4

Augmented reality performance: A site-specific volumetric video experience of Samuel Beckett's *Play*

Néill O'Dwyer, Gareth Young, Nicholas Johnson and Aljosa Smolic

Introduction

This chapter presents *Augmented Play* (Johnson 2019), the third and final part of a three-year practice-based research project entitled the *XR Play Trilogy*. This augmented reality project sought to reinterpret Samuel Beckett's *Play* (Beckett 1963), a pivotal mid-career drama, for various formats of digital media culture. The trilogy includes (1) a webcast, *Intermedial Play* (Johnson 2017a), (2) a virtual reality (VR) application, *Virtual Play* (Johnson 2017b), and (3) an augmented reality (AR) version, *Augmented Play*.

Play is a one-act play that features three speakers in urns, their heads the only visible part, whose speech is 'provoked' by a roving spotlight. It was written in English but performed first in German, at the Ulmer Theater in Ulm-Donau, W. Germany (1963). The play is known for its unique structure, which includes the stage direction 'repeat play' at the end, and its exploration of themes such as memory, identity and human connection. Extensive intermedial experimentation has been conducted with the play since its first decade of life, including adaptation to radio, film and new media (Johnson 2022).

Intermedial Play was a collaboration between Néill O'Dwyer (producer) and Nicholas Johnson (director), associate professor in Trinity College's Department of Drama and co-director of the Trinity Centre for Beckett Studies. The performance was screened live using a robotic pan-tilt-zoom (PTZ) camera, normally used in the context of surveillance, in combination with Wirecast and YouTube webcasting technologies (Johnson, O'Dwyer and Bates 2021). The PTZ, in this rendering of the piece, became the 'unique inquisitor' that prompts the actors, its 'victims' (Beckett 2006, 318), into speech. In 2017, it was broadcast from the Dance Studio in the Samuel Beckett Centre, Trinity College Dublin (TCD), with a live audience observing from a remote location in Trinity's east campus. This experiment inspired the creative team to extend the questions of virtuality and liveness, catalysing the next phase of both *Virtual Play* and *Augmented Play*.

Virtual Play was a more radical reinterpretation of *Play*, designed to engage a twenty-first-century audience increasingly accessing content via VR technologies. It was produced in collaboration with V-SENSE (a Science Foundation Ireland [SFI] project funded to research advanced visual computing), whose lab developed the core 3D volumetric video (VV) technology enabling this novel type of creative production. O'Dwyer was employed to champion and curate creative possibilities for the visual computing software innovations under development, the most advanced being VV, and *Play* was selected to be the inaugural creative arts project at V-SENSE.

The VR experience of *Virtual Play* attempted to push the limits of possibility in consumable video and film by eliciting the new power of digital interactive technologies to respond to Beckett's deep engagement with the stage technologies of his day. A central goal of the project was to address ongoing concerns in the creative–cultural sector regarding how to address the question of narrative progression in an interactive, immersive environment. 'Immersants' (cf. Introduction, 10) were invited to don a head-mounted display (HMD), embody the role of the inquisitorial light and explore the narrative by confronting virtual reconstructions of Beckett's characters. The virtual spotlight was aligned with the immersant's gaze, so that they could activate the characters into speaking simply by looking at them. The artwork acknowledged the new condition of active audiences and recognized new opportunities for narrative by affording audiences a central role in its unfurling. The creative team hypothesized that by placing the immersant (audience) at the centre of the storytelling process, they would be more thoroughly assimilated to the virtual world and empowered to explore, discover and decode the story, instead of passively watching and listening (O'Dwyer et al. 2017). The gaming sector has harnessed interactive storytelling techniques using procedural graphics and animation, implying the freedom of the user and providing continuous change. The traditional aesthetics of film, video and the performing arts have not

fully resolved how capture techniques might achieve a similar open-ended, 'unfurling' effect in older media. As such, this project attempted to investigate new narrative possibilities for interactive, immersive environments, using VV capture of live actors to generate a dynamic VR system.

