Investigating the Impact of Virtual Actors in Priming on Presence in Virtual Reality

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ABSTRACT

The use of virtual reality systems is commonly believed to be a unique experience that is typically out of the domain of regular life. This has been true for many years due to the impracticality of virtual reality equipment for home use and the cost of such devices. However, with technological advancements and the prominent rise of Head-Mounted Displays (HMDs) such as the Oculus Rift, virtual reality is now far more accessible. To accommodate for this rise in potential use over the next few years, it is important to understand what it is about virtual reality that makes it so compelling to use. This study seeks to explore the realms of presence or the feeling of ‘being there’ in virtual reality and how it can be affected by the way users are introduced into virtual reality through priming. In particular, we tried to understand what effect the use of a virtual actor in this process of priming would have on levels of presence in a virtual world. Results suggest that utilizing a virtual actor as a mediator in the virtual world, in an ‘experimenter’-type role, can potentially allow for heightened sense of presence but must be carefully constructed to ensure that believability and plausibility of the virtual actor is maintained. A further area of investigation of this thesis was to explore the potential for Hawthorne Effects in virtual reality experiments. Findings showed that even with no virtual experimenter and presence, it is possible for participants to feel like they are being ‘watched’ whilst there is also some indication that this feeling can be replicated by a virtual actor.
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1. Introduction

For many years virtual reality applications have centred around and have been most successful in areas such as immersive video games, phobia therapy (Pertaub, Slater and Barker, 2002) and training simulators (Bowman and McMahan, 2008). One of the primary advantages and reasons that virtual reality is used in these fields is its ability to encapsulate a user within a virtual environment and simulate the feeling of ‘being’ in a different place, or in other words, allow them to feel ‘presence’ in a digitally fabricated world. By encouraging users into this greater sense of presence, it then becomes possible for a computer to elicit responses and interactions from users in the same way as in the physical world (Pimentel and Teixeira, 1993), opening new avenues of human interaction with technology. This becomes especially important in research involving the use of virtual reality as prior works have attempted to understand human behaviour based on simulated virtual events (Slater et al, 2013). Thus, it raises the key issue of understanding what factors are capable of affecting levels of presence and how best to design experiences that will encourage the feeling of presence.

As such a broad topic in the field of virtual reality, there has been extensive research conducted into understanding the various factors that can help to increase levels of presence in virtual environments. Some previous work has focused on the angle of investigating the impact of the actual display of information through visual screens and how this can influence levels of presence through immersion (Slater, Sadagic, Usoh 2000). However, there has also been work into how social factors (Bulu, 2011), virtual body ownership (Benford et al, 1995) and use of virtual avatars (Garau et al, 2003) can impact on a user’s sense of presence in virtual reality. This clearly shows that there is
significant complexity in pinpointing the different ways it is possible to deepen presence and presents the opportunity to delve further into the ways in which we can positively affect a user’s sense of ‘being’ there. This can be additionally supported by the fact that elements of virtual environments such as levels of narrative (Pausch et al, 1996), task complexity (Slater, McCarthy, Maringelli, 1998) and interaction (Slater and Steed, 2000) have also been found to have significant effects.

The approach of this study focuses primarily on building on previous works in presence by investigating the impact of priming and the method of introduction to virtual reality on the overall perception of presence in a virtual environment. Specifically, we conducted a study that looked into how differences in the method of instruction can contribute to a greater sense of being and belonging to a virtual world. In this work, we explore the potential differences in a user’s experience when introduced to virtual reality either through the experimenter in the physical lab space or from a virtual experimenter from within the virtual reality when given a search task. By making use of a virtual actor to represent the experimenter in the virtual world it provides a period of acclimatisation to the virtual world and permits for a greater level of interaction with the virtual world before embarking on the rest of the experience. An additional concern of this study is related to co-presence and in how much a user may feel like they are being watched during experiments in virtual reality. As avatars have typically been used as mediums of representing other humans, the idea of virtual actors (Slater, Usoh, Steed, 1994) has not been extensively explored. Here, we investigate to what extent a virtual experimenter can elicit that feeling of being ‘watched’ and whether there is potential to create a Hawthorne Effect from a virtual character. We also aimed to observe how participants would interact with the virtual experimenter, how much attention they would pay to the virtual experimenter and also how much they felt that the virtual
experimenter was an actual experimenter. Presence questionnaires were used as a measurement for these factors.

The following chapters of this paper will document the entire process of this study and provide detailed information regarding this thesis. Chapter two will focus on a review of existing literature in the field of virtual reality relevant to this project scope. Chapter three will present the main research questions and hypotheses of this study along with our methodology to details how the study was ran. Chapter four will present the results obtained from our study and chapter five will outline our analysis of our findings and offer points of discussion that can be raised from the data. Chapter six will conclude this paper with closing remarks.
2. Literature Review

As stated in the introduction of this paper, presence has been a heavily researched area in the field of virtual reality. Through this research there has been significant developments in understanding the complexities and differing forms of presence that exist. This has further spanned into determining how these various types of presence can be influenced by specific factors that have the potential to be useful in both research and commercial applications.

This chapter will outline and discuss the current applications of virtual reality, findings regarding the study of presence itself and its contributing factors as well as methods of measurements that have been used in presence research. Furthermore, we will also discuss the idea of basis behind the Hawthorne effect and how it could potentially be replicated in virtual reality environments and experiments.

2.1 Applications of Virtual Reality

Contrary to popular belief, the use of virtual reality is already prevalent in peoples’ everyday lives. People commonly interact with information or data that is represented digitally, or in a ‘virtual’ manner. This ranges from browsing the internet, to chatting online and playing video games. In each of these tasks, the user interfaces with a virtual world and can be considered to be making use of a ‘virtual’ reality (Blascovich and Bailenson, 2011). The use of a telephone could also be thought of as a type of virtual reality, in that a man-made device is artificially allowing a person to communicate to another person who is not in close proximity to them (Pimentel et al, 1993). This shows us that the through the integration and adaptation of such devices into normal lives, we
can in some ways ignore the conceptualisation of how a device works and focus purely on the interactions that can be made with it.

Immersive virtual reality (IVR) is one of these areas that has for many years, been slowly making huge strides and advancements in its level of sophistication. IVR has already been widely utilised in applications for phobia therapy, training simulations, entertainment (Bowman et al, 2008) and even telecommunication (Steptoe et al, 2010). Even within each of these areas there is a large scope to IVR’s application, ranging from training military personnel or coaching doctors in medical procedures (such as in SimSurgery, Surgeon Simulator) to theme park attractions (Schell and Shochet, 2001), immersive video games and in research as well. A particular example of these significant developments in virtual reality can be seen from its application into understanding human behaviour through the recreation of potential real-life events.

The use of virtual reality has also become widely more commercialised in that it has become easier and less expensive to obtain virtual reality devices for home use. This has predominantly been championed by the increase of sophisticated, head-mounted display units (HMDs) such as the Oculus Rift (DK1 and DK2) and the Samsung Gear VR but has also been garnering wider interest from more basic methods such as Google Cardboard. With the ever increasing availability of such devices, there is an expectation for the market of virtual reality devices and applications to grow in the coming years (Mason, 2014), especially with the rise of fully immersive video game such as Hover Junkies and the emergence of omnidirectional treadmills (Virtuix Omni). This has been seen in how the use of virtual reality has become more commonplace for the purpose of hotel promotional campaigns, virtual site tours or car test driving simulations (Besecker, 2015).
With the expanding use of virtual reality, it is thus important to understand the reasons behind why the use of virtual reality in these various applications is effective. This is usually accredited to virtual reality’s ability to create an illusion that an event occurring in the virtual world is actually ‘real’ and is typically referred to by the term ‘presence’.

2.2 Presence

The concept of presence (or telepresence) allows us to relate virtual reality in the context of human experience (Gibson, 2014) and is commonly defined as “the sense of being in an environment” (Steuer, 1993). It is associated with a subjective experience of virtual reality, where a user “suspends their disbelief” (Slater and Usoh, 1993) of the virtual world and may feel as if they are truly in another location through the use of a device despite their physical presence in the real world (Sheridan, 1992; Witmer et al, 1994). This is a powerful notion in that the perception of actually ‘being there’ in the virtual space allows users to interact with a virtual world in the same manner they would the real world. As there are multitudes of potential factors that may assist in producing feelings of ‘presence’ in virtual reality, it is important to consider and explore the various component aspects of presence that exist in the literature.

These separate aspects of presence can be considered to be ‘dimensions’ of virtual presence and each have their impact on overall presence whilst in virtual reality. One such categorisation of presence is into the dimensions of personal presence, social presence and environmental presence (Heeter, 1992). Personal presence is concerned with the users themselves and how the senses can be used to stimulate the perception that the virtual world is ‘real’. In this regard, it is mostly influenced by elements such as visual, auditory or kinaesthetic feedback from the virtual world and derives from the
impression that a user exists as a separate entity in a virtual world. Further to this, personal presence is connected to the levels of self-representation (Bricken, 1991) in a particular application and how these applications reflect natural human movements in the virtual setting.

Social presence or co-presence can be boiled down to the simple idea that if there are other people in the virtual world, then there is more evidence to suggest that it is real (Heeter, 1992). This plays more towards the convention that human-to-human communication is an inherently ‘realistic’ interaction as people are constantly involved with one another and therefore allows a user to feel more present in the virtual world (de Gelder and Hortensius, 2014; Durlak, 1987). In applications for remote virtual communication, this idea of social presence has a huge role as the ability to speak with another person can emphasise the impression of genuine connection.

Lastly, environmental presence regards the interaction between the user and the virtual world itself. Here, we are concerned with looking at whether a user is able to affect their surroundings through their own actions. To phrase this in a different manner, environmental presence is about how responsive and receptive a virtual environment is to user input.

It is also important to note that despite outlining these areas of personal, social and environmental presence in this paper, there are many varying categorisations of presence with slight differences in definitions. These may include dimensions such as “physical presence” or “self presence” and a more in-depth analysis of these approaches can be found in (Lee, 2004).
2.2.1 Place Illusion and Plausibility Illusion

Another way of thinking about the idea of presence has been to separate the concept into the two terms of ‘Place Illusion’ and ‘Plausibility Illusion’ (Slater, 2009). In this consideration, place illusion denotes “the strong illusion of being in a place in spite of sure knowledge that you are not there” or in other words, how the world is perceived. Plausibility illusion on the other hand encompasses “the reality of the situation depicted” or what is being perceived by the user. These can be nicely compared with the following statements:

- **Place Illusion**: “the feeling of being in the place depicted by the virtual environment (even though you know that you are not there)”

- **Plausibility Illusion**: “the illusion that what is happening is real (even though you know that it is not real)”

With place illusion, there must be correlations between the actions of the user in the system and the outputs displayed by these movements in the images that the user perceives. In the case of plausibility illusion, there must be correlations between external events in the virtual world and the user’s own sensations (Slater, 2009).

