# Confrontational Behaviour in Virtual Reality: a study of user response.

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# Abstract

The following thesis presents a method to compare the affective response of participants in two conditions, virtual reality (VR) and 2D display, to a confrontational avatar in a virtual betting shop. This thesis is motivated by workers in betting shops who regularly face confrontational customers, with the aim of recommending VR technology as a medium to facilitate experiential training for these workers.

A two condition, between-subjects study was conducted measuring change of state anxiety and sense of presence recorded using self-report questionnaires. The results of this study conclude that participants in the VR condition experience a greater sense of presence over participants in the 2D display condition, in all four sub-scales of the ITC-SOPI. The study also concludes that participants in both conditions experience a significant increased sense of state anxiety recorded with the State-Trait Anxiety Inventory after exposure to the confrontational avatar, with participants in the VR condition experiencing a larger increase in state anxiety than participants in the 2D condition. This study demonstrates the feasibility of VR as a potential training solution for workers of betting shops in dealing with confrontational customers.

To accommodate the study, an application was designed and produced to work on both VR and 2D display technologies with a focus on ensuring the virtual environment and confrontational avatar was as believable as possible. An inter-disciplinary team was brought together to produce the confrontational avatar using motion capture technology. The result of the inter-disciplinary workflow is a produced avatar that was successful in producing an affective response in participants in both conditions. To finalise the production of the application, a method to ensure the avatar appeared at a normalised distance from the participants in both conditions is proposed of which has not been explored previously.

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# Chapter 1

# Introduction

## 1.1 Motivation

Virtual reality technology has many uses in society today, from entertainment purposes to education. Researchers in the past have shown that virtual reality can be used to train individuals in specific professions; from public sector roles such as law enforcement and emergency responders as demonstrated by Carlson and Caporusso (see Carlson and Caporusso, 2018) to private sector positions such as mining employees as investigated by Van Wyk and De Villiers (see Van Wyk and De Villiers, 2009). These studies have demonstrated how virtual reality and virtual environments are feasible being used to facilitate training for difficult scenarios that may be hard to train for in the real world, due to factors such as logistics and financial implications.

Research has shown that virtual avatars have the ability to elicit affective response in participants, similar to how individuals react to other people in the real world. This allows for the use of virtual reality to accommodate activities such as exposure therapy, as demonstrated by Anderson et. al who investigates the use of virtual reality to assist individuals with overcoming the public speaking social anxiety disorder (see Anderson et al., 2013). This ability by virtual reality to allow avatars to invoke affective response in participants has led to studies that investigate participant response to difficult social scenarios, as demonstrated by Bosse et al who investigate participants response to an avatar who has a negative attitude towards the participant, and acts aggressive towards the user. (see Bosse, Hartmann et al., 2018).

Virtual reality has been demonstrated to be effective at training individuals in specific professions, and capable of invoking affective response in participants via virtual avatars. This demonstrates the potential of virtual reality to facilitate training for employees of professions where there is regular exposure to difficult social scenarios such as confrontational or aggressive customers, as experienced by workers in the Gambling Industry.

## 1.2 Context

In the United Kingdom, Gambling is very prevalent in everyday life. The Gambling Commission, that was set up under the Gambling Act 2005 and was introduced in Great Britain to "regulate commercial gambling", stated in an annual report released in February 2019 that according to a survey conducted by the Gambling Commission, 46 per cent of adults (16+) have declared that they have "participated in one form of gambling in the previous four weeks". The Gambling Commission states that the most popular method of gambling in Great Britain in 2018 was the National Lottery (28 per cent), followed by scratch cards and other lotteries (11 per cent each). A less popular form of gambling, where 1.5 per cent of respondents to the survey have participated in, is playing on machines (also known as Fixed-odds betting terminals, or FOBTs) in betting shops. (Gambling Commission, 2019). This involves players interacting with these FOBTs in a physical location, using money to use to play for the chance to win games and in term, money back. According to Parke and Griffiths, Gambling is known to have "many negative effects on individuals, their significant others and, more indirectly, on society as a whole". One of the consequences of Gambling as observed by Parke and Griffiths in an observational study of 303 slot machine players, observed over four six-hour observation periods in an amusement arcade in the United Kingdom, is aggressive behaviour. More specifically, Parke and Griffiths categorise the aggressive behaviours witnessed into four categories of which are following: 1) verbal aggression towards the gambling arcade staff, 2) verbal aggression towards the slot machine, 3) verbal aggression towards other slot machine players and 4) physical aggression towards the slot machines. (Parke and M. Griffiths, 2004). It is further stated by Parkes and Griffiths in a later paper, that the observed verbal aggression towards the staff members "appeared to be caused by a misinterpretation of staff reactions towards incurred losses", suggesting that staff member's reactions to confrontational behaviour by customers can cause further escalations, highlighting the requirement to ensure correct training is provided to staff of betting shops. (Parke and M. Griffiths, 2005). Additionally, the authors conclude in another paper that "aggression was prevalent in the UK gambling arcade environment with an average of seven aggression incidents per hour". (Parke and M. D. Griffiths, 2005).

Tragically, there are cases when the physical aggression is directed towards the member of staff in the betting shop, resulting in physical assaults. The dangers of the lone-working policies imposed by some gambling companies were highlighted in 2017 in the United Kingdom, in a question to Parliament, where the Secretary of State and Health and Safety Executive was queried on whether or not "an assessment has been made by the Health and Safety Executive of the safety lone working in betting shops". Although the Government responded with an answer suggesting limited or no knowledge of assaults towards lone-workers, stating "HSE does not hold information on the proportion of Association of British Bookmakers member betting shops which have been deemed unsafe for single manning, nor has an assessment been made of the safety of lone staff working in betting shops", (Parliament, 2017), national press have acknowledged the dangers that lone-workers in betting shops face, in releases such as The Guardian's article titled "The big gamble: the dangerous world of British betting shops", of which discusses the murder of lone-worker Andrew Iacovou by an assailant who took advantage of the limited number of staff to commit robbery; the murder, an unfortunate consequence of the theft. (Lamont, 2016).

The acts of aggression observed by Parke and Griffiths in their observational study are committed by individuals known as problem gamblers. A problem gambler refers to an individual who's "gambling activity gives rise to harm to the individual player, and/or his or her family, and may extend into the community". (Dickerson et al., 1997). It is often that the acts of aggression towards members of staff in betting shops are committed by problem gamblers. With the risk to lone-working staff of aggression from problem gamblers aimed towards them, it is important that an effective method of training is provided for the staff of betting shops.

Is the current method of training an effective way of training staff how to deal with confrontational customers? Is there a better way to help staff at betting shops with dealing with confrontational customers through experiential training? This research aims to start investigating the feasibility of using virtual reality as a facilitator for experiential training regarding the safest and most effective way to help teach lone-workers of betting shops how to effectively deal with confrontational customers, by investigating affective response to a confrontational avatar in a virtual environment.

## 1.3 Research Questions

This thesis aims to answer the following research questions:

- Do users experience a more intense affective response to confrontational behaviour in VR, as compared to a 2D display?
- Do users experience an increased sense of presence, when engaged in such experiences in VR, as compared to a 2D display?

## 1.4 Objectives

In order to satisfy the requirements of this study, the thesis aims to complete the following objectives:

- Investigate related studies and review concepts important to this study, such as presence and affective response;
- Using the review of related work, propose a methodology to investigate whether virtual reality elicits a greater affective response compared to a 2D display, and if virtual reality elicits an increased sense of presence compared to a 2D display;
- Build an application that can be run on both virtual reality and a 2D display, with a heavy focus on ensuring the avatar and virtual environment is as believable as possible;

- Conduct an experiment that investigates the research questions; and
- Analyse, discuss and conclude results from the experiment.

## 1.5 Thesis Structure

This thesis structure is as following:

- Chapter 2 investigates previous related work, and focuses on virtual reality, affective response (more specifically response to aggressive and threatening stimuli), experiential training and exposure therapy with virtual reality.
- Chapter 3 presents the methodology to investigate the research questions; discussion of what measures are used and how they are measured are included in this chapter.
- Chapter 4 discusses the development of the application that will be used for the study. Each aspect of the development is discussed in detail explaining the thought and decision processes involved to result in the production of the application.
- Chapter 5 introduces the study design and presents the method of which data is collected in this study. An experimental methodology is proposed with details on the procedure and equipment used included.
- Chapter 6 presents the results of the study. In this chapter, a discussion is presented where different aspects of the experiment and it's results are discussed.
- Chapter 7 concludes the outcomes of the study, and proposes a technology medium which would be suited as a training solution for betting shop workers.

## 1.6 Contributions

This thesis aims to contribute to the field of training with the use of virtual reality, as well as the area of investigating emotional response using virtual reality as a medium for emotion producing stimuli such as demonstrated in existing virtual reality exposure therapy studies. The purpose of this study is to investigate the feasibility of the use of virtual reality as a medium to elicit anxiety responses to confrontational avatars in a betting shop setting, and comparing the invoked anxiety responses to that of a 2D display in order to ascertain which technology is better suited for use in potential future development of a training application for betting shop employees with a focus on assisting with confrontational customers situations and how to effectively de-escalate these situations.

The conclusions of this study indicate that scenarios that are designed to elicit affective responses from participants (such as that of a confrontational avatar) would better benefit from being displayed using virtual reality technology over a traditional 2D set-up. This finding could contribute to any study investigating participant response to anxiety inducing stimuli, where researchers are yet to determine the medium of technology to use to facilitate the study. Virtual reality demonstrates a greater ability to invoke affective responses from participants, as well as providing betting shop employers the ability to train their employees without the financial and logistical issues with real world training identified in the literature review.

The virtual reality application produced can be used as a basis in the production of a virtual reality training application for betting shop employees, demonstrating a method of which to create a realistic environment and confrontational avatar that has the potential to be used to expose betting shop employees to scenarios featuring confrontational customers and elicit emotional responses. This exposure to these virtual confrontational customers allows for the potential of the employees to train effective de-escalation methods, whilst experiencing realistic emotional responses in a safe environment. Further concepts such as pedagogy will need to be researched and incorporated into the final training application to ensure that the application is successful at imparting information onto it's users.

The produced application demonstrates good practice in the process of creating a realistic confrontational avatar in an emotionally engaging scene. An iterative process was undertaken with consistent feedback from an inter-disciplinary team, each with a specific expertise required for the production of an avatar bespoke to this specific study. This practice of producing the realistic confrontational avatar could benefit other researchers who are investigating user response to human avatars in virtual environments.

This thesis further contributes to the research community, particularly research projects comparing virtual reality to 2D displays. This thesis proposes a method of which normalises avatar's appearance and distance between the two technology mediums of which has not been completed in previous research studies. This method of normalisation could benefit other research projects that are investigating user response to an avatar, object, animal or scenario (as examples) and comparing them between virtual reality and 2D technology mediums. Ensuring that an avatar, object, animal or scenario appears at an equal distance in two conditions is important to prevent a potential confounding effect taking place.

# Chapter 2

# Related Work

The aim of this chapter is to investigate related studies to this thesis and identify similar methodologies used to measure participants anxiety responses to anxiety inducing stimuli. This literature review also aims to investigate the concepts used in this study, such as presence and the human response to anxiety as these topics are essential for producing the application which will be used in the study. The completion of the literature review will help the researchers learn the core concepts of human response to aggressive behaviour, the use of virtual reality in exposing participants to anxiety inducing stimuli and what issues researchers face in similar studies, the importance of ensuring a virtual reality application maintains a level of presence, and how virtual reality can be used as a method for training. This review is conducted to satisfy the objective stated in Section 1.3 to investigate related studies and review concepts important to this study of which will help guide the researcher in developing a methodology to investigate participant's responses to confrontational avatars in virtual reality.

The literature review first starts by defining virtual reality, and how it works before explaining the concept of presence. The review then continues onto discussing emotional response, more specifically anxiety and the fight or flight response and how existing studies have successfully invoked anxiety in virtual reality. The review next introduces virtual reality exposure therapy and demonstrates how virtual reality has been used in previous studies to assist with user's healing process to certain phobias. Next, the review discusses the feasibility of using virtual reality as a training tool and specifies existing studies that have investigated how virtual reality can be used in specific professions to train employees. Finally, the review is concluded where the key findings of the literature review are presented and motivations for the study are identified.

## 2.1 Virtual Reality.

Virtual reality (VR) is one of the most recent technologies used as a medium to impart experiences and ideas onto individuals. A recent method of communication with a range of features that allows it to be used for a number of purposes; from entertainment to education and training, virtual reality allows individuals to be placed into a virtual world that can be experienced in a specified way designed by developers. Virtual reality is described as an 'interface paradigm' that makes use of computers and human-computer interfaces to "create the effect of a three-dimensional world in which the user interacts directly with virtual objects" (Bryson, 1996). Virtual reality makes use of computer graphics, sounds and images to introduce a user to a virtual environment replicated from the real world. (Franchi, 1995). Virtual reality can also be used for entertainment purposes as discussed by Morie who provides examples of early virtual reality projects that investigated the use of virtual reality to provide participants with "emotional-based experience[s]". (Morie, 1994).

Virtual reality which make use of headsets, simulate binocular vision by either including two separate monitors with slightly different images for each eye, or by making use of one monitor separated into two images that are slightly different for each eye. These headsets are known as head-mounted displays (HMDs) and make use of head-tracking to make the virtual environment appear on the monitors as it would do if it was real life; as per how the user moves and perceives the environment. For example, if the user looks up, the head-tracking ensures that the view in the monitor[s] show the environment as if a person in that virtual environment is looking up. Users can still be immersed into a virtual environment without the use of a head-mounted display, such as demonstrated with the use of Cave Automatic Virtual Environments (CAVE) technology of which use a "rear projection" technique to display images of the virtual environment onto the walls, floor and ceiling of a room. This method provides the user with a greater field of view to help with immersion into the virtual environment. (Strickland, 2007).

This section introduces virtual reality and the technicalities involved to allow it to function as well as introduces the potential experiences the technology has to offer; Virtual reality offers the potential to impart a variety of experiences onto users, and can be used for a multitude of purposes, from entertainment to more practical purposes such as training and to assist with the overcoming of specific phobias by exposure therapy. These will be discussed in more detail over the next sections of this literature review.

## 2.2 Presence and Related Concepts.

Presence is an important concept relevant to the creation of virtual environments, and has had a number of different definitions applied to it. In Slater's work titled 'A note on Presence Terminology', it is suggested that there is a "significant confusion surrounding the notion of 'presence in virtual environments'". (Slater, 2003). To prevent confusion, the definition of presence that will be used in this study is one by Slater et al. of whom define presence as "the psychological sense of 'being there' in the environment". (Slater, Usoh and Steed, 1995). Skarbez et al. describes presence as having the advantage of being a metric that can be applied to all virtual environments, meaning that a user can be asked how subjectively they felt they were present in one virtual environment and then asked how present they felt in another virtual environment with a completely different environment or scenario, and a comparison can be made based on the subjective feedback of the user. (Skarbez, Brooks and Whitton, 2017). Skarbez et al. continue to discuss presence and similar concepts in the paper titled 'A survey of Presence and Related concepts', such as copresence and social presence. This review of presence and concepts related to presence forms a basis of the presence concepts that are used in this study.

Copresence is defined "as the sense of being together with another or others" and social presence is defined as "the moment-by-moment awareness of the copresense of another sentient being accompanied by a sense of engagement with them". It is further stated by Skarbez et al. that to experience copresence, one must only be aware that another being exists in a space, where as to experience social presence, "some degree of interaction" must occur with the other being(s) that affects one's behaviour and psychological state. (see Skarbez, Brooks and Whitton, 2017). In a paper written by Jo et al. of which compares virtual reality to augmented reality in it's ability to elicit the feeling of co-presence, it was hypothesised in the context of video-conferencing that ensuring the virtual avatar was "behaviourally faithful" would help to elicit the feeling of co-presence. (Jo, K.-H. Kim and G. J. Kim, 2016). As the motivation for this study is based on aggression in betting shops, it is important that the virtual character produced is able to elicit the sense of copresence in the user who is exposed to said character and so a primary focus of the development will be to ensure that the virtual character produced will appear and behave as realistic as possible.

