

# Synchronous Reality: Enhancing Sensory Perception in Immersive VR

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**Abstract:** This paper introduces the concept of Synchronous Reality whereby a combined sensory physical and virtual installation is created. The research is presented examining how the practice work evolved to establish the concepts which make up a Synchronous Reality installation. The research ultimately focused on creating a sensory landscape to complement the virtual layer of the installation, thus making a coherent whole which encompasses Synchronous Reality. The findings and conclusions indicate that this type of installation can increase the immersive quality and presence for the participant. The important considerations when making such an installation are also presented. The paper also touches upon a brief examination of the wider issues of how immersive virtual reality affects the digital economy and telecommunications.

**Keywords:** Synchronous Reality, Virtual Reality, Sensory input, Immersion, Presence.

## Introduction

In 2019, this researcher completed a practice-based Doctoral thesis at the Auckland University of Technology (Bailey, 2020). This paper is intended to present some of the key findings from that research, which could be useful to practitioners and others working or researching in the field of Virtual Reality (VR). The research centred primarily upon placing participants into immersive installations which combined sensory-based physical and virtual components which might then, in turn, elicit sensory recollections. The installations became a focus of visual, aural, olfactory and other perceptions which would attempt to evoke certain emotive responses to the reconstruction of a place from the researcher's past in the form of a composite memory. The term "Synchronous Reality" was developed during the research in order to adequately describe an installation which created a coincidence of physical sensory information with that of the virtual environment. For example, physical elements such as the seats of the major practice work Caravan (a virtual reconstruction of this researcher's live-in caravan) were 'synchronised' with the virtual seats so that a participant could sit, feel the 'give'

of the squabs, and experience the kinaesthetic positioning of the body. The research drew upon Mark Hansen (2006) who sees the body as the primary vehicle of sensory experience in a virtual installation. It was with this objective that the body itself was used to channel physical sensations through such components, for example, as objects which could be touched, or sounds which could be heard, in conjunction with the visual cues provided within the virtual environment itself. Participant feedback and observation indicated the Synchronous Reality environment enhanced the immersive quality and presence within the installation for the participants.

## Review of Literature

The review of literature for the study focused on the philosophical underpinning of the work, and research which was particularly relevant to immersive VR and sensory input. Gaston Bachelard's *The Poetics of Space* (1994) became central to the work in terms of orienting it through the senses, particularly his discussion of memory and how a space can trigger recollections which can engender a feeling of intimacy with the space. Bachelard implies that a reader's attention goes from the room they are reading about to the memory of a room of their own when he says: "The values of intimacy are so absorbing that the reader has ceased to read your room: he sees his own again" (Bachelard, 1994, p. 14). The research asked if this same type of engagement could be possible within an immersive VR environment and the subsequent findings from the qualitative interviews suggested it was. The project also focussed on the virtuality of the mind drawing parallels with a Virtual Space.

Bergson (1988) argues that a memory, daydream or mind perception could be suggested as virtual, which engendered the idea to use memory as a vehicle for the practice work. He suggests that the mind simplifies matter into a virtual representation, a superficial skin (1988, pp. 5-6). This is not unlike a virtual environment which paints textures onto hollow three-dimensional models. Thus, the creation of a memory in virtual space was something akin to the way, according to Bergson, the mind would perceive it. Massumi (2002) proposed the idea of a connection between a sensation and its articulation as an emotion or feeling. The sensation, Massumi says, is not immediately articulated, and may never be (Massumi, 2002, p. 28). However, sensation is needed for emotional response, they are co-conspirators in the production of an affect or emotional response. As the practice work progressed, there was more focus on putting sensation at the forefront of the work with the aim of eliciting certain emotional responses in the participant.

