to them (ie *P(1) 'You kept the mix tape!'/ P(2) 'Yes, I play it every day')* , and when they 'rejected' offers

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[3]https://derivative.ca/
[4]https://vdo.ninja/

[5]These 9 categories refer to various factors known to affect performance and often discussed in improvisational training scenarios.

in the from of suggesting 'new topics' (ie *P(3)'Pepsi is better than Coke'/ P(4) 'This is a nice view'*. The 'tense' of the conversations also appeared to change across conditions with many scenes almost exclusively referring to fictional 'past' or 'anticipated' events, while other scenes appeared to involve more 'real-time' problem solving in the moment, i.e. trying to get 'gum from the glove compartment' (p2). Ultimately, we analysed the semantic choices from the transcripts quantitatively to measure the frequency of each of these 9 features:

1) **Word Count**: Subjective review of transcripts suggested there was more silent 'physical interaction' in tele-immersive environments, further suggesting these scenes might have a lower word count than others. However, when word count was calculated, no statistically significant differences in word count were noticed between environments.

2) **Pronoun Usage**: Casual observation of transcripts indicated participants might use more intrinsically motivated language in some scenes, and more extrinsically motivated language in others. To capture the nature of referential language, we tabulated the usage of pronouns into: "I, me, mine, I've, I'd", "You, your, you're, yours", and "we, us, our(s)".

3) **Acceptance of offers**: A standard improvisational trope is that an improviser should 'accept the offers' of their partner. To determine the frequency of offer acceptance, transcripts were annotated for how frequently subsequent lines of dialogue incorporated previous statements from a partner.

4) **Adding to offer**: In addition to accepting the offers of scene partners, improvisers are encouraged to 'add' ("yes, and") to the suggestion. We counted the addition of information related to previous offers in each line of dialogue.

5) **Conflict**: Generally improvisers are encouraged to establish a common ground and encourage playful co-creation of narratives. Dialogue was annotated for lines which appeared to introduce a 'conflict' related to the previous statement.

We also annotated 6) **references to the visual environment** and to 7) **past**, 8) **present**, and 9) **future events**.

Some features relied on word count and word frequency, which could be counted with Python scripts and Microsoft Excel. Others required manual semantic annotation. To facilitate the annotation, we employed the generative pre-trained transformer (GPT-3) language model [4]. GPT-3 has been shown to have a few-shot learning capability for simple natural language processing tasks such as translation, part-of-speech tagging, etc. and thus we used it to qualify whether each individual line of dialogue was referring to "past", "present", "future" events, or whether a pair of consecutive lines of dialogue corresponded to an agreement or disagreement. Note that these preliminary annotations suffer from the lack of reliability of automated NLP methods, hence their results were reviewed and corrected by hand[6].

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[6]The inclusion of language model-based annotation for this study is presented for later discussion on how language models might be used to allow the study of larger improvisational theatre sample sizes.

3 RESULTS

The data results are divided into three categories: *Survey Results* (Section 3.1), *Quantitative Analysis of Improvisational Dialogue* (Section 3.2) and *Qualitative Analysis of Interviews* (Section 3.3). Where appropriate, survey data is compiled and presented alongside observations from the participants about their experience, as well as observations by the researchers of audio and video data from the performances. We performed a Kruskal-Wallis one-way analysis of variance to determine if there was statistical significance[7] for any of the survey results or any of the 9 features identified in improvisational dialogue (see Section 2.4).

3.1 Survey Results

A rank based non parametric Kruskal-Wallis H test indicated statistically significant differences between tele-immersion and video-feedback in participant self-reporting ($p < 0.05$): *"I found myself physically engaging with my whole body", "I felt physically connected with my partner", and "I felt transported in the driving scenes"*. A near statistical significance ($p < 0.08$) was reported for *"I was creatively inspired by the visual environment of the drive"*.

The remaining survey results did not yield statistically significant results, however charts on Figure 3 indicate small trends in user experience relevant for discussion and point to areas for further research with larger sample sizes.

3.2 Analysis of Improvisational Dialogue

A rank based non parametric Kruskal-Wallis H test indicated statistically significant ($p < 0.05$) differences between tele-immersive views and video-feedback, in the frequency of the following measures: 'Present tense' verb usage and semantic context of the 'present moment', and references to the virtual environment during the scene. Charts on Figure 4 indicate that 'tele-immersion' was the significantly correlated interface for both categories.