Augmented Play had much in common with the earlier VR version, because it used the same VV assets, modes of audience interaction and narrative development. However, the viewing paradigm was different. AR is a technology that allows people/audiences to visually merge virtual/graphical/computer-rendered objects with physical world objects and scenes using a mobile phone, tablet or HMD. Unlike VR, it permits the user to see the world around them; it does not close off the outside world by fully immersing the audience in a computerized world. Therefore, AR technology is highly suitable for allowing people to interact with stories in an architectural context. It is ideal for location-based, immersive, role-play and site-specific drama. In the case of *Augmented Play*, the content was originally built for the Microsoft HoloLens AR HMD, but had improved display on Magic Leap. The team also explored the effect of the AR experience on handheld phone and tablet devices.

This chapter takes the form of a reflective practice essay on the *XR Play Trilogy*'s third and final part. It provides an account of the methodological and technical working processes. And finally, it reports on feedback provided by subject matter experts (SMEs), offering a reflective discussion of the significance of the work and the benefits and shortcomings of working with these technologies in performance contexts. The *Augmented Play* project intersected with three main specialized knowledge areas: XR, the performing arts (especially theatre) and VV. What follows below is a brief survey of these fields, encompassing existing projects.

Background and related work

Extended reality (XR) is an umbrella term that encompasses a spectrum of technologies, including virtual reality (VR), augmented reality (AR) and mixed reality (MR) (cf. Introduction, 11–12). XR refers to the blending of real and virtual environments to create immersive experiences that can be interactive and multi-sensory. It encompasses various devices, such as HMDs, glasses or mobile phones, to simulate or enhance the user's perception of reality by combining elements from the physical and digital worlds. XR has applications across diverse fields, including gaming, entertainment, education, training, healthcare and more.

XR technologies have revolutionized theatre by enhancing performances and engaging audiences. Virtual sets create immersive environments,

transporting performers and audiences to different locations or fantastical worlds. AR overlays digital elements onto live performances, enhancing storytelling and creating interactive experiences. MR performances merge physical and virtual elements, allowing live actors to interact with virtual characters or objects in real time. These technologies also enable audience participation through interactive VR installations or AR applications that personalize narratives or allow audience members to affect the storyline. XR is also valuable for training and rehearsals, providing tools for exploring staging options and visual effects without physical constraints. XR technologies push the boundaries of traditional performances, creating captivating experiences that blur the line between physical and virtual worlds. Within XR performances (despite the disputed boundary between AR and MR), AR performances are relatively rare compared to VR, likely due to the complexity of developing apps and the limited computing power of AR glasses. Some notable examples of performance-based implementations that employ AR are detailed below.

The use of visual computing technology within theatre is often a clear signal that a piece could be classified as AR. Adrien Mondot and Claire Bardainne's installation *Mirages & Miracles* (2017) used choreography and graphical representations to animate and augment visual art objects via a tablet. Analogously, Gilles Jobin's iOS augmented reality dance piece, *Dance Trail*, enabled 'users to bring virtual dancers into the real world through their smartphone or tablet' (2020). *The Tempest* (2017) by the Royal Shakespeare Company harnessed AR and holography to create illusions, without placing individual devices with audience members. Advancing the Pepper's ghost technique by projection-mapping virtual characters like Ariel (created using motion capture technologies) onto innovative materials, the RSC designed interactions between physical and virtual elements and live, embodied actors, blending the physical and digital realms. Idris Elba and Kwame Kwei-Armah's *Tree* (2019) incorporated procedural graphics projected onto curved screens, surrounding the audience, allowing actors to interact with virtual props and characters, creating a sense of immersion for the audience while maintaining a strong anchor in physical world. More recently, Glitch Studios collaborated with three Norwegian theatres – Nordland Teater, Teater Vestland and Teatret Vårt – to fuse 'Far Throw AR' technologies with live theatre to enable 'digital characters to seamlessly interact with live actors, covering the entire stage volume and the vast space between the stage and the audience' (Glitch Studios 2024). They supplied everybody in the audience with a Viewforia MR HMD, broadcasting graphical overlays simultaneously to create a synchronized AR theatre experience.

