Animate: A Theatrical Exploration of Climate Transformation through the Medium of Extended Reality (XR)

Chris Salter, Timothy Thomasson, Pierrick Uro

Immersive Arts Space, Zurich University of the Arts, Concordia University, McGill University
christopher.salter@zhdk.ch , timothythomasson@gmail.com, pierrick.uro@mail.mcgill.ca

Abstract

This paper presents a critical account of the development of a large-scale theater work using emerging Extended Reality (XR) technologies. Detailing three aspects of the project and set against theoretical frameworks from STS (Science and Technology Studies) and the sociology of innovation around ideas of the future embedded in technologies, we examine the conceptual, aesthetic, organizational and social-technical underpinnings of the project. The paper's goal is thus to give a sense of the challenges and opportunities in the emerging integration of XR into new artistic morphologies that hybridize the visual-performing-media arts through new technological advances.

Keywords

XR, VR, AR, Spatial Computing, Passthrough, Presence, Climate Collapse, Technological Futures, Performance, Vitality Affects.

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Introduction

Animate is an Extended Reality-based theater work (XR) at the crossroads of performance, radio play and installation focused on a near-future Canada radically transformed by climate change. Developed by a team of Canadian and German artists and researchers, the work premiered in Summer 2022 in large theater festivals in Germany and is preparing for a 2023 international tour in Europe, Canada and Asia.

XR is a umbrella term emerging in the mid 2000s that describes computer-generated environments accessed and experienced through worn headsets and body interfaces. These environments are either simulated (virtual reality-VR) or overlay and mix real scenes with digital 3D images and sounds (augmented reality-AR). As part of its dramaturgical strategy, *Animate* harnesses a recent XR technology to explore this potential mixing of real and the simulated in worn AR: live video "passthrough" which takes a real time video feed from the tiny cameras attached to a head mounted display (HMD) and which allows the embedding of computer generated 3D objects into the video feed of the real environment.

This paper details three aspects of the project, set against theoretical frameworks from STS (Science and Technology Studies) and the sociology of innovation and expectations focused on how the future is embedded in both technological discourses and materials. In Part 1, the most extensive section, we discuss the initial concept and dramaturgy of the work. Although the technologies utilized in the project and the resulting experience for the audience can be claimed as new, the concepts that enable these possibilities date back to the 1960s with the development of early Virtual and Augmented Reality technologies.

Second, while numerous other media were key to the artistic process, space allows us only to describe the visual aesthetic concept behind the work. We focus on how our approach both differs from many standard VR-based projects while also articulating the technological background that made such artistic choices possible. In Part 3, we analyze the lead up to the final presentation of the project in a major theater arts festival in Germany. Here, we pay particular attention to an area which is rarely focused on in accounts of technologically-driven artistic practice – the coupling between the profound instability of emerging technological infrastructures and the manner in which such infrastructures ultimately affect artistic decision making.

What theoretically grounds the paper is recent work in STS (Science and Technology Studies) on issues of "boundary work," "technological futures" and "technological promises" together with emerging research concerning the rapidly transforming understanding of presence through XR technologies such as video passthrough. These technologies challenge long assumed ideas of presence in VR based on the "illusion" of place [6] and instead, suggest new scenarios where users become located "between the digitality of VR and the concrete reality of a user's surroundings."[18] This theoretical work is critical in grappling with new artistic possibilities of XR technologies in addressing larger aesthetic-social-technical issues the project is focused on; namely, the symbiotic "interrelationships between media technologies, environment and body."[2]

I. Background and Concept

Conceived in 2019 by one of the authors of this paper, the original impetus of the *Animate* project was to explore the thematic of climate change through the sensorial-aesthetic possibilities of "spatial computing." A term that emerged in the mid 2000s and encompassing a range of computing and HCI research, spatial computing can be defined as "human interaction with a machine in which the machine retains and manipulates referents to real objects and spaces" [13]. Although spatial computing's genealogical roots lie in environmentally-based computing paradigms like "ubiquitous computing" [23] and "enactive" or "embodied interaction" [9] from the mid 1990s, the principal application area for the concept arises in the domain of Augmented Reality in which digital information is overlayed and integrated onto a real environment.[2]

Primarily accessed on mobile devices (smartphones and tablets) until the mid 2000s, more recently large amounts of R&D have been poured into the design of "wearable AR" headsets from large tech companies like Microsoft, Google, Facebook (renamed as Meta) and importantly, Magic Leap. Magic Leap is a much-hyped US-based start-up who developed a wearable pair of AR-based glasses with extensive environmental sensing capabilities for the consumer market throughout a long stealth period; a device which spectacularly failed to catch on shortly after its 2018 release. The commonality among all of these AR technologies is two-fold.