Bringing the philosophical terrain to the virtual one ultimately involved the creation of a combined virtual and physical space where a memory would be reconstructed as a virtual/physical installation and a participant could experience it. The two important factors

to the success of a virtual environment are immersion and presence. It is not enough to simply fulfil the first by dint of using immersive technology, there are certain aspects which will ensure the feeling of immersion itself. Murray refers to the concept of virtual immersion as being similar to that of being immersed in water (Murray, 1997, p. 99). Slater more clearly explains it as preserving 'fidelity' to the real-world senses where the immersive quality is dependent on this factor (Slater, 2003, p. 1). He goes on to contend that presence, noted by Skarbez (2017) as 'being there', is the reaction to immersion. The two being connected, one could assume greater immersion gives a greater feeling of presence. Slater also says that, due to the activation of different sensory perceptions (perceptual, vestibular, proprioceptive and autonomic), the immersed individual will react as if it was a real-life situation. Thus overall, a focus on the sensory aspects of a virtual installation should increase the level of immersion and consequent feeling of presence. Given Hansen's assertion that the body is the primary access to the world (Hansen, 2006, p. 5), the more sensation a participant receives through their body, the more they are likely to feel part of the virtual environment they are immersed in. The practice work continued to develop its sensory aspects over the course of the research.

A number of researchers have examined particular aspects of sensory stimulus in VR. Anatol Lecuyer (2017) speaks of a conflict between the real world and a virtual world where the real-world senses are not supplied. He notes that a psychological or behavioural reaction can be elicited where this conflict is resolved by supplying a strong sensory and immersive experience in the virtual environment (Lecuyer, 2017, p. 20). Whitelaw (2012) argues in favour of an aesthetic aural experience where moments of intensity or otherwise fleeting or more visceral feelings might be engaged in the listener. Indeed, the Proust Effect is well-founded in the work of Marcel Proust (1992) where sensations gradually evoke memories, which become more distinct over time, and exposure to those particular sensations. Proske and Gandevia (2012) offer the idea that proprioception of the body, being those muscular sensations providing information on position and bodily movement, assists in orienting the body to the virtual environment and enhances the feeling of immersion. Mine (1997) indicates that where an actual object in VR is located coincident to the user's hand position, they would also acquire a sense of the position of the object. If physical elements are also located corresponding to virtual ones in the installation, this should result in increasing the proprioceptive sense of position. Lecuyer (2017) further argues that interruptions to the feeling of 'being there' may be more common where a noticeable disparity is evident between the physical and virtual elements of a simulation; the corollary being that a more seamless coincidence of these elements should give a more fluent and uninterrupted immersive experience. Then, examining sound, Larsson, Våljamäe, Västfjäll, Tajadura-Jiménez and Kleiner (2009) investigated the effect on presence using aural input in mixed-reality environments. Their conclusion is that

“while a visual scene – real or virtual – may be completely static, sound is by nature constantly ongoing and ‘alive’; it tells us that something is happening” (Larsson *et al.*, 2009, p. 225). Nordhal and Nilsson (2014) assert that sensory feedback should be presented in a way that mimics the real world. They argue the credibility of the virtual world increases if the participant is surrounded by aural stimulation, much as one is in the normal physical environment we inhabit. Munyan *et al.* (2016) concluded in an examination of factors increasing presence that olfactory stimulus is one of them. The common theme of such research appears to be that sensory components are an important part of immersive content and improve the factor of presence.

Using immersive technology centred around the HTC Vive, as the most suitable technology available to the project at the time of its commencement, the research project proceeded through a number of phases to develop the concept of a Synchronous Reality. The philosophical framework helped to shape the focus of the work towards place and memory as a way of examining emotional response to the created installations. The literature guided the practice towards an increasingly sensory-based platform which contributed to combining physical and virtual components as part of the same installation. The results from the study provide material for further work by artists in the field and other practitioners within VR.