Of particular note is the idea that place illusion is not governed and cannot be controlled by the specifications of a virtual reality system or application. What this means is that running two different participants through the same virtual environment will not necessarily mean that they will achieve the same level of place illusion. This is due to the fact that place illusion is also affected by how a user interacts with the world, where one user may be more likely to incur breaks-in-presence (Garau et al, 2008) that reduce place illusion. Additionally, it is also pertinent to understand that it is possible to feel
place illusion through individual modalities such as the visual or auditory senses (Slater et al, 1994). When considering plausibility illusion, it is also interesting that visual realism is not essential to maintaining a sense of illusion as evidenced in other studies (Slater et al, 2006). A final note regarding these two concepts is that whilst regaining a sense of place illusion can be relatively easily regained once lost, the same cannot be said of plausibility illusion as breaks in plausibility can cause a user to completely stop believing in the ‘reality’ of the situation.

As the focus of this study, it was important to differentiate between the different perspectives that exist on the concept of ‘presence’. By taking an in-depth look into this area, it became beneficial in understanding the rationale behind how people may feel the impression of ‘being there’ in virtual reality as well as why. In accounting for these components, it thus became possible to identify how changes to a virtual reality application can influence various aspects of presence. These changes can be considered to be factors that manipulate levels of presence and can span from more significant changes to hardware devices and systems to more subtle changes such as to the virtual environment. These factors are further outlined in the next section.

2.3 Factors that Influence Presence in Virtual Environments

There has been significant research undertaken for the purpose of examining how presence can be affected by controlled factors in virtual reality. These include factors relating more closely to the manipulation of the human senses. For example, the configuration of display parameters has been shown to influence presence in that elements such as graphics frame-rate, head tracking and geometric field of view have all been positively correlated with reported presence (Sanchez-Vives, 2005). In addition to
this, other research has also displayed the importance the role of sound (Hendrix and Barfield, 1996) and even simple haptic feedback (Basdogan et al, 2000) have in promoting a sense of ‘being’ in a virtual world. Surprisingly, the level of photo-realism exhibited in a virtual environment does not seem to affect levels of presence (Zimmons and Panter, 2003).

However, influence on presence is not solely dominated by guiding the senses. A large body of work has also been dedicated to the investigation of how body representation can assist users feel more present in virtual environments. By giving participants a simple ‘virtual body’ that may not be wholly realistic, the association between the participant and the virtual world becomes far stronger with the introduction of body ownership (Slater et al, 1993; Slater, Perez-Marcos et al, 2009). Alongside body representation, body movement has also been attributed to assisting the illusion of presence. Studies have shown that by correlating body movements in the physical world with identical movements in the virtual world through a virtual body, it is possible to fulfil a match between proprioception and sensory data that contributes as a determinant of presence (Slater et al, 2000). This effect can be produced in virtual reality from simple arm movements when playing Tri-Dimensional Chess as well as more sophisticated movements such as physically walking around a large virtual space (Usoh et al, 1999). Furthermore, these effects of body representation on presence are not limited to the virtual body itself and is possible through extensions of the body such as through the casting of shadows and reflections (Slater, Khanna, et al, 2009).

Presence has also been shown to not only be a consequence of the actual interaction between the participant and the virtual world, but also caused through the participant’s mental state going into the experience. Research has been conducted that supports the
claim that the act of ‘priming’ a participant for experiencing virtual reality has the capability of influencing levels of presence (Nunez and Blake, 2003). By priming a participant with text information relevant to a virtual experience, an enhanced processing of the virtual world can be achieved leading to greater association between the participant and the system. This idea of priming has been commonly used in applications such as in video games that use music to prepare users for certain events and have even been used in theme park attractions where customers accrue expectations from advertisements (Pausch et al, 1996). This concept of influencing the mental state can further be expanded to the area of generating narrative and story lines to evoke greater feelings of presence (Slater et al, 1994). Although not explicitly explored as a research area, a similar approach that touches on this idea of mentally preparing participants for virtual reality can be through the use of a virtual lab replica as an initial staging area for an experiment. This theorises that by providing a natural setting for participants to acclimatise to the virtual world in, an “elegant transition” between the virtual world and the real world (Slater et al, 1998).

As a last note on the potential effectors on presence, the design of the virtual environment itself must be considered as well. By incorporating elements into the virtual environment that may try to provoke specific emotional reactions or responses from participants, it can become possible to influence presence. This is clear from work conducted with virtual pits, where the ability of virtual reality to simulate a virtual ledge with a visible drop was able to elicit genuine fearful responses (Meehan et al, 2002). On top of this, the inclusion of avatars in the virtual world to represent participants in multi-party telecommunication has also been shown to enhance the sense of being in a new location. The ability of multiple people to co-exist within a virtual space across long distances fosters social presence (and therefore presence) via naturalistic
communicative interaction. Through associating each individual by an avatar representation in the virtual world this more closely maps to the real life situation of being in a physical room and speaking to other people (Tromp et al, 1998).

As evidenced, there are many causes that have been linked to creating the feeling of presence in virtual reality. The approach taken in this study was to take into account all of these previous findings to test for other potential sources of presence. As we were in particular more concerned with exploring gaps in the literature, this work serves as an appropriate starting point to addressing these uninvestigated areas. Specifically in this study, we addressed the factor of priming in the introduction and the easing in of participants into virtual reality. However, we wished to extend past the standard methods of visual, text or aural input (Nunez et al, 2003) and investigate the potential impact on social presence of using a virtual actor as an instructor. As both priming and virtual avatars have been seen to promote some form of presence, this work provided a basis for understanding if a combination of these factors would produce greater results. Of course it must be noted that virtual actors are not the same as virtual avatars as virtual actors cannot be considered representations of other people and are simply elements of the virtual world. Despite this, there are many areas of overlap in the research of these differing character representations that could be interchangeable and will be further discussed in the next section.

**2.4 Virtual Avatars and Virtual Actors**

As an initial step, the differentiation between virtual avatars and virtual actors should be established. Virtual avatars are used in virtual reality systems to represent a person from in the physical world in the virtual one. In contrast, a virtual actor is not meant to
embody a human user and is purely a humanoid-like character that exists in a virtual world, controlled by the virtual reality system.

There has been extensive research into the use of virtual avatars in the use of shared-space virtual reality systems (Benford et al, 1995). These are as their name suggests, where multiple human participants will co-exist in the same virtual location. The use of these avatars to allow people to perceive others as virtual entities (or bodies) in the virtual world have been seen to cause increase in quality of telecommunication and social presence. One of the key factors that can be incorporated into virtual avatars to achieve this is the use of humanistic behaviours and mannerisms (Garau et al, 2001). An example of this is the use of eye gaze tracking when a participant is communicating with the avatar. In these cases the avatar will simulate eye contact, allowing a greater feeling of engagement in interaction leading to increased social presence.

One particular study was targeted at understanding participant responses to level of anthropomorphism as well as perceived agency (Nowak and Biocca, 2003). The findings of this study are relevant to the use of both virtual avatars and virtual actors (or ‘agents’). The study revealed that less-anthropomorphic representations instigated more copresence and social presence than higher-anthropomorphic representations. This has been partially put down to suggestions that more realistic visual representations of virtual characters can place them into the ‘uncanny valley’, leading to greater expectations in behaviour which cannot be matched by the system (Bailenson et al, 2005; Mori, 2012).

When looking specifically at the application of virtual reality to the treatment of the fear of public speaking, it can also be seen that virtual actors can elicit realistic physiological
and emotional responses from participants (Pertaub et al, 2002). As the variation of
facial expression on non-photo-realistic virtual actors are capable of affecting
participants’ responses, this shows the potential for the use of virtual actors in the use of
promoting presence.

From this collection of findings regarding the use of virtual avatars and virtual actors,
we can see that the application of these virtual characters can have an impact on
presence experienced by participants but has never been used as a method of priming
participants for virtual reality. In addition, although there has been some evidence of
studies making use of part of a virtual environment as a transitional space between the
physical and virtual world via the use of a virtual lab (Slater et al, 1998), the
incorporation of a transitional character that can act as the liaison between these two
worlds has not been explored. This is a role that could be filled by a virtual actor
standing-in as an experimenter in the virtual world to help ease participants into the
virtual world and promote the feeling of overall presence for the experience.

2.5 Measures of Presence

When considering an experiment related to presence, it is important to understand the
measures that could be used to asses levels of presence from a virtual experience. These
have typically been through subjective means such as the use of a questionnaire. These
rely on participants recalling their experience in a virtual reality and answering
questions based on Likert scales where typically higher scores correlate to higher levels
of presence. One of the first examples of a standard presence questionnaire can be seen
in Witmer and Singer (1994). There are multiple variations of these questionnaires in
research with some even targeting more specific areas of presence such as co-presence.
While perhaps not the most ideal way of gathering this type of data due to the nature of having to recall a past experience, these subjective questionnaires are simple to make use of and analyse.

Another way of measuring presence has been categorised as a ‘behavioural measurement’ of ‘behavioural presence’ (Slater et al, 1998). In this case, there is more attention given to observing participants to see if their behavioural coincides with the impression of being in the virtual world. For example, a participant could be reported as being behaviourally present if they exhibit vertigo whilst near a virtual ledge.

Alternatively, there has also been a case for using physiological measurements of participant body data to make inferences about presence. This may be appropriate in cases where participants are placed within a ‘pressure’ situation and exhibit physiological signs of stress such as increased sweating or skin conductance (Meehan et al, 2002).

For the purposes of this study, a presence questionnaire was selected as the method of measurement although subsets of questions targeting specific areas of the experience are included to gather sufficient data for analysis. The addition of these questions was necessary as no previous works incorporated questions that were relevant for use in this application.

2.6 Hawthorne Effect

The Hawthorne effect (also known as the observer effect) is when participants in an experiment modify their behaviour in response to the awareness that they are being
watched (McCarney et al, 2007). This type of effect is interesting to acknowledge in the field of virtual reality when thought about in conjunction with the concept of presence. The sensation of engagement through presence would potentially indicate the possibility for participants to become less aware of their physical surroundings as well as anybody watching them. Further to this, the use of virtual actors in such an environment would then raise the question of - if these virtual actors are capable of providing the impression of co-presence in virtual reality, can they also exhibit the feeling of observation? This study also aims to address this question and bring insights into understanding the utility of virtual actors in virtual reality.
3. Methodology

This chapter will state our established research questions for this thesis and present the hypotheses that were tested in this study. An overview of the methodology of how the study was conducted and carried out is also included in this chapter alongside the necessary steps that were taken to prepare the experiment.

3.1 Research Questions

Based on the findings of our literature review, we can derive our key Research Questions:

1. Can the use of a virtual experimenter or virtual actor to introduce and acclimatise a user into virtual reality lead to higher levels of presence?

As stated in Nunez et al (2003), the concept of ‘priming’ participants for virtual experiences is a little researched area and there is a need to investigate how different forms of priming may affect presence levels. We attempt to address this issue by putting forward potential methods of priming participants into a virtual environment to investigate what impacts this will have on presence. In particular, we will also explore the utility of using virtual actors as virtual experimenters to incorporate greater levels of interaction and presence for participants.

2. Is it possible to elicit the feeling of ‘being watched’, similar to a Hawthorne Effect on participants when undertaking an experiment in a virtual world?
Since presence has been connected with the feeling of ‘dissociation’ with the external world (Pimentel et al., 1993), it gives potential weight to the expectation that participants may no longer be aware of the presence of a physical experimenter watching their actions. As the Hawthorne Effect can be present in any type of experimental study, it provides an interesting avenue to pursue to identify whether this is the case in virtual reality studies as well. To add another dimension to this question, we also put forth the proposition that if virtual actors or avatars are capable of eliciting feelings of social presence, can this be replicated to make participants feel as if they are being watched by a virtual experimenter.