Given that AR sits on the spectrum of XRP (cf. Introduction, 11–12), several relevant examples arise that could be considered borderline cases. Even without HMDs for audience engagement, some contemporary theatre crosses

into AR territory when technology deepens immersivity across multiple media channels. In *The Encounter* (2016) by Complicité, for example, the audience wore headphones while watching performers to experience a binaural soundscape of the Amazon rainforest. While the heavy computing power is on the audio in this instance, the experience of binaural sound relies on the presence of visual cues. AR is also important for paratextual and peripheral elements of framing performance. For *UNeditions* (2014) by Unlimited Theatre, the company offered immersive, digital script reading experiences with spatial sound, light and bonus material. Users could access additional digital content on their smartphones, such as interactive visuals, videos and supplementary information. In some performances of *The Lion King* (1997) by Disney Theatrical Productions, AR technology created interactive experiences for the audience. Through specialized AR apps, audience members could bring printed programs or certain scenes to life, revealing hidden animations and immersive content.

To provide content for AR and as a performative capture technique, VV is maturing and finding its way to performance practice. VV technology captures a three-dimensional representation of real-world objects or people, recording external appearance, spatial depth and movement to create a dynamic 3D model. Using an array of cameras or depth sensors from multiple angles, VV allows viewers to move around and interact with the captured content, offering a more immersive experience than traditional 2D video. This technology is often utilized in XR applications, enabling lifelike representations within virtual environments. With AR/VR devices, the resulting VV can be viewed from any angle, allowing audiences or actors to explore content from different perspectives. VV creates photorealistic characters, enabling viewers to enter an interactive, immersive experience, engage with content more naturally and feel present within the same space as the subject.

VV has only recently started to enter the theatre world, and its adoption is still limited. However, it offers intriguing possibilities for capturing live performances in three-dimensional space. VV technology enables theatre productions to explore new forms of documentation, preservation and presentation, offering audiences unique perspectives and a sense of presence. *Museum of Austerity* (Wares 2021) was a moving performance-cum-installation that documented true life stories of the disenfranchisement and marginalization of disabled people during the UK's austerity period (post-2008). Visitors explored the stories as performed VV installations in a holographic gallery using Hololens 2, closely resembling the audience paradigm used in *Augmented Play*. Such performances highlight the potential of merging live performances with recorded elements in immersive experiences. As VV technology advances, we will likely see more innovative and frequent uses in theatre productions.

The *XR Play Trilogy*

Play is a one-act play written by Samuel Beckett, one of the most influential playwrights of the twentieth century. Developed by Beckett in English and German from 1962 to 1963, it is widely considered to be a radically avant-garde text for its time, as well as a pivot point in Beckett's decades-long career. Due to several unusual features of the play – its highly restricted aesthetic of three heads in three urns, illuminated by a single spotlight that prompts their speech; its circular structure, ending with the stage direction 'Repeat play'; and its history of intermedial experimentation – it sparked the interest of the creative team as an ideal test space for VR and AR. The three characters, known as 'W1', 'W2' and 'M', engage in a relentless, circular dialogue, each character recounting their version of a past love triangle involving themselves and the other two characters. The conversation is fragmented, repetitive and overlapping, highlighting the characters' struggle to make sense of their shared experiences. It is also prompted by the movement of the undefined external force of the light, raising deep questions about the relation between the speakers and the technology of the theatre itself. The drama arises not from the unfolding of actions within the plot, which is notably banal, but rather from the real situation of the actors and the conditions of the system. This offers a framing of the play as a game in which variation, uncertainty and agency on the part of both actors and audiences are possible, hinting at an alignment between the performance and VR/AR aesthetics.

As such, *Play* was selected as the main focus of the 'Creative Experiments' remit by the V-SENSE research group at TCD (2016–22). The concept was to remaster it for the emergent genre of XR performance and to reinvigorate audience interest in twentieth-century literature using twenty-first-century technology, thereby generating 'new experiences, modelling the problematics of how cultural knowledge is transmitted from one generation to the next' (O'Dwyer and Johnson 2019, 4).