Continuing on to immersion, another concept related to presence of which is described by Slater et al. as simply relating to what the technology can deliver. Slater et al. defines immersion as an "objective description of what any particular system does provide", further stating that immersion is dependent on how much the system used to show a virtual environment has displays that are "extensive, surrounding, inclusive, vivid and matching"; where a display that is more 'extensive' refers to one that "accommodates" more sensory systems, a display that is more 'surrounding' refers to one that provides stimuli to a user's sensory organs from "any (virtual) direction", a display that is more inclusive is more effective of "shutting-out" real world sensory data, a display that has a greater amount of 'vividness' refers to one with higher quality and resolution and a display that is 'matching' is one that ensures a match between the user's proprioception feedback and what is displayed on the display. (Slater, Linakis et al., 1996). Modern virtual reality technology is an example of a display that is objectively more immersive, with features such as high field of views (FOV) from displays build into headsets that are effective at 'shutting-out' the real world, higher resolutions of these displays of which are connected to powerful computers that have the capability to process graphics which are much higher quality. Other features of VR include effective software that handle sensory data such as sound, where the example of spatial audio is often found used in modern VR applications; allowing for sound to feel like it is coming from the direction it is produced in the virtual world. For example, imagine a user standing in a virtual concert hall. This user is facing the opposite direction of the stage, where one virtual character is playing the piano. Spatial audio will facilitate making the sound appear to the user that it is travelling to them from behind. And if the user turns towards the stage, the sound will alternate to appear as if the sound is travelling from directly in front. Spatial audio contributes to a display that is considered more 'surrounding' and therefore improves the immersion associated with the device that facilitates it. Immersion facilitates presence, where Slater presents the statement that "Immersion provides the boundaries within which [presence] can occur". (Slater, 2009). A technological system that includes all the features mentioned previously (extensive, surrounding, inclusive, vivid and matching) will be one that is objectively immersive and will help to provide the conditions for the feeling of being there, in a virtual environment, to occur.

The next concept to be discussed is fidelity. For a virtual reality application that has an intended use for training purposes (such as experiential training, of which will be discussed in Section 2.5), fidelity and the realism of an application is important. Fidelity is defined as "the extent to which the virtual environment emulates the real world" by Alexander et al., where the software and hardware used contribute to how real a scenario feels to a user. (Alexander et al., 2005). The fidelity of an application presented to a user can be altered by a range of determinants, such as display fidelity, of which is defined as "the objective degree of exactness with which real-world sensory stimuli are reproduced" by McMahan et al., and identical to Slater's immersion definition referring to the technical capabilities of the system that runs the application. (McMahan et al., 2012). A system with a higher level of display fidelity will better represent the real world, and will help to provide the conditions of which a user feels as if they are in a virtual environment. Physical fidelity also helps to contribute to the increased feeling of realism, where physical fidelity is defined as "the degree to which the physical simulation looks, sounds, and feels like the operational environment in terms of the visual displays, controls, and audio as well as the physics models driving each of these variables". (See Alexander et al., 2005.) Physical fidelity refers to how real the visual, audio and control factors feel to the user, and is different to display fidelity; an application running on a modern VR HMD system with a high field of view, high refresh rate, spatial audio etc. (deemed objectively immersive with high display fidelity) but has low quality and unrealistic graphics (such as a human model with low polygons and therefore appears 'square', similar to that of human models in early 1990's games), low quality audio (with low sampling rate and bit rate), unrealistic physics animations etc. would be deemed an application with low physical fidelity.

An application with a high level of display and physical fidelity will contribute to a sense of presence, and an increased feeling of Place Illusion (PI) and Plausibility Illusion (Psi). Slater defines Place Illusion as "the type of presence" that refers to the "strong illusion of being in a place in spite of the sure knowledge that you are not there". PI is reliant on immersion, where Slater states "immersion provides the boundaries within which PI can occur", of which makes sense; a system considered having low immersion will have an increased chance of a break in PI as there will be more opportunities for a user of the system to identify aspects (for example low resolution, that will make the environment look more 'blurry') of an application that do not replicate being in a real environment. (Slater, 2009). Having an environment that looks realistic is important to maintain presence, but as Skarbez et al. explains the environment should feel real as well; Skarbez et al. uses a library virtual environment as an example, and state that the feeling of presence would be attendant if the user feels like they are in a real library. PI would be "reinforced" if the user looks around and sees more bookshelves and other furniture associated with a library, but if the patrons of the library were observed to be shouting at each other and acting in a way not expected of that in a library, this would break Plausibility Illusion. (See Skarbez, Brooks and Whitton, 2017). Plausibility Illusion (Psi) is defined by Slater as the "illusion that what is apparently happening is really happening (even though you know for sure that it is not)". A virtual environment featuring a high level of Psi is one that will cause the user to react to the virtual scenario automatically and will include events that change as per what the user does. (See Slater, 2009). On the other hand, building an application that has a limited feeling of plausibility illusion risks participants questioning the "credibility" of the scenario as demonstrated in the study by Slater et. al of which is related to this study in it's goal of investigating participant's response to a violent incident in a virtual environment. (Slater, Rovira et al., 2013).

Presence is a huge field to look into and understand fully, with numerous concepts and definitions from a wide range of researchers. As stated previously, the overall definition of presence that the researcher will abide to in this study is "the psychological sense of 'being there' in the environment" (see Slater, Usoh and Steed, 1995). The review of literature in this section helped the researcher to better understand the thoughts and considerations required whilst developing a virtual reality application, to better ensure that a feeling of 'being there' is invoked. It is the researchers goal to consider all the concepts of presence discussed throughout the design process of the study; with the knowledge that a high level of presence will encourage a user of a virtual environment to feel as if they are a part of the environment and that they are "there", encouraging the psychological and emotional responses that are to be investigated.

## 2.3 Emotional Response.

Emotional response is an important factor in this study, as the motivation of this study regards betting shop staff who have to face confrontational and aggressive customers whilst working their roles. First, it is important to define aggression. Aggression is defined by Baron and Richardson as "any form of behaviour directed toward the goal of harming or injuring another living being who is motivated to avoid such treatment" (Baron and Richardson, 1994). If a customer is acting aggressive towards a shop worker, it will invoke the fight or flight response of which can be "conceptualized as a behavior that emerges from the emotional and cognitive appraisal of a threatening stimulus". (Kunimatsu and Marsee, 2012). The fight or flight response is a physiological response to threatening situations and causes the activation of the adrenal glands and the sympathetic nervous system. (Goldstein, 2010). The fight or flight response is also said to be a response to stress by Dhabhar and McEwen who define stress as "a constellation of events, which begins with a stimulus (stressor), which precipitates a reaction in the brain (stress perception), which subsequently results in the activation of certain physiologic systems in the body (stress response)". (Dhabhar and Mcewen, 1997). In the case of a Betting Shop, the aggressive customer will act as the stressor, and physiological response to the aggressor (the fight or flight response) is the stress response.

The use of virtual reality to elicit emotional responses to stimuli has been investigated over the recent years, with studies looking into the potential use of virtual reality to assist with the treatment of phobias and other disorders. This will be discussed in Section 2.4 in more detail. Firstly, a recent study conducted by Ding et al. in 2018 compares VR technology to traditional 2D displays in their ability to invoke emotional response through digital film media. The researchers of this project expose two groups to the same clips from Disney's 'A Jungle Book', with one group viewing the clips in VR and the other viewing the clips traditionally on a 2D screen. Both groups have physiological sensors attached and are asked to fill out the PANAS self report scale before and after the experiment. The results of the experiment conclude that participants in the VR condition did have a greater subjective emotional effect as compared to participants in the 2D condition. The results from the physiological sensors also concluded that participants in the VR condition experienced a stronger emotional effect. (Ding, Zhou and Fung, 2018). This study demonstrates how virtual reality has the ability to invoke a greater emotional response in participants as compared to traditional 2D displays in the context of films and standard digital media. But will VR invoke a greater emotional response as compared to a 2D display when immersing participants into a virtual environment and exposing them to a confrontational character?

Next, a review by Diemer et al. discusses the importance of perception and presence on emotional reactions in virtual reality settings, especially when used to research emotional experiences and behaviours to stimuli and specifies how vitally essential the virtual reality scenario "can actually induce emotional reactions". The review looks at different aspects of emotional response and the effect presence has on emotion in virtual reality. Diemer et al. suggest that a VR scenario that elicits emotions will also increase presence felt, as "arousal is a particular strong indicator of emotional involvement" and this emotional involvement "should" lead to higher presence ratings than "calm or serene emotional states". (Diemer et al., 2015). This is backed up by another study by Riva et al. that placed participants in three virtual reality scenarios. Each scenario represented a virtual park with a different theme; one neutral, one anxiety inducing, and one relaxing. The results of this study show that participants in the anxiety inducing and relaxing parks reported a higher sense of presence than the neutral control condition park. (Riva et al., 2007). Diemer et al. and Riva et al. point to the conclusion that participants that are exposed to anxiety inducing stimuli that causes the fight or flight response will also report a higher level of presence felt.

There has been an increase in the use of virtual reality for research in the field of psychology, as it has been argued by Loomis et al. (Loomis, Blascovich and Beall, 1999) that virtual reality has the ability to elicit real world responses and therefore proves a possible solution to the issue of limited ecological validity in laboratory based observational studies due to the issue of not being "generalisable" to the real world as identified by Schmuckler (see Schmuckler, 2001). One study by Rovira et al. argues as motivation for the project that "Immersive virtual reality provides an ecologically valid setting" to investigate what circumstances bystanders are likely to intervene to prevent harm to a victim, as well as removing the danger involved and the ethical issues that would arise from such a study if it was conducted in the real world. The researchers conclude that virtual reality provides the opportunity to carry out laboratory-based controlled studies that have greater ecological validity compared to traditional lab-based studies that as mentioned before risks not being generalisable to the real world. Rovira et al. further comment on the advantages of virtual reality studies such as the ability to easily change stimuli as an example; the researchers comment on the ability to change the appearance of the agent in their study, which opens up another avenue of research. (Rovira et al., 2009).

With virtual reality being shown to be successfully used to investigate user response to different stimuli and providing potentially more ecological valid research conditions, there is evidence that virtual reality can facilitate research into emotional response of aggressive avatars. There has been a number of studies that look into the response of participants to virtual avatars who act aggressively. One study conducted by Blankendaal et al. investigates whether virtual aggressive agents are able to elicit the same level of anxiety from a participant compared to that of a participant that is exposed to the same aggressive situation but by a real human. The results of this study show that the real human condition elicits a larger physiological response (heart rate and electrodermal activity). It must be noted that in this study participants were not placed into a virtual reality environment, but were shown the virtual agent on a 2D monitor. (Blankendaal et al., 2015). The study from Blankendaal et al. shows that virtual avatars are capable of causing the fight or flight response, albeit at a level not similar to that of an individual facing the same stressor in real life. Bosse et al. further researches this area by investigating if virtual aggressors cause stress and physiological responses in a virtual environment. In this study, participants were introduced to a virtual environment (a pub) and half of the participants were informed before hand that they had the potential to be shocked if the agent in the scene became too aggressive. The other half of participants were told the real purpose of the skin conductance sensor attached to them. The results of the study conclude that the aggressive virtual agent in the virtual environment was able to create physiological responses and a self reported feeling of stress and anxiety in both conditions, where the participants who were informed of the risk of shock experienced higher levels of physiological stress than their counterparts. (Bosse, Hartmann et al., 2018). This study shows that avatars in virtual reality who act aggressive towards the participant are able to elicit feelings of stress and anxiety in said participants.

When searching for literature of related work to this study, it was found that there were no studies that investigated the difference of emotional response of aggressive / confrontational virtual avatars comparing between exposure in virtual reality and 2D. Many of the studies found compared two (or more) conditions in virtual reality, or there was a comparison between virtual reality and the real world.

The literature reviewed in this past section provides an introduction to the emotional response humans experience when exposed to aggressive individuals in the real world. As this study aims to investigate the response of participants to an aggressive individual in a virtual environment, the literature read in this section provides the fundamental biological and psychological knowledge required to undertake the study. The literature in this section also demonstrates previous studies that investigate emotional response to stimuli in virtual reality, and how presence as discussed in the previous section is an important factor needing to be considered when producing a virtual reality application for such studies. Furthermore, the research reviewed highlights the benefits of using virtual reality in psychology experiments and how virtual reality has the ability to counter one of the major issues of conducting lab based experiments.

## 2.4 Exposure Therapy with Virtual Reality.

Exposure therapy is an effective method for treatment of phobias and disorders (such as PTSD) and is used with the rationale that exposure to a safe amount of frightening or anxiety inducing stimuli in a continuous method can eventually reduce the anxiety felt until the anxiety diminishes. (Rothbaum and Schwartz, 2002). Since the introduction of virtual reality technology, studies into the use of VR technology for exposure therapy have been conducted with results suggest that virtual reality exposure therapy (VRET) is as effective as *in vivo* therapy (therapy where the individual faces the phobia in real life) as suggested by Valmaggia et al. who state in their review of VRET studies that virtual reality exposure therapy has "shown to be more effective than treatment as usual or waiting list control" and "has similar results as conventional CBT and or *in vivo* exposure". (Valmaggia et al., 2016). VRET studies have been used to investigate the effectiveness of such therapy in many examples of different phobias and conditions. One example is the study conducted by Rothbaum et al. of who compare VRET to standard exposure therapy and wait-list control on the fear of flying. The results from this study show that participants who completed the VRET and standard exposure therapy were "equally effective" in decreasing symptoms of fear of flying and by the number of participants who flew on real planes after the experiment. (Rothbaum, Hodges et al., 2000). Another example is a study by Bouchard et al. that investigates the use of virtual reality exposure therapy on arachnophobia. In this study, participants were asked to meet for five weekly sessions of which the last three sessions were used for gradual exposure therapy using virtual reality technology. The results of this study demonstrate that arachnophobic patients scores of arachnophobia questionnaires "significantly reduced" over the course of the study. (Bouchard et al., 2006). Both of these studies comment on the advantages of using virtual reality as an alternative to *in vivo* exposure therapy. Bouchard et al. mentions that VRET offers the advantage of having a "controllable, adaptable, always available and secure" stimuli. In the example of arachnophobia, this means having the ability to program a spider to behave in a way that the psychologists involved will feel will help with the therapy. The programmed spider will always be available, and can be used with VR equipment when needed as patients seeking help with arachnophobia come forward without the costs / logistics that arise with having real world spiders available for such treatment. The study from Rotbaum et al. also mention the advantages of VRET over traditional exposure therapy regarding costs involved. The researchers comment on the fact that traditional exposure therapy to combat the fear of flying is often expensive and time-consuming, with sessions outside of the therapist's office and the costs involved to organise real world flights. These studies show the advantage of using VRET over traditional therapy, and the potentiality to reduce costs involved during the treatment of the mentioned phobias. Furthermore, a meta-analysis by Parsons and Rizzo concludes that for a range of anxiety disorders, VRET is "relatively effective from a psychotherapeutic standpoint in carefully selected patients" at reducing the symptoms of phobias and anxiety. (Parsons and Rizzo, 2008). These studies demonstrate the advantages of using virtual reality as a facilitator for exposure therapy.

There has been little research related to the use of virtual reality as a tool for exposure therapy to aggressive or confrontational individuals, but virtual reality has been used to investigate it's capability as a facilitator for exposure therapy to assist with social anxiety disorder. A study conducted by Anderson et al. compares the use of virtual reality with exposure group therapy and wait list (control condition) to assist with social anxiety disorder that is primarily the fear of public speaking. The participants involved with VRET in this study were placed into different virtual environments; a virtual conference room (of around five virtual audience members), a virtual classroom (of around thirty five audience members) and a virtual auditorium (of around one hundred virtual audience members). The therapists involved are stated to be able to manipulate audience reactions and the audience were programmed to ask questions also. The results of the study conducted by Anderson et al. further demonstrate the capability of virtual reality as a medium for exposure therapy, with the results concluding that virtual reality exposure therapy proved effective at reducing public speaking fears from participants diagnosed with social anxiety disorder. (Anderson et al., 2013). The study also highlights the advantages of using virtual reality as a medium for exposure therapy. As mentioned, three virtual environments were produced for this specific exposure therapy, with potentially infinite scalability. As an example, the environment could be altered quite easily to accommodate musicians with social anxiety disorders, who perform to tens of thousands, providing the opportunity to help individuals with social anxiety disorders who have to regularly perform to a large amount of individuals. Virtual reality has the advantage that scenarios can be programmed bespoke to the individual.

The studies discussed in this section demonstrate the ability for virtual reality technology to facilitate exposure therapy; with the advantages mentioned such as the cost and logistical benefits to using virtual reality over traditional *in vivo* therapy sessions. Virtual reality also allows for the simulation of specific scenarios that can not be replicated in the real world. These advantages suggest that virtual reality could be tailored for selected scenarios and individuals, to assist with the overcoming of specific phobias and disorders. With regards to this study, the literature discussed in this section shows the potentiality of the use of virtual reality to facilitate training for individuals on dealing with confrontational customers, where training using virtual reality will be discussed in the next section.

