# Psychology Documentation

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# PRESENCE & IMMERSION

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# Introduction

The sense of presence and the level of immersion attainable in VR is unrivalled by any other technology medium. It forms a critical part of what makes VR so unique, lending weight to the cognitive and emotional impact of virtual worlds. This explore section is designed to encourage a considered approach to design factors occasionally overlooked and less relevant in traditional game design. When considerations are made to enhance the level of presence and immersion, you can expect to create a more powerful and enjoyable VR experience.

## Definitions

**Presence:** the sensation and belief of being in a VE (virtual environment), to the extent where the user forgets the physical location they are in and accepts the new world they are presented with. Slater and Wilbur (1997) described it as when users report having visited a ‘place’ rather than having simply seen images generated by a computer. The sense of belief and realism which accompanies presence is commonly regarded as a necessary mediator, allowing for real emotions to be activated by virtual environments (Parsons & Rizzo, 2008; Price et al., 2011).

Presence is usually assessed via self-report measures and rating scales. For example: “Rate your sense of being in the virtual environment” “Do you feel this park is real, is it a place you are visiting?” (Riva et al., 2007).

**Immersion:** the degree to which our senses and attentional resources are connected to a VE. Consider how much time is spent thinking or attending to sensations in the virtual vs. the physical world. A fully immersive VR experience would engage our senses, thoughts, motivations and our imaginations, drawing them away from the physical world.

Immersion is generally assessed through experimental manipulations comparing different hardware components (e.g. high vs. low picture quality, HMD vs. computer screen viewing) or functions of a virtual experience (e.g. interactive vs. non-interactive, sound vs. no sound).

# Design considerations – Presence and Immersion

Presence and immersion are two heavily intertwined components of VR. Greater immersion increases the likelihood that a virtual setting will dominate over a person’s physical reality. In turn this increases ones’ ability to accept a virtual environment and experience a greater sense of presence (Diemer et al., 2015). The following design considerations outline research evidence related to factors that influence presence and immersion in VR. Due to practicality or creative issues, adhering to an optimised presence and immersion design may not be appropriate. It’s important to recognise the potential trade-offs within the design factors discussed.

## (1) Sensory immersion

The extent of sensory information presented to a user within a virtual environment is considered a key determinant of presence (Sheridan, 1992). Through VR we can target three main senses: sight, sound and touch. Stimulation of these sensory pathways can reflect our normal sensory perception and prevent distraction from the outside world. Just one sense left unattended (i.e. a lack of sound) leaves a bridge between the physical and virtual worlds as they compete with one another for our attention.

### Spatialised sound

Sound effects should somewhat reflect the way we experience sound in the outside world. In doing so it should convey contextual factors about the sound source (Is it a familiar sound? What made the noise?), distance cues (how loud is it? How close is the source?) and location cues (which ear heard it first? Which direction did it come from?). We constantly use auditory clues to gain a better understanding of our environments. When applied to VR settings they provide a much more realistic and intuitive experience.

Sound Localisation | MED-EL

Sound localisation explained

dearVR UNITY | Binaural 3D audio sound design for VR

**'dearVR'**: interesting example of spatialised acoustics

**Example 1** (Poeschl, Wall & Doering, 2013):

The researchers compared the impact of a short VR experience with and without a soundscape (described below). Without spatialised sound effects, participants consistently reported significantly lower levels of presence in the VE.

VE used by Poeschl, Wall and Doering (2013). Participants observed the environment for 30 seconds, with or without the addition of audio. The soundscape included some moving sounds (footsteps, frogs croaking), whilst others were fixed (ambient sounds, waterfall).

**Example 2:**

Other investigations have compared the user experience of surround sound against sound from a singular output device. Even though participants were playing video games on a 2D monitor (considered a low-immersion set up), they still reported high levels of presence (in the sense of being there in the game) whilst experiencing the sound effects of the games in a surround sound set up (Lessiter & Freeman, 2001; Skalski & Whitbred, 2010). The results demonstrate the importance of using sound cues in a way which reflects our perception of sound in the outside world, to provide the most realistic and engaging VR experience possible.