The stated hypotheses for this study are:

**Hypothesis 1:** The use of a virtual actor in the role of a virtual experimenter to assist in priming a participant for a virtual reality experiment will increase overall levels of presence for the virtual experience in comparison to the case where there is no virtual experimenter at all.

**Hypothesis 2:** The use of a virtual actor with greater ability to interact with a participant will perform better at influencing levels of presence than a virtual actor without these capabilities.

Hypotheses 1 and 2 can both be related to the findings regarding virtual avatars and virtual actors in Chapter 2 of this paper. As both virtual avatars and virtual actors have been used across a wide range of different applications and helped to achieve higher levels of social presence, it is our assertion here that the very existence of a humanoid-like character in the virtual world will promote this and therefore increase levels of presence. Furthermore, if one virtual actor is able to more closely resemble human
behaviour than another it would likely assist in creating greater plausibility illusion (Slater, 2009) and influence presence as well.

**Hypothesis 3:** The presence of a virtual experimenter in the virtual world along with the participant will cause participants to feel as if they are being watched assuming that there is some degree of social presence between the participant and virtual experimenter.

Here, it is hypothesised that it will be possible for a participant to get the impression that they are being ‘watched’ by a virtual actor. This is again based on social presence with regards to perceiving the virtual experimenter as having its own ‘presence’. If a participant is able to believe that the virtual experimenter is ‘real’ then the act of the virtual experimenter monitoring the participant in the virtual world should exhibit the reaction of feeling ‘watched’.

### 3.2 Participants

For this study a total of thirty-four participants (18 male, 16 female) were recruited from a pool of respondents to advertisements by email and social media distributions. Participants were primarily university students (both undergraduate and postgraduate) with other a few participants in full-time employment. The ages ranged from 18-33 (mean = 23.6, standard deviation = 3.03). Care was taken to only recruit participants above the age of 18 to ensure compliance with ethics restrictions. Each participant was entered in a prize draw for a £50 Amazon Voucher to compensate for their time. Sessions for each participant lasted for approximately 30-40 minutes.
3.3 Design

In order to determine whether the presence of a virtual experimenter can influence the level of presence experienced in a virtual environment, we ran a between-subjects experiment consisting of a single independent variable with three levels. The three conditions for the experiment were as follows:

(1) Control Group: Participants were given instructions by a physical experimenter in the physical world before donning the HMD and performing their task

(2) Avatar Group: Participants were given instructions by a virtual experimenter from within the virtual environment who stayed in a static position the entire time

(3) Watching Group: Participants were given instructions by a virtual experimenter from within the virtual environment who was realigned to always be facing the participant (even throughout the task)

The main dependent variables from this experiment were levels of presence and co-presence experienced by each participant. This was measured through the use of questionnaires given prior to and after the experiment as well as in de-briefing sessions conducted as short semi-structured interviews. Further qualitative data was gathered through screen-capture recordings of participant sessions.
3.4 Constructing the Experiment

3.4.1 Task Scenario

The task scenario given to each participant involved a search task in a virtual environment. The virtual environment itself was set up as a construction site. Within the site, participants were required to spot and count ‘hazard signs’ indicated by an exclamation mark within a yellow triangle (see Figure 4). Each sign was situated nearby to highlighted inspection points in the construction site that participants were instructed to pass through. After going through the entire virtual environment, participants were required to report back on how many of the hazard signs they had spotted.

Prior to entering the main construction site part of the virtual environment, participants were initially situated within a virtual lab (which was made to resemble the physical lab the experiments were taking place in). If in the conditions with virtual experimenters, participants were given their instructions for the task within this virtual lab. In all conditions, participants were given some time before the task began to acclimatise themselves to the virtual experience.

3.4.2 Environment

The entire virtual environment used in this study was created using Unity 5.1. A sample project named Vostopia Mecanim Demo was used as a template for the construction site although some significant alterations were made to suit the purposes of this study. Assets that were consistent with the location of a construction site were also downloaded and incorporated into the completed virtual world.

The virtual environment used in this study was split into two main areas – (1) the virtual lab and (2) the construction site.
Virtual Lab

The virtual lab was used as a representation of the physical lab where the experiments were taking place. The general colour, shape and layout of the physical room was used although the virtual room was left mostly unfurnished to detract from visual distractions. A TV was placed into the virtual lab to indicate an example of the hazard signs that participants would be looking for in their task. Additionally, a one-way mirror was used in the room to prevent participants from seeing the rest of the virtual world from the virtual lab but allow them to see back into the room when out in the construction site.

Figure 1. The virtual lab (top) and the physical lab (bottom)
a. Avatar

In the conditions where an avatar was present, the avatar would be located next to the one-way mirror in the virtual lab and would not move from this location.

![Avatar in virtual lab](Figure 2. Virtual experimenter standing in virtual lab)

Construction Site

The construction site was set up to have a generally linear path through the entire virtual environment. Appropriate props were used to simulate an actual physical construction site with the use of barriers, barrels, containers and boxes used to populate the open space. Towards the end of the construction site, leading up to the final inspection point, a virtual pit is also present.

a. Inspection Areas

Across the construction site, there were specific areas that participants were supposed to travel through dotted across the virtual environment. There were no specific indicators
for order of inspection. Each of these areas were identifiable by a blue spotlight on the ground.

b. **Hazard Signs**

Within the vicinity of each inspection area, participants were required to spot and make a note of how many of the hazards signs they had found to be reported back at the end of the session. Some of these were more hidden than others to encourage greater engagement with the virtual world.

![Figure 3. Overview of the Construction Site with hazard areas highlighted blue](image)
3.4.3 Avatar

The key element of the virtual environment was the inclusion and use of a virtual avatar to act as an ‘experimenter’ within the virtual world to see if it would affect overall levels of presence during the experiment. The avatar was to act as the experimenter after participants entered the virtual world and would provide all instructions and direction from there on. To achieve this, the avatar had to be able to portray the humanistic behaviours of movement and ability to speak and communicate with participants.
Figure 5. Closer view of the virtual experimenter whilst speaking

Motion Capture

Animations for the avatar were obtained through the use of motion capture sessions. Within this session, one of the experimenters for this study mimicked the movements of speaking out all necessary parts of the interactions between the experimenter and participant.

This was conducted at a UCL motion capture lab where OptiTrack Motion Capture Cameras were utilised to record the movements of the experimenter. The process included the use of a Motion Capture suit with Motion Capture Markers placed on specific parts of the body.
The movements were recorded to Motive software and ported over to Autodesk MotionBuilder. From here, a pre-defined avatar was selected to map the recorded movements on to. The avatar selected for this experiment was chosen to have smart-casual clothing, to be consistent with how the experimenters would present themselves in the actual experiments. The movement file had to be then re-targeted onto the avatar template to map the movements to the avatar.

The animation file was further cleaned up to remove elements of clipping or jittering from the animation using MotionBuilder.
Audio takes of the experimenter script were recorded to be aligned with the avatar animations. These were recorded on a Blue Snowball Microphone using Voice Recording software.

To allow for conversational exchange between the avatar and the participant, shorter animation and audio clips were generated make snippets of interaction. For example, a combined clip allowed the avatar to express movements and audio whilst introducing itself to the participant at the beginning of the experience.

A list of clips that the avatar was capable of using follows:
(1) Welcome to the Virtual Space and Self-Introduction

(2) Asking participant how they are and responding

(3) Instructions regarding the task scenario

(4) Instructions regarding looking around and moving in the virtual world

(5) Repeating sections of instructions

(6) Answering basic questions (yes/no)

(7) Short remarks (e.g. “good luck”, “I’ll be keeping watch from here”)

The basic conversational interaction between the virtual experimenter and the participant was staged in a Wizard-of-Oz fashion where the avatar animation would be cued by key presses (Slater, 2013). Best efforts were made to ensure that the avatar had responses that could be used to respond to likely statements or questions by the participant. However, due to the responses being pre-recorded, the responses heard by participants may have suffered from seeming less natural and not having the correct intonations. Additionally, lag times between responses were in some cases an issue.

Whilst the avatar was capable of giving humanistic behaviour through ability to speak with some degree of interactivity and used body language when speaking, facial animations and behaviours were not included in the design of the avatar.

After completing all the necessary clips for the avatar, these were exported as .fbx files and imported into the virtual environment, created in Unity 5.1.
3.5 Materials

3.5.1 Documentation

Information sheets outlined the details of the study conducted, highlighting the purpose and aims. These information sheets also contained warnings to participants regarding the potential for feelings of nausea and simulator sickness. Consent forms outlined the ethical procedures in place for the study and the rights of participants during the study. (See Appendix for Information Sheet and Consent Form examples).

A script outlining the intended pattern of instructions that the experimenter would give to participants was also available if needed.

3.5.2 Hardware

The Head-Mounted Display unit used in this experiment was the Oculus Rift Development Kit 2 (using 1920 x 1080 resolution and 75 Hz refresh rate). This was used in conjunction with a PC machine running Windows 8.1 with an Intel(R) Core(TM) i5-4670 CPU @ 3.40Ghz (8 GB RAM) Processor and Nvidia GTX Titan X graphics card. Whilst initially, there was the intention of using the InterSense Tracking system in the lab to provide positional and rotational tracking at lower latency, compatibility issues occurred resulting in the use of the Oculus Positional Tracking camera being used together with the in-built rotational tracking.

\[1\] In the outline of the study, information regarding our interest in investigating whether participants feel as if they are being watched or how aware they are of the experimenter was excluded to prevent biasing results.
A pair of Bose noise-cancelling headphones was also used as an audio source for participants. This was used in favour of speakers to alleviate for issues with directional sound and to attempt to mask exterior sounds from outside the lab environment.

To permit participants to move in the virtual environment, a wireless Xbox 360 controller was provided. This was connected to the PC through a wireless receiver. Only the left joystick was mapped to movement with all other buttons disabled.

### 3.5.3 Software

Experiments were run directly from the Unity 5.1 editor. A completed Unity 5.1 project with all necessary assets (props, avatar, etc.) was utilised for the experiment. Appropriate settings changes were made to allow for Integrated VR Support to permit the use of the Oculus Rift DK2 as the display device. The Unity Oculus Utilities package was also needed to allow for this.

SnagIt was used as a screen capture software to record the sessions of each participant.

### 3.5.4 Questionnaires

Two questionnaires were administered to each participant for every session. In both of these, elements of the SSQ (Simulator Sickness Questionnaire) (Kennedy et al, 1993) were included. The pre-experiment questionnaire included additional questions relating to more general information whilst the post-experiment interview incorporated questions relating to presence and the experimenter. A pre-existing set of presence
questions (Slater, 1998) were included in the post-experiment questionnaire, with additional subsets of questions included relating to various aspects of the virtual environment and their potential effects on presence.

For ease of data collection, both questionnaires were built using Typeform and was displayed on the lab computer for participants to use.

### 3.6 Pilot Study

Prior to running the experiment, a pilot study was performed to identify potential issues with the experiment design and methodology. Initial responses stated that the instructions were not clear enough and were in some cases confusing for participants. Some participants interpreted the instructions as needing to count what they thought were hazards as opposed to actually just counting the number of hazard signs that they could find. To alleviate this issue, the instructions were further refined to be more clear about the task and emphasise that participants only needed to count the signs.