## 2.5 Training with Virtual Reality.

Experiential training builds upon the theory of experiential learning of which is defined by Kolb as "the process whereby knowledge is created through the transformation of experience". (Kolb, 2014). It has been demonstrated in past studies that virtual reality has the potential to be used to facilitate experiential training. One study conducted by Quang Tuan Le et al. investigates the use of mobile VR and AR technologies to assist construction workers with safety training. A prototype was developed by the researchers of whom conclude the proposed framework was "effective in improving access to safety information and transferring safety knowledge". (Le et al., 2015).

The use of virtual reality as a medium to facilitate training has been investigated by researchers conducting studies into whether the technology can contribute to learning in specific fields. One study conducted by Stinson and Bowman investigated the feasibility of using virtual reality to facilitate training athletes for high pressured situations. In this study, participants were placed in a CAVE set-up where one condition was low field of regard (FOR) utilising one screen with a horizontal FOR of 90 degrees, and the alternate condition was high field of regard utilizing four screens resulting in a FOR of 270 degrees. The researchers stated that their goal of the study was to "determine whether or not VR is a suitable platform for treating sport-induced anxiety" of which if proven could be used to help treat sport-induced anxiety in other sporting activities (relating to virtual reality exposure therapy; discussed in Section 2.4) and / or be used for resilience training. The study concludes that participants in the high FOR experienced the most anxiety but the anxiety induced was individualistic. Similarly, as mentioned in Section 2.4, this study demonstrates the capability of using the advantages virtual reality includes for research purposes; it is stated as one of the independent variables that simulation fidelity is to be investigated. In the case of the discussed study, simulation fidelity (SF) referred to conditions of the virtual environment the participants were exposed to. In the LOW SF participants were placed in a training field with limited sounds and characters. In the HIGH SF, participants were placed in a large filled stadium, with more sounds and other features such as a score board visible to indicate to the participant what the score was. This again demonstrates how two conditions are easily produced to be investigated, and in this case, where to replicate the study with identical real world settings would prove to be logistically and financially much more difficult than completing the study with virtual reality. (Stinson and Bowman, 2014).

Other studies have looked into the feasibility of virtual reality as a training tool for difficult scenarios, such as training police officers. Moskaliuk et al. investigate the use of virtual environments to assist training police officers in Germany. The researchers state that police have to regularly deal with situations that are of high complexity, and often involve danger to humans and training for such situations can be difficult and costly depending on the situation. Although this study doesn't make use of virtual reality technology, it concludes that the virtual environment produced was seen as a "valuable tool for the acquisition of knowledge and knowledge-in-use" by the police trainers involved in the study. The participants of the study did disclose that the virtual environment training software did not facilitate the capability to train for the sense of danger. (Moskaliuk, Bertram and Cress, 2013).

Another study by Carlson and Caporusso introduces a virtual reality based physically immersive platform and tests the feasibility of said platform for use in training emergency responders and police officers. In this proof of concept design, participants are placed in a virtual environment with the use of a Head Mounted Display, and are tracked with motion capture equipment. The motion capture tracking drives a simulated virtual character that acts as representation of the participant in the virtual environment. Carlson and Caporusso state that the design of the virtual environment makes use of "scenario scaffolding" of which enables multiple scenarios to be easily created by re-using scenario dynamics and environments and combining them to result in numerous different scenarios for police officers and emergency responders to train in. The system also facilitates multiple users, and 'simunitions' (physical objects that are relevant for training, such as fire extinguishers, that can be tracked by the motion capture equipment and placed in the virtual environment and interacted with by the user). The benefits of this proof of concept system are identified by Carlson and Caporusso include the potential to improve training for police officers and emergency responders in rural locations, allowing these workers to train for scenarios (such as active shooter scenarios) that rural workers could be called in to for assistance, yet do not have the resources to train for such scenarios. Another advantage of the proposed system identified is the "versatility" of the system of which allows the hardware and software to be configured to facilitate training for many different scenarios. (Carlson and Caporusso, 2018).

Furthermore, a study conducted by Bosse et al. of which has a similar goal of this study, to investigate the feasibility of the use of virtual reality to train for de-escalation but in the context of tram conductors. The study states when discussing de-escalation techniques that in order for public service workers to de-escalate an aggressive individual, they first need to "understand the specific type of aggression they are dealing with" as depending on the type of aggression, a different approach to de-escalate the situation will be used. The researchers state that if "dealing with a functional aggressor", the public service worker should invoke a a "directive type" of intervention to demonstrate to the aggressor that "there is a limit to how far he can pursue his aggressive behavior, and making him aware of the consequences of this behavior". If the public service worker is dealing with an "emotional aggressor", the public service worker should demonstrate "more supportive behavior" with examples such as "ignoring the conflict-seeking behavior, making contact with the aggressor and actively listening to what he has to say". (Bosse, Gerritsen et al., 2014). This paper provides a detailed framework on how to implement an adaptive system for a a trainee, and important information regarding correct de-escalation techniques. As the goal of this study is to investigate the feasibility of the use of VR to elicit emotional response to confrontational avatars, the information gained from this study would prove beneficial in future work.

The studies by Moskaliuk et al., Carlson and Caporusso and Bosse et al. demonstrate the feasibility of training in virtual environments with regards to public service workers such as police officers. There are studies that also show the feasibility of virtual reality as a medium for training in the private sector, such as the study conducted by Van Wyk and De Villiers that investigates if virtual reality can be used to train South African mining industry workers, with a specific focus on safety. In this study, a none-immersive computer application was developed to test the feasibility of using virtual environments for training miners with identified aspects of safety such as hazard awareness, pedestrian and driver hazards considering trackless moving machinery and smelting plant hazards. Van Wyk and De Villiers conclude that the none-immersive application produced "improved the safety culture and awareness of the workforce" and that the miners at the South African sites indicated that they preferred this method of training over traditional presentations and videos. The researchers also comment on the potential advantages of implementing a virtual reality version of the produced application; including the financial implications, of which are stated to be low-cost compared to real-life training scenarios. It is also stated as a potential advantage to a virtual reality version would be the ability to produce a wide variety of scenarios, such as mentioned previously with training for emergency service workers. (Van Wyk and De Villiers, 2009).

In conclusion, there has been multiple investigations into the use of virtual reality as a training tool, to facilitate experiential learning where users are provided the opportunity to gain knowledge through experience in virtual environments. Studies have investigated virtual reality as a medium to facilitate training in a range of professions, from public sector workers such as police officers and surgeons to private sector workers such as the South African miners as discussed previously. The studies discussed mention the benefits of using VR as a training tool, such as the financial and logistical advantages of using VR rather than real-world scenario training. Another benefit mentioned was the ability of virtual reality to facilitate training that is hard to replicate in the real world. This benefit relates with the potentiality of training betting shop staff using VR, where training for confrontational customers could be achieved with realistic and believable avatars that are comparable with real life to provide the opportunity for staff to learn how to correctly and safely deal with difficult customers with experiential learning. The research reviewed in this section demonstrates examples of where virtual reality has been used as a tool to facilitate experiential training, helping the researchers to understand the potential benefits and drawbacks of using virtual reality as a training tool for betting shop workers.

## 2.6 Summary.

The literature review conducted has introduced virtual reality as a technology and it's ability to facilitate training and to be used in exposure therapy for specific phobias. The studies discussed show that virtual reality has the capability to invoke affective responses from users who are immersed. Completing the literature review satisfies the objective specified in Section 1.3 to investigate related studies and review concepts that are necessary to understand for the study.

After the introduction of virtual reality, the concept of presence was investigated. The feeling of presence felt by a user in virtual reality can be influenced by a range of different factors, from fidelity of which is the extent a virtual environment is successful in emulating the real world to the technical capabilities of the system used to immerse a user into a virtual environment. The focus on presence and it's related concepts allows the researchers to understand the importance of ensuring the confrontational avatar appears as realistic and life-like as possible, to avoid the problems faced by other researchers in having avatars that do not appear believable (see Slater, Rovira et al., 2013.) The review of presence also demonstrates the importance of the equipment used to immerse a user into a virtual environment, when referring to immersion. This motivates the researcher to ensure the equipment used in the study is objectively as immersive as possible; using a headset that has features such as high level of field of view, high resolution, a headset that is successful in 'shutting out' the real-world and can be connected to a computer that facilitates high quality graphical processing. The concepts of presence and immersion are important in this study, as the researchers need to ensure that the participants are able to feel as if they are "there" in the virtual environment, to help elicit the affective responses (specifically anxiety) that are to be investigated in this study.

Upon completing the review of literature, it was found that the question of whether or not virtual reality is able to invoke affective responses in participants from a virtual avatar acting aggressively was unanswered. This provided the basis of the research questions discussed in the next chapter. The concepts discussed in this literature review also helped guide the development of the application and the study design, both of which are discussed in the chapters ahead.

# Chapter 3

# Research Design

## 3.1 Research Questions

Previous studies discussed in the literature review demonstrate how virtual reality and 2D displays can elicit affective responses from users. The literature review also discusses several studies comparing the real world and virtual reality, but it was found that there are limited studies comparing 2D display technology with virtual reality, specifically when comparing the effect of presence. Considering these points, we propose two research questions:

- *Research Question 1*: Do users experience a more intense affective response to confrontational behaviour in VR, as compared to a 2D display?
- *Research Question 2*: Do users experience an increased sense of presence, when engaged in such experiences in VR, as compared to a 2D display?

## 3.2 Study Overview

As discussed previously, this study is investigating if the use of virtual reality will elicit a more intense affective response (in this study, anxiety that is a result of the activation of the fight or flight response) from a participant when exposed to a confrontational avatar than from 2D technology. A two-condition between-subjects study design will be used, with the conditions being the virtual reality condition and the 2D display condition. The VR condition aims to place a participant into a virtual Betting Shop using a Head Mounted Display (HMD) which will have the capability for the participant to look around, with the hypothesised increased feeling of presence compared to the 2D condition. The 2D condition will involve a participant observing the same scenario in the same virtual environment but observing on a monitor without the ability to look around.

At first, there was a consideration of having a within-subjects design where participants would complete alternating scenarios on both VR and 2D conditions. But after initial discussions it was decided that the within-subjects design would risk participants becoming desensitised to the scenario, even if there was several different stories of a confrontational avatar showing aggressive behaviour. It was then decided that a between-subjects design would be best and would remove the risk of desensitisation, where participants will only complete the study once on one of the conditions. This would also reduce the need to create multiple story lines and produce multiple applications for the experiment, resulting in one scenario that was to be produced for both conditions.

## 3.3 Measures

### 3.3.1 Measuring Anxiety and the State-Trait Anxiety Inventory

The end-goal of the study is to identify whether virtual reality or 2D technology invokes a greater anxiety response to confrontational stimuli present in an application that will be run on both of these technologies, taking into consideration the subjective presence felt on both technologies. When referring to anxiety, the researchers investigate participants change of emotional state anxiety. State anxiety is defined as "how one feels at the moment" by Marteau and Bekker and can be measured with the State-Trait Anxiety Inventory (STAI) produced by Spielberger of which has been described as "one of the most frequently used measures of anxiety in applied psychology research". (Marteau and Bekker, 1992). The self-report questionnaire consists of twenty questions to measure state anxiety, and a further twenty questions to measure trait anxiety. Two versions of the STAI has been produced by

Spielberger, the original in 1970 (Form-X), and the second in 1983 (Form-Y). The version that will be used in this study is Form-Y, with the licence to reproduced acquired from MindGarden.com. (*State-Trait Anxiety Inventory for Adults (STAI-AD) - Assessments, Tests: Mind Garden* n.d.).

There are a number of existing studies that investigate anxiety responses of participants exposed to anxiety-inducing situations with and without the use of virtual reality simulations, of which use the STAI to measure anxiety, such as the study conducted by Villani et al. where the authors investigate whether or not virtual reality has the ability to induce the same anxiety experienced by individuals who are partaking in a job interview in the real world. The authors of this paper state that the rationale behind using the STAI-S (state anxiety sub-scale) is to measure the "transitory emotional states" as well as the fact that the STAI has "good concurrent validity". (Villani et al., 2012). Another study that makes use of the STAI, in a non-VR experimental setting, is conducted by Breivik et al., of which investigates the "similarities and differences of [physiological] activation in expert and novice [parachute] jumpers" and to explore "how personality influenced physiological and psychological reactions during a parachute jump, both in novices and experts". In this study, parachutists were given the STAI questionnaire before take-off, three minutes after take-off and five minutes after landing. As the researchers were investigating personality traits of the participants in this study, the researchers made use of the STAI-T (trait anxiety sub-scale). The results of the study included the fact that the "STAI trait correlates positively with anxiousness, STAI state, and symptoms.", indicating that the STAI is effective at measuring anxiety, and correlates with the physiological reactions expected of an individual exposed to an anxiety inducing stimuli. (Breivik, Roth and Jørgensen, 1998).

State and trait anxiety are described to be influenced by each other, where it is stated by Spielberger that "persons, with high T-Anxiety [trait anxiety] exhibit S-Anxiety [state anxiety] elevations more frequently than low T-Anxiety individuals" as these individuals often interpret more situations and scenarios as "dangerous or life threatening". Spielberger explains that individuals who have a greater level of trait anxiety are more likely to react with "greater increases in the intensity of S-

Anxiety" than individuals who have a lower level of trait anxiety. (Spielberger, 1983). To control for the influence of trait anxiety on state anxiety, the participants were asked to fill out the trait anxiety sub-scale of the STAI before the start of the experiment, along with the state anxiety sub-scale of the STAI, to determine the participant's state anxiety that is to be compared with the participant's state anxiety at the end of the experiment.

The studies discussed demonstrate a wide a varied use of the State-Trait Anxiety Inventory, both in and out of virtual reality experiments, of which contributes to the decision that the STAI is used to measure participant's affective responses to the anxiety-inducing stimuli that is to be presented to them in this experiment. The researcher opted not to use physiological sensors, such as heart rate monitors and skin conductance sensors in this study due to the fact that measuring anxiety with physiological sensors can record 'noisy' data if equipment is not research grade (as demonstrated in the study by Stinson and Bowman, 2014) and the consideration that participants may experience anxiety by knowing that they have equipment attached to them due to the obtrusiveness of some sensors. The use of skin conductivity as a measure was also argued against, due to the fact that it would only benefit the experiment if the participant remained completely still of which is argued to remove one of the fundamental features of using virtual reality; the ability to look around and feel more present. (Ikehara and Crosby, 2005). Furthermore, the use of an ECG to measure heart-rate variability (an indicator of physiological state in a participant) brings challenges due to the requirement for physical contact. It is argued by Kranjec et al. that the process to take measurements using an ECG may be "annoying, unpleasant or even inappropriate for specific groups of patients" and that the awareness a participant has of the monitor can cause a "certain degree of stress and/or anxiety of the subject" (as mentioned previously) which is argued to potentially affect the value of the recorded measures. (Kranjec et al., 2014).

As validated self-report questionnaires are used much more commonly than physiological sensors, and the STAI having being described as the "definitive instrument" by MindGarden.com for measuring anxiety in adults, the researcher concludes the STAI will suffice in measuring anxiety in this experiment.

### 3.3.2 Presence and the ITC - Sense of Presence Inventory

In order to address the second research question, a method of which to measure presence was required. There are numerous self-report questionnaires that can be used to measure presence, as demonstrated in 'A Survey of Presence and Related Concepts' (see Skarbez, Brooks and Whitton, 2017). The researcher opted to use the ITC - Sence of Presence Inventory (ITC-SOPI) produced by Lessiter et al. The ITC-SOPI is a self-report questionnaire with four sub-scales (Sense of Physical Space / Spatial Presence, Engagement, Ecological Validity, and Negative Effects) that focuses on "users' experiences of media" without consideration of the objective system parameters the user is immersed into. (Lessiter et al., 2001). The decision to use the ITC-SOPI self-report questionnaire over other presence self-report questionnaires is due to the ITC-SOPI's focus on cross-media comparison, which makes it well suited to compare a virtual reality experience to a 2D display experience.

The ITC-SOPI has been demonstrated to be effective in other virtual reality studies, such as the study conducted by Villani et al. The researchers state that the ITC-SOPI demonstrates good internal reliability (see Villani et al., 2012). This study by Villani et al. also makes use of the State-Trait Anxiety Inventory, which shows how the method of which we have decided to use for our measures has been conducted in previous published studies. Participants in this study will be provided the ITC-SOPI to complete after the STAI post experiment.

## 3.4 Hypotheses

The following hypotheses are proposed to investigate the research questions with referring to the study design and measures discussed:

- *H1*: Participants will report higher scores on all sub-scales of the ITC-SOPI in the VR condition.
- *H2*: Participants in both groups will experience an increased sense of anxiety after the exposure to the confrontational avatar, evidenced by pre and post experiment state anxiety scores recorded using the STAI.

- *H3*: Participants in the VR group will experience a larger increase in state anxiety, recorded using the STAI, than the 2D display group.