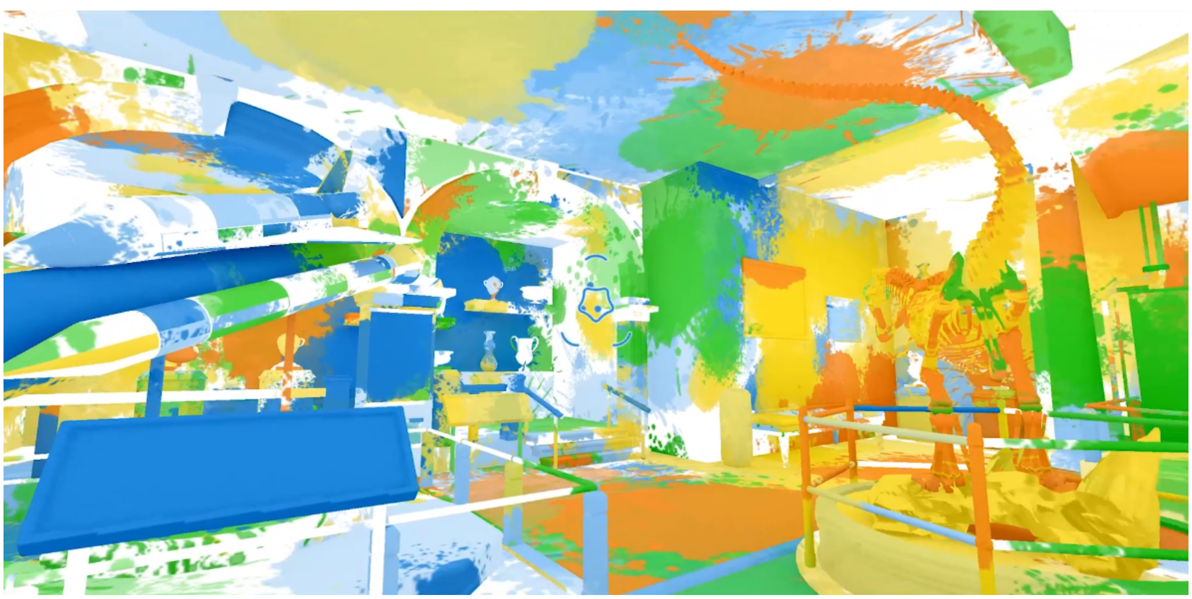
## Image quality

Findings from researchers investigating the impact of image quality is consistent, whereby users generally report greater feelings of presence when viewing higher quality graphical displays (Bracken & Skalski, 2009; McMahan, 2011). This relationship is indicative of the need for visually pleasing and detailed assets/environments to encourage user's acceptance and engagement with the visual components of the experience. Most importantly image quality must contribute to the sense of perceptual realism within the experience.

# (2) Interactions

Interactions contribute to a complete immersion of the senses by incorporating movements which distract away from touch-based distractions in the outside world. If someone is busy using a controller to interact in VR they are less likely to spend time fidgeting or attending to objects in the physical world. The extent to which users can interact and participate in modifying a virtual environment is considered one of the key factors influencing presence (Ye, 2017). Experiences which provide a rich assortment of interactive potential immediately enhance the sense of realism and excitement afforded in VR, largely because it reflects the interactive capabilities we have in the real world.

**Example:** In Splat!, users interact using gaze control in a 360° field of view. The virtual environment is dynamic in that users can paint each feature of the room in accordance with a changing selection of colours.