3.3 Interviews

Qualitative analysis of participant feedback after each drive and from post-study interviews supported findings from survey responses. 12/14 participants commented similarly that tele-immersion *"was a lot more enjoyable"* (p6) than the other two interfaces. 9 participants reported variations of the feeling that with tele-immersion *"it was easier to physically respond and to see both myself and my partner"* (p1). 8 indicated taking the most inspiration from the tele-immersed virtual environment, commenting how it was *"great being in the same car, and the scenery helped with context and information"* (p12). The feeling of connection and attunement was most frequently commented on with both the tele-immersed environment (6/14) as well as no-mirror (5/14), but for different reasons. With tele-immersion, participants commented how *"being able to play physically... felt more natural and I was a lot more focused on and able to respond to my partner"* (p11). Without a mirror other participants

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[7]The Kruskal-Wallis test 'is a non-parametric method for testing whether samples originate from the same distribution'. It is used to indicate if 'at least one sample stochastically dominates one other sample' [16]. It assumes a null hypothesis that the medians of all groups are equal, and indicates when that hypothesis can be rejected as a result of a significant variance in one of the samples from the others. The results do not indicate which group is significantly different, only that there is one or more samples with a significantly different mean ranking between groups.
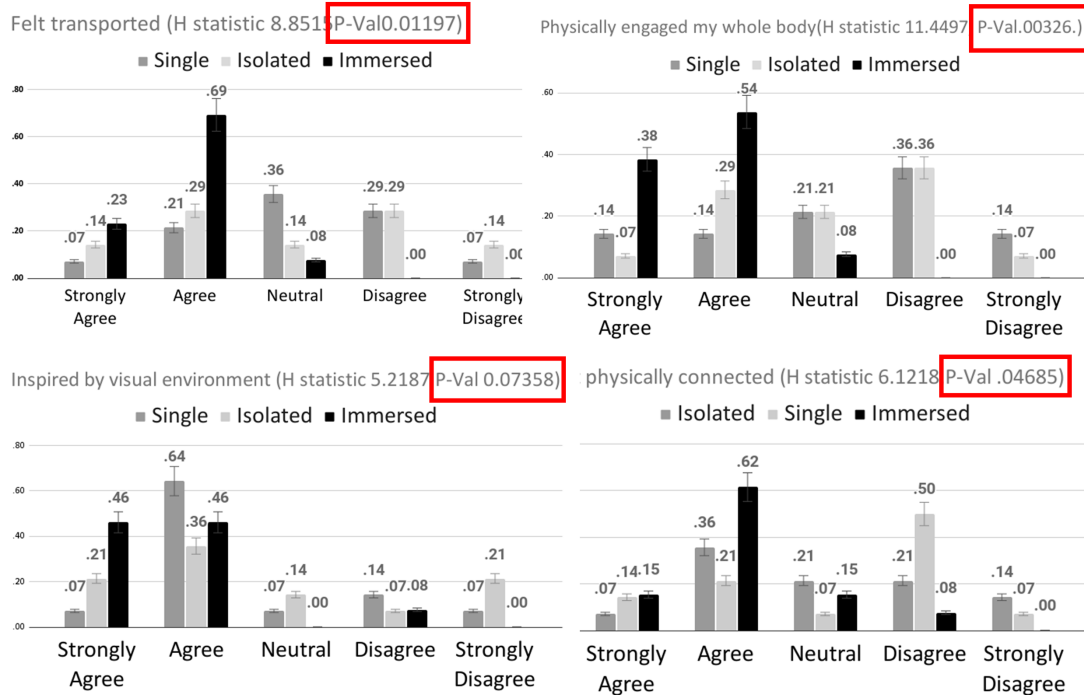
Figure 3: Survey responses with significant (p<.05) and near significant (p<.08) results. Participants reported physical engagement, sense of physical connection with partner, and feeling transported into the scene as highest with tele-immersion. Taking inspiration from the visual environment was nearly signficantly associated with tele-immersion, 2022.
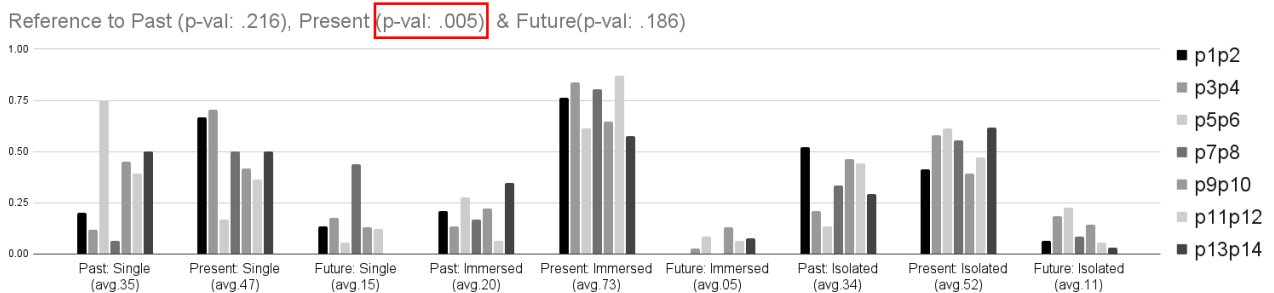