In this chapter, the design of the the study is discussed where it is stated that a two-condition between-subjects study will be conducted to assist with answering both *Research Question 1* and *Research Question 2* and to investigate the three hypotheses stated. Self-report questionnaires will be used to measure anxiety and presence; where the STAI will be used to measure state anxiety pre and post experiment, and the ITC-SOPI will be used to measure presence and provided to the participant post experiment. The next chapter will explain the development of the application and the confrontational avatar that is to presented to the participants in both conditions.

# Chapter 4

# Development

With the experimental design decided, the next stage of the project was to develop the virtual reality and 2D application that was to be used to facilitate the exposure of the participants to a confrontational avatar. This next section discusses the overall process conducted to create the application needed.

## 4.1 Unity Editor and setting the Virtual Scene

The development of the application that was to be presented to the participants, whom were to view a confrontational avatar in virtual reality or standing in front of a 2D monitor, was to be designed and produced using the Unity Engine. The Unity Editor, is stated to feature "multiple tools that enable rapid editing and iteration" in development cycles and includes features such as 'Play Mode', that allows for "quick previews of your work in real-time". (Unity, 2019). Unity, with it's many features including the ability to produce applications that are able to be used with the HTC Vive of which will be discussed in the next section, was used due to the researcher's experience with the software. A betting shop was provided, featuring four Fixed-Odds Betting Terminals, an office and three tables with a view of three wall Televisions of which is displayed in Figure 4.1. This betting shop was featured in another study that investigated the feasibility of using virtual reality as a tool for research into gambling behaviour (see Dickinson et al., 2020).

Although the betting shop provided, in the form of a Unity Project, featured a well designed and realistic layout, some extra design and implementation was needed

Figure 4.1: Original Betting Shop Provided.

to ensure the virtual environment appeared as believable and realistic as possible and to ensure a high level of ecological validity. The first step, was to design and create a virtual world that was visible outside of the shop. As demonstrated in the screenshot below (Figure 4.2), the betting shop provided featured a large front window that showed an outside world with only the default Unity Skybox visible. Since there was no world outside the betting shop, it was argued the lack of outside world would have the potential to break presence, helping the participant to realise that they are in fact in a virtual world and removing how believable the environment is. A low-poly city model was downloaded and placed, and duplicated to ensure that the view from the window would not include any of the Skybox in unrealistic places. Street furniture was placed in the view seen from the shop, and the final addition was to add a Van parked in front of the shop. Following on from designing and producing an environment outside of the betting shop, the interior of the betting shop was changed to improve the realism of the environment. A number of changes were made, including the addition of everyday objects featured in a public building (such as fire alarms, fire exit and escape plan signage, a fire extinguisher etc.), signage expected in a betting shop (posters, a fictional company logo placed on the large window and the top plane of the door), the office was populated with a desktop computer and monitor and other objects expected to be found in an office, the Fixed-Odds Betting Terminal's screens were populated with a roulette wheel and roulette game, and finally more objects (such as the coffee cups seen in Figure 4.2) were added help build up a realistic environment.

Figure 4.2: Betting Shop Updated.

In addition, lighting and shadow effects were introduced to create more photo-realistic lighting, as well as dynamic shadows on the avatar and objects in the scene - essentially ensuring the shadows were realistic and not static. This was completed to encourage the plausibility illusion experienced by participants.

## 4.2 Steam VR and the HTC Vive

To ensure that the Unity Project that was being used to create the application for the study was compatible on the hardware that was available, the Unity SteamVR Plugin was used due to it's ability to ensure interoperability with the virtual reality hardware. The SteamVR Plugin, available on the Unity Asset Store, allows developers to "target one API that all the popular PC VR headsets can connect to", allowing the Unity Project to be built for the hardware that was accessible. (Valve, n.d.). The Virtual Reality Head Mounted Display (HMD) and hardware that were available was the HTC VIVE Pro, a "precise, 360-degree controller and headset tracking" HMD including a resolution of 1440 by 1600 pixels per eye with a field of view (FOV) of 110 degrees and a refresh rate of 90Hz. (HTC, n.d.). The HTC Vive Pro came accompanied with two 'Base Stations', that were used to track the Head Mounted Display and two VIVE controllers. The decision to make use of the HTC Vive Pro as the technology to facilitate the virtual reality condition was based on the increased resolution it features over other VR headsets, such as the Oculus Rift (which features a resolution of 1080 by 1200 per eye). Having an increased resolution will result in a more 'vivid' system, that allows for a more immersive experience. (see Slater, Linakis et al., 1996). Furthermore, the HTC Vive Pro features an easily adjustable head-strap which makes use of a 'cog' for ease of use adjustment, helping to ensure that participants are comfortable wearing the headset through the experiment.

## 4.3 Adobe Fuse, Mixamo and the creation of the Confrontational Avatar

For the creation of the virtual confrontational avatar, Adobe's Fuse software was used in conjunction with Adobe Mixamo. Adobe Fuse is a free 3D model producing software, available as part of the Adobe Creative Cloud package as well as a standalone software for developers who do not have access to the Creative Cloud. Fuse allows developers to design and produce 3D human character models efficiently, and with an easy to use interface, no previous modelling experience was needed. Fuse allows the developer to change character attributes (such as size of nose, colour of eyes, hair style etc.) easily as a library of assets are available for the developer to use. Once the character was designed with Fuse, it was then exported to Adobe's Mixamo service. Mixamo allows developers to create, rig and animate unique characters, and like with Fuse, benefits developers with limited to no experience with 3D modelling and animation. Mixamo also includes a library of free animations that can be applied to the rigged 3D models, including movement and idle animations. Once the 3D model has been designed and rigged using Adobe's Fuse and Mixamo, it is then ready to be animated using motion capture technology, which is to be discussed in the next section.

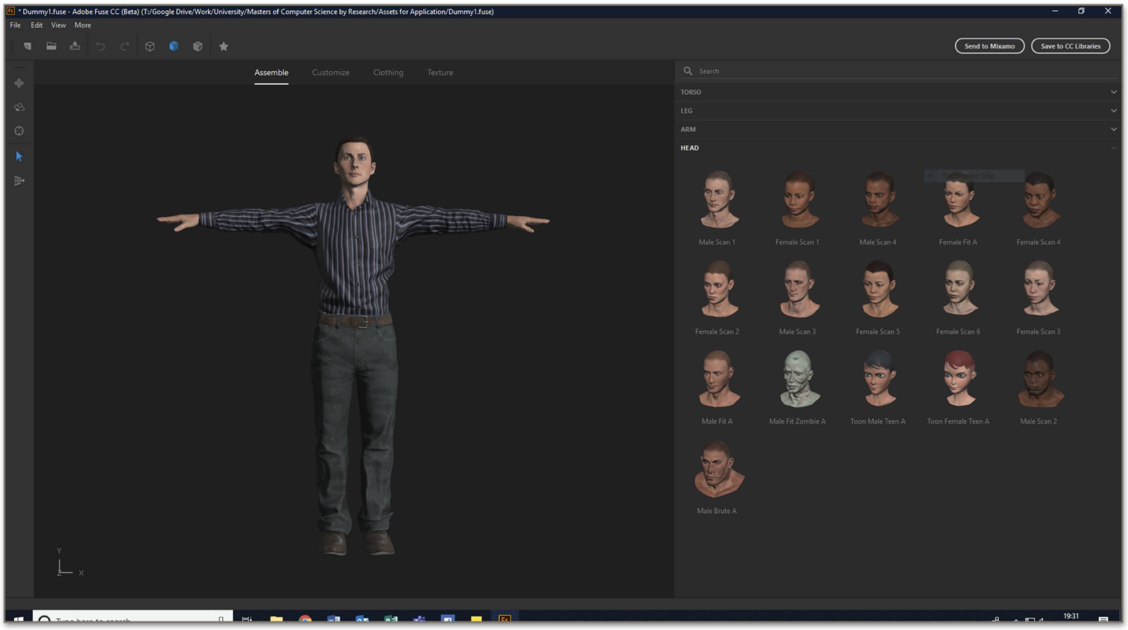


Figure 4.3: Adobe Fuse Software.

To design a virtual character that depicted an individual who would be found in a betting shop, a number of considerations were implemented. Firstly, for the age and gender of the character, the British Gambling Prevalence Survey 2010 of which includes the socio-demographic characteristics of a gambler including information such as age, marital status, ethnicity, highest educational qualification, economic activity, income etc. was used. According to the British Gambling Prevalence Survey 2010, 78 percent of the age group 55-64 partook in 'any gambling activity' in 2010, and that 76 percent of gamblers were White / White British. These statistics were used to develop the confrontational avatar's age and looks, a 55-64 year old White / White British male, along with verbal recommendations from Dr Adrian Parke based on his observations of Gamblers in past studies (including the recommendation that the Gambler did not look too groomed), to produce an avatar that was ecologically valid. (*British Gambling Prevalence Survey 2010* 2010). Throughout the design process of the confrontational avatar, continued feedback was received from Dr Adrian Parke on the appearance and how believable the model was. Originally, the character was designed by the researcher to look very rough and purposely intimidating with the addition of accessories such as a cap, often associated with violent individuals in gangs (as shown in Figure 4.5). After an initial meeting discussing the appearance of the original design of the confrontational avatar, it was determined the model was too unrealistic. It was mentioned by Dr Adrian Parke that from his observational research undertaken, that individuals who acted aggressive in Betting Shops appeared as normal individuals, not too smart but not too "scruffy". This was also found when research was conducted that involved watching videos on YouTube of incidents where individuals in betting shops acted aggressively; where the individuals involved appeared to look regular, with no visual appearances that indicated that they may be aggressive individuals. Taking on board the comments from Dr Adrian Parke, the appearances of individuals featured on the YouTube videos and the statistics from the British Gambling Survey 2010, the final appearance of the confrontational avatar was produced as shown in Figure 4.4.

## 4.4 Motion Capture and acting out the Confrontational Avatar.

From the initial meetings regarding the experimental design of the research, it was determined that realism of the confrontational avatar in the experiment was a priority to ensure that presence was not disrupted, such as the case in the study by Rovira et al., 2009, where participants, who were observed by researchers who were interested in whether or not they were to attempt to intervene when a virtual avatar begins to act aggressively towards another virtual avatar in a bar setting, commented on the lack of realism; the researchers expressed that “Five [participants] stated that the dialog itself was not realistic. 10 drew attention to the lack of lip sync, 8 to the lack of realism of the hand movements, 5 mentioned the lack of eye blinking” and although the researchers concluded that even with the presence disrupting features mentioned that a number of participants did in fact “become quite involved in a realistic way in the scenario”, they also concluded that their participants were less

Figure 4.4: Confrontational Avatar designed in Adobe Fuse.

likely to intervene if they were aware from a technical standpoint that to intervene would not “achieve anything”. (Rovira et al., 2009). This study demonstrates the importance of ensuring that the virtual avatars in a virtual reality experiment act realistically when measuring affective responses, and so it was determined that to make sure the confrontational avatar behaved in a realistic manner was a priority.

Initially, Mixamo (as discussed previously) was investigated to determine if it was possible to make use of the free animations that the service provided; by gathering a number of free animations, was it possible to stitch these animations together to create the realistic behaviour that the study required? After a search of the Mixamo animations library, it was concluded that the free service did not have the animations that captured the realism or subtleness of real human behaviours, nor behavioural features we wished to reproduce.

### 4.4.1 Motion Capture Equipment.

After some research, it was decided that motion capture (MoCap) would provide the best opportunity to produce animations that were bespoke to the project, and would supply the behaviours that would invoke the affective responses that were to be investigated. To produce the animations that were needed, a motion capture system would be required. The School of Sports and Exercise Science at the University of Lincoln had a complete motion capture system that is used for research undertaken by staff and researchers in the school. Dr Franky Mulloy, a lecturer in Biomechanics, very kindly offered to liaise with the researchers of this project; offering to provide technical support and advice, along with organising technical staff to set-up the motion capture system. The motion capture system that was available was one using technology from Motion Analysis. Twelve 'Raptor' Cameras were distributed around a central point with a radius of five meters, sampling data at 150Hz. To capture the data, software from Motion Analysis called 'Cortex' was used to record the position of every marker attached to the actor.

### 4.4.2 Animating a 3D Model with Motion Capture Data.

Before any motion capture was to be recorded for the project, it was yet to be determined if the data from the motion capture system was compatible with the Adobe Fuse rigged model that was designed to represent the confrontational avatar. A previously captured motion capture data file was provided, one of which contained the data of a student from the School of Sports and Exercise Sciences squatting repeatedly. The file format that was provided was that of a Hierarchical Translations and Rotations (HTR) file, that proved difficult to work with for the purpose of animating a rigged 3D model from Mixamo. Research and experimentation was conducted to find an efficient workflow method to extract data from the motion capture system and animate rigged models with .C3D format; the Cortex software of the motion capture system was able to export the motion capture data into the required C3D file format, allowing a process to be undertaken (of which will be discussed next) that resulted in the motion capture of the student squatting being applied to the Confrontational Avatar's model, as shown in Figure 4.5.

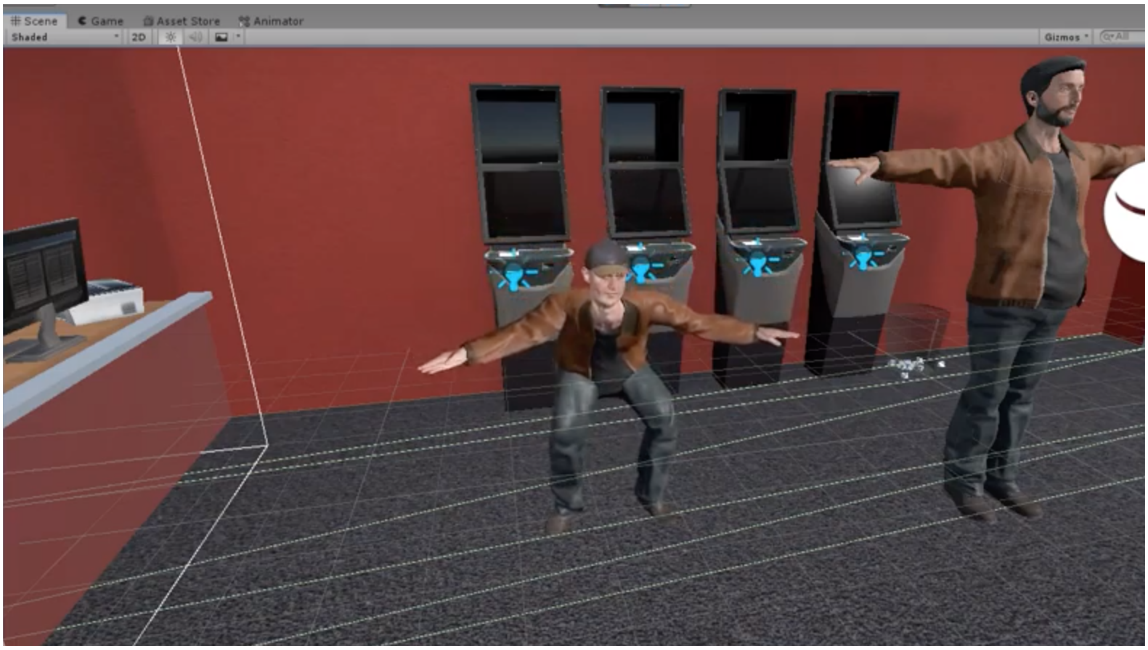

Figure 4.5: Squat Motion Capture applied to initial Confrontational Avatar model.

The process that allowed the motion capture data to drive the rigged 3D model's animations required several software programmes that each had a role in producing the final animated confrontational avatar. The first programme that was required was Autodesk's MotionBuilder, which was used to take the C3D motion capture data recorded, and use that data to drive a rigged 3D model. The first step involved importing the MoCap data and mapping each motion capture point (the 'Blue Cubes' shown in Figure 4.6, which represent the markers placed on the student's body) to a model known as an 'Actor' (the blue model also shown in Figure 4.6). The Actor was then used to drive the rigged 3D model of the confrontational avatar. MotionBuilder includes a feature that imports the rigged 3D model, and then once imported applies the motion of the Actor (driven by the motion capture points), to the rigged 3D model resulting in the 3D model animating as per the motion capture recorded. Once the animated 3D model was ready (after tweaks made to the actor to ensure the model behaved as naturally as possible), the animated 3D model of the confrontational avatar was then exported to Autodesk's Maya software, which had a purpose to export the animated 3D model into a .FBX format, that allows it to be used in the Unity Engine.