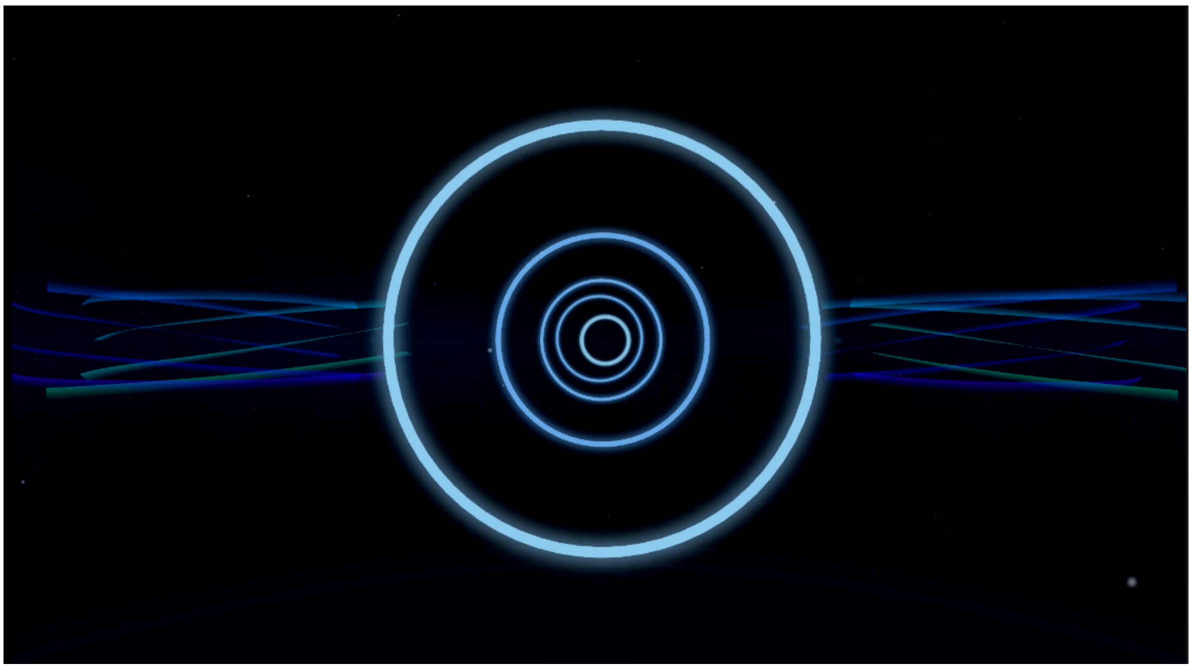


**Splat!**

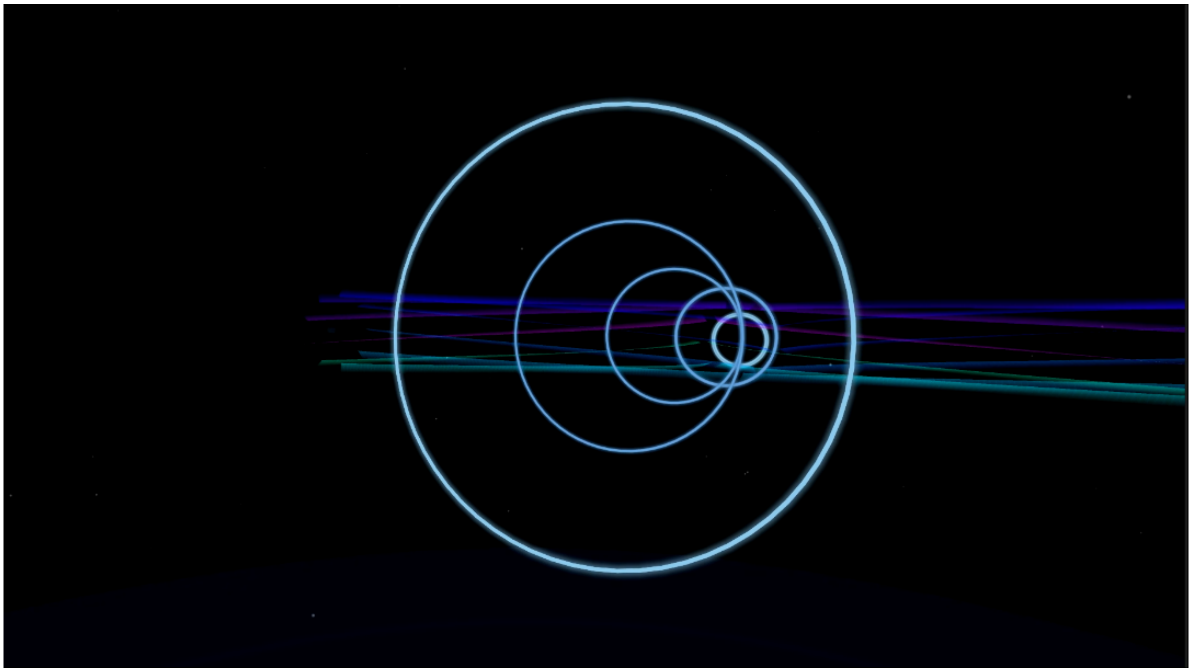
## Consideration

On the flip-side, if users are encouraged to interact (move/grab/throw) within the virtual world, this may draw attention away from more important components of the VE, or it may encourage users to exert effort and energy in a way which is counterproductive to the overall goal.