The project website[1] is the online hub for the *XR Play Trilogy*, which focused on exploring and developing XR technologies in theatrical contexts to merge the worlds of theatre and technology by utilizing innovative technologies such as VV. The project consisted of three distinct versions of *Play*, each employing different XR techniques and approaches to extend the theatrical experience. Several research papers, videos, images and other multimedia content documenting the project's progress and outcomes have been previously published, sharing the findings and results of the research project and contributing to the broader discourse on the intersection of technology

and performing arts. Some publications explicate the technologies and techniques used (O'Dwyer et al. 2017) or empirical research methodologies employed to assess successes and shortcomings (O'Dwyer et al. 2020). Others offer insights into the creative process behind the project (Johnson and O'Dwyer 2018), pedagogical and perceptual findings emerging from the research (O'Dwyer, Johnson, Bates, et al. 2018, 1–10; O'Dwyer, Johnson, Pagés, et al. 2018), or the aesthetic vision driving the exploration of XR in theatre (O'Dwyer and Johnson 2019). Overall, the project provided a rich terrain for investigating the potential of transforming and reimagining modern theatre under the aegis of XR technologies and remains a robust resource for those interested in the field.

Methodology: Production pipeline

Although the production pipeline is described in previously published research papers (O'Dwyer et al. 2017), it is necessary to include a brief overview of the process for the coherence of this chapter. Furthermore, after creating the VV assets, the AR experience's conceptualization and fabrication substantially differed from the VR version. Below is a description of both processes, including the artistic and technical rationales.

There are two main types of VV techniques: online and offline. Online VV involves streaming and interactive playback of 3D video content over networks. It uses cameras and depth sensors to capture objects or actors, with as few capture devices as possible.[2] These data are compressed and transmitted via Ethernet to audiences,[3] who can access and interact with the content in real time. Utilizing real-time processing and streaming, online VV enables users to engage with immersive 3D experiences, like VR or AR, without needing local processing or heavy data storage on their devices. The resulting visual output is usually low resolution and glitchy, a trade-off for liveness.

Offline VV involves capturing and rendering content without real-time streaming or internet connectivity. It records a subject or scene from multiple angles using cameras and sometimes depth-sensing devices. These data are processed offline using innovative software algorithms, powerful computers, dedicated rendering systems or cloud servers to reconstruct the 3D representation (Pagés et al. 2018). Once processed, the resulting VV can be stored and played back locally on compatible devices or platforms; however, the footage cannot be edited because, firstly, there is currently no such software, and secondly, within the AR/VR viewing paradigm,

> editing is not used to create situational *continuity* from a sequence of different shots, nor is it used to generate *discontinuity*, for example through montage. VR instead attempts to create a verisimilitude, that is, the simulation of an encounter with the characters, whereby the digital objects appear to have volume and mass.
>
> (Johnson and O'Dwyer 2018, 8)

Offline VV is useful when real-time streaming is not feasible or when precise control over the rendering process is desired. The output is usually higher fidelity and resolution than online VV, resulting in larger file sizes.

The technique used for this project was the offline process, which was under development in V-SENSE at the time. The pipeline involved setting up an array of HD digital SLR cameras in a 180-degree arc, with actors positioned in a similarly curved green screen environment. Each actor was recorded individually, as required by the VV system and the characters' experience in *Play*. Although not necessary, actors were recorded kneeling in the urns to induce genuine physical discomfort, generating a vocal quality and pressured scenario analogous to Beckett's specifications (Beckett 2006, 319). Since user action determined the start/stop points of each text segment, the interlocking, rapid-fire dialogue was restructured into single monologues, performed continuously without interruption. This approach aligned the technically robust way to transmit the story into VR with the preferred method of rehearsing and enacting Beckett's system (Johnson 2022, 202–5). The textual jumps and interruptions, caused in theatre by the roving spotlight, were achieved here by pausing/unpausing the VV audio-visual in the application in relation to the immersant's gaze. Other recording options, such as using hand signals to stay the actor's speech, proved too fragmented during playback and required several hundred short video clips instead of one per character.