Another issue found from the pilot study included participants reporting that the hazard signs were located in areas that were too difficult to find. This was purposefully done initially as it was a method to encourage participants to search more thoroughly in the virtual world. However, this was also taken into account and the overall difficulty of finding the signs was decreased and tested again with other participants.

Technical problems were also encountered along the course of the pilot studies with some participants capable of walking through certain objects in the environment. In some trials the avatar used also did not work as intended with the rotational vector
incorrect. This meant that instead of the avatar facing the participant at all times, it would be staring off in another direction. These were all revised and tested before running the actual experiment.

Lastly, one of the key pieces of feedback gathered from the pilot studies was that the initial avatar did not have the required level of plausibility for participants. It was claimed that the avatar seemed too “robotic” or “mechanical” for participants to perceive them as one of the experimenters of the study. As our hypothesis is based on the assumption that participants would feel more presence from a virtual experimenter, provided they believe the avatar to be an experimenter in the study (or at least find it plausible enough), it became necessary to expand the capabilities of the avatar.

The initial avatar was created in a way that it would launch straight into telling the participant about the task without any prior introduction or conversation and would not take any pauses or breaks. The recording of the audio was also done in a manner that eliminated any natural tones in speaking voice. It was then decided to re-record the audio using a more natural voice with more natural breaks and gaps in speaking. Furthermore, it was determined that a greater level of interaction with the avatar would be more beneficial and thus led to the creation of a separate conversational capability as outlined earlier in this section. The changes that were made to the avatar condition introduction to the virtual world was also then reflected into the script for speaking to participants in the control condition.
3.7 Procedure

Participants were initially pseudo-randomly assigned into one of the three experimental conditions before their allotted times.

Upon arrival participants were met at the main reception of the UCL Roberts Engineering Building and were guided up to the allocated lab space. Participants were then provided with an information sheet and consent form to sign. During this time it was made clear to each individual that they would be allowed to take as many breaks from the study as needed and could pull out of the study completely if desired.

Participants were then asked to fill in a pre-experiment questionnaire. Following this, participants were moved into the designated experimental area of the lab and given a short briefing session to outline the task scenario for the experiment. This occurred in one of three different ways (in each, a script was followed to attempt to ensure as similar an experience in each condition):

(1) Participants would be instructed in the physical lab by the experimenter before donning the HMD

(2) Participants would be instructed to don the HMD and were told that they would be meeting a virtual experimenter who would tell them their task for the experiment. The virtual experimenter would be looking in the direction the participant is first placed in within the virtual world but would not change its orientation to face them if they moved

(3) Identical to Condition (2) except that the virtual experimenter would constantly be turned to face the participant if they moved around the virtual world
A standard procedure was performed when placing equipment on the participant for the study. Initially they would be asked to stand in the middle of the lab, facing the Oculus positional tracker (to ensure they were in the range of the tracker and were oriented in the correct direction). A pair of noise cancelling headphones were then placed over their ears. Finally, they were asked to hold out their hands so that the wireless controller could be placed in their hands. At any point when the HMD display was running, a SnagIt screen capture recording would be initiated.

![Participant undertaking experiment in designated experimental area of the lab](image.png)

**Figure 8. Participant undertaking experiment in designated experimental area of the lab**

To acclimatise participants to being in the virtual reality, they were then asked to test looking around themselves in all directions (including behind them) and were also asked to practice moving around the virtual world through the use of the wireless Xbox.
360 controller’s left joystick. In the case of condition (1), participants were asked to place the HMD on after being given their task and were guided through the movement practices from the speaking voice of the physical experimenter. In conditions (2) and (3), the virtual experimenter provided these tutorials.

At the end of the tutorial, participants were informed that to begin the task, they would need to say that they were ready and the experimenter would open the door from the virtual lab into the construction site. However, they were also notified that the experimenter would not be able to respond to any questions during the actual task and were requested to ask any questions they had before saying they were ready to begin. Each session in the virtual world was concluded when either the participant had been through all the inspection areas or said they had completed the entire site.

At the end of the virtual experience, participants were asked and assisted in removing all of the equipment used (Oculus, headphones, controller). They were then informed that the next stage of the experiment would be to complete a post-questionnaire. However, they were also told that they could take as much time as needed to rest before completing the questionnaire in case of potential symptoms of simulator sickness or nausea.

Following the completion of the post-questionnaire, participants undertook a short debriefing session designed as a semi-structured interview. If anything the participant did during their virtual experience stood out, this was pursued in these sessions. At the end of the interview, participants were thanked for their time and were entered in the raffle draw as compensation. In most cases, participants were escorted back to the main
reception (exclusions were when participants were UCL students intending to go elsewhere).
4. Results

In this chapter, the outcomes of the quantitative and qualitative data gathered from our study are presented. The key areas of measurement for examining presence and 'watching' effects are examined in separate sections. Finally, this chapter will conclude with a brief overview of the results from qualitative data obtained through screen-capture recordings and post-experiment interviews.

After compiling all the necessary questionnaire response data for this experiment into spreadsheet formats, our data was subjected to statistical analysis to determine if there was any relation between our tested avatar condition and greater levels of presence or a feeling of being watched. Statistical analysis was conducted using IBM SPSS Statistics 22. As our questionnaires incorporated all questions that related to the different investigation areas, it was necessary to take the appropriate subsets of questions to analyse. However, we also conducted a comparison between these questionnaire response scores to identify if there were any trends present.

4.1 General Information Overview from Questionnaire Responses

One key consideration when analysing these results was that the total number of participants data included for each of the different conditions was different. For the Control group, 11 entries were analysed, the Avatar group, 10 entries and the Watching group, 13 entries. The differences in these numbers were due to participant cancellations as well as exclusions to the data set due to issues such as technical problems that rendered a participant’s data as potentially biased.
Within the pre-experiment questionnaire, a few questions were included to gather some potential explanatory variable information. These questions included the participants’ age, gender, and number of hours of video game play in a week. Participants were also asked if they had previously experienced immersive virtual reality.

Figure 9. Graph displaying distribution of gaming hours per week

Figure 9 displays participants’ amount of hours per week spent on games for each experimental condition separated into the groups of low, medium and high. The ‘Low’ group denotes under 10 hours of games per week, the ‘Medium’ group represents 10-20 hours per week and the ‘High’ group 30 hours and above per week. Figure 10 presents information for each condition regarding whether participants had previously experienced immersive virtual reality prior to taking part in this study.
In the post-experiment questionnaire, participants were asked to fill in how many hazards they had found as part of the task they had been given for the experiment. Since this task was given mostly with the purpose of encouraging participants to engage with the virtual world, this data is not an essential part of our analysis despite being gathered.

The full list of questions presented to participants both at the beginning and end of the experiments are shown in the Appendix section of this paper.

4.2 Simulator Sickness Questionnaire (SSQ) Responses

The Simulator Sickness Questionnaire was applied to participants once before the beginning of the experiment and once again after completing the virtual reality
experience. The specific questions that were related to the SSQ involved asking participants about levels of particular symptoms affecting them at that present moment.

In both cases before and after the experiment, 16 questions were asked to address the SSQ. In the pre-experiment version these covered Questions 6-21 and in the post-experiment version these were Questions 3-18.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Experiment SSQ</th>
<th>Post-Experiment SSQ</th>
<th>Score Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>Group Control</td>
<td>12.92</td>
<td>39.10</td>
<td>26.18</td>
</tr>
<tr>
<td>Avatar</td>
<td>9.35</td>
<td>38.15</td>
<td>28.80</td>
</tr>
<tr>
<td>Watching</td>
<td>16.40</td>
<td>53.51</td>
<td>37.11</td>
</tr>
</tbody>
</table>

Table 1. Mean scores of Simulator Sickness Questionnaire responses

As can be seen from the above table, the means for the differences in scores between pre and post-experiment questionnaires incorporating the Simulator Sickness Questionnaire elements did not vary by any significant amount although there was a slight indication that the Watching condition instigated a small degree of additional symptoms in participants.
4.3 Presence Scores

4.3.1 Main Presence Questionnaire

A key subset of questions was targeted at determining the levels of presence that participants felt in each of the three experimental conditions (Post-Experiment Questionnaire Q19-24). These included 6 questions (denoted below as PQ(n)) and are displayed below:

PQ1. Please rate your sense of being in the virtual environment

PQ2. To what extent were there times during the experience when the virtual reality became the "reality" for you, and you almost forgot about the "real world" in which the whole experience was really taking place?

PQ3. During the time of the experience, which was strongest on the whole, your sense of being in the site, or of being in the real world?

PQ4. Consider your memory of being in the virtual world. How similar in terms of the structure of the memory is this to the structure of the memory of other places you have been today? By ‘structure of the memory’ consider things like the extent to which you have a visual memory, whether that memory is in colour, the extent to which the memory seems vivid or realistic, its size, location in your imagination, the extent to which it is panoramic in your imagination, and other such structural elements.

PQ5. When you think back about your experience, do you think of the virtual world more as images that you saw, or more as somewhere that you visited?

PQ6. During the time of the experience, did you often think to yourself that you were actually just standing in a room wearing a helmet or did the virtual reality overwhelm you?
These questions were analysed as a separate bracket of questions as previous work has used this as a basis for measuring presence (Slater, 1998). Each of the above questions were rated on a Likert scale between 1-7, where 7 indicated higher levels of presence.

<table>
<thead>
<tr>
<th>Group</th>
<th>PQ1 Mean</th>
<th>PQ2 Mean</th>
<th>PQ3 Mean</th>
<th>PQ4 Mean</th>
<th>PQ5 Mean</th>
<th>PQ6 Mean</th>
<th>PQ Totals Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4.27</td>
<td>4.09</td>
<td>3.37</td>
<td>4.45</td>
<td>4.82</td>
<td>4.37</td>
<td>25.36</td>
</tr>
<tr>
<td>Avatar</td>
<td>3.60</td>
<td>2.80</td>
<td>3.40</td>
<td>3.20</td>
<td>3.40</td>
<td>3.90</td>
<td>20.30</td>
</tr>
<tr>
<td>Watching</td>
<td>5.31</td>
<td>4.62</td>
<td>4.15</td>
<td>3.54</td>
<td>3.69</td>
<td>5.31</td>
<td>26.62</td>
</tr>
</tbody>
</table>

Table 2. Mean scores for responses to Presence questions

From the table above, we can identify that the Control and Watching conditions did not have hugely varying total score differences. However, it does appear as if the Avatar Only condition performed worse in terms of presence score responses compared to the other conditions.

One-way ANOVA statistical tests were applied to both the means of individual question responses as well as the aggregate combined total scores (PQ Totals). To identify which experimental condition groups had significant differences between them, a Post-Hoc Tukey test was also applied to the data.
The statistics shown in Tables 3 and 4 depict that there were significant differences found between the results of the presence questionnaire used. Specifically we can identify that the mean values for both the Control and Watching conditions were significantly higher than the Avatar condition (p = 0.29 and p = 0.04 respectively). This supports the hypothesis that the Watching condition would perform better in terms of levels of presence experienced by participants compared to the Avatar condition. However, the results of the ANOVA test revealed that the presence scores for the Control condition was also significantly higher than the Avatar condition whilst not having any significant difference from the Watching condition. This contradicts our hypothesis and will be further explored in the ‘Discussion’ chapter of this paper.