**Example:** There are circumstances where a static environment with limited interaction capabilities may be more appropriate. For instance, the interactive potential in Liminal's 'Ripple Effect' is limited to changing the alignment of the rings (ripples) by shifting gaze direction. Users are instructed to maintain the alignment of the rings and remain relatively inactive throughout the course of the experience. Relaxation is encouraged through a complete focus on the breathing guidance without the interference of internal (VR) or external (physical world) distractions.



**Ripple Effect**: Fixed gaze, rings aligned



**Ripple Effect**: Gaze moved away from focal point

# (3) Narratives

Narratives can transform a simple objective or task into an absorbing motivational goal tied with emotions and feelings. The narrative justifies our actions and provides an element of order and logic to the virtual world we arrive in. All in all, this leads to a much greater sense of presence and a feeling of complete immersion in a virtual world.

**Example 1:**

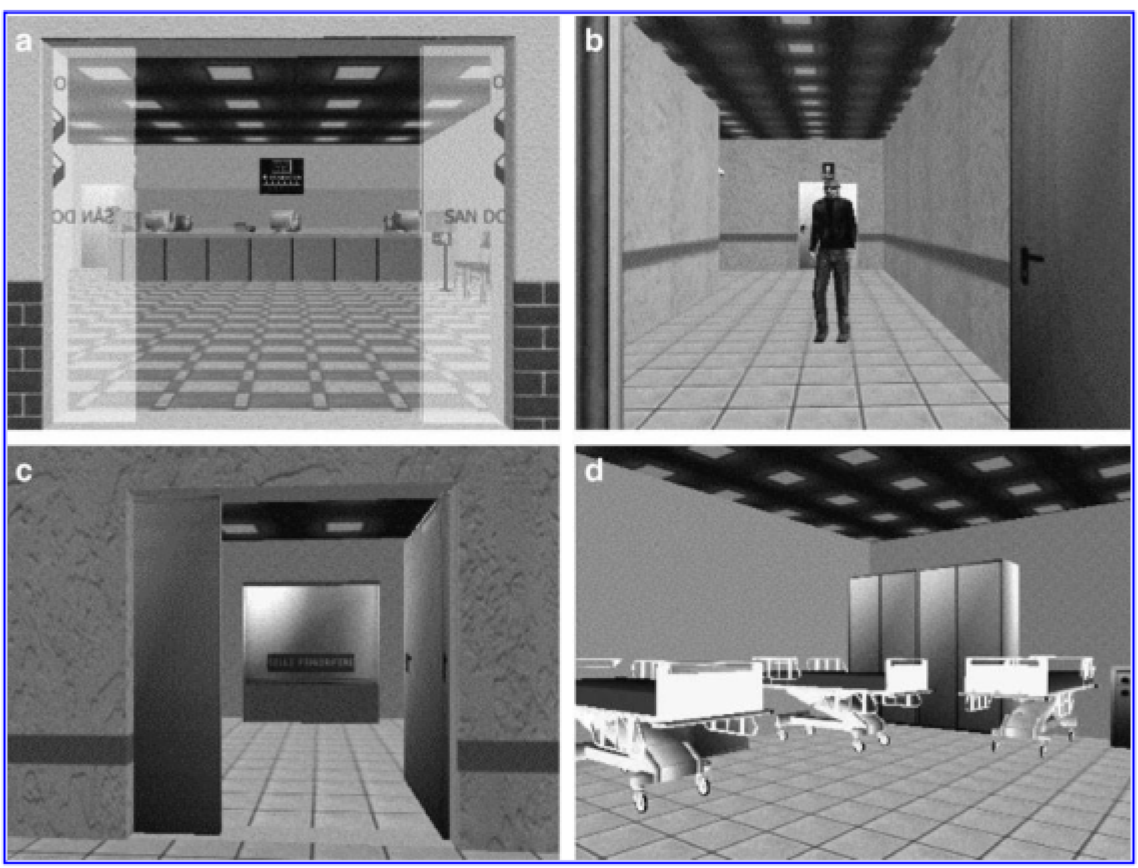
The VR game ‘InMind’ uses a very simple story narrative in which users “infiltrate patients’ brains” and “identify disordered neurons”. The phrase “initiating minimisation sequence” speaks volumes about the environment and the users’ ability to be there. With only minimal information, we instantly have a setting, a goal and a motivation. All of this contributes to a more complete and engaging VR experience which helps users to believe they have arrived in this new mediated environment.