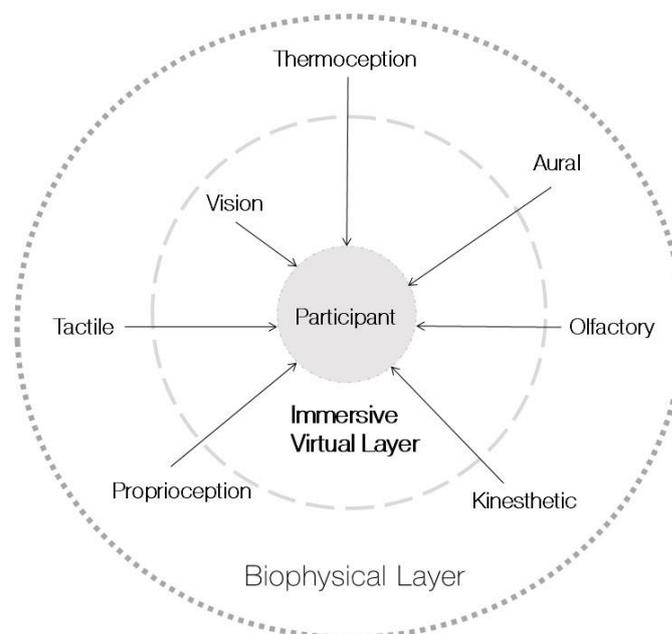
## Synchronous Reality

This term emerged through the Doctoral research project. Other terms used to describe Virtual Reality environments including Mixed and Augmented Reality, did not sufficiently define how the installations created through the practice functioned. This new term was offered as a better and more appropriate articulation of what was actually being done. The word ‘synchronous’ is defined by the *English Oxford Living Dictionaries* (2019), as “to occur at the same time or rate” and derives from the mid-seventeenth century late Latin *synchronous* (from Greek *sunchronos*, from *sun* ‘together’ and *khronos* ‘time’). A companion word ‘synchronise’ also means to “agree with something else” or “coordinate; combine” and derives from the Greek *synchronízein*, to be contemporary with. The term Synchronous Reality thus describes the co-ordination of the physical environment with the virtual one. This doesn’t imply they mimic each other precisely, but that instead they are in agreement, or have a form of mutual coherence.

There is also a temporal element to Synchronous Reality. Time passing in the installations is conveyed by the passage of light and does not necessarily relate to ‘real time’ in the physical world or an inner sense of time. In the installation, eight minutes may mark the passing of an entire day, which in the ‘real world’ would amount to twenty-four hours. The participant encounters time at a different rhythm to normal, as Bergson confirms — “The duration lived

by our consciousness is a duration with its own determined rhythm” (Bergson, 1988, p. 205) – while Digital media researcher Timothy Scott Barker (2012) suggests that we place ourselves between the time in the present and the aesthetic images and processes of the past with digital artworks. This makes an intersection between the memory of what was and what is. A Synchronous Reality can have a time of its own which, although it might run counter to accepted real-time, is nevertheless acceptable to the participant when immersed in the installation.

The following diagram attempts to represent a Synchronous Reality as the combination of the virtual computer simulation and biophysical environments as an immersive whole. It is not a binary either/or, but rather a combined sensory-driven environment. The diagram is a simplified depiction which at the same time suggests the difficulty of the endeavour of describing how the multiple conditions of Synchronous Reality operate in an installation.



**Figure 1. Multiple sensory modes in a Synchronous Reality installation where both the simulation and our biophysical reality are equally ‘real’.**

## Research Methodology and Practice Work

The research was conducted within a practice-oriented paradigm with, as noted by Skains (2018), an element of experimentation which is inherent in any medium where work is created. It was also subject to imaginative and yet robust enquiry (Sullivan, 2006) through the use of interviews and observation of participants in the work. The primary methodology was ‘autoethnography’ which as per Adams (2015) facilitates personal experience to engage an examination of ourselves and other people in various facets. From this, we can gain a perspective on perhaps wider experience than our own. Since this researcher’s personal

memories formed the subject matter of the practice work, autoethnography was a suitable choice.

The particular final vehicle for the practice-led installations was the recreation of a caravan in which this researcher had once lived for a number of years on an isolated campsite in Yorkshire. The development of the Caravan installation through a number of iterations evolved into a tight registration between its physical and virtual elements, which formed the *raison d'être* of the created term Synchronous Reality. The installation focused upon the qualities of sensory and imaginative immersion as noted by Ermi and Mayra (2005), as opposed to being challenge based. It was designed as an experience where the participant was not required to 'do' anything in particular, other than enjoy or partake of its perceptive qualities. The installation developed further through participant feedback to become one where quietude and solitude could be felt.