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### Table 3. Results of One-Way ANOVA test on PQ Totals

**Multiple Comparisons**

**Dependent Variable:** Presence Questionnaire Scores

<table>
<thead>
<tr>
<th>(I) Group</th>
<th>(J) Group</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Avatar</td>
<td>5.064*</td>
<td>1.876</td>
<td>.029</td>
<td>.45 - 9.68</td>
</tr>
<tr>
<td>Watching</td>
<td>Control</td>
<td>-1.252</td>
<td>1.759</td>
<td>.759</td>
<td>-5.58 - 3.08</td>
</tr>
<tr>
<td>Avatar</td>
<td>Control</td>
<td>-5.064*</td>
<td>1.876</td>
<td>.029</td>
<td>-9.68 - 4.52</td>
</tr>
<tr>
<td>Watching</td>
<td>Avatar</td>
<td>-6.315*</td>
<td>1.806</td>
<td>.004</td>
<td>-10.76 - 1.87</td>
</tr>
<tr>
<td>Watching</td>
<td>Avatar</td>
<td>1.252</td>
<td>1.759</td>
<td>.759</td>
<td>-3.08 - 5.58</td>
</tr>
<tr>
<td>Control</td>
<td>Avatar</td>
<td>6.315*</td>
<td>1.806</td>
<td>.004</td>
<td>1.87 - 10.76</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.
One point of interest that was found during the analysis of this set of presence questions was that only the first two questions (PQ1 and PQ2) of the questionnaire produced significant differences in the mean values. Questions PQ3-PQ6 did not return any significant results. A summary results table of statistical tests for each individual question can be found in the Appendix.

4.3.2 Reported Presence at Multiple Points in the Environment

Question 25 of the questionnaire encompassed four sub-questions that queried participants about their reported levels of presence across multiple different points across the experience. This was used to gauge at which points participants felt more present in the virtual world. For these questions, no significant results were observed.
4.3.3 Using Number of ‘High’ Value Responses for Statistical Analysis

In previous work (Slater, 1994; Slater 2000), there has been argument raised about the use of ordinal scale summations for statistical analysis as there is no definite measurable unit that defines the difference between a Likert scale rating of 3 or 4. To compensate for this, we decided to also include an analysis of the data using this approach by collecting a count of the ‘high’ scores in each presence question. For this particular study, a ‘high’ score from one of the questions is given if the response is either a 5, 6 or 7. The results of a one-way ANOVA test is shown in the table below.

<table>
<thead>
<tr>
<th></th>
<th>HighScores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td>Avatar</td>
</tr>
<tr>
<td></td>
<td>Watching</td>
</tr>
</tbody>
</table>

Table 5. Mean number of ‘high’ scores in each condition
Observing this data shows that we still receive a statistically significant differences between the Avatar and Watching experimental conditions (p = 0.037) with the Watching condition performing better in terms of presence scores. This again coincides with the hypothesis that the Watching condition would outperform the Avatar condition although our other hypotheses are not met.

### 4.3.4 Task Related Presence Questions

Two questions (Q26 and Q27) were specifically related towards whether the task element of the experience influenced the levels of presence. All statistical tests across these questions did not reveal any significant results.

**Q26.** To what extent did you feel as if the events in the virtual world were actually happening to you? 1 being not at all, 7 being very much
Q27. Did the task feel like a real task that you had been assigned and needed to complete or just a task you were performing for this experiment? 7 being feeling like a real task

4.3.5 Instructor Related Presence Questions

Questions that were included to address the effect of the method of instruction into the virtual environment were also analysed (Q28-30). These again did not produce any significant results, although from the boxplot displayed, there is clearly a very large range of responses existing for the Watching condition. This will be explored further in our discussion. Interestingly, the Avatar condition also appears to have a higher mean value than in the Control condition, which up until this point has been untypical.

Q28. Think back to the beginning of the experiment when you were given instructions. How much did it feel as if they were part of the virtual or physical world? 1 being physical world, 7 being virtual world

Q29. To what extent do you believe that the method of introducing you to virtual reality (through the instructions) helped to situate yourself in the virtual world? 1 being not at all, 7 being really helped

Q30. When communicating with the instructor, did it help or hinder your feeling of being in the virtual world? 1 being hindered, 7 being helped
Figure 13. Boxplot of Instructor Related Questions results

4.4 Questions Relating to Social Presence and Feeling Watched

The last few questions (Q31-32) of the post-questionnaire were aimed at receiving data regarding how much participants felt they were co-located in the virtual reality with another ‘person’ and if they felt they were being watched. The statistical analysis of this data revealed no significant differences. This was inconsistent with the hypothesis that participants would feel more like they were being watched in either of the Avatar or Watching conditions.

Q31. How strong was the feeling that you were being watched during the experiment? 1 being not at all, 7 being very much.

Q32. How much were you aware of the presence of the experimenter during the experiment? 1 being not at all, 7 being very much.
Figure 14. Boxplot of questions relating to social presence and feeling watched results

The results for the Watching group for Question 33 in particular is of interest as shown by the graph below. As can be seen, there is a wide distribution of scores that were found for this question. It was expected that these results would have been more skewed towards one side of the scale and will be further discussed in the next chapter where we will take into account the qualitative data gathered from the interviews.

Q33. How much did it feel like the experimenter was part of the virtual world? 1 being not at all, 7 being completely
4.5 Video Data Analysis

The screen captured sessions for each participant were also reviewed to identify how participants associated with the virtual world in the different conditions.

One observation that could be identified from these recordings was that participants in the Control condition had less time in the virtual lab tutorial compared to the Avatar and Watching conditions. However, this was due to the fact that part of the Control groups’ tutorial (instructions) were performed in the physical world.

In relation to addressing our research questions of effects on presence and whether participants felt as if they were being watched, the analysis of the screen recordings revealed two key points:

1. In the Avatar and Watching conditions, participants generally used the virtual experimenter as a reference point or focal point for the interaction in the virtual lab.
Participants would appear to turn towards the avatar when it was speaking even if only for short durations and would also appear to look in the direction of the avatar when they required prompting for the next thing they should be doing. Additionally, in most cases participants would turn towards the avatar when a new line of speech began, as if they were giving attention to the avatar’s voice (these traits were found with 20 out of 23 participants who experienced an avatar). A side point to this is that, even with participants who did not pay as much attention to the virtual experimenter, almost all participants paid attention to the instructions relating to turning their heads to look around as well as moving around.

(2) Participants in the Control condition appeared to be more care-free about the actions that they took in the virtual lab in comparison to the other experimental conditions (6 of 11 participants). By this, we mean that participants were more readily exaggerating their movements in turning and moving in the virtual lab. It also appeared as if participants in this group were more inclined to explore more and test the limits of what they could do in the virtual world. Whilst there were a few occurrences of participants in the other groups displaying the same behaviour, this stood out primarily in the Control condition.

4.6 Interviews Overview

The post-experiment interview data that had been gathered revealed a set of frequent comments made by participants of the study:

(1) Participants in the Control condition stated that having to communicate with the experimenter from the physical world, decreased feeling of presence in the virtual world with many suggesting that some kind of internal virtual instructions as a substitute for having to listen to instructions from the physical world.
(2) In both the Avatar and Watching conditions, participants referred to the virtual experimenter’s ability to exchange simple forms of communication as a positive factor in influencing them to believe that they were interacting with a real person. However, the majority of participants still referred to the idea that they did not believe the virtual experimenter was ‘real’ enough to believe it was an actual person. This was especially clear when participants were prompted on whether they felt they were being watched by the avatar.

(3) Through all three experimental conditions, the vast majority of participants indicated that they did not feel as if they were being watched at all. There were a few exceptions where participants self-reported about their sense of self-consciousness or paranoia that induced the feeling that they were being watched by the physical experimenter (this also led to some mentioning differences in the way they would have acted). In conditions with the virtual experimenter, participants indicated that they noticed the virtual experimenter looking at them, but typically did not pay this much attention.

(4) During moments of the experience where they were required to concentrate more, participants self-reported having higher levels of presence. For example, having a task to focus on completing was one of the frequently mentioned comments that participants referred to as allowing them to feel more present in the virtual world.

(5) The ambient sound track as well as the sound of footsteps were brought up many times as positively reinforcing a sense of presence. In some cases, participants referred to hearing external noises from the physical environment (these were uncontrolled confounding variables) that affected their feeling of presence.

(6) Typical responses to what elements of the virtual environment disrupted their sense of presence:

   a. Graphics

   b. Inconsistencies of interaction compared to real world
c.  Tangling of physical cables

d.  Technical issues (blurriness, occasional jitter or stutter)

(7) Many participants referred to the experience as a “game”
5. Discussion

The primary aims of this study were to investigate how different ways of introducing participants to virtual reality could affect their overall levels of presence and whether the use of a virtual experimenter or avatar could instigate a feeling of being ‘watched’. In this chapter we will summarise and outline the implications of the results of this experiment by going into greater depth to explain the outcomes and how it relates to previous work. We will highlight how these results relate to our hypotheses for this work and make mention to the potential limitations of this study as well as routes towards future work.

5.1 Main Presence Questionnaire

The results obtained in this study partially support our hypothesis regarding the use of a virtual experimenter for the purposes of introducing and instructing a participant into virtual reality. It was our determination that the Control condition would perform the lowest in scoring for levels of presence, with the Avatar condition performing slightly better. It was also hypothesised that of the three conditions, the Watching condition would elicit higher presence responses than both the Control and Avatar conditions.

In our main presence questionnaire, it was revealed that there was a significant difference between the Avatar condition and the Watching condition. Depending on whether we scored our presence questionnaire on raw total scores or number of ‘high’ scores there was also significant difference between the Avatar and Control condition. In both cases of scoring however, there was no such significant difference between our
Control and Watching conditions. This conformed to our hypothesis stating that the Watching condition should outperform the Avatar condition in terms of presence but contradicted with our hypotheses that the Avatar and Watching conditions should outperform the Control condition. In actuality, the data depicted that there was no significant difference in presence levels between our Control and Watching conditions, whilst the Avatar condition performed poorly in comparison. Delving deeper into our main presence questionnaire (as outlined by Section 4.3.1) showed that the questions that produced significant differences were PQ1 and PQ2, which could help to provide justification for these results.

**PQ1.** Please rate your sense of being in the virtual environment

**PQ2.** To what extent were there times during the experience when the virtual reality became the "reality" for you, and you almost forgot about the "real world" in which the whole experience was really taking place?

For both of these questions, the same results of significant difference between the Avatar and Watching condition were found. This could be explained by the level of interactivity that the virtual experimenter seemed to provide with the participant. In the Watching condition, by simply having the virtual experimenter constantly face the participant, it created an illusion of the virtual experimenter directly addressing the participant generating a stronger link of interaction. Through emphasising this communication link between the participant and the avatar to a greater extent, it created greater engagement with the virtual world potentially leading to a ‘greater sense of being in the virtual environment’.
5.1.1 Qualitative Feedback

This was supported from our interview data where participants from the Watching group gave more positive responses when prompted on their reactions to having been introduced by a virtual experimenter. One key revelation from analysing this qualitative data was that participants appeared to listen more to instructions and know what they were doing in the Watching condition as opposed to the Avatar condition. This points to the virtual experimenter that tracked the participant as more attention-grabbing and perhaps even more realistic. By controlling the attention of the participant, it thus gave participants something to focus on and therefore assisted in making participants feel more interaction with the virtual world and more present within it.