InMind VR

**InMind** (Nival)

**Example 2** (Gorini et al., 2011)**:**

Using a computer, subjects were required to search a virtual hospital and find a hidden blood container. All subjects explored the same environment, except one group of participants were given a narrative to coincide with the task, the other group were given no narrative at all. In the narrative condition, participants were given the role of a doctor searching for a container of a rare blood type to save the life of a child, all the while a murderer wanders the corridors of the hospital. Comparing the narrative and non-narrative conditions, there was a significant increase in the sense of presence and rise in heart rates of those who were given a story to coincide the task. The narrative provided a purpose behind the game objective, enhancing the 'realness' and importance of the task which in turn provided a more intense emotional experience.




Different rooms in the virtual hospital (Gorini et al., 2011)

# (4) Navigation

The way users navigate and traverse through a VR experience has a significant impact on the level of control they are afforded. When given freedom to move and navigate a virtual environment themselves, users tend to report a greater sense of presence.

**Example** (Freeman et al., 2005):

Participants reported their levels of engagement and presence within a virtual beach environment when the ability to navigate was manipulated. One group were given a keyboard and instructed to follow the signs to a destination using the arrow keys. Another group had no keyboard and were taken to the same destination via the same route, but the experimenter did the navigating. Unsurprisingly, the participants who navigated themselves around the beach environment consistently reported higher levels of engagement and presence.

Target navigation area in the virtual beach environment (Freeman et al. 2005)

## Restricted navigation

There are many circumstances in which an explorative experience where users can navigate freely are not ideal. In which case, the use of a static environment or a controlled, automatic navigation path is most appropriate. In most circumstances this would be restrictive for presence; users are placed in an environment in which movement does not reflect the physical world, and so users are left understandably wondering how they are moving or why they are stuck in a fixed position. The simplest solutions to this involve manipulations to the environment or the narrative which indicate the reason behind the navigation restrictions. Going back to the VR game 'InMind', navigation is set to a pre-determined path through the neuronal connections of a virtual brain. At regular occurrences you can see the control panel of some kind of craft. Immediately this tells us we're aboard a ship, so we're not randomly floating around, we're being directed. If a user is left seemingly floating around in space, are they in a zero-gravity area? Do they have super powers? This information helps users to assimilate with new and novel worlds.

Navigation aboard a 'ship' in InMind (Nival)

# (5) Perceptual realism

In VR, perceptual realism can be defined as the extent to which a VE is reflective of our physical world; through a combination of sensory information (i.e. visuals and sound) and contextual information (i.e. the role of the user in the virtual world). There will always be elements within a VE that may or may not be perceived to resemble reality which can have a significant impact on our ability to accept the environment and become fully immersed in it.

Perceptual realism is an important concept for both highly realistic environments (those representative of our physical world) and highly abstract environments (those bearing little resemblance to anything we have seen or done before). Even the most abstract and fantastical virtual worlds need to provide elements of realism to be accepted as a place that a user visits, as opposed to a computer-generated simulation they are simply viewing. The right contextual cues (e.g. light, shadow, depth) enhance believability because they mirror the basic components of sensory perception we rely on to understand our physical environments.