After capturing the footage, significant postproduction was required. The actors were segmented (chroma-keyed) using postproduction software, and all videos were colour balanced to ensure consistency during the texture mapping and volumetric reconstruction process. The videos were trimmed to the same length and exported as a series of jpegs. These images were fed into the bespoke VV software developed by V-SENSE. At the time, this cutting-edge software was executed through the command line interface; there was no out-of-the-box VV software package with a graphical user interface (GUI) accessible to creative artists.

The volumetric video pipeline developed by V-SENSE relied on two main computer-vision volume estimation techniques: (1) a 'multi-source,

FIGURE 4.1 *XR Play Trilogy*, 2019. Director (Nicholas Johnson) in the foreground with W1 actor (Maeve O'Mahony) positioned in the urn against the curved green screen, with the cameras in the foreground also positioned in an arc, 2019 (© Néill O'Dwyer).

shape-from-silhouette (MS-SfS) approach', using silhouettes, 3D skeleton estimation and colour consistency to generate a 3D volume, and (2) multi-view stereo (MVS) to create a dense 3D point cloud (Pagés et al. 2018). These data were merged using a fusion technique to form photorealistic 3D models for each video frame. The process was computationally expensive, taking several days to process on a desktop computer, requiring a skilled operator to fine-tune parameters and correct errors, often restarting from scratch. It took over a month to process 3 VVs, each approximately 3.5 minutes long. Notwithstanding the labour intensity, 3 dynamic 3D representations of live-action human performances were produced,[4] viewable in 6 degrees of freedom (6DoF).[5] These versatile 3D VV assets could be watched on VR, AR glasses, smartphones and tablets, forming the backbone of the first Beckett in VR project and one of the first VV VR reproductions of a complete dramatic script. However, in VV production, it is not enough to film the actors; the virtual scene must also be designed, and the entire project (including dynamic video assets and static scene assets) must be built in a game engine.

AR scenography

Unlike the preceding VR version, it was not necessary to design and build a scene for this AR version, as the characters were strategically placed around the physical architectural space. Visualization and interaction were achieved through AR glasses or a handheld AR device. The physical architectural features – walls, floors, columns, arches, brickwork – remain visible, reminding the audience of their context. Therefore, the venue choice is paramount to supporting the story and the mise-en-scène. Showing this type of work in a black-box theatre or white-cube art gallery makes no sense, as the architecture may lack contextual coherence with the thematics. We hosted the exhibition in the stone/brick vaulted basement of an eighteenth-century warehouse in Dublin's historic docklands (see Plate 8).[6] This choice amplified the sense of being in an underworld, crypt-like structure, maintaining thematic consistency with Beckett's purgatorial vision.

The only virtual prop consistent across the VR and AR versions was the stone urn, designed and built in 3DStudio Max. One urn was fabricated and replicated for each character in both versions. The VV assets (the characters' heads) were the same as those used in VR. The interaction (or gameplay) mechanic was also the same: when the immersant looks at a character, they speak; when they look away, the character stops speaking. The goal is for the audience to decode the narrative through an inquisitive gaze, shifting between characters, divulging the text and grasping more of the world and its affective texture the longer they engage.

The scenographic feature distinctly different from the VR version was the integration of the physical building and its materials into the scene. AR glasses allowed the audience to see the physical room and perceive the characters as co-present, affording them new mobility. Spectators could walk around the building and up to the characters, choosing their perspective (see Plate 6). This mobile, exploratory audience experience has much in common with immersive theatre productions, such as *These Rooms* (2016) by ANÚ Productions and Cois Céim, *Burnt City* (2022) by Punchdrunk or *Room Service* (2003) by Gob Squad. In these productions, performers inhabit entire buildings, and the audience moves between rooms for close-up, intimate experiences. This engagement was not possible in *Virtual Play*, where immersants cannot see the physical room or furniture, risking injury if they wandered.[7] Consequently, the VR scenography positioned characters in an arc around the central immersant. In the AR (Magic Leap) version, the room could be mapped through the hardware, allowing the scenographer to place characters anywhere, such as corners or alcoves (see Plate 7).