One participant in the Watching group mentioned “I could see he was following my movements” and due to the exchange of pleasantries and questions, speaking to the virtual experimenter felt “kind of like I’m interacting with someone real”. Another mentioned that “I tried to walk up to him and talk to him, we had an interaction”. In contrast, the impression that participants were less inclined to give attention to the virtual experimenter in the Avatar condition is supported by participants mentioning that they would just look around the room, not listen to/miss out on instructions or disregard the virtual experimenter as “just some random computer talking to me”. A particular statement that helped to enforce this point was “I wondered why I was making eye contact with him, then I walked around the room to explore”.

Comparing screen capture videos between the Avatar and Watching conditions also provided further evidence of a greater level of interaction with the virtual experimenter from the Watching condition participants. In the Watching condition, participants
appeared to be more inclined to face the virtual experimenter when he spoke and were not as prone to wandering around the virtual lab as those in the Avatar condition.

A key consideration that has to be made in reference to these interview findings is the role of plausibility illusion (Slater, 2009). It could be argued that depending on the personality of an individual participant, they could potentially be less receptive to the use of a virtual experimenter. Some participants shared that they almost immediately disregarded the virtual experimenter as “he just doesn’t seem real” whilst others reported that they “felt like his presence was actually there”. This could point to individuals having different thresholds for what they may perceive to be believable coming from a virtual avatar. If this threshold is low, then we may infer that the plausibility illusion is more easily broken, thus reducing the impression that the events of the virtual world are actually happening and lowering overall levels of presence. In the cases where participants are more willing to believe and interact with the virtual avatar this plausibility illusion can be maintained, accounting for the higher levels of presence. This can be extended into the study where the Watching condition virtual experimenter was able to be viewed as more ‘plausible’ than the Avatar condition virtual experimenter.

We can also point to work (Slater et al, 2002) that concluded that higher levels of photorealism can incur higher expectation of realistic behaviour when applied to an avatar. If participants had gone into our study with an expectation of behaviour from the virtual experimenter due to its appearance, the fact that it would not directly face participants when speaking to them could also explain the significant difference in presence scores between the Avatar and Watching groups.
From the data collected, it is not clear why there was no significant difference between the Control and Watching conditions and why the Control condition outperformed the Avatar condition although some possible explanations can be put forward. One of these could be that the appearance of the virtual experimenter meant that it could have fell within the ‘uncanny valley’ (Mori, 2012) with the additional interaction provided by the Watching condition compensating for the disbelief of the virtual experimenter as a ‘real’ person.

5.2 Task Related Presence Questions

Part of the post-experiment questionnaire was aimed at understanding if the difference in method of introduction into virtual reality would have an effect on participants’ impression on the task element of the experiment. No particular hypothesis was made for this set of questions as this was only incorporated after the initial pilot study. The reason for this was that feedback gathered from the pilot study indicated that the task element of the experiment was a strong factor in engrossing a participant in the virtual world.

Analysing our data showed no significant difference between the experimental conditions. This allows us to determine that the use of a virtual avatar in assigning a task to a participant does not significantly affect the way participants view the task itself.

Whilst we may not have seen any differences in the experimental groups we can still report that the task itself assisted in creating a sense of presence. Our interview data replicated previous findings (Sheridan, 1992; Slater et al, 1998) regarding the ability of
task complexity to influence levels of presence. Example responses from participants that support this include one participant stating that the “task did sort of push me towards being in the virtual reality world”. Another indication of this ‘task effect’ was shown in the quote that a participant was “keen to get the task done” and noted this as helping them feel present in the virtual reality.

From this, we can formulate that having some sort of task for participant’s to occupy themselves with or concentrate on is important in ensuring they do not experience any breaks in presence. Although a more thorough analysis of the data would be needed, there can be a tentative conclusion made that participants who had not properly understood the instructions and were thus unclear of what to do during the actual task had lowered levels of presence. This was identified when participants commonly reported that they would become more aware of being in a physical lab performing an experiment when they were not sure about what to do next.

5.3 Instructor Related Presence Questions

The analysis of this question set did not reveal any significant results. This was a surprise as it was strongly believed that having to communicate with an external speaker in the Control group would negatively impact feelings of presence in virtual reality. By simply addressing an entity that was a part of the physical world, it was reasoned that this should force a participant into becoming more aware of their surroundings in the physical space. However, it may also be possible to argue that presence is influenced by a participants’ individual primary representation system (Slater et al, 1994). As the communication with the experimenter was purely auditory in the Control condition, it
could be reasoned that participants experienced greater presence through their other senses.

Furthermore, we must also take into account that the questionnaire was a subjective measure relying on the participant to recall their experience in the virtual world. This potentially could have been confounding as the method of instruction was conducted at the beginning of the experience, meaning there is a chance participants are not fully able to remember that phase of the experiment. Additionally, a larger data set would have been preferable to address this issue as a shallow analysis of the scores for these questions do somewhat indicate that the conditions with virtual experimenters performed slightly better than the Control condition.

5.4 Social Presence and Feeling Watched

It was expected that the interaction with the virtual experimenter would have accounted for a greater feeling of social presence (Heeter, 1992) and therefore an impression of being watched from within the virtual world. This was not reflected in the data collected, with no significant differences found in these presence measures across the experimental conditions.

One of the first things to consider is that during the questionnaire phase of the experiment, participants were frequently confused as to whether the ‘experimenter’ mentioned in the questions referred to the physical or virtual experimenter. Many assumed this to be the physical experimenter which could explain the distribution of scores in the graph found in Section 4.4.
We can also look into individual differences in participants as well as the loss of feeling of social presence throughout the entire experience as causes for our results. Across all three conditions, some participants recorded high scores for feeling as if they were being ‘watched’ by the physical experimenter in the real world. When queried on this, most put this down to feelings of self-consciousness and paranoia about the actions they were making and how this would appear in the real world regardless of which condition they were part of. It was also clear that participants were more likely to think about the physical experimenter watching them when they were unsure of what to do or thought they had not conducted the task properly. This is exemplified by one participant thinking that the physical experimenter would have been thinking “I can’t believe he couldn’t see that one” in relation to finding the hazard signs in the virtual world. Another was brought into believing the physical experimenter to be watching when thinking about “how embarrassing it would be if I had tripped over”. In an extreme case, a participant also reported that they believed that they “felt like I was in a glass cage…like I was being watched through a camera lens”.

We can also raise some interesting findings relating to the virtual experimenter himself in contributing to these results. In the conditions with the virtual experimenter, almost all participants stated that during the actual task phase of the experiment (in the construction site) they had forgotten about the virtual experimenter entirely. This points to the idea that without the interactions between the virtual character and the participant themselves, they may lose the plausibility illusion and feeling of social presence as they are no longer directly relating with the virtual experimenter. As the virtual experimenter made no effort to grab the attention of the participant during their task such as gesturing towards them or speaking to them (Slater, 2009), participants believed “he no longer felt part of the experiment”. To build on this, we may cite previous work (Slater et al, 2013)
that without interaction with virtual characters, participants may feel disconnected and lose any sense that the virtual character possess ‘presence’.

Information of note gathered from our interview data allowed us to identify however, that there were times when participants felt watched by the virtual experimenter. This was rooted in the times when they would actually be interacting with the virtual experimenter (in the tutorial) as well in brief split-second reactions to seeing the virtual experimenter from the construction site. It was reported that participants felt initially like they were being watched before quickly realising that it must be virtual and not real. This gives credence to the idea that it does seem possible to incur the feeling of being watched in participants but perhaps there must be a certain level of interaction still available to maintain this perception.

The surprising distribution of participant responses to the question of whether they felt the experimenter was part of the virtual world (Figure 15) can be also be partially explained by the fact that some participants needed to ask the physical experimenter whether this question referred to the physical experimenter or the virtual experimental. This could have potentially influenced the results as we cannot account for which experimenter every participant referred to when responding to the question but this at least shows us that the impression that the virtual experimenter was an experimenter had some effect.

5.4.1 Potential Hawthorne Effects

When looking into the possibility for Hawthorne effects in the experiment, it must be noted that this was reliant on the perception of the participant in believing the virtual
experimenter was an actual real experimenter and part of the study. This proved to be difficult for reasons outlined in this section relating to plausibility illusion and feelings of social presence. However, we can still present some of our findings in relation to this area.

Screen capture recordings revealed that participants in the Control condition were more willing to make exaggerated and odd movements in the virtual lab whilst those in the Avatar and Watching conditions less so. Although the virtual experimenter was reported as being ‘unrealistic’, it may have to some extent exhibited social presence as it had a controlling effect on how much participants were willing to test the boundaries of the virtual reality. This is supported by one participant mentioning that “when he was talking to me, I felt I had to look at him” and that “I didn’t feel like I could just spin around in a circle”. However, we could not conclusively say whether this change in behaviour can be attributed to a Hawthorne effect or simply social presence dictating social grace.

It may also be interesting to report that despite participants reporting that they felt immersed and present in the virtual reality at points throughout the experience, they still had the lingering feeling that the physical experimenter was watching them and that they had to complete a certain task for the experiment. Casual thoughts such as “sometimes I felt I had to walk better” were enough to show that participants were being impacted by the physical experimenter. There was also evidence suggesting that participants either felt the need to perform the task quickly or perform the task well because they could recall that they were part of an experiment. This points to the difficulty in ensuring that participants are consistently engulfed by the virtual reality to ignore these feelings.
As a last comment, there were also some indications that the virtual experimenter could cause a Hawthorne effect. Most participants in the Watching condition took note that the virtual experimenter was tracking their movements, but claimed this did not affect them as “I know he is not real”. Despite this, two participants commented that this did indeed alter how they went about their task. One participant compared his experience with a real-life event and noted that upon seeing the virtual experimenter looking at him that “the emotion I had was a real emotion” in terms of feeling observed. The participant also stated “I became more serious with the task” and “became more focused”.

5.5 Implications

The key implications of this discussion are outlined below:

(1) The use of a virtual character in introducing users into virtual reality has the potential to increase levels of presence through manipulation of plausibility illusion

(2) Believability of a virtual character is essential in determining how successful a virtual character will be in influencing feelings of presence in participants and how much they believe the virtual character to have a presence itself. This is a combination of both the appearance of the character as well as its interaction capabilities

(3) Participants can easily lose the perception of social presence with a virtual character when no longer interacting with it
(4) The perception of feeling watched by an external experimental can be exhibited by participants in virtual worlds despite the use of immersive devices.

(5) The presence of a virtual character can make participants feel as if they are being watched although this may only be for split-moments. However, the presence of the virtual character does appear to be capable of altering participant behaviour.