## Ecological validity

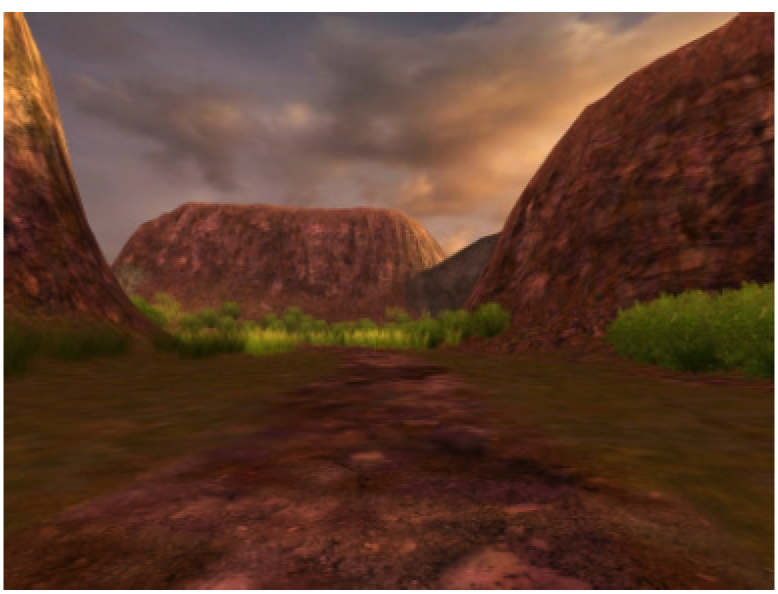
Virtual environments which are purposefully modelled on our physical world are more impactful when they look and behave as we would expect them to.

**Example 1** (Cummings & Bailenson, 2016):

In VR, participants explored two different virtual environments searching for a boat. They were given either a positive or negative narrative as an explanation for the task. In the positive narrative condition, participants were on the island/canyon as a prize for winning a game and they were searching for the boat to go home at the end of a holiday. In the negative narrative condition, participants were stranded on the island/canyon due to a natural disaster and they were searching for a boat to save themselves.

Each participant rated the ecological validity (the sense of realism and believability) of the virtual environments differently. These ratings were directly related to the positive and negative emotional experiences of the participants, i.e. feelings of excitement/enthusiasm (positive) or feelings of distress/fear (negative) were more intense the more the environments were perceived as realistic.

Virtual island (Villani et al., 2009)

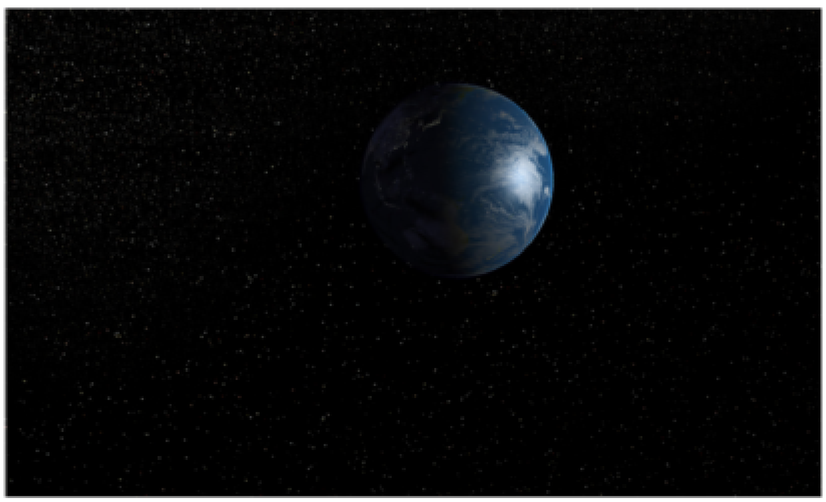


Virtual canyon (Villani et al., 2009)

**Example 2** (Chirico et al., 2018):

In VR, participants explored three purposely built virtual environments (Earth from space, a mountain range and a forest environment). Out of the three, participants reported considerably less feelings of presence in the Earth from space environment, despite scoring highly for how realistic (ecologically valid) the environment looked. As outlined in the descriptions below, each environment included characteristics designed to increase the sense of feeling physically present. Due to the abnormality of being in space (compared to a forest or mountain range) it's reasonable to understand why people might find it harder to accept they have 'arrived' there. However, although many of the factors were in place to establish realism (high fidelity Earth and stars, a lack of sound) there was a complete lack of additional contextual factors which might explain how the user is floating in space (no space suit, shuttle, narrative), which may have contributed to a sense of confusion and the lack of presence.

**Earth from space**



Users could navigate towards the earth and observe its natural rotations from space. No sounds were included to reflect the real sitation. Yet also there was no space suit, shuttle or narrative which could support the construct of a 'real' situation.