Installations of the work Caravan were exhibited in gallery spaces at the Auckland University of Technology, where participants and audience were invited to experience it on an individual basis. The final exhibition took place in a theatrical 'black box' to emphasise the aesthetic qualities of the physical parts, using focused lighting in an otherwise darkened room. The physical and sensory aspects of the caravan consisted of the benches, squabs, one side of the caravan, the kitchen unit, toaster, mug and kettle. Aural sensory input was supplied by a recorded and created soundscape of ambient bird and other incidental sounds. Olfactory input was supplied by toasting 'cinnamon muffins' in a toaster, and the thermoceptive sensation of the sun rising was produced by a two-kilowatt spotlight strategically placed, which was manually activated in synchronisation with the virtual sun rising. Other incidental smells noted by participants included such odours as the varnish on the woodwork of the benches. The virtual caravan and accompanying landscape was effectively another sensory visual layer which was registered with the physical components in the space. The participant could only see the virtual environment once they had donned the HMD (Head Mounted Display). However, because of the Synchronous Reality, the physical elements corresponding to parts of the virtual environment would still be present. Thus, when a participant saw a seat, they would be able to sit on it in the exact place they could see it in the virtual environment. Similarly, they could touch other virtual/physical objects such as the caravan side, toaster, mug and kettle. There was a high degree of tactile 'feel' supplied by the physical parts to correlate with what the participant could see once immersed in the virtual component. In addition, the ambient soundtrack provided auditory sensory information, with olfactory and thermoceptive sensory input as described. Each one of these components helped to build a more complete immersive environment for the participant.



Figure 2. Bailey, D. (2018). First iteration of *Caravan* installation, July 2018. [Photograph].

The virtual world was scripted with a repeating day/night cycle, and animated creatures: birds, a cat, an owl, sheep and a fox. These animations served to assist in bringing the installation to life. The participant could witness the sunrise, the movement across the sky, the sunset, followed by moonrise and moonset. The light quality and colour changed according to the time of day, and the shadows cast by the sun and the moon moved with the motion of those objects. The repeating sun/moon cycle ran for eight minutes. During this time the participant could experience all of the sensory input connected either directly or indirectly to what they could see virtually. Participants were given the opportunity to remain in the installation for one or more cycles.

## Findings

Fifteen participants engaged in the qualitative research where they had experienced the caravan installation alone with the researcher as an observer. Each participant was individually interviewed afterwards. Two iterations of the Caravan were used for data gathering, the second including more physical components than the first. The feedback gained from participants guided the enhancements to the installation. The final exhibition was convened for the purpose of PhD examination. A further exhibition was held in conjunction with the School of Clinical Sciences at the North Campus of AUT for their academic staff. Thirty-one staff members individually experienced this exhibition at the North Campus, which provided some further interesting observational points.



Figure 3. Bailey, D. (2018). Caravan, Iteration Two. Participant seated in the interior. [Photograph].



Figure 4. Bailey, D. (2019). Caravan, Iteration Three. Installation in the Black Box AUT [Photograph].



**Figure 5. Bailey, D. (2019). Caravan Reverie. Exhibition at AUT North Shore Campus, School of Clinical Sciences [Photograph].**

Participants were typically observed to have exhibited two types of behaviour within the installation. The first could be termed an active or exploratory phase. At this juncture, they were seen to be examining or testing the limits of the environment, touching physical components and looking out through the windows or even exiting the caravan to view the exterior virtual world. Following the active phase, there came a phase, which was usually much longer, of absorption. The participant would simply sit or remain in one place for a longer period, looking and listening. Typically, at this point participants would note they also engaged or connected with their own memories of similar spaces or places as a result. As mentioned, this was the point of intimacy with the installation where they overlaid something of themselves into the space. In the North Campus Exhibition, many remained in the installation for up to thirty minutes without prompting and through several day/night cycles of the virtual world.

The immersive quality and factors of presence in the caravan installation were found to be high by observation and from feedback. Comments such as these were typical of those received:

It felt so real. I really felt like I'm in the space (P.M., Caravan Iteration One, 2018).

Completely immersed. Completely forget the fact that I was not there (A.T., Caravan Iteration Two, 2018).



Figure 6. Bailey, D. (2018). Caravan, Iteration Two. Participant relaxing in the installation. [Photograph].