On the one hand, they all seek to enable a computing paradigm that has long been theoretically discussed and experimented upon (but with few widespread

applications) called “Mixed Reality” (MR), in which the computer-generated world and the physical world meld, blur and blend. MR is situated on what researchers have called the “reality-virtuality continuum”[15]: a well cited paper in computer science that describes a taxonomy between completely simulated (or virtual) experiences and real ones.

On the other, wearable AR presents a social-perceptual challenge. While VR uses a headset to completely surround the wearer with a closed off world of computer-generated images and sounds based on sensing head and (mainly) hand movement, wearable AR demands a negotiation between what Azuma names as “virtual content that is integrated with the surrounding real world, while users remain engaged with and aware of that ‘real world’” [4]. It is this conceptual idea that forms the basis of the entire Animate project.

Spatial Computing and CliFi

The comment above from Azuma acts as a strong framework for the choice to explore a critical issue, that of climate collapse, through the technological-phenomenological context of wearable AR/XR. After surveying the state of the art of wearable AR technologies in 2019-2020 and spending part of the pandemic experimenting with the see-through Magic Leap system, the artistic team gathered for the project reached two conclusions. The first was that the Magic Leap or similar were too immature and costly for use in a professional live performance artistic context due to multiple factors: comfort, low resolution, limited battery life and most important, extremely limited field of view (FOV)—a term used to describe how large an augmented reality image is when viewed through a headset.

Given the state of art, the second and more important consideration was that a purely technological exploration of XR in typical “demo mode” would not be artistically adequate. These conclusions thus lead (after almost 6 months of reading different texts) to the concept of staging a narrative Climate Fiction (CliFi) short story called “Animate” by a Canadian author; a story which was discovered in a Canadian “CliFi” (Climate Fiction) anthology.

The plot of the story “Animate” focuses on two characters, Daniel and Laurie, who are fleeing a near future of climate disasters. Emotionally distraught from their hidden pasts, the pair set out on a journey through the wild landscape of Newfoundland, Canada. While news of global climate catastrophes is broadcast on their car radio, they drive towards the Tablelands, a real Mars-like landscape in the middle of Gros Morne National Park where one can directly walk on the mantle of the Earth. Gradually, the climate-change transformed landscape exerts a force on them as if it was a conscious, living and breathing entity. It emits strange sounds and affects Daniel and Laurie’s personal relationship. But it is only in the dramatic conclusion, where the earth comes alive in an apocalyptic scene of rocks rising from the earth and attacking the characters, where the intricate interconnectedness of humans and a natural world under the throes of radical environmental change is symbolically and viscerally manifested.

The basic dramaturgical strategy that evolved in the early phases of the project (during a period of conceptualizing while fund-raising) involved a collaborating with the author to adapt the short story and turn it into four dramatic scenes (Driving to the Tablelands, Camping Overnight, Hiking to the Tablelands and the Earth Strikes Back) like a theatre text, then record actors speaking the text for a radio play and finally use the radio play as a complex sonic accompaniment with additional visual elements in XR for a live theatre-like installation with actors.

Walkthrough and Passthrough

It was clear from the start of the *Animate* project that due to the potential production and presentation contexts, the project would need to perform a kind of “boundary work” between the genre of theatre (involving human performers) and the technological environment of an audience wearing HMDs in order to enable an interplay between real physical space and the imaginary world of computer augmented space.