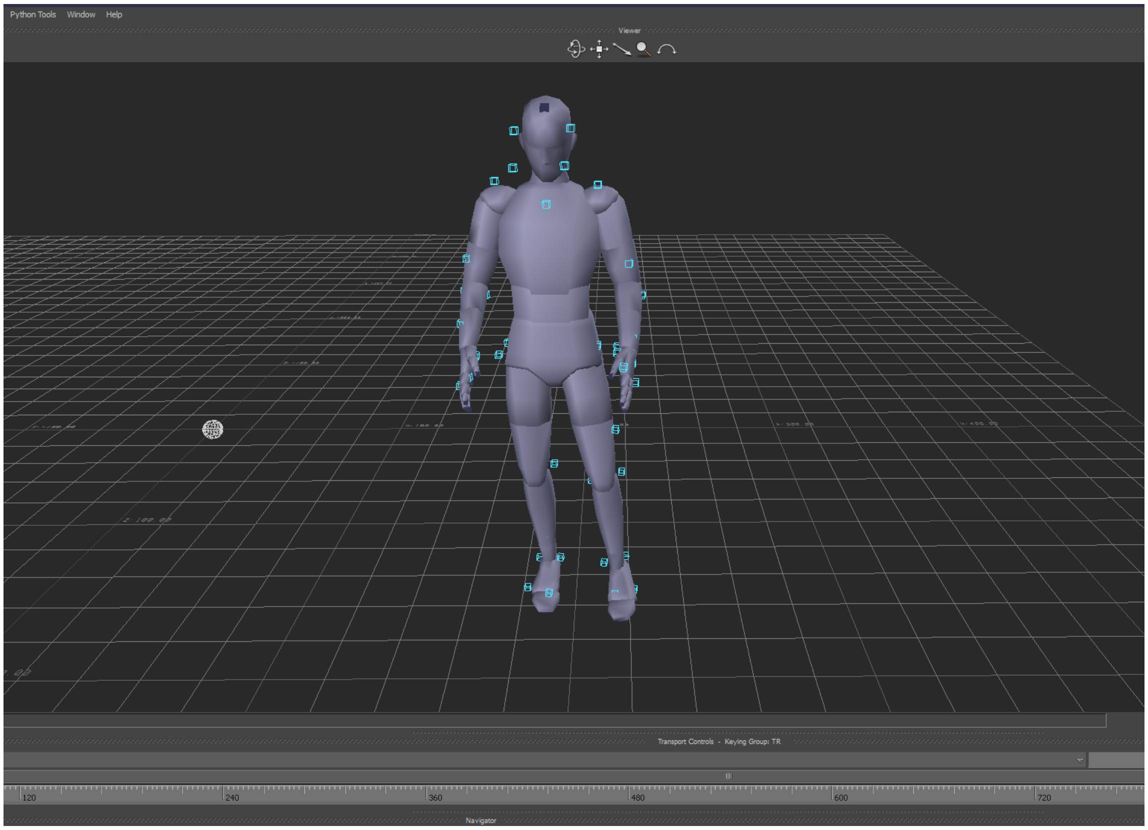


Figure 4.6: Motion Capture markers represented as blue cubes which are used to drive the 'Actor' represented by the blue model.

### 4.4.3 Acting out the Confrontational Avatar.

The process of which to take motion capture from the MoCap Hub in the School of Sports and Exercise Science and apply it to a rigged 3D model produced by Adobe Fuse and Mixamo was found. Next, the process of acting out the confrontational scene was to be planned. A script was then produced, taking inspiration from clips online of cases of individuals acting confrontational in betting shops in the United Kingdom, and using quotes from Parke and Griffiths work (see Parke and M. Griffiths, 2004), including statements from confrontational individuals that were observed by the researchers. Once the script was produced, an Actor was needed to act out the scenes. A graduate drama student was contacted, who had graduated from the School of Fine and Performing Arts at the University, and agreed to assist with the acting that was required. To finalise the planning before the MoCap session, one issue had to be addressed; since the motion capture area was limited (the area that the motion capture system can effectively capture the markers attached to the Actor's body), a method of which to capture the different takes was required. It was determined that taping different paths for different scenes would be effective both in indicating to the Actor where they should be walking during the takes, but also allowing for different takes to be taken for different scenes of the script. This is demonstrated in Figure 4.7.

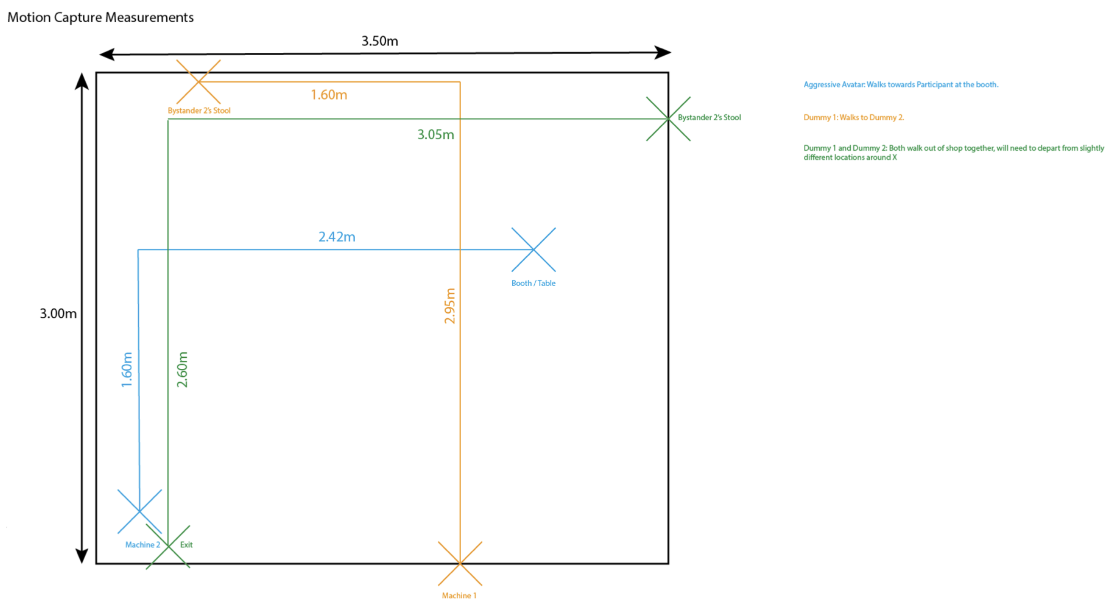


Figure 4.7: Measurements for the different scenes to be Motion Captured (from a later MoCap session).

Once the Actor was prepared, in terms of having all the markers placed on the relevant points on their body, the motion capture recording commenced. This involved the Actor performing scenes as per the script written, but ensuring they followed the measurement tape placed on the floor for directions, and to ensure that they were performing in the area that would pick up the markers used to record the motion capture. Table 4.1 explains the scenes that were motion captured in the first session, and how many takes of each scene were recorded. The first motion capture session provided the opportunity to test out the motion capture equipment and how the process the researcher conducted fared. A second session was then organised allowing the researcher to refine the process. In the second session, the actor recorded the

Table 4.1: Session 1 Scene Descriptions

| **Scene** | **Scene Description** | **Num. of Takes** |
|---|---|---|
| 1. Playing Arcade Machine. | In this scene, the gambler is playing on the Fixed Odds Betting Machine. He continues to lose, and carries on playing. Each time he get's progressively more and more frustrated. | 1. |
| 2. Avatar acting aggressively. | The gambler ends up losing one time too many, and in an instant becomes extremely agitated and physically hits the Fixed Odds Betting machine he was playing on. He then directs his attention towards the shop assistant and starts verbally abusing them. At the end of the verbal attack, he walks off towards the shop exit. | 1 |
| 3. Other Customer Leaving. | In this scene, the other customer in the shop observes the television before getting off the stool he is sitting on and then walking out of the betting shop. | 1 |
| 4. Full Take. | This take consists of a full recording with both scene one and two put together. | 1 |
| 5. Avatar walking out of the shop aggressively. | In this take, the aggressor walks towards the exit, and opens the door violently before walking out of the betting shop. | 2 |

full scene (starting with the build up, where the avatar plays the machine and progressively shows more frustration, and ending with the avatar verbally abusing the shop worker, identical to scene four in Table 4.1) twice rather than have two separate takes, but continued recording a second scene for the aggressor walking out of the shop, as well as the separate scene for the other customer walking out of the shop. Each session resulted in improved efficiency and outcome when recording the scenes in motion capture; for example with each processing session of the motion capture data in MotionBuilder, the output animation was more realistic in appearance and smoother, due to the increase of skills developing the animations with practice.

### 4.4.4 Evaluating initial Motion Capture Recordings and ensuring the Confrontational Avatar's realism.

After two completed recording sessions with the Drama Graduate, a meeting was held with supervisors, Dr Adrian Parke and Dr Andrew Westerside, an academic and practitioner from the School of Fine and Performing Arts, who was invited to determine if there was any improvements that could be made on the acting side of the motion capture. The purpose of the meeting was to evaluate the motion capture recordings and animations produced at that point. A number of comments were made regarding the realism; it was stated that the build-up to the aggressive behaviour was too short, which did not allow tension to be built up by the participant. Other statements made in the meeting regarded the script, where Dr Adrian Parke offered to write a script for the scene of which was to be acted out, making use of his previous research and experience in observing confrontational individuals in betting shops. Also included in the new script was the incorporation of two other customers in the shop, of which the first customer sits on the table watching the Televisions and the second customer is playing on another Fixed-Odds Betting Machine, they both then walk out of the betting shop before the confrontational avatar starts to act aggressively. Another discussion held was regarding the Actor that was used for the initial Motion Capture sessions. It was determined from Dr Adrian Parke that the actor was rather too flamboyant, a skill better suited to live performances but in the case where realism was of upmost importance, flamboyance was not necessary and risked affecting how believable the confrontational avatar appeared. This led to the final outcome of the meeting, where Dr Andrew Westerside volunteered to be the Actor to be motion captured, providing highly regarded performing and acting skills to the project, to help produce a more believable confrontational avatar. It was decided that the creation of a real world prop to represent the Arcade Machine would be beneficial in creating realistic and believable actions during the scenes of which was created in time for the following motion capture sessions (see Figure 4.8).

### 4.4.5 Re-recording the Confrontational Avatar's Motion.

When the time came to complete the first motion capture session with Dr Andrew Westerside, a new layout of measurements to represent where the Actor walks was produced (shown in Figure 4.7). The measurements show different colours to represent the different scenes to be recorded for the three different characters. In the session, four takes were recorded for the main confrontational avatar and one take

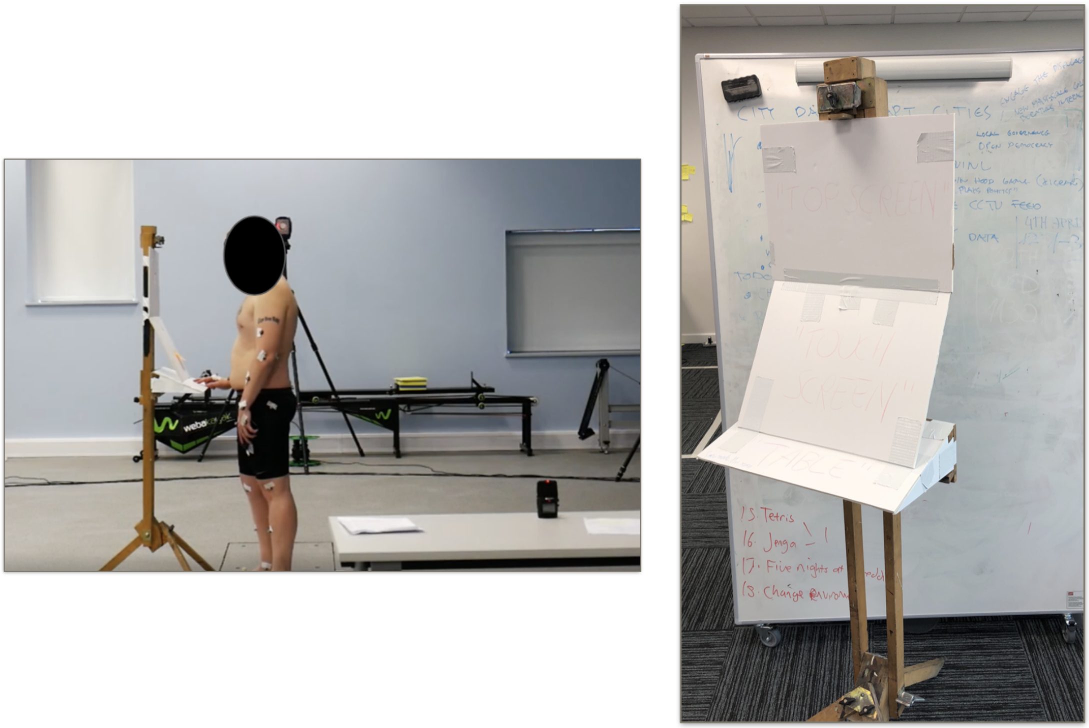


Figure 4.8: The produced prop that represents the Arcade Machine, and Actor Dr Andrew Westerside standing next to the prop.

each for the two bystanders in the shop. The recordings took between one and two hours, including thirty minutes setup time. Unfortunately, it was later found that all the recordings from that capture session were unusable due to having two camera's down and later learning that the Arcade Machine prop was actually blocking another two cameras, totalling in four cameras down; meaning that at multiple points across each recording's timeline, many of the markers were not recorded, meaning the process of which to clean the recorded data (a process that required a specialist technician) before it is delivered was not possible. This provided a number of learned lessons, including to ensure that the prop of the Arcade Machine is placed in a position where it is not blocking the line of sight of the 'Raptor' cameras to the Actor and markers, as well as ensuring that the correct number of cameras are working. The session also taught us that the audio recordings recording on a separate camera that were to be used as the audio in Unity were unusable as they featured heavy echoing picked up from the motion capture being conducted in a large hall. After speaking to Dr Andrew Westerside, it was decided that a further audio recording session would be completed as soon as all Motion Capture recording sessions were concluded. It was also decided that in the next recording session, there was to also be consideration of where the participant would be standing; would placing the participant outside of the staff booth be better to elicit the responses that we were to investigate? This is in reference to the concept of proxemics, of which is later discussed in Section 4.7.

A further motion capture session was then organised for a time that suited the researcher, the technicians and staff from the School of Sports and Exercise Science and Dr Andrew Westerside. The same measurements were used and taped down for the Actor to use, with an extra cross taped down in front of the booth edge to represent the position of the participant who was out of the booth, and the prop of the Arcade Machine was placed in a position where it was not blocking the line of sight of the cameras. A 'Snowball' microphone was provided by Dr Andrew Westerside to record the audio from the capture sessions, providing higher quality audio that does not pick-up the echoing as much as the camera. In this session, four takes were recorded for the confrontational avatar, and one take for one of the bystanders. It was also decided that two of the takes for the confrontational avatar would be recorded without the prop, mitigating the risk of the the prop causing any recording issues, which at this stage could not be afforded. The description of the takes are displayed in Table 4.2. In this session, the recordings took between one and two hours including thirty minutes for setting up. After this recording session, it was found that there were a number of usable takes.

Once the process of taking the motion capture data and applying it to the rigged confrontational avatar was completed for all recorded takes, a meeting was organised with supervisors and Dr Andrew Westerside where all takes of the confrontational avatar were put into Unity and observed. A discussion followed, where each take was critiqued and a number of points were made. It was determined that the build up in one of the takes was what the team was looking for, but the commencing aggressive behaviour in all takes were too-short. It was argued that the length of the aggressive behaviour would not give sufficient time for the participant to recognise what was happening and for the emotional response to occur. It was also put forward that the fact that the confrontational avatar walked towards the door of the shop at the end

Table 4.2: Session 4 Scene Descriptions

| Scene | Scene Description | Num. of Takes |
|---|---|---|
| 1. Full Scene without Props - Out of Booth. | In this scene, the gambler is playing on the Fixed Odds Betting Machine. He continues to lose, and carries on playing. Each time he get's progressively more and more frustrated. The gambler ends up losing one time too many, and in an instant becomes extremely agitated and physically hits the Fixed Odds Betting machine he was playing on. He then directs his attention towards the shop assistant and starts verbally abusing them. At the end of the verbal attack, he walks off towards the shop exit. There are no props used in this take, and the actor aims the aggression as if the shop worker is standing in front of the booth in the Virtual Environment. | 1 |
| 2. Full Scene without Props - In Booth. | Same description as Scene 1. With this take, the actor aims the aggression as if the shop worker is standing in the booth of the Virtual Environment. | 1 |
| 3. Full Scene with Props - Out of Booth. | Same description as Scene 1. With this take, props are used and the actor aims the aggression as if the shop worker is standing in front of the booth in the Virtual Environment. | 1 |
| 4. Full Scene with Props - In Booth. | Same description as Scene 1. With this take, props are used and the actor aims the aggression as if the shop worker is standing in the booth of the Virtual Environment. | 1 |
| 5. Other Customer Leaving. | In this scene, the other customer in the shop observes the television, looks at the confrontational avatar several times and then walks out of the betting shop. | 1 |

of the animation would help the participant relax, making it clear to them that they are out of confrontation, which could reduce the state anxiety experienced at the end of the experiment. From these points made, a change to the script was made which extended the length of the aggressive behaviour at the end of the scene, including a section where the avatar walks away from the participant and then returns to continue showing confrontational behaviour towards the participant. Also, it was determined that the avatar would finish the aggressive behaviour located in front of the participant. These changes were implemented to allow the participant to fully understand that they are in fact the target of the confrontation and to remove the chance for the participant to calm down before filling out the state anxiety questionnaire so the researchers a fully aware of the self-report emotional response of the participant immediately after the aggressive behaviour.