These findings show that the use of virtual characters is a potentially viable option in the use of virtual reality applications. There is evidence to suggest that when constructed appropriately, virtual characters will indeed assist in situating participants in the virtual world and increase their sense of ‘being’ in the virtual place. This could be applied to any application where developers are keen to prime their users in a manner that they will be more engaged with their virtual worlds and could be important to areas such as studying human behaviour or training simulations. In identifying that it may be possible to create the feeling of being watched by virtual characters, it also opens up greater avenues to creating more realistic environments where participants are expected to feel a degree of social or peer pressure. That participants also reported that they believed the virtual experimenter was effective in acclimatising and situating them into the virtual space through a transitional period also points to potential utility of virtual character implementation.

5.6 Limitations

A few factors of the study potentially influenced a lack of clear variability in our results. Firstly, due to the constraints of the project, only a limited sample size was used to gather data from. Additionally, the fact that the number of participants for each experimental condition was not balanced was unideal although out of our control due to
unforeseen circumstances. The use of a between-subjects design also meant that we could not account for individual variability between participants that could have impacted on our results.

One of the major limitations of this study was in the virtual environment itself and how it could have been improved. For starters, one limitation from the environment itself could have been the relative lack of interaction possible from participant input. This could have assisted in creating a more realistic experience for participants. However, the starker restriction was in relation to the virtual experimenter itself and how it was able to interact with participants. Whilst simulating communication by listening to participants and responding by selecting the appropriate speech response through key presses seemed to work quite effectively, it is still no comparison to a proper conversation. The nature of the recorded audio also meant that there were unnatural pauses and un-matching intonations when speaking with participants. As our hypothesis regarding the use of a virtual experimenter was based on the assumption that participants would need to believe that the virtual experimenter was a ‘real’ person or experimenter, this could have negatively affected the results of this work. The virtual experimenter would have also likely benefited from having behaviours such as eye gaze and facial expressions (Garau, 2001; Lee, 2002) with more human-like movements in turning towards participants. These changes were not possible in the scope of this project as there was a lack of resources and expertise in certain technical areas to implement them.

Another potential limitation of the study was in the method of measurement. Questionnaires were used as a subjective method of gauging levels of presence in the virtual world. However, this raises issues as it relies on a participant being able to
reliably recall their prior experience. This may have been particularly difficult as some questions were directly asking about occurrences that happened at the beginning of the experience and may not be so easily remembered. This could somewhat be evidenced by the fact that qualitative data revealed frequent positive evaluations of the virtual experimenter in introducing the virtual world but was not reflected in the quantitative data.

There was also a slight inconsistency between the procedure of the Control condition and the other two conditions. This was caused by the necessary hand-over from the physical experimenter to the virtual experimenter. An attempt to at least simulate some form of re-location similar to that of being placed in the virtual world was done in the Control condition, by moving participants into the area of the lab where they would be actually be donning the Oculus Rift. It is unknown to us whether this would have had any real impact on the results and although unlikely, wouldn’t have been a problem if another physical experimenter had been available to run the study.

Lastly, technical difficulties existed within the experiments conducted for this study. This ranged from slight stuttering or jittering problems on the HMD itself for some participants that could not be expressly controlled to restrictions placed on participants because of physical limitations such as the length of wires and cables. The use of the SnagIt software also potentially had a negative effect on framerates. In addition, sounds from external sources outside the lab were uncontrolled and intruded upon some participants’ experiences. Curiously, some incorporated these into their virtual experience although most questioned whether these additional sounds were a form of test for the experiment. These would clearly have an impact on a study focused on
presence as these elements were reported to have caused participants to remember they were simply undergoing a virtual reality experiment.

5.7 Future Work

As alluded to previously in the chapter, there are a few key areas that could be changed or investigated to expand this study.

The main area that would be of an interest in altering for future work would be in relation to the virtual experimenter. It would be of interest to examine the performance of the virtual experimenter with a higher level of interaction capabilities and expressiveness. This could be done by incorporating facial and gestural animations for the avatar itself to increase levels of plausibility (Garau 2001; Garau 2003; Lee 2002) or could go to greater lengths by incorporating artificially intelligent behaviour (Aylett and Luck, 2000). Another avenue of research could be to co-locate an actual experimenter into the virtual world through motion capture and allow the participant to directly communicate with an actual person. This would likely promote feelings of social presence (Heeter, 1992) but could also raise a range of other problems related to multi-participant virtual reality applications (Tromp, 1998).

It would also be of interest to take a closer look at potential Hawthorne effects in virtual reality studies. Participants seemed to indicate that they did not feel as if they were being watched but commonly mentioned that they still “knew in the back of my mind” that an experimenter was watching. This could then be expanded to understand if these reported feelings are still expressed in situations where they are not being actively observed.
A further item of note that could be used in future work would be to make use of either behavioural or physiological measures to gauge presence. This would compensate for any issues relating to recalling a past event as was used for this study.
6. Conclusion

This study investigated the effects of different forms of priming on the levels of presence experienced by participants in a virtual reality setting. This was achieved by testing three methods of priming across different experimental groups - one involving instruction from a physical experimenter and the other two involving instruction from a virtual experimenter. An additional area of interest for this work was in determining the extent to which participants felt they were being watched during their experiences and whether virtual experimenters can instigate a Hawthorne Effect on participants.

The results of this study allow us to conclude that the use of a virtual experimenter for the purpose of priming participants of an experiment for virtual reality indeed has the ability to affect levels of overall presence. While we are unable to confirm that the inclusion of a virtual experimenter was beneficial to feelings of presence due to a lack of significant quantitative results, a further analysis of the data points to the potential of a virtual actor to fulfil this kind of role to encourage presence. This is inferred from our findings during interviews with participants who generally believed that this acclimatisation to the virtual world was helpful despite the virtual experimenter needing some interactional improvements to ensure that its believability and therefore plausibility illusion were maintained. One thing, however, that is clear is that a virtual character that lacks certain human-like capabilities can have a detrimental effect on levels of presence and should therefore not be included into a virtual environment unless meeting a certain level of interaction level. Additionally, it can be concluded that this ability to interact with a participant is essential to maintaining a sense of social presence with participants, and that when this interaction stops, so does the illusion.
Conclusions that can be drawn from our other research question showcase that despite the supposed feeling of ‘presence’ and disconnection from the physical world when using virtual reality, it is still possible for participants to feel watched by an experimenter. This was shown to be caused by individual differences in self-consciousness and paranoia whilst also occurring during breaks in presence, where participants would lose their focus of being in the virtual world (such as through not knowing what to do next) and again become aware of the physical space. It was also of note that despite participants usually stating that they did not believe the virtual experimenter to be a real person or possess any presence, there was a tendency for less exaggerated movements from within the virtual lab setting in the condition where the virtual experimenter would appear to be directly addressing the participant.

Furthermore, we can state that whilst there is some evidence to support the ability of a virtual experimenter to cause a Hawthorne Effect, there is certainly a necessity to build the belief that the virtual experimenter is truly an experimenter and to ensure that participants remain socially connected with it. These findings encourage the notion that the use of virtual reality systems can enhance the way humans interact with the technology in the future by not only presenting a representation of the physical world but by also producing ‘realistic’ responses in users from virtual input.

Whilst it must be acknowledged that the findings of this study are only tentative and reveal a multitude of other potential research areas, the outcomes of this study should help provide a starting point for exploring the effectiveness of different forms of priming and in the application of virtual actors in virtual reality.


References


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Appendix I – Participant Information Sheet

Information Sheet for Participants

You will be given a copy of this information sheet.

Title of Project: Investigating the Impact of Virtual Actors in Priming on Presence in Virtual Reality

This study has been approved by the UCL Interaction Centre Department’s Ethics Chair (Project ID Number): UCLIC/1415/014/MSc Steed/Lam

Name Anthony Steed, Nicholas Lam

Work Address Department of Computer Science, University College London, Gower Street, London WC1E 6BT

Contact Details A.Steed@ucl.ac.uk, nicholas.lam.14@ucl.ac.uk

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, please read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

Details of Study:
The purpose of the experiment is to investigate how the way people are introduced to a virtual world affects their level of presence within a virtual environment. During the experiment you will be given some form of instruction method that will outline the tasks that you will perform.

You will be asked to perform these tasks in a virtual reality system. The virtual reality system is comprised of a head-mounted display that you wear, with integrated tracking system that provides a first person view of a virtual world. A controller will also be provided to allow you to move around in the virtual environment. Instructions on how to use the equipment will be provided before commencing with the experiment.

The whole experiment should take approximately 45 minutes to 1 hour.

If you have any questions about the study now please ask the experimenter. If you have any questions at a later date, please email Anthony Steed or Nicholas Lam at the addresses above.

**IMPORTANT**

*When people use virtual reality systems, some people sometimes experience some degree of nausea. If this is adversely affecting you during the study please let the experimenter know and we will take a break or stop completely. If at any time you*
wish to stop taking part in the study due to this or any other reason, please just say so and we will stop.

There has been some research, which suggests that people using head-mounted displays might experience some disturbances in vision afterwards. No long term studies are known to us, but the studies which have been carried out do testing after about 30 minutes, and find the effect is still sometimes there.

There have been various reported side effects of using virtual reality equipment, such as 'flashbacks'. With any type of video equipment there is a possibility that an epileptic episode may be generated. This, for example, has been reported for computer video games or television viewing. If you believe these symptoms to be severe or long-lasting, please consult a physician.

Please Turn Over

Procedure:

You will be asked to read, understand and sign a Consent Form. If you agree to take part in this experiment then we will ask you sign it, and the study will continue with your participation. Otherwise your involvement will cease at that point. Note that in any case you can withdraw at any later time without giving any reasons.

You will be asked to switch off mobile phones during the experiment.

You will be asked to complete some questionnaires, so that we can try to understand your actions during the study.

You will be provided with a set of instructions from the experimenter.
You will move into the virtual reality system.

You will then be requested to complete the tasks outlined in the instructions in the virtual world.

After the virtual environment experience you will complete a questionnaire.

Finally there will be a short discussion with the experimenters about your experience in the experiment. This interview may be audio recorded.

You will be provided with compensation for your participation.

Because this study is ongoing, please do not discuss it with others for about three months.

Thank you for your participation.

Note:

A decision to withdraw at any time, or decision not to take part, will not affect the standard of care you receive.

You may withdraw your data from the project at any time up until it is transcribed for use in the final report on the 9th September 2015.

We will record your name and assign you a participant number. A record matching your name and participant number will be made on a piece of paper separate from all other data collection means. The reason for keeping this record is so that we can facilitate removal of your data from the project as stated above. This record will be destroyed by shredding the relevant paper on or shortly after 10th September 2015, so that only anonymous data records are retained. This anonymous data is that data that we are asking your permission to retain for writing reports and for future research projects.
If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form.

It is up to you to decide whether or not to take part. If you choose not to participate, you won't incur any penalties or lose any benefits to which you might have been entitled. However, if you do decide to take part, you will be given this information sheet to keep and asked to sign a consent form. Even after agreeing to take part, you can still withdraw at any time and without giving a reason.