Figure 4: Significant (p<.05) results of dialogue analysis. Participants referred to virtual environment and the present moment significantly more often while tele-immersed, 2022.

shared how *"not being able to see myself meant I was more focused on what my scene partner was doing"* (p1). Few commented directly on their experience of flow, however 6/14 indirectly described how the presence of an isolated mirror negatively affected their focus and how they *"felt quite disconnected because I was unable to see my body in the car"* (p13). A strong sense of presence with the scene was reported for tele-immersion by 4 participants who described similar sentiments to being *"very drawn into the space of the car journey"* (p4), and 1 describing how they *"felt the car movement"* (p3). For 3 participants, not having a mirror however also appeared to be beneficial in fostering a sense of presence, *"because you can sometimes find that you check your own appearance instead of focusing on your partner"* (p2).

4 DISCUSSION

This study set out to answer whether tele-immersive 'mirror' configurations provide advantages over traditional video conferencing platforms to mitigate some symptoms of 'Zoom Fatigue' for improvisers, by enhancing the sense of presence between performers, the

experience of flow, the quality of attunement as well as the physical engagement while improvising. Furthermore, we asked if the presence or absence of the video feedback mirror in the different configurations had a measurable impact on improvisational focus and storytelling subject matter and style.

4.1 Designing Tele-Conference Platforms for Performance and Mitigating Symptoms of 'Zoom Fatigue'

4.1.1 Physical Engagement. While being tele-immersed, participants were able to overcome the inclination to be stationary credited for contributing to ZF associated with traditional conferencing environments. Observing the drives, it appeared that participants were visually motivated to physically engage with the virtual scenery and to simulate naturalistic poses and postures as well as physical contact with their partners. This interaction correlated with a ludic response as participants described the enjoyment and fun they experienced by playfully interacting with each other. Interestingly, the playfulness and physical engagement did not necessarily translate to the sensation of performing better improvisation as some reported that physical engagement came at the cost of being focused more directly on their partner and developing the improvised scene. These observations suggest that tele-immersion while, potentially mitigating some ZF symptoms may not be ideal for all types of remote collaboration, but instead may be best used for specific tasks, with the ability to easily switch to other layouts more appropriate for the given activity. For instance, tele-immersion might be useful for rehearsing scripted theatre before a performance to discover types of physical engagement that can unlock different behaviours, before switching to a no VF interface for rehearsing dialogue. For general remote collaboration, meetings might be structured with short breaks that include tele-immersion as a way to energise participants, and trigger playful engagement before returning to the main collaborative task.

4.1.2 Referencing the Visual Environment and the Now. A significant finding of the study was that during the sessions, participants intuitively made more references to not only the visual environment, but also the dialogue itself stayed in the present moment. Whereas in the other two scenarios, participants started scenes referencing a past event or a character outside of the scene (i.e. comparing who received more Christmas gifts when they were children), the tele-immersed participants tended to generate dialogue around being together in the car in that moment (i.e. searching the car for tarpaulin). For improvisational theatre, this is interesting as it demonstrates tele-immersion is drawing the focus of the improviser externally, which is important for maintaining a more collaborative approach to scene building. These initial findings along with previous observations related to tele-immersive improv [3] point to opportunities for more research into how platforms can be designed specifically for improvisational training that encourages improvisers to learn how to better incorporate external offers into their spontaneous storytelling.