A term coined by the sociologist Thomas Gieryn, boundary work describes work in which “boundaries, demarcations, or other divisions between fields of knowledge are created, advocated, attacked, or reinforced” [11]. Most often such demarcations are described in more “high stakes” ideological contexts as the natural sciences. Yet, one should not underestimate the different communities of practice that operate even in assumed “fluid” artistic contexts. Indeed, the insistence on one of the co-producers of the project (themselves anchored in theater performance contexts in a European cultural festival context) that we should include human performers to appeal to a more traditional theater audience who might be suspicious of the potential “media barrage” brought on by utilizing AR technologies clearly demonstrates the occurrence of such boundary work .

The external demand of adapting to certain kinds of theatrical norms in both organizational and artistic ways as well as the aesthetic choice to emphasize audio over computer-generated image (due to technical limitations in AR headsets described above), posed a dual conceptual and artistic challenge in terms of integrating live performers into the larger XR context. This context thus drove a fundamental artistic choice from the start of the project: the idea that the audience would move from one physical space to another while they listened to the spatialized radio-play based on the short story "Animate" over their HMDs.

This radio play accompanies installation with performers idea isn't entire original but inspired by the work of a 1980s San Francisco Bay Area theater-technology company who grappled with the similar situation of trying to integrate a new technology (at the time) into live performance: the Sony Walkman. Known more for their invention of a wireless museum guide/tour system that later became the largest audio tour company worldwide, in the 1980s, Antenna Theater, directed by the American theater maker Chris Hardman, pioneered a new form of walk-through performance-installation which Hardman labeled "Walkmanology."
"I've always found airplanes to be claustrophobic, there is always a kid crying in the back and you forgot the book you intended to read so you realized that you're stuck there for hours with nothing productive to do. Then this new fangled bizarre device came out on the market called a Walkman and I decided to get one. I turned on the Walkman and just as the airplane lifted into the sky, Wagner's "The Ride of the Valkyries" began to play. Suddenly I realized that there was this amazing theatrical event happening and it was called Syncronicity! The visual and the audio were working in sync and furthermore instead of watching from afar, I was literally inside the event" [1].

In many ways, the choice in *Animate* to use the emerging technology of AR follows a similar path dependent story as Antenna's work with the Walkman: treating the technology of worn AR as a device that accompanies a larger dramaturgical experience rather than creating theatre work inside VR or AR [17]. Yet, what is key to the project is the emergence of a technology during the early phases of production that was unknown at the time of the planning of *Animate*: the 2021 introduction of a new generation of wireless VR headset from Oculus/Facebook/Meta which utilizes a video technology called "passthrough."

Originally designed as a safety feature to alert VR users when they would potentially go beyond a demarcated spatial area called "the guardian," passthrough uses the tiny black and white infrared cameras built into the Oculus Quest 2 HMD which enables the device to sense where it is in space. These cameras deliver and process live video images of the outside world inside the headset in place of our eyes, approximating what one would see if directly looking into the real surrounding world. Importantly, what passthrough technology does is transform VR devices (in this case, the Quest 2), which traditionally immersed the user in a closed off, socially isolated world, into a new kind of wearable augmented reality where digital objects can be embedded/overlayed onto the real world via the live video image and one sees/senses the physical presence of oneself and others.

The introduction of passthrough technology as a kind of stop gap immersive AR not only represents a technical change – it also suggests an epistemological and *phenomenological* one as well; a transformation that is both historically grounded while, at the same time, shifting concepts of presence that have been long established from research into human interaction and experience in VR. Indeed, while the passthrough technology was already included in the first release of the Oculus Quest Pro in 2021, the ability to manipulate the passthrough image by gaining access to it through the device's SDK (software development kit) was only available after production on *Animate* started in December 2021.

Technological Futures courtesy of the Metaverse

Yet, a larger question around passthrough arises. Why did Meta move to allow users to access and manipulate the live passthrough camera image, thus turning the Oculus Quest 2 into a "immersive" worn AR / MR device? The answer to this question suggests a larger narrative at play rather than simply creating a technology to ward off potential accidents with users who would stray too far from a safe area while playing games in their living rooms. Indeed, it wouldn't be a stretch to claim that the passthrough-based AR capabilities of the Quest 2 are tied into a larger socio-technical imaginaries of Meta's "technological futures" and "promises" for the software/hardware integration of platforms to enable the so-called "Metaverse." That is, to enable people to begin to occupy both physical and computer-generated spaces that the Metaverse seems to promise.