Observed behaviour such as attempting to squeeze through the small opening made by the half-closed caravan door indicated the achievement of the ‘illusion of nonmediation’ (Lombard & Ditton, 1997, p. 32). Lombard and Ditton state this illusion of nonmediation is achieved when the person responds to the virtual environment as if it was the real world. Furthermore, participants also articulated their thoughts in terms of feeling deeply immersed or feeling as if they were ‘really there’ during interviews. The Synchronous Reality aspect of the installation was also a contributing factor to its immersive quality. Some participants noted a high level of trust in the virtual environment due to the presence of the physical benches similar to the trust placed in their normal everyday environment. For example:

So, as long as I knew that I was navigating around the seats, I was okay. And they were kind of my safe haven where I knew that they were solid. So, I could navigate around them in the virtual space...Yep, I completely trusted them. (A.G., Caravan Iteration Two, 2018)

Conversely, participants were observed to have forgotten which parts were really there and were seen attempting to touch things not physically present, again an indication of their high level of environmental acceptance. An example of this immersion level was observed when the mobile phone of one participant rang and they attempted to answer it with the headset on:

I felt so natural with myself and the environment. So, first of all, I forget about the fact that I’m not seeing my body...I felt completely natural and my phone rang and, “Let

me check my phone”, and I grabbed my phone out. I just remembered, “Okay. I can’t see it,” because it’s in real mode. (A.T., Caravan Iteration Two, 2018)

The contemplative quality of the installation also provided a space for the participant’s own recollections. Most of those interviewed indicated they had recalled either experiences of their own in caravans or at least places which were similar in content to the installation. One of the aims of the work was to foster an atmosphere which would allow this. The fact that participants became part of the space and accepted it as real is attributable certainly in a large part to the created Synchronous Reality. The recollections were often quite detailed:

My parents had a similar caravan...It was sort of a retro caravan that they bought second hand in New Zealand and travelled around for many years [in] it and I came along with them...I had a flashback to when we stayed in a particular campsite in, I think it was, Coromandel...This also reminded me of another campsite...It was a very deserted one by Invercargill...was very sort of lonely and wild kind of, and there were sheep somewhere, and it was misty, and it was very cold. (S.S., Caravan Iteration Two, 2018)

I’ve got a friend [who] used to have a little cute, little yellow caravan, like one of those really old-fashioned ones. And she’s just now gone away and she’s living in a van. It’s quite open but it reminded me of that. It reminded me of going away in her caravan. And the other thing was the scene where it was parked. Yeah, it was kind of memories of being in the country and having birds around and being quite peaceful, yeah. (E.C., Caravan, Iteration Two, 2018)



**Figure 7. Bailey, D. (2018), Caravan, Iteration One with participant. [Still from Video].**

Overall participants liked the calmness and quietude of the space. It provided an immediate location for contemplation. In its simplicity, it was, a place to just be and assume, perhaps, a

more reflective state of mind. It is useful to note that, even from such a small cadre of participants, thirteen of the participants (87%) gave one or more of the following words or variations when relating their experience: calm, relaxed, safe, cosy, peaceful. Calm and peaceful were found to be the most common words, given by half the participants. Other words included exciting, melancholic, pensive, solitude, alone, lonely, isolated, moody, curious, eerie, creepy, and intimate. One of the aims of the practice work was to create a space of calm contemplative solitude, and the results indicated this was successful.



**Figure 8.** Bailey, D. (2018). *Caravan, Iteration Two*, virtual interior showing part of landscape, with participant. [Still from Video].

Achieving a high degree of confidence in the installation and environment is evidently key to also gaining a high level of immersion and presence. This allows the participant to then take in the emotive content and qualities of the installation itself. Although no specific comparison was made with an environment which was wholly virtual, it can nevertheless be said that the Synchronous Reality environment seems to have been a major factor, based upon the qualitative research. One can, therefore, conclude that a VR type of environment is inherently more immersive when physical sensory inputs are combined with the virtual landscape, creating a coherent merging of the physical and virtual layers as in a Synchronous Reality.