Reception and response

Augmented Play premiered to a select audience of academic and industry subject matter experts (SMEs) at the CHQ building in September 2019. Feedback was gathered from these experts on the evening and again at private screenings in January 2020. A detailed account of the feedback (in relation to XR generally) was published in 2020 (O'Dwyer et al.). Below is a selection of prevailing themes from the feedback discussion, along with our responses and reflections. We have structured this concluding section as a dialogue, with the feedback received in italics and the responses following.

> *While some SMEs identified themselves as relatively traditional in terms of Beckett, the cohort generally displayed an openness to AR technology. They acknowledged that technology brought fresh perspectives to the work, and the AR audience paradigm held significant potential, especially its inherent capacity to captivate audiences.*

The novelty factor has a huge impact on audience captivation. Given that AR glasses are so new, donning them for the first time can be an intense experience. The horizon-expanding potential for arts and culture is immediately apparent, with the expectation that XR performances will gain prominence and viewership. However, emerging art forms must speak to the specificities of new media. This will be pivotal in the success of *Augmented Play*; its circular narrative and active audience paradigm were fundamental to its success, a factor where many new XR performance-experiences fail. Establishing a new *grammar of XR* is essential for nurturing more intriguing artistic endeavours as standalone art forms (O'Dwyer et al. 2020).

A second, more subliminal reason for this observation is the attention-grabbing nature of the screen in general. Screens have long been acknowledged for their ability to capture attention; hence their application in learning environments (Mayor 1997, 1–19). A major finding of our research was the improved comprehension of a notoriously fast-paced text when viewed in VR compared to live theatre. This has sparked further research into applications of the technology in drama education contexts.

> *Although there was a general acknowledgment of theatre's inherent relationship with technology, SMEs expressed caution regarding excessive reliance on it, which could potentially jeopardize theatre's tradition of 'situated action' in which the audience and actor–characters share the same physical space (Salter 2010, xxxiv).*

We would be wary of reducing the argument to a binary polemic similar to that teased out by Phelan and Auslander regarding screens, video and liveness. The adoption of VV to portray characters in AR and VR could be described as potentially disruptive to the ontology of theatre. Just as video enabled the real-time (mediated) duplication of an actor during a live performance (Causey 1999), this AR technology blurs the boundary between live and mediated experiences. This is particularly notable when considering theatre's reliance on the idea of being present in the 'here and now'.

In opposition to VR, AR retains a sense of being present in physical reality because immersants continue to see their physical environments. This also permits a shared experience. While this work operated with one viewer at a time wearing the AR glasses, advances in networked technology could offer viewing paradigms for multiple AR users to simultaneously partake in live-streamed, shared experiences. This holds the promise of enhancing audience intimacy and connection not just with the performers, but also with other audience members, increasing the appeal of extended reality performances. This is known as a feedback loop of emotional contagion, 'whereby we "catch" the emotions of others through a process of low-level, non-conscious, involuntary mimicry' (Smith 2014, 37). It is a crucial social phenomenon that makes communal watching a pleasurable experience, which may otherwise be eroded by the potentially more solitary technologies of VR.

It is arguable that the demands for (inter)activity afforded by AR tech further enhance the sense of presence and immersion for the audience, advancing the sense of immediacy beyond theatre that relies purely on embodied presence. Consequently, the temporal and spatial dynamics of the stage can undergo substantial upheaval in the context of AR.

Several experts problematized XR's accessibility, for example, in terms of expenses associated with it, its operational complexity, content availability and its compatibility with existing storytelling and narrative forms.

The cost of AR technology, including hardware and content development, remains a significant barrier, limiting access for both creators and audiences and restricting the widespread adoption of AR in theatrical productions. For sectoral success there is a growing need for industry partnerships, similar to *The Tempest* (2017).

AR technology can be complex to operate, requiring specialized knowledge. This complexity poses challenges for theatre companies lacking the technical expertise to seamlessly integrate AR for non-expert audiences. The operational simplicity of *Augmented Play* (aligning the narrative trigger with the gaze) was a major driver in its success.