Recent work in the sociology of expectations and STS has focused on the concept that certain imaginaries of the future are performative in that "expectations,

visions, scenarios, and other forms of anticipation affect what may actually happen" [14]. This idea of technical "visions" describes certain normative conditions – of what is desired by a particular constituency rather than what is plausible or needed *from* a particular technology, setup or infrastructure. Normally, scholars study such visions under the context of *discourse*, including statements concerning "practices that systematically form the objects of which they speak" [10]. Yet, the transformation of a particular material technology such as a set of cameras originally used for sensing the spatial orientation of the Oculus Quest 2 by way of software additions, also results in a new perceptual paradigm (this is the case of video passthrough). This suggests a literal materialization of such practices of discourse that Foucault speaks about through a purposeful management of "future expectations."

As STS researchers are keen to point out, the production of expectations around emerging "breakthrough" technologies "which promise a vast potential of market prospects and solving societal problems and create a sense of urgency in the context of international competition," is instead conceptualized as a "regime of economics of technoscientific promises," rather than a social-technical imaginary in which alternative futures that are equitable and desirable for larger collectives are produced.[14]

Such clearly seems to be the case of the "Metaverse," which is announced as future technology to "change human interaction as we know it." There thus seems to be no better way to manage future expectations of an unproven technology platform like the Metaverse than to construct a taste of what such a "proximate future," a future that is always on the horizon but never comes,[5] might be in the present.

Shifts of Presence

The introduction and manipulation of such passthrough technology not only changed our technological approach in *Animate*, allowing us to move from Magic Leap-based Augmented Reality to that of passthrough delivered video image. The possibilities of passthrough also changed the aesthetic-perceptual framework as it quickly became clear that visitors would have to wear and adapt to the Oculus Quest 2's bulky form factor and closed off environment throughout the performance.

But the use of these worn AR technologies within *Animate* raises also important phenomenological questions as well, namely, how the sense of presence of oneself and others is actually reconfigured through technologies that allow full body experience. It must be stated that the idea of one being able to confront a mix between the computer-generated world and the real one (albeit one brought by cameras as in passthrough) is an idea that dates back to computer graphics researcher Ivan Sutherland at the University of Utah in 1968.

Sutherland is credited as one of the first to develop the technology (if not the concept) for the head mounted display – what he famously termed "the ultimate display" in a 1965 visioning article. Yet, Sutherland's description of a "display connected to a digital computer" [that] gives us a chance to gain familiarity with concepts not realizable in the physical world" [21] which sounds like the basis for current virtual reality, is actually enlarged in a follow up technical paper in 1968 which describes the actual construction and workings of a 3D head mounted display. Here, Sutherland gives already a sense of the Quest's (and other) push towards integrating passthrough technologies into the real environment. "Half-silvered mirrors in the prisms through which the user looks allow him to see both the images from the cathode ray tubes and objects in the room simultaneously. Thus, displayed material can be made either to hang disembodied in space or to coincide with maps, desk tops, walls, or the keys of a typewriter" [22].

At the same time, however, what is more interesting about the introduction of passthrough technology is that it also enables a paradigmatic shift in another area of knowledge and consequently, experience (which is why we term its effect both epistemological and phenomenological). Passthrough changes the understanding of one of the core foundations of VR-based research which is that of *presence*.

In fact, the introduction of consumer grade AR that mixes the real and simulated together shift not only the user's experience of their own presence but also "the conditions in which human individuals interact with one another face to face from body to body" [25] " what Goffman [12] famously called co-presence. As key XR researchers admit, while these technologies have existed for decades, "little is known about how social interactions are affected by the technology" [16] and how social interaction in turn shapes these systems. Part of this gap stems from the overarching focus in VR/AR research on an individual experience of "presence" as "outwardly 'dislocated' from its physical setting."[18, 7]

It should also be clear that the move to worn AR prototyped by Sutherland in the 1960s and commercially available in 2021 is a marked contrast to earlier conceptions of presence in VR understood as the "virtual experience of being in an environment, even

when one is physically situated in another." [6, 24] While *Animate*'s focus was not specifically on researching how such co-present interaction is reimagined (and vice versa) through camera-based technologies like passthrough, the experiential effects of being embedded in the real environment while also experiencing Sutherland's vision of a "mathematically generated wonderland" clearly constituted a necessary experiential context for the production.