### 4.4.6 Finalising the Motion of the Confrontational Avatar.

The changes discussed previously led on to the final motion capture session. In this session, it was planned to only record the longer scenes of aggressive behaviour, as well as the MoCap recordings of the other customers in the scene. As the previous MoCap session provided the build-up required, it was decided that the final MoCap session would provide the opportunity to record three takes, of which one of the takes would be chosen as the best one and would be merged onto the build-up animation recorded from the previous MoCap session. The final recording session took between sixty and ninety minutes, including thirty minutes of setting up time. Once all the takes were recorded, the process of which to apply to MoCap data to the rigged 3D model of the confrontational avatar was undertaken. When the final takes were completed, they were placed into the Unity scene and screen recorded so they could be sent to Dr Adrian Parke who was asked to decide an aggressive behaviour take that seemed the most realistic and believable in his opinion. Dr Adrian Parke responded with a take, of which was also agreed by the researcher, supervisors and Dr Andrew Westerside. The full animation of the confrontational avatar was complete when the build-up take and the final aggressive behaviour take was stitched together and after some manual tweaks to the animation was completed using the Unity animator feature; it was identified in testing that the left arm of the confrontational avatar would rotate all the way round and back several times and in the space of milliseconds, resulting in an obvious 'glitchy' appearance that would very much contribute to a break in presence. The 'Unity Animator' feature was used to remove the animations attached to the avatar's left arm and manual animating was conducted to prevent the arm from appearing too 'buggy' by animating the arm as it would appear if it was not rotating and twisting. Since there were no markers added to the fingers of the actor, the hands of the avatar had to be manually animated as well with the left hand animated to look as if it was holding a Smartphone, and the right hand was animated to play the arcade machine. At this point, it was also decided to ditch the two other characters in the scene as it proved difficult to animate the avatars leaving the shop without producing an animation that looked extremely unrealistic and also risked breaking presence.

The animation of the confrontational avatar underwent a number of iterations with continued feedback from Dr Adrian Parke, of whom as mentioned previously is an expert in aggression in betting shops and has undertaken a number of observational studies of aggressive behaviour in these betting environments, as well as Dr Andrew Westerside, who is an expert in the performing Arts and successfully took the brief provided and helped produced an animation that was deemed believable.

## 4.5 Animating the Face of the Confrontational Avatar and LipSync Pro

The realism of the confrontational avatar, being one of the priorities with regards to the development of the application that the participants are to be exposed to, led the researcher to focus on the facial animations of the avatar. As previously mentioned, it was noted in the discussed study regarding confrontation in a bar by Slater et al. that participants noticed the lack of lip-sync and blinking (facial animations) that affected the presence felt and resulted in many of the participants quickly identifying that the characters did not behave realistically and so affected the plausibility illusion, and then not intervening of which was the focus of the

Figure 4.9: Still of Confrontational Avatar during the aggressive behaviour sequence.

study (see Slater, Rovira et al., 2013). To avoid similar results, it was decided that realistic facial animations were a priority in the development process, and to achieve this a Plugin known as LipSync Pro, available on the Unity Asset Store was purchased and used. The Plugin works in conjunction with Mixamo 3D rigged models, altering the blend shapes of the face of the model as per phoneme identified by the Plugin's algorithms or phoneme that is manually imported if the identification process doesn't recognise all phonemes. The Plugin takes in an audio file (in this case, the audio recording of Dr Andrew Westerside performing the aggressive behaviour of the confrontational avatar), and uses an algorithm to recognise the phonemes from the audio. As mentioned previously, often the algorithms of the Plugin does not recognise all the phonemes, and so to ensure the animation looks as realistic as possible, manual importing of phonemes at specific points of the audio timeline (see Figure 4.10) is required. The result of the LipSync Pro process is a relatively realistic facial animation that perform on top of the Motion Capture animations that produce the believable animations of the confrontational avatar of which were a priority of the development stage.

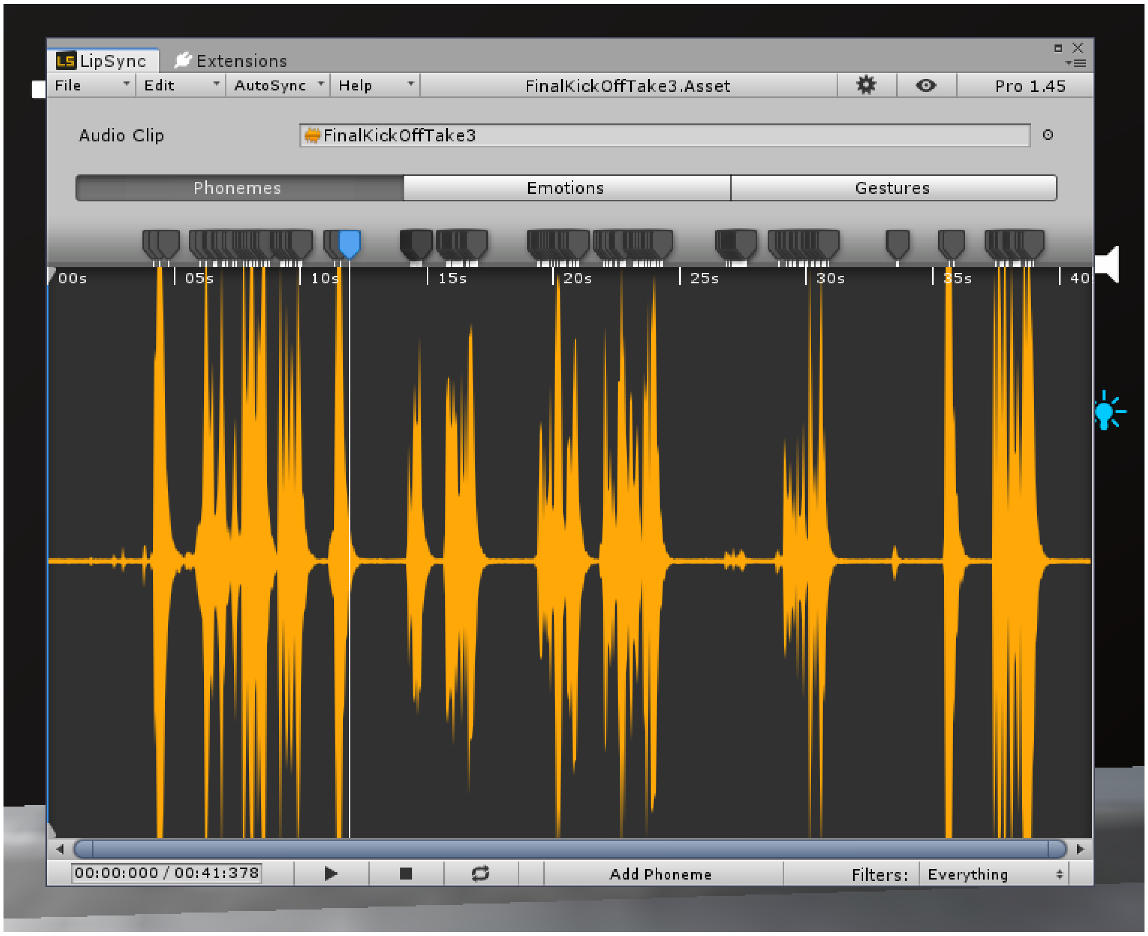


Figure 4.10: Audio recording of aggressive behaviour scene with animations representing the different phonemes applied at specific points to drive the movement of the mouth.

At this stage, the mouth of the confrontational avatar had animations that were deemed as realistic as could be produced with the resources available. The focus was next onto the eyes of the avatar. At this point during the animation the eyes of the avatar would face forward at all points of the animation timeline and not move at all. This made the avatar appear unrealistic. It was determined that to work around this problem, an easy solution would be to have the eye balls of the confrontational avatar always follow the direction of the camera object (for both the 2D camera, and the VR camera). This method was considered carefully with assistance from a colleague who also required human avatars to look at their participants. The method proposed included a number of scripts with different purposes to ensure the avatar appears to look at the participant in a realistic manner. The first script involved has a purpose to move two small cubes that are horizontally level with each other to the position of the camera (depending on condition, the script was altered for the relevant camera) as shown in Figure 4.11. Each small cube represented a target for each eye of the confrontational avatar to follow, where as it was not suitable to have the eyes just target the camera due to the resulting cross-eyed appearance. The second script was applied to each eye, and had a purpose to ensure that each eye was always targeting the specific cube relevant for the correct eye. Once these scripts were in place, the result was a final animation that included realistic features such as the confrontational avatar appearing to focus on the participant.

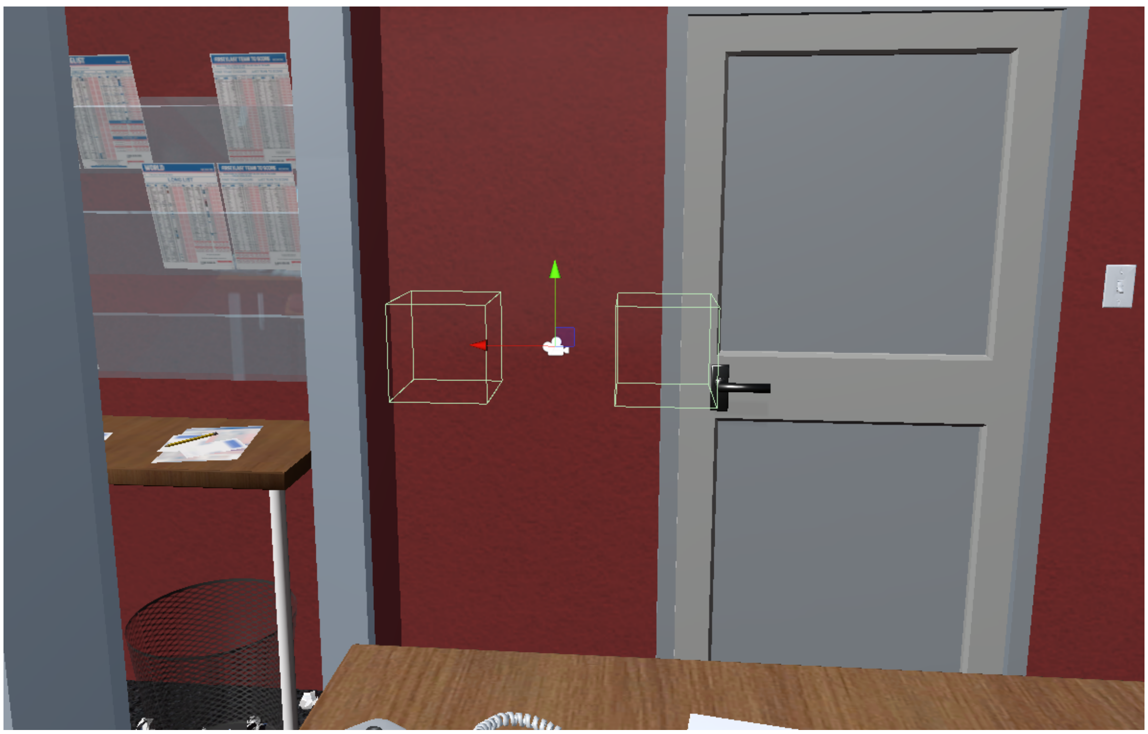

Figure 4.11: Two cubes, each representing a target for each eye of the Confrontational Avatar to follow, following the camera's position.

## 4.6 Final IK and the Participant's Virtual Body

With the environment and confrontational avatar designed with presence and believablility in mind; it was also determined that to avoid breaking presence in the virtual reality environment, it was necessary to incorporate a virtual body for the participant into the application. It is stated by Slater and Usoh that immersion "may lead to a sense of presence" and that an increase in immersion can be achieved by "richer body representations", and therefore a potential increased feeling of presence. Slater and Usoh describe the importance of incorporating a virtual body to improve presence by referring to what is known as 'proprioception'. According to Slater and Usoh, proprioception "allows us to form a mental model that describes the dynamic spatial and relational disposition of our body and its parts". Proprioception is what allows us to point to a body part with our eyes closed; that unconscious knowing where each body part is. Without the virtual body in a virtual reality environment, our minds deal with contradicting data. Slater and Usoh describe how in a virtual reality experience where there is no virtual body present, the individual in the VR environment will be informed by proprioception that the body is there, but sensory data from the eyes contradicts the proprioception stream, as the individual will perceive there to be no body present. This has the potential to break presence. It is also noted in the study conducted by Slater and Usoh that presence is "likely to be enhanced the more that the mental body model behaviourally matches the virtual body representation in the VE", meaning that to have a virtual body that does not match behaviourally to the mental body model also has the potential to break presence. The study completed by Slater and Usoh concludes that to include a virtual body that behaviourally acts identical to the immersed individual's body will "enhance" presence. (Slater and Usoh, 1994).

With this in mind, a plug-in known as Final IK was used to implement a virtual body into our environment on Unity. Adobe Fuse was then used to create another avatar, one of which was to represent the participant. As the participant will be asked to "role-play" as a betting shop employee, the avatar was designed to look like a worker in our fictional betting shop (i.e red shirt to represent the fictional company colour scheme etc.) See Figure 4.12 which displays the model that was used to represent the participant in the virtual environment. The plug-in features a script (titled VRIK) that is applied onto the participant's avatar; then manually, certain limbs of the avatar (left hand, right hand, head, left leg etc.) are added to this script. The script works by transforming specific limbs of the avatar (hands and head) to the Steam VR equipment in the virtual space; i.e the head of the avatar will transform to the camera (that represents the HMD in virtual space), the left hand of the avatar will transform to the position of the left controller etc.

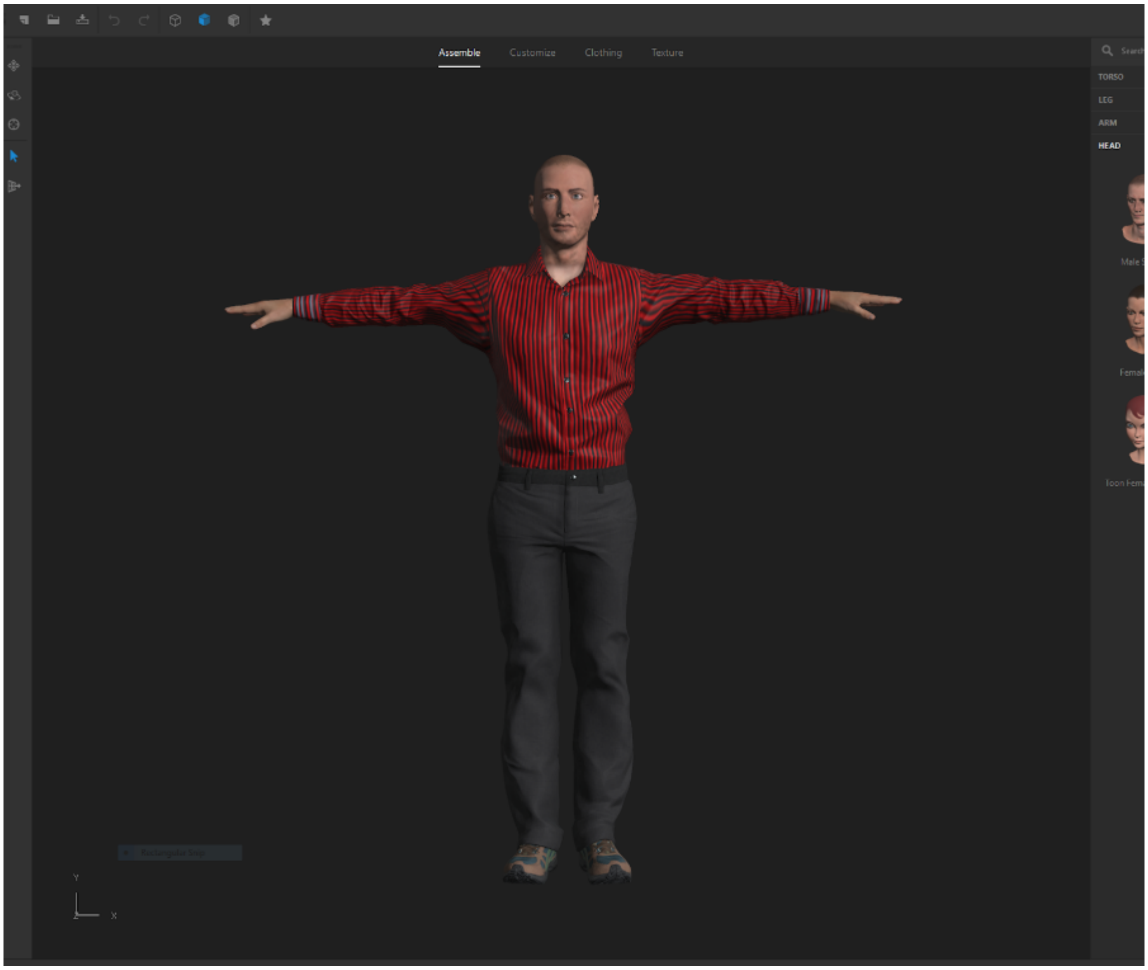


Figure 4.12: Participant's Avatar designed on Adobe Fuse which was used with VRIK.

