

Tele-Immersive Improv

Effects of Immersive Visualisations on Rehearsing and Performing Theatre Online

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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.**

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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 [40]. 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 [33]. While there have been many experiments over the last few decades into the potential of remote collaboration tools for building performance [52], 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’ [43]. 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 directly performing together for digital spaces in any of the biennial reports by the the Arts Council that began analysing the industry in 2016 [14, 43]. 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 [42].

Improvisation in theatre is a rehearsal tool, a process for creating new work, and a genre of performance [15]. As a genre, *‘it is a form of live theatre where artists perform real-time, dynamic problem solving to collaboratively generate interesting narratives’* [7, 26, 35, 36]. Improvising involves engaging a cognitive state called *flow* described by psychologist Mihaly Csikszentmihaly as *‘an almost automatic, effortless, yet highly focused state of consciousness’* [8]. Improvising and entering into flow in performance require collaboration that is supported by a deep awareness of the presence of others [56]. 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’* [10]. 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 [37]. 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 [47]. ‘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*

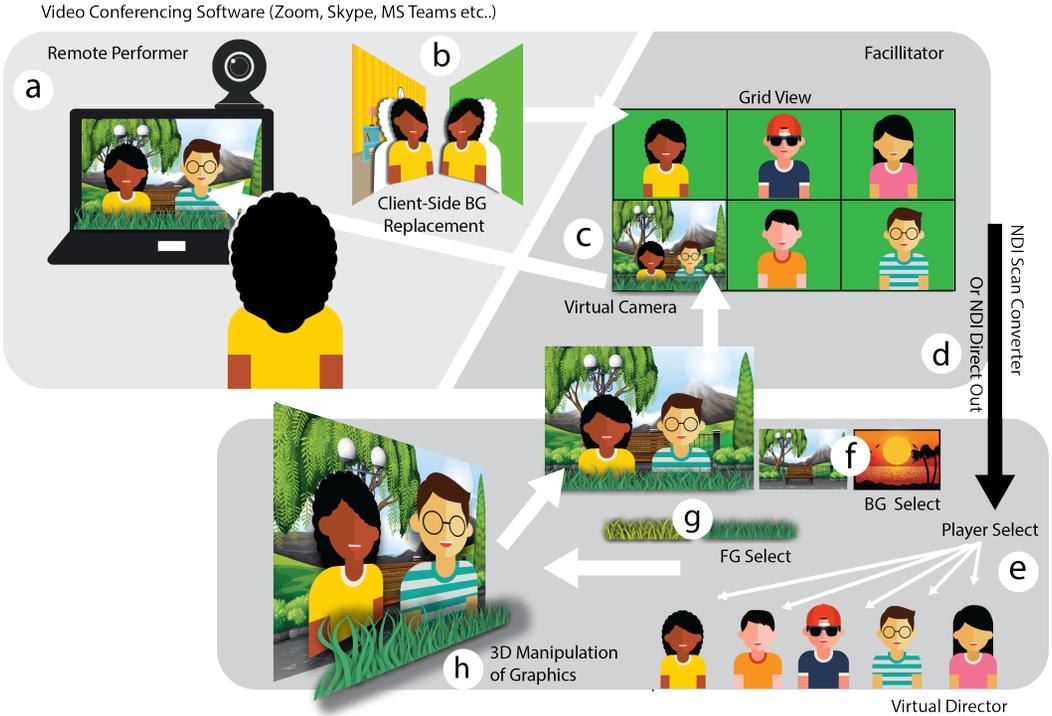


Fig. 2. System overview, Virtual Director 2020: (a) Isolated performer connects via client software, (b) Background segmentation is performed by client software, (c) Performer sees a video of themselves co-located with partners in virtual space, (d) NDI macros supply client video to Virtual Director, (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.

communicating' [39]. 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' [4] 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 [2, 5]. 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 [6, 16, 23, 50, 51], 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 [21, 23]. 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 [52, 53]. Recently however, performers in unprecedented numbers have been engaging in remote rehearsal and performances outside of studios and laboratories [48]. 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 [13, 23] and studies of presence in virtual worlds[21]. 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 [22]. 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’ [32]. 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 [17, 41, 46]. 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 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 [22]. 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 [28]. 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 [4]. 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 [9, 30, 32].

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 [11, 52]. There has been some research involving dance and tele-immersion, investigating how the time delay between dancers interacting tele-immersively impacted synchronicity [31, 54, 55]. 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 [19]. 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'* [49]. 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 [34]. Key to understanding the experience of this cognitive shift is psychologist Mihaly Csikszentmihaly's 'nine dimensions of flow' [8]. 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 [12, 20, 29]. 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 remotely that could guide future research in this emergent phenomenon. 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 a suspension of disbelief experienced by the performer?*

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.

¹<https://theflowcentre.com/9-dimensions-to-flow/>

3.2 Virtual Director

Virtual Director 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. The three main tele-immersive features that we examine therefore are:

- 1) *The virtual placement of participants in a shared background.*
- 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.*

Virtual Director was built inside of TouchDesigner², 'a node based visual programming language for real time interactive multimedia content'. TouchDesigner natively supports capturing and streaming $\text{\textcircled{N}}\text{DI}$ ³ 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 Skype⁴ which provide $\text{\textcircled{N}}\text{DI}$ feeds for each participant (Fig. 2d). With conferencing tools that do not provide discrete $\text{\textcircled{N}}\text{DI}$ video channels for participants, macros are launched to perform a screen-capture using $\text{\textcircled{N}}\text{DI}$ 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 OpenGL⁵ 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.