Given the newness of the genre, the availability of content for the intersection of theatre and AR is limited. Whereas adapting a book into a movie made sense in the past, transitioning linear narratives (which often dominate popular media) to the spatialized format of XR is not straightforward. There is a need for exploring new narrative forms to address these paradigmatic shifts, rather than simply porting old story formats into new media. *Play* is unique because of its circular and gamified narrative mechanics, but most existing performance productions are not organically suitable for adaptation to XR platforms.

Education, particularly equipping third-level film, music and performance students with the grammar to engage these technologies, can play a pivotal role in addressing the challenges of content availability and the integration of AR with traditional storytelling and narrative forms. PIX-ART, an Irish Research Council-funded project established to extend the work of V-SENSE and the *XR Play Trilogy*, aims to mitigate accessibility and inclusivity challenges associated with XR by: (1) incorporating XR into the curriculum, (2) establishing an XR lab facilitating collaborative projects, (3) forming partnerships with XR technology companies and (4) encouraging research and development through interdisciplinary and collaborative approaches.

By embedding XR technology and its applications into performing art education, institutions can produce a new generation of theatre practitioners adept at creating AR content and integrating it with traditional storytelling forms. This approach addresses current challenges and paves the way for the evolution of theatrical performances.

> *The AR glasses also provoked unease among the cohort due to current biopolitical apprehensions around surveillance and information manipulation.*

If worn constantly, AR glasses could interfere with perception and manipulate political ideologies even more than mobile phones. The 'pervasive surveillance and powerful algorithmic control procedures' (O'Dwyer 2021, 159) already embedded in mobile computing can deeply invade personal privacy, profiling users' behaviours and manipulating consciousnesses. This intrusion aligns with biopolitical fears, as these technologies possess

the power to monitor, influence and potentially determine 'individual and collective destinies, foreclosing the possibility of qualitative embodied individuation and curtailing freedom' (159). This underscores the ethical imperative for transparency and regulation in deploying AR technologies to prevent misuse and ensure that they enhance rather than compromise the autonomy and privacy of users.

This raises questions about power dynamics and who controls the means of access. Technology and creative industries can create exclusionary dynamics, as financial, algorithmic and political power are unequally distributed among engineers, billionaires, states and users. Companies that act transnationally pursue 'a liberal capitalist paradigm and its advocation of proprietorship, commodification, consumerism, and marketing' (132), restricting accessibility and affecting sociopolitical dynamics and individual freedoms.

From an educational and research standpoint, the entire spectrum of XR technologies presents captivating platforms for engaging with both contemporary and classic materials. It was not seen as a misapplication of technology, but rather a means to delve deeper into the playwright's original intentions. Participants also expressed the belief that if Beckett were alive today, he would readily embrace new technology, as he had always been a proponent of exploring technological capabilities. Presently, AR technology allows us to view drama through a new lens, encouraging different modes of analysis and interpretation without necessitating wholesale changes.

Notes

1 https://v-sense.scss.tcd.ie/research/mr-play-trilogy/.

2 It can be achieved with one depth camera, e.g., the Azure Kinect. Even with one camera the data sets are huge; so, adding more cameras quickly makes the dataset unwieldly for transmitting in real time.

3 We are currently unaware of any fully fledged performance projects that transmit live VV data over the internet; hence, we employ the term 'ethernet' here.

4 This particular performance only concerned recording the actor's faces/heads; it was unnecessary to capture their full bodies.

5 6DoF refers to the ability for an immersant to experience full freedom of movement VR; they can look around in all directions, and they can move their entire body horizontally and vertically. Conversely, in 360 cinema (3DoF) users can only look around from a 'baked in' viewpoint correlating to the camera's position.

6 Other more thematically appropriate venues were explored, including the historic crypt of Dublin's Christchurch. This would have been a better setting/context; however, the cost was prohibitive.

7 There are some innovations in the mixed reality genre involving the co-relation of virtual set elements with furniture and structural members in the physical space (c.f. Weijdom, Chapter 6). However, even when virtual and physical set elements are aligned, it is still quite disconcerting for the audience members to move around, and really a guide is required for each participant.