II. Aesthetic Considerations

We have so far described some of the historical, artistic and sociological background of *Animate*. But the larger question looms of how all of these ideas actually play themselves out in the trenches of practice? This section Thus, focuses briefly on two of the principal image-based media that forms the basis of *Animate* during the approximately seven-month production period, from late November 2020 up until production in Germany in August 2021.

Alternative 3D Images in VR Land

The visual aspect of VR is often intertwined with historical theorization around cinema and as an extension of early immersive technologies such as panorama screens. However, with new XR technology the language borrowed from cinema [camera, frame, mise-en-scène, cut, montage, projection, screen] can only take one so far.

This situation prompts a complete reconfiguration of artistic and dramaturgical decision-making when sequencing elements of an XR work. Virtual objects are no longer elements to be 'looked at', but instead have the potential to be investigated from all angles and vantage points. The salient attribute of these technologies is their ability to render virtual spaces such that they perceptually feel 'real'. Although the illusionistic 3D space projected onto a flat surface remains technically 'flat' in XR, perceptually the virtual rendering of objects and the physical space in which those objects are situated becomes integrated. As such, in the context of XR, we could no longer rely on the accustomed conventions held by the cinematic language (perhaps suitable for 3D of VR work), as one must edit and configure images not only over time, but also over physical space, while also being aware of how bodies might move through that time and space.

In the second act of *Animate*, the switch to passthrough AR immediately following a rope guided VR 'journey' provided a direct perceptual contrast between the experiential qualities of both XR modalities. During this dizzying rope guided journey, the participants must meander through a foggy Tarkovsky-esque virtual trail with distant hills and trees, listening to spatialized audio while losing their orientation in the physical space. Here we planned to take a restrained approach to the image, rather than adhering to the cultural expectation of visual effects overload, such as the case in many VR works. This scene transitions into an opening of the passthrough image.

One realizes the sealed off, socially isolated quality of VR when participants can suddenly see their bodies (rather than virtual avatars as is the case with many other XR works), other participants, the real environment, and the performers. As such, developing a dramaturgy that unfolds to accommodate both VR *and* AR technology—and not either/or—reveals the perceptual nuances of these technologies as held in such striking temporal and dramaturgical contrast.

As previously stated, in the context of *Animate*, the passthrough feature was deployed outside its intended practical use case of creating a guardian safety boundary for a VR experience. Due to its practical functionality, the passthrough image produces a low resolution, grainy, black and white image. This image as incorporated into *Animate* suggested an early film aesthetic, as well as the contrasted black and white images of films from Antonioni or Tarkovsky. Indeed, at points in the work we lean into this aesthetic quality, adding simulated grain over virtual objects, so they feel visually and perceptually integrated into the passthrough image. In other instances, such as the initial reveal of the Tablelands environment, a highly saturated virtual space is presented—portraying a vivid full colour virtuality at odds with a more subdued black and white passthrough reality. Meta's recent release of the Quest Pro headset comes with high-definition full colour passthrough. We are currently experimenting with the technical and aesthetic affordances of this new headset for the upcoming performances of *Animate* in 2023. This speaks to the technical and artistic adaptability that is required when working with such emerging technologies.

As the passthrough image appears in the last scene, both virtual and real rocks are revealed to be scattered around the physical space. As the narrative continues, these virtual rocks begin to move in a carefully choreographed way– climaxing in an explosion and in a clustering and swarming pattern, as if they were birds or

insects. The sites in which the performance has taken place thus far were remodelled such that the virtual elements spatially could overlay the physical architecture to real-world scale as seen through the headset. These virtual models are hidden from the spectator's vision, but remain in the software's memory to carry out physics calculations and render occlusion. Due to these virtual mapping techniques, the rocks collide with the physical environment, crashing into walls, pillars, and the floor. Participants can extend their hands and bodies and 'touch' these rocks, which in turn causes them to move as their physics are simulated in real-time.