## Analysis and Discussion

The creation of a Synchronous Reality environment relies on a number of factors and considerations to be taken into account when planning or building such an installation. This type of installation is obviously not suitable for all types of VR content or applications. One constraint is the fact that physical objects and virtual objects need to be coherent and thus inherently tied together. The ability to move freely through the virtual space is thus restricted by the size of the physical space which can be made. The virtual layer which sits over the

physical layer is not moveable once it has been properly registered with the physical components.

When considering a Synchronous Reality installation, there are fundamental choices to be made as to what physical components to put in and what to leave out. This can be a logical and an artistic choice. With the caravan, for example, participants strongly indicated that sitting down was something they desired in the space. It was also logical, since the positioning of the windows meant that it was easier to see out of them when seated, just as in an actual physical caravan. Beyond that, it was an artistic choice to install only one physical side of the caravan suggesting the physical shape, and the lino on the floor, or the kitchen bench with items. These were placed there for physical context and also to provide a more authentic tactile experience. The participant reaction to the objects in the space cannot always be anticipated and one might contend this is part of the experiment. The squabs on the benches supplied the feel of ‘give’ when sat on and fulfilled that expectation when they were viewed virtually. It wasn’t necessary to visually show the ‘give’ in the virtual component since the participant simply accepted it without needing to see it happening. The same level of acceptance is supplied by the registration. It is not necessary to have pinpoint registration of virtual and physical objects, such as seating; also it is not always achievable with the technology being used. However, there is a point of leeway beyond which the immersion will be broken if the physical objects are not close to being in the right place. There is no hard rule for this, and the determination of the acceptable distance can be discovered during the process of registering the virtual layer to the physical layer.



Figure 9. Bailey, D. (2018). Caravan, Iteration Two showing virtual interior. [Still from Video].



Figure 10. Bailey, D. (2019). Caravan, Iteration Three. Interior of caravan with sun rising. [Still from video].



Figure 11. Bailey, D. (2019). Caravan, Iteration Three. Participant in Installation in the Black Box AUT [Photograph].

The siting of the physical installation is also an important point. Different settings for Caravan were tried, in a gallery and in a more theatrical (black box) type of space with theatrical lighting. The gallery setting had limited lighting control and thus it was harder to create an atmosphere prior to the participant putting on a headset. The theatrical setting allowed for much more controlled and intimate lighting. The darkness contributed to that sense of intimacy and meant that the virtual layer acted almost like a reveal when the headset was put on. For participants, the setting and the appearance of the physical ‘set’ was important. It created an expectation and anticipation of something more. It was particularly noticeable in

the North Shore exhibition that putting on the headset was often greeted with surprise. Sixty-eight percent of these attendees had never experienced VR before, which could also be a factor in the ‘surprise’ they felt on viewing the virtual environment. When creating a Synchronous Reality environment, the setting of the installation is an important part of the decision-making and should be given sufficient attention.



**Figure 12. Bailey, D. (2019). Caravan, Iteration Three. Participant in Installation in the Black Box AUT. Rear console, and 2000 KW Spot for thermoception sun effect [Photograph].**

A soundscape is of prime importance for Synchronous Reality. This contributes to bringing the scene alive. Sounds don't necessarily have to register directly with objects in the scene, although they can. The sounds may be ambient, or they may relate directly to, for example, an animal such as a sheep. The inclusion of music would change the atmosphere and careful thought needs to be put into whether this would be beneficial. Further types of sensory input are desirable, where possible, and creating them in a physical form rather than simulating them is to be recommended. The aim of the Caravan installation was that only the headset would be used and no affordances would be required. No controllers were used, which would have perhaps rendered it more ‘game-like’, and no other sensory simulators directly connected to the body. Thus, for example, heat was supplied by a lamp, smell by an actual smell of toast in real-time. There are many choices to be made in regard to such sensory additions, which are part of the formation of the installation and need careful consideration. What to include is dependent, in a large part, on what the intention of the installation is and what response is being sought from the participants.