Upon testing the virtual body on the HTC Vive, it was found that if the user twists the HTC Vive controller, then the hand model twists too, to a point where the wrist twisted and crumpled, similar to that of a balloon. It was also found that the arms appeared stiff when they moved. Since, as mentioned by Slater and Usoh, if the body does not act behaviourally similar to that of the mental proprioception stream, there is the chance that the user may have their sense of presence disrupted, it was decided that the virtual body would not have arms, but rather have model hands (transforming to the location of the Vive controllers, always following the controllers) to represent the hands. After testing the participant's virtual body again, without the arms and with 'floating' hands that followed the Vive controllers, it was decided this set-up would be sufficient to help provide the participant with the sense they have a body in the virtual world, but not break presence by having unrealistic behaving limbs.

## 4.7 Normalising the Distance between Participant and Confrontational Avatar in the two conditions.

To ensure that the participants in both conditions were exposed to the confrontational avatar in a normalised way, a method was needed to ensure the avatar appeared similarly in both conditions. Originally, the 2D condition involved a virtual camera that was placed in the virtual environment at head height above a virtual cross, that the VR participants were asked to stand on so that they were located in a position in the virtual environment that allowed the participants to view and experience the motion capture to it's desired effect. Upon building the 2D application and viewing it on the Television that was to be used for the study, it was observed that towards the end of the aggressive behaviour demonstrated, the confrontational avatar's head would appear massive (appearing relative to the real world, around two to three times the size of a normal human head) of which if left unchanged could influence the results to be found when taking into consideration the effects of proxemics, and the fact that the 'massive' avatar could appear closer.

Proxemics, as defined by Edward T. Hall, is "the study of how man un-consciously structures microspace". Hall puts forward the concept that proxemics influences interpersonal communication, where the distance two individuals are away from each other when communicating can result in a number of physiological behaviours depending on their relationship with each other. (Hall, 1963). In further work, Hall et al. develop a diagram explaining the distances required to result in specific behavioural responses between two individuals. In this this diagram, four zones are classified describing the distance between two individuals; intimate (0 - 1.5ft), personal (1.5 to 4ft), social-consultive (4-10ft) and public (10+ft). The diagram also provides examples of the dimensions of proxemic behaviours (the different behaviours associated with difference distances between two individuals), such as kinesthetic factors. (Hall et al., 1968). Hall (1963) describes kinesthetic factors as being based on "what people can do with their arms, legs, and bodies, and the memory of past experiences with one's own as well as other bodies" and further states that individuals are close if "there is the potential for holding, caressing, or of being struck". It is evident in proxemics studies that an invasion of the personal and intimate zones will encourage discomfort in participants, even in virtual reality such as is shown in the 2006 study by Wilcox et al. who determine that perceived stereoscopically projected stimuli who intrude the personal distance zone can "cause significant increases in viewer discomfort". (Wilcox et al., 2006). Furthermore, Llobera et al. conduct a study using Head Mounted Display VR technology and find that the closer the distance between an avatar and a participant, the "greater the arousal" using skin conductance recording technology. (Llobera et al., 2010). Both these studies are evident that a virtual avatar displayed has the ability to elicit physiological responses if the participant feel as if the avatar is invading their personal space. To limit the potential compounding effect of the 'massive' 2D avatar's appearance on the Television on the intrusion of personal space, a method to ensure that the confrontational avatar appeared on the Television as a size that was realistic was necessary, of which then would allow for the determining of the participant's distance away from the confrontational avatar that can be applied in both conditions (normalising the distance).

At first, an understanding of how the virtual camera in Unity worked was needed. According to scratchapixel.com, a virtual camera works by making use of perspective projection, a method of which allows for the building of an image (canvas) using a viewing frustum of which includes both a near clipping plane and far clipping plane. The clipping planes are used to determine what objects in the scene are rendered. For example, any object behind the far clipping plane will not be rendered, and any object in front of the near clipping plane will also not be rendered. The viewing frustum originates from the camera origin outwards in a pyramid shape. The canvas is described as the 2D surface of which the image of the screen is "projected" onto. (Scratchapixel, 2014). With the knowledge of how the virtual camera operates in Unity, a formula provided by Unity Technologies was discovered, that can be incorporated in a script and when fed the frustum height value outputs a distance. (Unity Technologies, n.d.).

```
var distance = frustumHeight * 0.5f / Mathf.Tan(camera.fieldOfView * 0.5f * Mathf.Deg2Rad);
```

=

$$\text{distance} = \frac{\text{frustumHeight (height of monitor) x 0.5}}{\text{tan(virtualCameraFOV x 0.5 x ((PI x 2) / 360))}}$$

Figure 4.13: Formula provided by Unity (in C sharp format and then converted to a mathematical format)

At first glance of the formula (as shown in Figure 4.13), it appeared that the distance provided by the formula represented the distance away from the Television (when the formula was provided with the height of the Television screen of which represented the Frustum Height) that the participant needed to stand to view the objects and the confrontational avatar as they would appear in real life. A tape was placed in front of the Television, representing the distance away from the Television that formula suggested the participant should stand, and the application was started. The results of this test showed that the avatar still appeared a lot larger on the screen (towards the end of the aggressive act performed by the confrontational avatar) then a human would be in the real world. Another method to solve the problem of projecting the avatar on the Television so it would appear regular human size was needed. As there was limited research found that compares virtual avatars between VR and 2D technologies, another method was attempted. In this attempt to figure out the problem, a virtual piece of A4 paper was added to the virtual environment, located at head height and centre of head width, adjacent to the position of where the confrontational avatar's animation ends. This allowed a produced script that moves the virtual camera backwards, that could be used to determine the distance the virtual camera would need to be away from the virtual A4 paper so the virtual A4 paper would appear on the Television Screen the same dimensions as a real world A4 piece of paper. Upon discussing and planning this method, it was identified that all the objects in the virtual environment are at a scale factor of 3.4, as well as the

Steam VR camera rig to compensate this scale factor (to ensure that the objects don't appear 3.4 times larger than they would do in real life), meaning that the 1:1 (1 unity unit to 1 meter) scale factor was not in play and that all calculations regarding virtual distance needed to consider the scale factor of 3.4 (for example if a virtual chair is 5 unity units distance away from a wall in a virtual environment, the real life distance would be 5 / 3.4 = 1.47 meters), and so the virtual A4 piece of paper would need to have it's dimensions multiplied by 3.4 so that was at the correct scale to the virtual environment. To continue, the previously mentioned script was constructed so that once the application started running, if the space button on the keyboard was pressed, the virtual camera would move 0.1 Unity units backwards (in this case along the x-axis). The space button was pressed a number of times until the virtual A4 piece of paper appeared on the screen the same size as the real A4 piece of paper as shown in Figure 4.14.

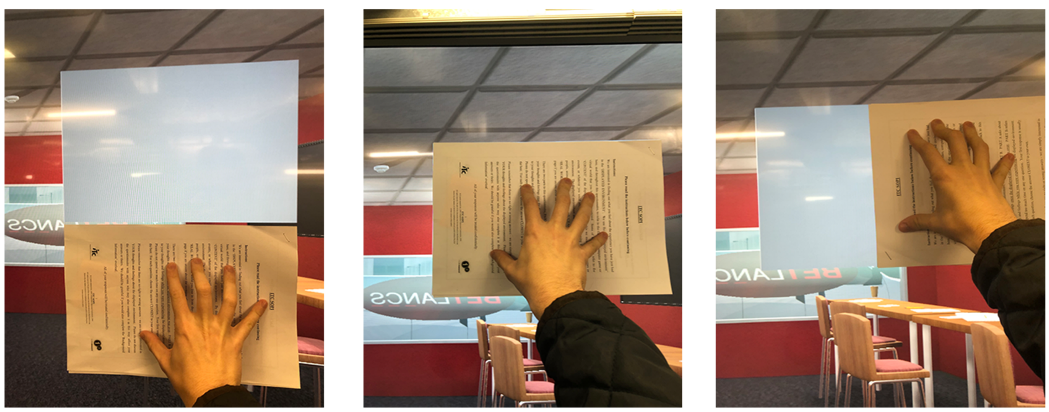

Figure 4.14: Real life A4 Paper pressed against 4K TV to compare size to Virtual A4 Paper.

The number of times the space button was pressed was written down and used to calculate how many Unity units the virtual camera was away from the virtual A4 paper so that it would appear to real life scale on the Television. The distance in Unity that the virtual camera was from the virtual A4 piece of paper was calculated to be 2.002 Unity units, and once divided by 3.4 (the scale factor) resulted in a real life distance of 58.8 cm. What proved interesting, is that the formula provided by

Unity of which was mentioned previously, produced a value of 59.32, of what was previously thought as the distance the participant needed to stand away from the Television. It arose suspicions that the formula could actually be used to calculate the distance in Unity (if the scale factor was 1:1) the virtual camera needed to be from an object so that it would appear as real world dimensions on the screen. Since the values were not exactly the same, it was also suspected this could be a coincidence, so another test would be conducted on a different monitor to see if the Unity formula can be used to determine a virtual distance (at scale factor 1) an object needed to be from the virtual camera to appear life size on a screen. In this test, a 1440p Monitor was used, of which had a screen height (or for the formula, the frustum height) of 34.0cm. The application was built and ran with the same script that allowed the user to move the camera back and forth until the real life A4 piece of paper was the same size as the virtual piece of A4 paper (as demonstrated in Figure 4.15). The distance between the virtual camera and virtual paper was then found to be 0.951 unity units apart, of which once divided by 3.4 (the scale factor), the result was 27.97 cm. The formula script had outputted a distance of 29.44 (similar to the distance worked out manually). This then proved the suspicions that the formula provided from Unity can be used to work out how far the virtual camera is to be located (in a scale factor of 1) from an object in the virtual environment so that it appears as the same dimensions as it would do in real life on a monitor with height h.

Knowing that the formula from Unity can be used to calculate a distance the virtual camera needs to be away from the confrontational avatar for him to appear life size on a Television that has a screen height of 68.5cm, the distance provided by the formula was then applied in the Unity Engine; making the virtual camera the specified distance away from the avatar (centre of avatars head) to ensure he appears life size on the Television. For the height of the virtual camera, the half way point of the height of the Television was measured, and then the height of that point was measured from the floor which resulted in a height of 165cm. The virtual camera was then specified a height of 165cm times by 3.4 (Scale Factor) Unity Units from the virtual floor. This resulted in a view of the confrontational avatar that would appear life size and at the correct height. To finally equalise the distance of the participant's

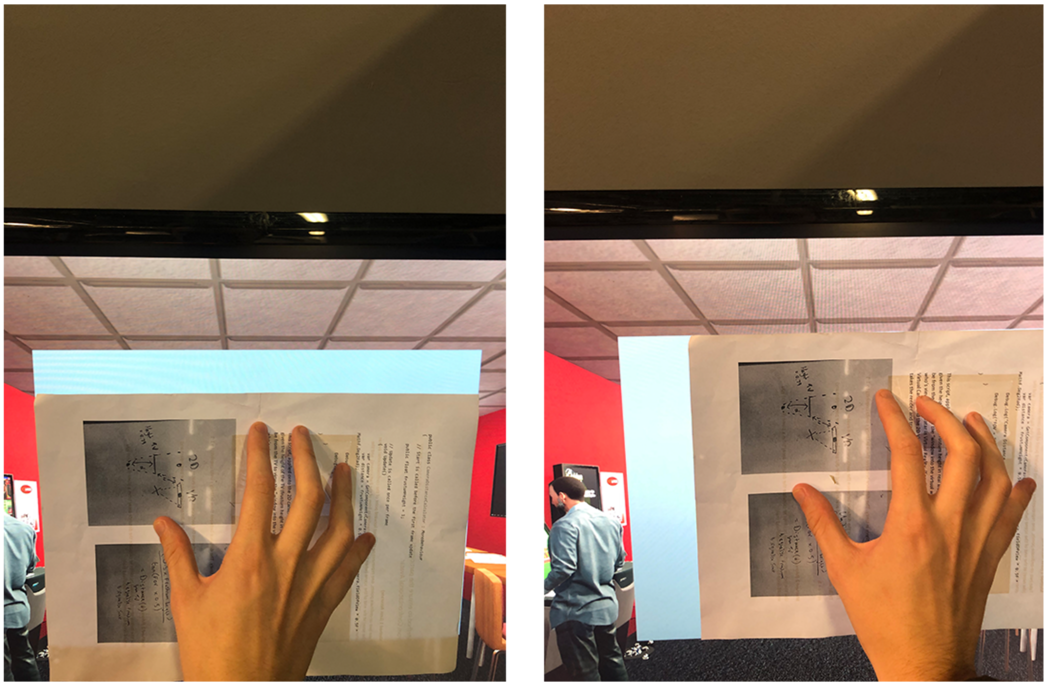

Figure 4.15: Real life A4 Paper pressed against 1440p Monitor to compare size to Virtual A4 Paper.

view of the confrontational avatar, the distance between the avatar and the virtual reality grey cross was measured using the HTC Vive controllers and a tape measure. This distance was recorded. To ensure that the distance was correct, two virtual cubes were added on the centre of the grey cross and the centre of the confrontational avatar, and the co-ordinate positions of the cubes in the Unity environment were used to calculate the distance between them. The distance calculated was then divided by 3.4 to figure out the real world distance of 46cm, of which when referring back to proxemics, would mean the participant is just in the intimate zone (up to 45.7cm) as the distance does not include the front half of the avatar. The manual measurement with the Vive Controllers and the tape measure resulted in a distance very similar to the distance calculated using Unity co-ordinates. With the distance calculated, the distance between the television and the participant was taped on the floor, with a clear white cross to indicate where the participant was to stand (as demonstrated in Figure 5.3), and the distance between the participant's and the confrontational avatar in both conditions was normalised.

# Chapter 5

# Experiments

## 5.1 Procedure of Experiment

### 5.1.1 Pilot Study

A pilot study was conducted previous to the start of recruitment to finalise the experimental procedure. The pilot study provided an opportunity for colleagues to test out the application and comment on the procedure of the experiment. The feedback of the pilot study included fixes to the script that was to be read to all participants, identifying issues with the application that resulted in final fixes and tweaks as well as final corrections in the forms given to participants.

### 5.1.2 Participants and Recruitment

The study involved sixty eight participants, of which twenty six were female and forty two were male. Of the sixty eight participants that successfully completed the experiment, thirty four completed the VR condition and thirty four completed the 2D condition. With regards to the sex of participants, thirteen females completed the VR condition and thirteen females completed the 2D condition. Twenty one males completed the VR condition, and twenty one males completed the 2D condition. Participants were recruited through personal contact and word of mouth, and a majority were students and staff at the University of Lincoln. The age of participants ranged from eighteen to fifty three, where the mean age is 23.8 years and the standard deviation is 6.35.

A power analysis was conducted using the G*Power application (as shown in Figure 5.1) to help estimate a sufficient number of participants. In line with the study design, we estimated numbers for independent means t-test, using an alpha value of 0.5, power of 0.8, and large effect size (0.8) to compute a minimum number of 26 per condition. Based on this estimate, we determined that 30-40 participants would be sufficient to detect a moderate to large effect size. Recruitment was stopped when we achieved a total of 34 participants per condition.

Participants were screened at the start of the experiment, where participants had to complete a Medical Screening Form. In this form, participants were asked questions to screen for the following:

- Epilepsy.
- Uncorrected visionary issues (such as tunnel vision).
- Pregnancy.
- Conditions related to mobility that could cause unduly injury by bumping into objects, people or falling on the floor.
- Any condition that may affect ability to use virtual reality equipment.