Interacting with Flying Rocks

As stated in Part 1, *Animate* ends with a spectacular scene in which audience members find themselves in a field of rocks, some virtual and some real. As the scene progresses, the simulated rocks begin floating, moving around and seemingly gain consciousness as they chase the actors and audience members. Any of these rocks can be interacted with by pushing them around using the hand tracking featured by each headset. However, with the aim to give these 3D objects more corporality, we focused on interaction between the rocks and the audience.

Early live tests revealed that allowing hands to directly collide with the rocks made it too easy to introduce energy in the environment, as a simple slap could effortlessly send a massive rock flying to the other side of the room. The adopted solution was instead to implement a force field around each hand that continuously pushes away rocks that get too close, with more power the closer they get. This approach restricted how much energy, and thus chaos, could be injected into the system, limiting the amount of control one has over the rocks and guaranteeing an agency to the objects. As the scene progresses in intensity, the rocks gain more energy, which makes it easier for them to ignore the attempts by the spectators to alter their course or shield themselves, denying them the drive to disrupt the harmonious choreography.

Since the artistic intent was to virtually drown the participants in boulders and pebbles, just like the characters in the story are swallowed by the earth, the number of virtual rocks totaled over 600 individual objects. This made it impossible to perfectly synchronize the rock's state across a dozen headsets over a WiFi network and thus demanded an alternative procedure. A way to combine interactable rocks, locally solved physical simulation, and a behavior recurrent enough for a scripted show is to implement a flexible system. Since all headsets were to be spatio-temporally aligned, they all could share the exact same behavior, which instead of controlling the rocks directly, positioned their targets. Throughout the scene, the floating objects were assigned different moving targets that serve to steer them on the stage since the rocks would be continuously pushed towards their target. As the targets' behaviors are determined, the rocks could then flexibly and independently react to a spectator's actions, synchronizing the state of each object and solving simultaneous interaction over the network thus becoming unnecessary.

Both measures undertaken ensured that even though the state of the system on a microscopic scale would differ for any spectator and performance, it would also stay similar enough on a macroscopic scale to fulfill three requirements: the audience members could feel as though they are sharing the same environment; the actors could move and react around learned cues on stage; and the spatialized room-scale sound (which would eventually be synched to a 49 channel audio system) would stay consistent in time and space with the current state of the virtual environment.

III. Production and Transformation

In part 3 of this paper, we describe the final production period of *Animate*, a relatively short time frame of 10 days that took place in the actual location where the work was to be premiered: one part of the interior of a vast, almost 100,000 square meter former factory that manufactured agricultural machines for the entire former East Germany.

Like many works involving the integration of new technological infrastructures, the technical production of *Animate* was beset with challenges. More specifically, the ontological nature of theater as a distinct time-based event which demands an integration of multiple elements poses a major challenge to the use of technologies like Meta's VR headsets that have been explicitly designed and engineered for a different scale of use: small spaces like living rooms. Here, we want to focus on two specific issues that had major artistic implications: (1) the difficulty of integrating live performers into passthrough-based AR; and (2) the mismatch between an organizational workflow derived from theater versus one derived from VR-AR development and production.

Live versus Virtual

From the start of the *Animate* process, the core artistic concept was to leverage the relations and tension between live theater with performers and passthrough-based AR. This was to be conceptually accomplished by the performers, who would be “live” actors essentially “acting out” in “dumbshow” format (conveying a meaning or message without speech through miming) core scenes while being accompanied by the overall spatialized musical/sonic/text/visual “score” accessed by audience members via the worn HMDs.

This concept in practice, however, proved to be a significant challenge. First, due to the high cost of the professional (and in this case, well-known) actors who were active in the German theater scene, the amount of rehearsal time required to integrate these performers was extremely short (5 days). Second, the complexity of mixing 3D graphics into the real scenes by way of passthrough was grossly underestimated, particularly since the actual performers were only integrated during the technical production period and not during development in Canada.