²<https://derivative.ca/>

³<https://ndi.tv/tools/>

⁴<https://www.skype.com/en/content-creators/>

⁵<https://www.khronos.org/opengl/>



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

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’* [44]. 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’* [44]. 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 [23]. 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’* [18].

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 [1]. 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 [27]. 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 [45]. 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

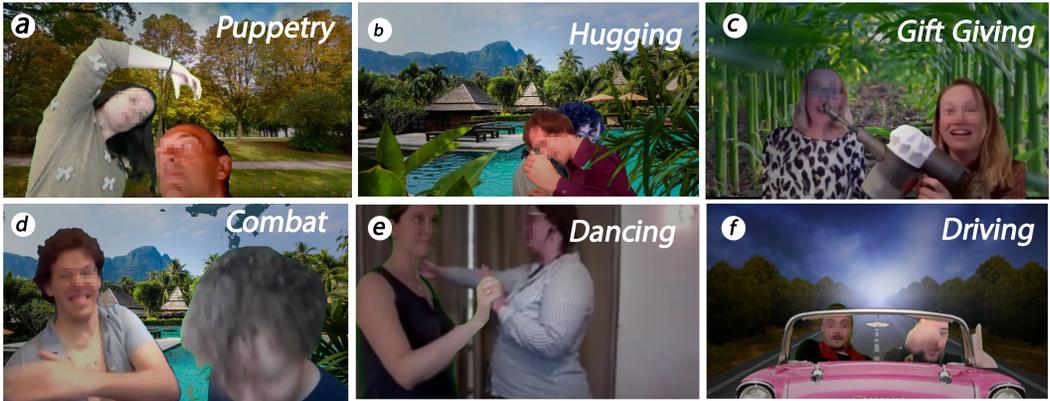


Fig. 4. Examples of tele-immersive improv training: (a) p3 'controls' p4 movements, (b) p5 and p6 practice hugging, (c) p1 and p2 give each other gifts, (d) p7 and p8 practice combat, p9 and p10 virtually dance, (f) p11 and p12 simulate driving.

games 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

In order to maintain consistency in instruction and 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, Zoom⁶ 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.

⁶<https://zoom.us/>

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.

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'*⁷ with dynamically shifting backgrounds. For initial rehearsals, participants were invited to perform a popular format called *'montage'* [3] 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. The scope of this initial study however, is limited to the experience of practicing and rehearsing in the tele-immersive environment. Data related to performing tele-immersively for a live virtual audience was collected for use in a follow up study.

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.*

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

⁷Long-form improv is a continuous series of scenes inspired by a word or phrase.

the public on average for six years, with the least experienced having performed publicly for two years. We did not observe any correlations between length of past experience and the results.

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)’. 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-immersive 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 [24] 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 [25]. 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 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

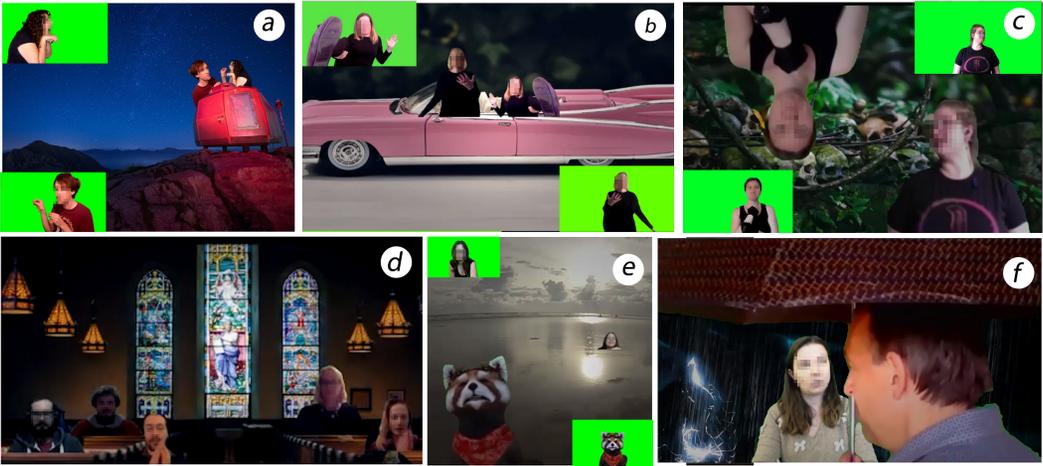


Fig. 5. Players interact with virtual environment and each other. **Dialogue excerpt (a):** p1: *You can see for miles around.* p2: *Yes, you can see that there are no more humans, that's a bit sad.* p1: *You want that? You want some more Moss?* p2: *It's my favorite.*

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 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 LIMITATIONS AND FUTURE WORK

As this study was conducted during a national lockdown our focus was to examine how tele-immersion might be used generally by performers in highly variable 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 account 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 verses seated performance,

display size, lighting conditions, and audio interfaces as well as studying how other facilitators would use Virtual Director. During this initial study we also collected preliminary data on using Virtual Director for live public performance which we plan to use for a follow up study. 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 freely downloaded at: https://github.com/Geitenkaas/VirtualDirector_app.

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 et al (1992) who also observed that users generally identified more strongly with their virtual selves than their real selves [22]. 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 [38]. 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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