4.1.3 Tele-Immersion for Designers. Beyond improvisational theatre, the finding that tele-immersion encourages an external focus on the visual environment may present opportunities for other fields or practices that are interested in getting feedback from clients or focus groups about their product, such as interior designers or architects. Some possible applications include designing new social spaces for a building where there is an interest to explore how the colours or shapes of a space or even the artwork on a wall might influence behaviour and how people engage. Potential users of the space could be tele-immersed in the environments and encouraged to have conversations that are later analysed for emergent themes the way the improvisational dialogue was analysed.

4.1.4 Psychosocial Applications of Tele-Immersion. Outside of theatrical applications, this finding has potential relevance for remote collaborations that have a goal of responding in realtime to the behaviour and given environment. Psychosocial experiences might also benefit from exploring this feature of tele-immersion, where it is important that participants stay in the present moment. Couples therapy, conflict resolution, or public debates might each find interesting applications of a tele-immersive environment that encourages participants to stay focused on what is happening right now, rather than focusing on past or future events.

4.2 Limitations and Future Work

Given the small sample size, it was interesting that we observed significant results in many areas. However these observations should not be used to make too general an argument about the effects of tele-immersion, since participants only engaged with the environments for relatively short periods. Instead, the findings provide support for future research into the features of tele-immersion for larger and more diverse groups. Moreover, these results add some empirical weight to previous anecdotal reports on the power of tele-immersion to make people feel like they are really 'there' in the virtual world. The findings further provide an impetus for conducting longer studies of people working in tele-immersed environments, as well as other possible configurations to examine how social interactions and dialogue might be affected. It is also important to note, that users relied on their own internet speeds to connect, and there was variable quality of connection and experience of 'lag' during the trials. In future studies, we plan to control for variability in hardware and connection speed by performing tests in a laboratory setting, as well as comparing tele-immersion experienced on a screen to tele-immersion experienced with a virtual reality headset.

5 CONCLUSION

In this paper we compared the effects of video feedback (VF) presented as an isolated window, within a tele-immersive environment, and no video feedback at all, on a remote collaboration task. Our novel field study of 14 domain experts performing improvisational theatre under all three conditions produced significant results from our mixed method study. Results from surveys, participant interviews, and quantitative analytics of the dialogue produced during improvisational scenes, found that tele-immersion significantly impacted five different domains of performance. 'Physical engagement' and 'presence' were perceived highest with tele-immersion, while 'attunement' and 'flow' between performers were comparable between tele-immersion and no mirror. Isolated VF was perceived

worse for most conditions. Analysis of improvisation dialogue indicated TI significantly impacted verb tense and direct references to a given scenic environment.

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Appendices

A APPENDIX

A.1 Survey Questions

- I was 'totally involved'.
- I was 'tuned in' to what I was doing.
- I was 'in the zone'.
- I felt completely immersed in the activities.
- I enjoyed performing with my scene partners.
- My driving companion seemed to enjoy working with me today.
- My driving companion's comments enabled me to be creative today.
- My driving companion understood me.
- What my driving companion did and said was helpful today
- My driving companion seemed comfortable with all of my reactions today
- I felt accepted by my driving companion today
- I felt a sense of having a meaningful person-to-person relationship with my driving companion today
- I felt fully present with my partner.
- I found myself physically engaging with my body.
- I was very aware of my partner's body.
- I was often making extra effort to think of interesting things to say.
- I become so immersed in the scene that I forget my physical surroundings.
- I was distracted by my physical surroundings.
- It was easy for me to add to and participate in the conversation.
- I was often making effort to be funny.
- I relied significantly on my partner's reactions to inform my performance.
- I was very aware of my partners reactions.
- I felt physically connected with my partner.

Supplementary Figure 1: Screenshot of TouchDesigner network developed for the study and the GUI for controlling drives, 2022.

- I was inspired creatively by the visual environment of the drive.
- I was distracted by the visual environment of the drive.
- I felt transported into the driving scene.
- My ability to feel connected was limited by the technology used.

- Please describe your general experience of DriveTogether during this most recent session.

A.2 Tele-Immersive Environment Design

See Supplementary Figure 1.

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