Since the performers could not see what was going on in two crucial scenes (Scene 2, “Camping” and Scene 4, “Tablelands”) since they wore no HMDs themselves, it was increasingly difficult for the actors to know where virtual objects in the space were located in relation to real objects. More pointedly, 3D game engines as creation and rendering environments for XR production are WYSINWIG (What you see is NOT what you get). In other words, what appears on the screen has little to do with how such 3D objects are perceived when they are embedded into real environments via passthrough technology. This issue of not being able to see and hear entire scenes in *Animate* without wearing an HMD reached an almost comic proportion when the dramaturg/movement consultant who was supposed to take notes to aid the artistic director and the actors, was unable to perform these duties since all of the HMDs were occupied for testing by the technical-design team.

A third and major difficulty arose in the extremely low quality of the black and white passthrough video feed; an issue exacerbated by the harsh lighting conditions in the industrial hall where the performance was to take place.

While the team tested passthrough technologies continually during the development process, the original concept was that there would be no scenes with human performers without accompanying 3D objects and behavior of those objects (like the complex rock scene) acting alongside the human performers. The pressures of production deadlines combined with the extreme latency of framerates with the Quest 2 led to the reduction of all heavy 3D graphics, thus transforming the overall visual aesthetics of the two crucial scenes with the actors. Indeed, watching highly trained performers miming a complex dramatic text through a black and white and frequently distorting video feed using an uncomfortable and awkward device proved to be too much.

The Vitality Gap

While the above issues demonstrate that the integration of live performers into passthrough XR is not trivial, a much larger issue was present in the final production period; one which led to a radical reorganization of the entire production twenty-four hours before the premiere for audiences and press. This core “show stopper” involved the inability of the technical team to make needed artistic changes in *real time* to virtual environments in Unity 3D, based on the direct real time experience of working with the actors.

Unlike the production process of VR applications like games or already produced experiences such as film, the real time experience of making theater with performers and machines is completely different, akin more to improvisation than to the filmmaking or gaming production workflows that seem to be default for XR development. Live performance practice demands a sophisticated attention to timing and rhythm, as well as highly tuned dynamics in order to ensure that the flow of action reaches what the psychologist Daniel Stern called “vitality affects” – in which “physical action and traceable mental operations" become "inherent in the act of [both physical and mental] movement” [20]. Vitality affects, which involve the dynamic flow of time through the expression of rhythms, pulses, changes of tempo and direction are experienced in the entanglement between human bodies and nonhuman objects and processes like light, sound and vibration outside of us. Such “forms of vitality” sweep us up into dynamic moments of intensity.

Unfortunately, such forms of vitality were extremely difficult to construct between the human performers and the workflow of XR production. In contrast to real time audio-video processing environments, where developers and creators can make changes essentially “on the fly,” based on changing dynamics of performers and light, sound or image in the ever shifting context of the performance environment, the sheer amount of time required by the workflow of making changes in Unity 3D and then uploading (“building”) those changes to the hardware-based Oculus Quest 2 (bordering on hours)

made quick changes extremely time consuming and inefficient. This inability to rapidly change or eliminate elements or even scenes that did not work or whose timing was aesthetically problematic in the heat of rehearsal proved to be major hindrance to creating a dynamic live event.

The Nature of (Dramatic) Change

It goes without saying that that *Animate*'s live performance context presented both a formidable challenge as well as opportunity for thinking of the further development of XR as an aesthetic-social-technical domain of knowledge and experience. Indeed, the challenges that the performance context presented were indeed so formidable to the ultimate successful artistic realization of the work that Salter undertook radical changes one day before the public premiere: completely eliminating two of the core scenes (Driving and Camping/Dream) of the production that the team had worked months on and replacing these with a much more simplified concept involving the actors dramatically reading the original short story to the audience for the opening scene.

After this initial scene, in which the actors sit underneath the camping scenography originally designed for the integrated production between performers and XR, the audience is brought by the actors into a second space: the enormous main part of the industrial hall. It is here that the media experience promised by *Animate* begins. After the ubiquitous onboarding sequence, where the audience receives Oculus Quests 2 and specially designed headphones that allow audio from outside to also be audible inside the headphones, the actors collectively lead the small audience who are connected together with a rope through the space while the group experiences the VR part of the performance: in the dramaturgy of the work, the experience of hiking to the top of the Tablelands. Lasting approximately seven minutes, the scene ends with the audience briefly inside a 360-film shot in the actual tablelands in Newfoundland; a landscape which gradually fades, revealing the actual physical environment of the industrial hall via video passthrough.