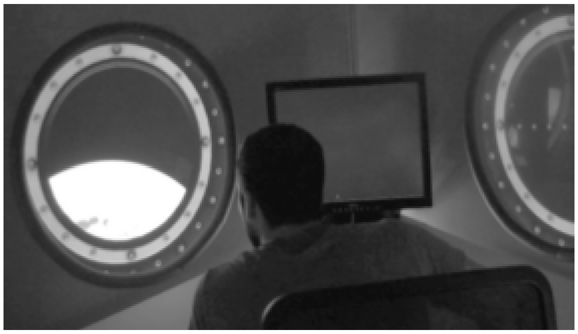
**Mountains**

Path of stones leads users through high snow mountains with a beautiful panorama. Background inclusion of wind blowing through the peaks enhancing the sense of presence.

### Forest

Luxuriant tall forest with a high waterfall hidden behind trees. Incorporates localised sounds (birds chirping, wind flowing through trees) contributing to the sense of presence.

A significantly more believable virtual experience of space was created by Reinerman-Jones et al. (2015) who created a mixed reality installation resembling the international space station. Participants observed simulated views of Earth through space shuttle portals. A narrative was also provided which involved a launch sequence, priming participants to feel rushed before take-off to contrast with the subsequent feelings of calmness whilst observing space.



Mixed reality installation (Reinerman-Jones et al., 2013)

## Standing position

For users to feel physically located in a VE, the experience must address the user standing/sitting position. This is a common issue in abstract 'space-like' environments where there is no obvious planet and gravitational force fixing the user to a solid ground. Without a platform situated beneath the user, a transportation device, or narrative to explain a floating position, the sense of realism is diminished and it can be difficult for people to fully accept their physical presence in that environment. This was a problem we encountered at Liminal with an early prototype of 'Ripple Effect'. Initially users had no platform to sit on and were seemingly floating in nothingness. Coupled with the similarities that the environment has with space, this created a rather unnerving experience, quite the opposite of the intended feelings of calm and relaxation. A small, subtle yet effective platform was placed directly beneath the user's position in the VE to resolve this issue.

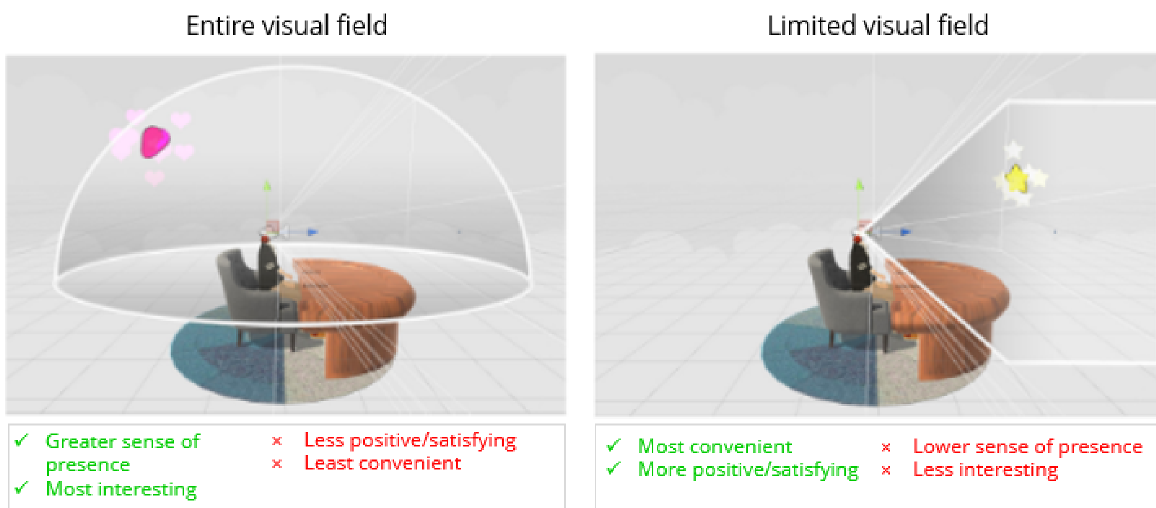
**Ripple effect**: inclusion of standing platform

# (6) Field of view

The field of view in which a VR experience takes place will have an impact on the sense of presence felt by users. That is, that a wider field of view in VR (one which represents the 360° surroundings of our physical space) tends to encourage a greater sense of presence.