**All data will be collected and stored in accordance with the Data Protection Act 1998.**
Appendix II – Participant Consent Form

Informed Consent Form

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Project: Investigating the Impact of Virtual Actors in Priming on Presence in Virtual Reality

This study has been approved by the UCL Interaction Centre Department’s Ethics Chair (Project ID Number): UCLIC/1415/014/MSc Steed/Lam

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the project to you.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you to decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.
Participant’s Statement

I

have read the notes written above and the Information Sheet, and understand what
the study involves.

understand that if I decide at any time that I no longer wish to take part in this
project, I can notify the researchers involved and withdraw immediately.

consent to the processing of my personal information for the purposes of this
research study.

understand that such information will be treated as strictly confidential and
handled in accordance with the provisions of the Data Protection Act 1998.

agree that the research project named above has been explained to me to my
satisfaction and I agree to take part in this study.

understand that the information I have submitted will be published as a report and
I may request a copy. Confidentiality and anonymity will be maintained and it
will not be possible to identify me from any publications.

agree that my non-personal research data may be used by others for future
research. I am assured that the confidentiality of my personal data will be upheld
through the removal of identifiers.

understand that my participation may be taped/video recorded, and I am aware of,
and consent to, any use you intend to make of the recordings after the end of the
project.
understand that I must not take part if I have a history of epilepsy due to safety risks

Signed: Date:

Investigator’s Statement

I ,

confirm that I have carefully explained the purpose of the study to the participant and outlined any reasonable foreseeable risks or benefits (where applicable)

Signed: Date:
Appendix III – Pre-Experiment Questionnaire

1. Participant Number
2. What is your age?
3. Gender
4. How many hours do you play computer, video or mobile games in a typical week?
5. Have you experienced immersive virtual reality before?
6. How much is the following symptom affecting you right now? General Discomfort
   None  Slight  Moderate  Severe
7. How much is the following symptom affecting you right now? Fatigue
   None  Slight  Moderate  Severe
8. How much is the following symptom affecting you right now? Headache
   None  Slight  Moderate  Severe
9. How much is the following symptom affecting you right now? Eyestrain?
   None  Slight  Moderate  Severe
10. How much is the following symptom affecting you right now? Difficulty Focusing
    None  Slight  Moderate  Severe
11. How much is the following symptom affecting you right now? Salivation Increasing
    None  Slight  Moderate  Severe
12. How much is the following symptom affecting you **right now**? Sweating
   None  Slight  Moderate  Severe

13. How much is the following symptom affecting you **right now**? Nausea
   None  Slight  Moderate  Severe

14. How much is the following symptom affecting you **right now**? Difficulty Concentrating
   None  Slight  Moderate  Severe

15. How much is the following symptom affecting you **right now**? Fullness of the Head
   None  Slight  Moderate  Severe

16. How much is the following symptom affecting you **right now**? Blurred Vision
   None  Slight  Moderate  Severe

17. How much is the following symptom affecting you **right now**? Dizziness with Eyes Open
   None  Slight  Moderate  Severe

18. How much is the following symptom affecting you **right now**? Dizziness with Eyes Closed
   None  Slight  Moderate  Severe

19. How much is the following symptom affecting you **right now**? Vertigo
   None  Slight  Moderate  Severe
20. How much is the following symptom affecting you **right now**? Stomach Awareness

| None | Slight | Moderate | Severe |

21. How much is the following symptom affecting you **right now**? Burping

| None | Slight | Moderate | Severe |
Appendix IV – Post-Experiment Questionnaire

1. Participant Number

2. How many hazards did you find?

3. How much is the following symptom affecting you right now? General Discomfort
   - None
   - Slight
   - Moderate
   - Severe

4. How much is the following symptom affecting you right now? Fatigue
   - None
   - Slight
   - Moderate
   - Severe

5. How much is the following symptom affecting you right now? Headache
   - None
   - Slight
   - Moderate
   - Severe

6. How much is the following symptom affecting you right now? Eyestrain?
   - None
   - Slight
   - Moderate
   - Severe

7. How much is the following symptom affecting you right now? Difficulty Focusing
   - None
   - Slight
   - Moderate
   - Severe

8. How much is the following symptom affecting you right now? Salivation Increasing
   - None
   - Slight
   - Moderate
   - Severe

9. How much is the following symptom affecting you right now? Sweating
   - None
   - Slight
   - Moderate
   - Severe
10. How much is the following symptom affecting you **right now**? Nausea
   None    Slight    Moderate    Severe

11. How much is the following symptom affecting you **right now**? Difficulty Concentrating
   None    Slight    Moderate    Severe

12. How much is the following symptom affecting you **right now**? Fullness of the Head
   None    Slight    Moderate    Severe

13. How much is the following symptom affecting you **right now**? Blurred Vision
   None    Slight    Moderate    Severe

14. How much is the following symptom affecting you **right now**? Dizziness with Eyes Open
   None    Slight    Moderate    Severe

15. How much is the following symptom affecting you **right now**? Dizziness with Eyes Closed
   None    Slight    Moderate    Severe

16. How much is the following symptom affecting you **right now**? Vertigo
   None    Slight    Moderate    Severe

17. How much is the following symptom affecting you **right now**? Stomach Awareness
   None    Slight    Moderate    Severe
18. How much is the following symptom affecting you **right now**? Burping

None  Slight  Moderate  Severe

19. Please rate your sense of being in the virtual environment, on the following scale from 1 to 7, where 7 represents your normal experience of being in a place.

1  2  3  4  5  6  7

20. To what extent were there times during the experience when the virtual reality became the "reality" for you, and you almost forgot about the "real world" in which the whole experience was really taking place? 1 indicates not all, 7 indicates all the time.

1  2  3  4  5  6  7

21. During the time of the experience, which was strongest on the whole, your sense of being in the site, or of being in the real world? 1 being the virtual world, and 7 being the real world.

1  2  3  4  5  6  7

22. Consider your memory of being in the virtual world. How similar in terms of the structure of the memory is this to the structure of the memory of other places you have been today? By ‘structure of the memory’ consider things like the extent to which you have a visual memory, whether that memory is in colour, the extent to which the memory seems vivid or realistic, its size, location in your imagination, the extent to which it is panoramic in your imagination, and other such structural elements. 1 indicates not at all similar to other places I’ve been today, and 7 indicates a similar way to other places that I’ve been today.

1  2  3  4  5  6  7
23. When you think back about your experience, do you think of the virtual world more as images that you saw, or more as somewhere that you visited? 1 indicates images that you saw, 7 indicates somewhere that you visited.

\[ 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \]

24. During the time of the experience, did you often think to yourself that you were actually just standing in a room wearing a helmet or did the virtual reality overwhelm you? 1 = Standing in a room, 7 = Immersed

\[ 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \]

25. For each of the following areas of the virtual experience, please rate your sense of actually being in the environment (7 being the most)

a. Virtual Lab

\[ 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \]

b. Ledge directly outside the lab entrance

\[ 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \]

c. Near the Fire Door Inspection Area (next to the ramp)

\[ 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \]

d. At the pit (where the plank is)

\[ 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \]

26. To what extent did you feel as if the events in the virtual world were actually happening to you? 1 being not at all, 7 being very much
27. Did the task feel like a real task that you had been assigned and needed to complete or just a task you were performing for this experiment? 7 being feeling like a real task

28. Think back to the beginning of the experiment when you were given instructions. How much did it feel as if they were part of the virtual or physical world? 1 being physical world, 7 being virtual world

29. To what extent do you believe that the method of introducing you to virtual reality (through the instructions) helped to situate yourself in the virtual world? 1 being not at all, 7 being really helped

30. When communicating with the instructor, did it help or hinder your feeling of being in the virtual world? 1 being hindered, 7 being helped

31. How strong was the feeling that you were being watched during the experiment? 1 being not at all, 7 being very much.

32. How much were you aware of the presence of the experimenter during the experiment? 1 being not at all, 7 being very much.
33. How much did it feel like the experimenter was part of the virtual world? 1 being not at all, 7 being completely
### Appendix V – Summary Results Tables for Main Presence Questionnaire

#### ANOVA

<table>
<thead>
<tr>
<th>Question</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PQ1</strong></td>
<td>Between Groups</td>
<td>17.120</td>
<td>2</td>
<td>8.560</td>
<td>7.956</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>33.351</td>
<td>31</td>
<td>1.076</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50.471</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PQ2</strong></td>
<td>Between Groups</td>
<td>19.149</td>
<td>2</td>
<td>9.575</td>
<td>5.154</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>57.586</td>
<td>31</td>
<td>1.858</td>
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<td></td>
<td>Total</td>
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<td></td>
<td></td>
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<tr>
<td><strong>PQ3</strong></td>
<td>Between Groups</td>
<td>4.803</td>
<td>2</td>
<td>2.402</td>
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<tr>
<td></td>
<td>Within Groups</td>
<td>70.638</td>
<td>31</td>
<td>2.279</td>
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</tr>
<tr>
<td></td>
<td>Total</td>
<td>75.441</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PQ4</strong></td>
<td>Between Groups</td>
<td>9.060</td>
<td>2</td>
<td>4.530</td>
<td>1.681</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>83.558</td>
<td>31</td>
<td>2.695</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>92.618</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PQ5</strong></td>
<td>Between Groups</td>
<td>12.165</td>
<td>2</td>
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<td>1.871</td>
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<tr>
<td></td>
<td>Within Groups</td>
<td>100.806</td>
<td>31</td>
<td>3.252</td>
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<tr>
<td></td>
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<tr>
<td><strong>PQ6</strong></td>
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<td>6.010</td>
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<tr>
<td></td>
<td>Within Groups</td>
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<td>2.846</td>
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<tr>
<td></td>
<td>Total</td>
<td>100.235</td>
<td>33</td>
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</tbody>
</table>
### Multiple Comparisons

Dependent Variable: Please rate your sense of being in the virtual environment, on the following scale from 1 to 7, where 7 represents your normal experience of being in a place.

Tukey HSD

<table>
<thead>
<tr>
<th>(I) Group</th>
<th>(J) Group</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Avatar</td>
<td>.673</td>
<td>.453</td>
<td>.312</td>
<td>- .44 - 1.79</td>
</tr>
<tr>
<td>Watching</td>
<td>Avatar</td>
<td>-1.035</td>
<td>.425</td>
<td>.053</td>
<td>-2.08 - .01</td>
</tr>
<tr>
<td>Avatar</td>
<td>Control</td>
<td>-.673</td>
<td>.453</td>
<td>.312</td>
<td>-1.79 - .44</td>
</tr>
<tr>
<td>Watching</td>
<td>Control</td>
<td>-1.708*</td>
<td>.436</td>
<td>.001</td>
<td>-2.78 - -.63</td>
</tr>
<tr>
<td>Watching</td>
<td>Avatar</td>
<td>1.035</td>
<td>.425</td>
<td>.053</td>
<td>-.01 - 2.08</td>
</tr>
<tr>
<td>Avatar</td>
<td>Control</td>
<td>1.708*</td>
<td>.436</td>
<td>.001</td>
<td>.63 - 2.78</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.
Multiple Comparisons

Dependent Variable: To what extent were there times during the experience when the virtual reality became the "reality" for you, and you almost forgot about the "real world" in which the whole experience was really taking place? 1 indicates not all, 7 indicates all the time.

Tukey HSD

<table>
<thead>
<tr>
<th>(I) Group</th>
<th>(J) Group</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>Control</td>
<td>Avatar</td>
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<td>.596</td>
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<tr>
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<td>.573</td>
<td>.009</td>
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<td>Watching</td>
<td>Control</td>
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<td>.558</td>
<td>.620</td>
<td>-.85</td>
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<td>Avatar</td>
<td></td>
<td>1.815*</td>
<td>.573</td>
<td>.009</td>
<td>-.40</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.