Within the virtual environment, a number of decisions also need to be made. Animation of the environment in some form seems to be desirable. This can be accomplished by the inclusion of environmental movement such as wind, which then raises the consideration of whether to provide actual wind in the form of a fan. Temporality in the form of the passage of the sun and moon and shadows was a feature which participants liked. The accelerated time and movement of these objects seemed easily accepted. How fast or slow this temporal movement should be is another consideration for the artist or creator. Other types of animation can include animals, such as flying birds, or butterflies and insects. The relevance of such elements to the virtual scene can be important. The choice of textures and how realistic or otherwise these are, is also another aesthetic decision to make. The acceptance level of participants to the environment does not appear, by observation, to depend on the level of textural realism. The Caravan textures were realistic but not exact representations of real-world objects in all their detail. There was no feedback or specific mention on this aspect of the installation by participants, which indicates they accepted the reality level of the textures. How the virtual environment compares texturally to the physical is also important. The choice with Caravan was to create similar textural choices in the squabs, bench items and varnished wood of the seating for the virtual and physical parts. This provided artistic continuity. However, the physical components could equally have been left plain white as another choice, suggesting an overlay of colour and texture when in the virtual environment, as if one completes the other.

Attention to the above details and decision points is important to create a successful immersive Synchronous Reality installation. The artist or practitioner is bringing together a number of elements to create their installation where these choices are very much dependent upon their own objectives. It might be said there are no wrong choices, but the inclusion of certain elements is more beneficial to the installation. The physical tactile components and the soundscape are two of the most important parts beyond the virtual content and environment itself. One might state that these are the building blocks of Synchronous Reality. At this stage, all such endeavours are to some degree experimental since this is a relatively new concept in a burgeoning field.

## The Digital Economy

The support of virtual spaces in general by telecommunications is usually reserved for multi-user types of environment. Such applications as VR Chat have found a niche for this kind of application where multiple users can congregate within a virtual space. Those types of applications are wholly concerned with a virtual environment as opposed to a Synchronous Reality one. The applications, in general, rely upon a server to retain positional and other data related to all of the actors in the scene. As noted, the graphical interface is generally built on

the individual desktop of each participant in the environment. The idea of extending a Synchronous Reality installation in particular through the use of telecommunications is complex. The presence of the physical sensory components adds an overhead of replicating these at each location to be used. It would be entirely possible to have the graphic virtual component in a server-driven context, where the VR graphics are built at each location. The registration of physical components against virtual would be done on a location by location basis. The application of such a setup as a multi-location art piece is therefore possible. There are perhaps other fields where it also might be applicable, for example, where a fixed physical environment for simultaneous teaching across several locations may be required. These uses have yet to be determined.

The economics of virtual spaces is also a changing field. Much of this is due to the continual development of technology to facilitate VR in both the immersive and augmented form. The technology is moving from setups which require motion capture lighthouses, like the HTC Vive, to integrated self-tracking headsets, like the Oculus Quest. Only the HTC Vive was used for this research for reasons of continuity across developing installations, to reduce the financial investment and the overhead of reworking virtual environments. Different technologies would potentially change the way that virtual and physical environments can be registered together and it would be a matter of experiment to discover the best approaches. Nevertheless, in terms of cost, Synchronous Reality environments must factor in physical sensory components as well as the virtual ones. There is the cost of materials and building the physical installation, as well as a site for it, which may be either temporary or permanent. These types of installations are unlikely to be viewed as mainstream based on the constraints involved in creating them. Their impact on the digital economy as a whole is unlikely to be great compared to the overall use of virtual technology across the board. However, it is hoped the concepts behind Synchronous Reality and its further application for future research or installations will continue to help to push forward the boundaries of this field.

## Conclusions/Recommendations

There are potential applications for Synchronous Reality outside of the obvious artistic ones in the field of health and wellbeing. As an example, an installation such as the Caravan could be set up as an environment for contemplation. The depth of immersion and presence provided could help to transport a person away from daily life to a more relaxing or destressing environment. Clinical tests of such an environment are recommended since, if it was effective, then the cost of providing it to larger numbers of people is potentially lower than an actual arranged trip to the country and users can avail themselves of it whenever they like.

Synchronous Reality is also a field open to more explorative and experimental art using sensory physical environments. It might also have potential in such applications where particular emphasis is wanted on particular senses, such as mental health or disabilities. It is hoped that researchers, artists and practitioners will build on this research with experiments or projects to explore the concept of Synchronous Reality further.

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