**Example** (Kim et al., 2017):

Participants reported their feelings of presence, interest, satisfaction and convenience whilst completing an object recognition task in VR. Objects appeared through either the entire virtual space, or within a fixed location to that of the user's gaze. Results showed that participants reported significantly higher levels of presence when interacting within the entire virtual space, as opposed to a limited field of view. The results replicate that of several other investigations (Prothero, 1995; Lin et al., 2002; Ling et al., 203).




## Considerations

When considering how much of a user's surroundings to utilise in a virtual environment there are additional factors to consider alongside presence. The study by Kim et al. (2017) also compared measures of user satisfaction, interest and convenience whilst interacting with the task within the two visual field ranges. The entire visual field version was associated with much greater levels of user interest, whereas the limited visual field range failed to engage interest levels to the same degree. However, the limited visual field range was viewed as significantly more convenient for the object recognition task they had to complete. In other words, it allowed an easier, more seamless approach to finding and memorising the objects. Users who participated with the limited visual field range also reported significantly higher levels of enjoyment and satisfaction. This can be attributed to the added levels of difficulty and awkwardness involved with a visual search in one's entire surroundings.

# Research evidence – Pain relief

If an experience fails to generate a high level of immersion and presence, it will fail to provide the necessary level of distraction needed to maximise pain relief. A higher level of involvement and belief in a VE is required to draw users away from their physical environment, which consequently reduces the perception and experience of pain. Example studies which signify the strength of this relationship are outlined in Table 1.

| Authors | Study overview | Findings |
|---|---|---|
| Hoffman et al. (2006) | Compared the pain-relieving effects of a VR game when subjects used a 'high-tech' vs. a 'low-tech' HMD (see Figure 1 below for more detail) whilst receiving thermal pain stimulation | Only 29% of users with the low-tech HMD showed a clinically significant reduction in pain intensity, compared to a much larger 65% in users of the high-tech HMD |
| Gutierrez-Martinez et al. (2010) | Assessed the performance of a VR experience called 'Surreal World' (Figure 2) to provide pain relief. The amount of pain relief was compared with the amount of presence that was felt by subjects when inside the VR world | There was a correlation between pain relief and the sense of presence: those who reported a greater sense of presence (the sensation of being in the experience) also reported feeling less pain whilst having their hands submerged in cold water |
| Hoffman et al. (2008) | Hospitalised burn wound patients underwent a painful wound re-dressing whilst distracted in VR | The patients who reported the strongest illusion of "going inside" the virtual world reported the strongest reductions in experienced pain, from severe to mild pain |

**Table 1**: Research evidence supporting the effects of presence and immersion for enhanced pain relief

**Figure 1** (A) "Low-tech" HMD used by Hoffman et al. (2006) Cy-Visor (800 x 600 pixels per eye) (35- degree field of view). Users can still see part of the physical world

**Figure 1** (B) “High-tech” HMD used by Hoffman et al. (2006) Nvis NvisorSX (1280 x 1024 pixels) (60 degree field of view). The view of the outside world is completely obstructed.

**Figure 2**: Surreal World (Gutierrez-Martinez et al., 2010). Involves attention-diversion techniques centred around strange and evocative images which challenge the laws of physics.

# Research evidence – Awe

The study of awe in relation to virtual environments is in its infancy, and so the direct evidence supporting the role of presence and immersion causing an increased intensity of awe is slightly limited. However, a recent investigation using immersive 360° footage does provide evidence that increased levels of presence and immersion can enhance feelings of awe. Chirico et al. (2017) exposed participants to awe-inducing natural scenes of tall trees in a forest. The videos were filmed looking up from the base of the trees, providing viewers with a greater sense of smallness and appreciation of scale. Participants reported greater feelings of awe whilst viewing the footage through a HMD compared to viewing on a 2D screen, indicating that the more immersive set-up enhanced feelings of awe. In addition, the more immersive set up was found to contribute to greater feelings of physical presence within the forest which also corresponded with more intense feelings of awe.

Screenshot of 360° footage used by Chirico et al. (2017)

As outlined by Keltner and Haidt (2003), awe involves a challenge to our current knowledge structures when we fail to make sense of something abnormally vast. If we are to compare our experiences in a virtual world with our knowledge structures from the physical world, we can expect that experiences of awe in VR will rely on some form of acceptance or belief in the virtual world. Any disconnection to the VE felt by users will likely minimise the need to accommodate the 'vastness' portrayed within the experience.

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