Finally, in the dramatic last scene, the audience is plunged into a full XR experience – essentially, the original vision of *Animate* as a work focused on the affective and bodily impact of climate transformation. A field of detailed, 3D modelled rocks lie on the floor courtesy of the passthrough-VR mix. As the scene progresses and the landscape becomes alive, the rocks slowly lift off the floor, accompanied by thundering, multi-channel audio in the physical room and in the headsets. The actors begin to dance as blinding light from the other side of the enormous space bursts into the black and white video feed in the HMD, essentially causing a momentary white out for the audience. As the actors begin a kind of *dans macabre*, eventually disappearing from the scene, the assemblage of 3D rocks gathers speed, first assembling in a rotating ball and then exploding across the physical-virtual space. The performance concludes with the long planned *Endzeitsturm* (apocalyptic storm) of rocks, that spin in a gravity-defying machine enabled choreography and concludes by rushing through the industrial hall in a massive snake-like form, only to fall onto the transfixed (and sometimes escaping) audience members.

The radical artistic choice to edit, reduce or eliminate painstakingly produced artistic material is not particularly unusual but rather a standard artistic survival strategy. In the heat of practice, there is a clear sense of what works and a clear sense of what doesn't. In *Animate* in particular, however, the massive restructuring of the performance 24 hours before the premiere not only enabled the performance to achieve the kinds of vitality affects necessary for its success: it also clarified added certain conceptional and dramaturgical structures that had been buried in the initial concept but not well articulated, namely, the historical story of how different forms of media have and will enable in the future different modes of storytelling. As *Animate* moves from live theatre to VR (itself an older technology) to the futuristic promises and possibilities of worn AR through the almost anachronistic quality of black and white video passthrough, the audience experiences a double move from one form of historical media to another and from passive spectator to active participant.

Conclusion

We have described the production process involved in a new attempt to integrate unproven XR technologies into the complex dynamics of real time performance, framed by recent work in STS, the sociology of innovation and performance theory on the social-technical imaginaries and futures that technology harnesses and the real-world challenges and practices that put these futures into a kind of situated, concrete knowledge and experience.

What we have not have time to describe in this paper is the audience reaction to the project as little ethnographic interview work was formally done given the already complex demands on the artistic and

technical team. But perhaps a long citation from a review of the production in one of Germany's major newspapers, the *Frankfurter Allgemeine Zeitung*, gives one sense of the affective promise envisioned in the complex entanglement between technology and environment, past and future, imagination and reality. "This year, the Kunstfest Weimar is focusing on the utopias of the future and has included pieces that talk about climate change, political polarization and new social systems. Animate" is the boldest one. In this immersive production, the latest generation of virtual reality glasses is used to tell a dystopian love story that blossoms and then shatters in the midst of the climate crisis. The text comes from Canadian author Kate Story. Laurie and Daniel, the main protagonists, are newly divorced and come together in their loneliness. Both are traumatized by past relationships and experiences. Their homeland has been destroyed by a climatic catastrophe. While the sound plays, the audience of only eight is led through the hall on a rope in a one-hour time slot. Actors ecstatically tell the story and perform in harmony with digital reality. While she balances on the stones and always close to the abyss, he falls into a depressive trance and despairs more and more. "I'm finished, we're finished," he says in a sobbing voice. The industrial hall with all its natural obstacles provides a surreal backdrop. In the VR part of the performance, the images blur, the chirping of birds turns into a booming bass sound, and boulders seem to be moving around. At that moment, the performance begins to fulfill its immersive promise. Now the rope is put down. The audience moves freely in the space, following and dodging the whirling rocks – which are both there in the glasses and not there in the real world. With their hands they try to fend off the debris, which really works thanks to the latest VR technology. Salter's piece, realized with technology from Meta, gives a foretaste of theater ten years from now."

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