Any participant found to have any of the listed conditions would be informed that they were not able to participate in the study.

### 5.1.3 Assignment and Anonymisation

As participants applied and booked a time to take part, they were assigned a randomised three character ID. This randomised ID was then written on each document that was provided to every participant. The purpose of the randomised ID and anonymisation is to provide each participant with an ID that is specific to them but hard to guess by other individuals, allowing for a unique identifier for each set of collected data. This also helps contribute to data security helping to ensure no one can access other participant's data and that the data does not allow any individual to be identifiable. The individual ID allows participants to retract their participation in the study if they so chose to.

At first the participants were alternately assigned, but as more experiments were completed it was evident that the gender split for each condition was starting to become uneven. The ratio of male to female continued to increase in favour of male participants, and the split of condition for each gender was becoming uneven as well. It was decided at this point that a focus would be on trying to recruit female participants over male participants to try and equalise the gender ratio, as well as assigning each experiment to equalise number of participant's completing each condition.

### 5.1.4 Pre-Experiment Briefing, Training and Questionnaires

Every participant was briefed at the start of the experiment from a script (to reduce deviation of the experimental process) that included information regarding the format of the experiment that they were to participate in and the participants rights regarding the study and the data that was to be taken. Once the participants had signed the consent form, the participant was then asked to fill out a demographics questionnaire - that gave an indication of how much experience each participant had with virtual reality. Once the demographics questionnaire was completed, a background information form (from the ITC-SOPI) was passed to the participant to collect a range of information from them; including the participant's experience with computers, television and virtual reality. Once the background information form was completed, the participant were passed the full forty questions of the State-Trait Anxiety Inventory (twenty questions measuring state anxiety and the following twenty questions that measure trait anxiety). Once the STAI was completed, the participants were instructed that they would be completing the first twenty questions (measuring state anxiety) again immediately after the experiment and that following the completion of the STAI State questions that the participants would then be completing both Part A and Part B of the ITC - Sense of Presence Inventory. When all documents and questionnaires were completed by the participant, they would then be walked through information regarding the equipment to be used. For the virtual reality condition participants, they were then read statements explaining the School of Computer Science's Health and Safety Guidelines with regards to use of the virtual reality equipment. Once the statements were read to the participant, they were introduced to a virtual environment (SteamVR Home) using the equipment and given the opportunity to explore the setting which had the purpose of allowing the participant to get accustomed to using the virtual reality equipment and being in a virtual environment. Once the participant had stated they were ready to move onto the next step of the experiment, the virtual reality equipment was removed from the participant and the participant was then briefed with more information regarding what they were expected to do during the experiment as well as being told that they were to role-play a betting shop employee during the experiment, but could not interact with the avatar in the environment. The participant was reminded that their task was to observe the avatar in the scene and make mental notes of the behaviours that they were to witness. At this stage, participants of the 2D condition were also reminded their task in the experiment and the fact that they were to role-play as a betting shop employee but could not interact with the avatar. When the participants were ready to start the experiment, they were instructed to stand on the taped white cross on the floor (one of two crosses taped on the floor of the experiment space for the specific condition they were to take part in) and participants in the virtual reality condition were helped with getting set up with the VR equipment and bluetooth headphones. At this point, the participants were ready to start the experiment.

### 5.1.5 Experiment

Once the experiment was started, each participant was asked if they were able to hear sound through the Bluetooth headphones and as the participant confirmed they were able to hear the sound through the headphones, the researcher conducting the experiment would remove themselves from the study area. During the experiment, the researcher would observe the participant to take note if there were any irregularities during the experiment. The researcher would also observe the monitors to observe when the experiment was complete so they could inform the participant and then help remove the equipment from the participant. As the equipment was removed from the participant, the researcher would then usher the participant back to a desk to fill out the post experiment questionnaires.

### 5.1.6 Post-Experiment Questionnaires and Semi-Structured Interview

As soon as the experiment was complete, participants in both conditions were swiftly ushered to complete the first twenty questions of the State-Trait Anxiety Inventory, of which measures the self-reported level of State Anxiety the participant was experiencing at the end of the experiment. Once the State-Trait Anxiety Inventory State questions were completed, the participant was then asked to complete both Part A and Part B of the ITC - Sense of Presence Inventory (ITC-SOPI) which measures Spatial Presence, Engagement, Ecological Validity / Naturalness and Negative Effects. As soon as the participant had completed both questionnaires, they were informed that the next stage would be an audio recorded semi-structured interview. Previous to the experiment, the participants were informed that they were to make mental notes of the behaviours of the avatar in the experiment, of which would then be discussed in the interview after the experiment. Although the participants were asked this, to help ensure they would focus on the avatar in the scene, the questions asked allowed for the opportunity to discuss what they saw and how it made them feel. The following questions were asked to every participant after they finished the experiment and questionnaires:

1. How did the experiment make you feel?
2. Did you think that the avatar was believable? Yes / No / Partially
3. Why did you think that?
4. Is there anything you believe would make the character more believable?

All interviews with participants had the audio recorded on an iPhone 8, and then transferred off and stored on the University's OneDrive to adhere with Data Protection Regulations. Every interview was transcribed post study. When the interview with the participant was over, a debrief was given to the participant; including an explanation to the purpose of the study and providing some contact information in the case that a participant wanted to withdraw data.

## 5.2 Experimental Equipment and Set-Up

### 5.2.1 Virtual Reality Condition

The virtual reality (VR) condition was run on a Computer equipped with an Intel i5-6500 Processor running at 3.20GHz, a NVIDIA GTX 970 Graphics Card and 16GB of RAM running Windows 10, of which was used to operate the HTC VIVE Pro. The VIVE Pro accommodates a resolution of 1440 x 1600 pixels per eye, a Field of View (FoV) of 110 degrees and a refresh rate of 90 Hz. Although the VIVE Pro headset includes headphones attached, a pair of Sennheiser HD 4.40 BT bluetooth headphones would be used along side a Mpow Bluetooth 4.0 USB Dongle Adapter to provide an audio experience more suited for the experiment, as well as to ensure that the participants in both conditions were exposed to audio of the same quality. The participant was also handed two VIVE Controllers that would represent the participant's virtual hands in the experiment. A white cross was taped to the floor to represent to the participant where they were to stand at the start of the experiment, and a grey cross was placed on the floor in the virtual environment, synced to where the white cross is placed in the real world. The experimental set-up for the virtual reality condition is demonstrated in Figure 5.2.

### 5.2.2 2D Condition

The 2D condition was run on a Computer equipped with an Intel i7-4470 Processor running at 3.40GHz, a NVIDIA GeForce GTX 1050 Ti Graphics Card and 16GB of RAM and was also running Windows 10. The Computer was connected to a Sony 55" BRAVIA Professional 4K Colour LED Display Television (Model Number FW - 55XD8501) via a HDMI cable, to display to the participant of the 2D condition a first person view. The TV had a resolution of 4096 by 2160 and a refresh rate of 60 Hz. Equal to the VR condition, audio was transferred via bluetooth to a pair of Sennheiser HD 4.40 BT bluetooth headphones using the same Mpow Bluetooth 4.0 USB Dongle Adapter. Also equal to the VR condition, a white cross was taped in front of the Television as to indicate to the participant where they are to stand during the experiment; as mentioned previously, this distance is specific to normalise the distance between the avatar and the participant. The experimental set-up for the 2D condition is demonstrated in Figure 5.3.

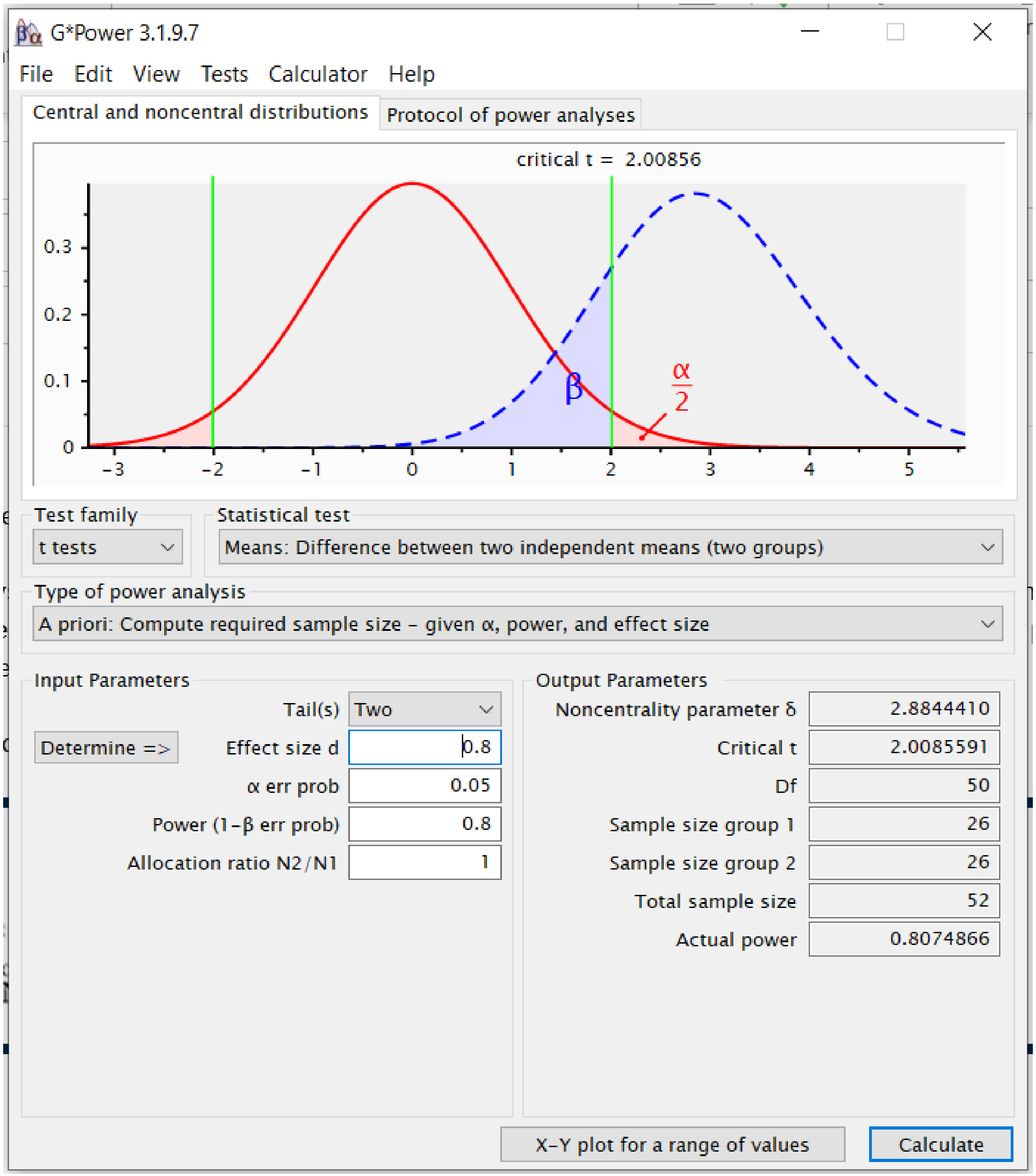


Figure 5.1: Power Analysis conducted in G*Power.

Figure 5.2: Set-up of virtual reality condition, with participant standing on white cross.

Figure 5.3: Set-up of 2D condition, with participant standing on white cross.

# Chapter 6

# Results and Analysis

## 6.1 Results

A two-way mixed ANOVA was used to measure the effect that the confrontational avatar has on participant's state anxiety (the deep-ended variable, measured pre and post experiment) based on the condition participant's were placed in (VR or 2D). Three of the 2D participant's were excluded from the results due to their pre-experiment state anxiety scores being more than three standard deviations from the mean, as identified with box-plots. Being exposed to the simulation of the confrontational avatar in the betting shop had a statistically significant main effect on participant's state anxiety, F(1,63) = 130.46, $P < 0.001$, Partial $\eta^2$ 0.67, regardless of the technological medium (2D or VR) the participant was exposed to. This supports *H2* that participants will experience an increased sense of anxiety after exposure to the confrontational avatar in both groups. The two-way mixed ANOVA also concludes that the effect of exposure to the simulation of the confrontational avatar has on change in state anxiety (stress) is different on the two mediums, F(1,63) = 15.18, $P = 0.001$, Partial $\eta^2$ 0.19, with participants in the VR condition experiencing a greater change in state anxiety compared to participants in the 2D condition. This is visualised in Figure 6.1. These results support *H3* that participants in the VR group will experience a larger increase in state anxiety than the 2D display group, and also *H2* that participants in both conditions will experience an increase in state anxiety.

Regarding presence and the results of the ITC - Sense of Presence Inventory, the

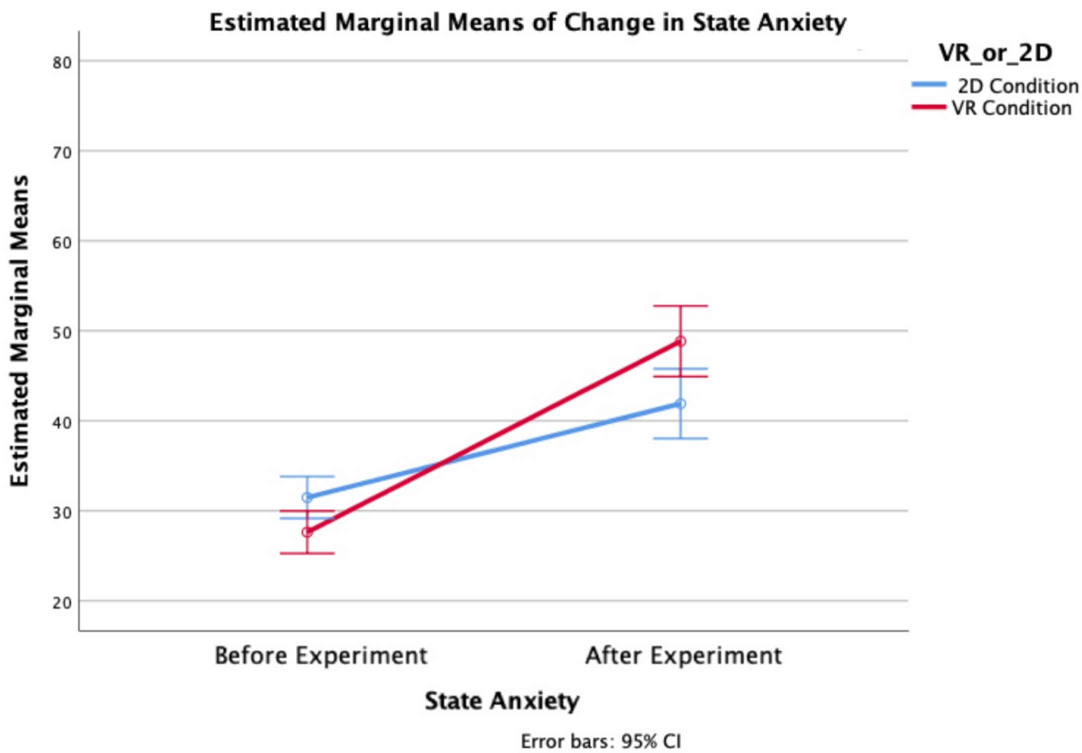


Figure 6.1: Chart of Estimated Marginal Means of Change in State Anxiety.

Independent Samples Test used to investigate the difference between two independent means shows that the mean level of Spatial Presence in the VR condition was higher (M = 3.78, SD = 0.50) than in the 2D condition (M = 2.52, SD = 0.65), and this difference was statistically significant $T(63) = -8.78$, $P < 0.001$. The mean level of Engagement was higher in the VR condition (M = 3.70, SD = 0.57) than in the 2D condition (M = 3.10, SD = 0.61), and this difference was statistically significant $T(63) = -4.10$, $P < 0.001$. The mean level of Ecological Validity was higher in the VR condition (M = 4.13, SD = 0.49) than in the 2D condition (M = 3.19, SD = 0.63), and this difference was statistically significant, $T(63) = -6.67$, $P < 0.001$. Finally, the mean level of Negative Effects was higher in the VR condition (M = 1.65, SD = 0.49) than the 2D condition (M = 1.63, SD = 0.66), but this difference was not statistically significant, $T(63) = -0.17$, $P = 0.87$. Spatial Presence, Engagement and Ecological Validity were all significantly higher in the VR condition of which supports *H1*. Although there was an insignificant difference, VR participants reported a higher mean level of Negative Effects of which also supports *H1*. The mean differences of the ITC-SOPI sub scales between the technology mediums are visualised in Figure 6.2.

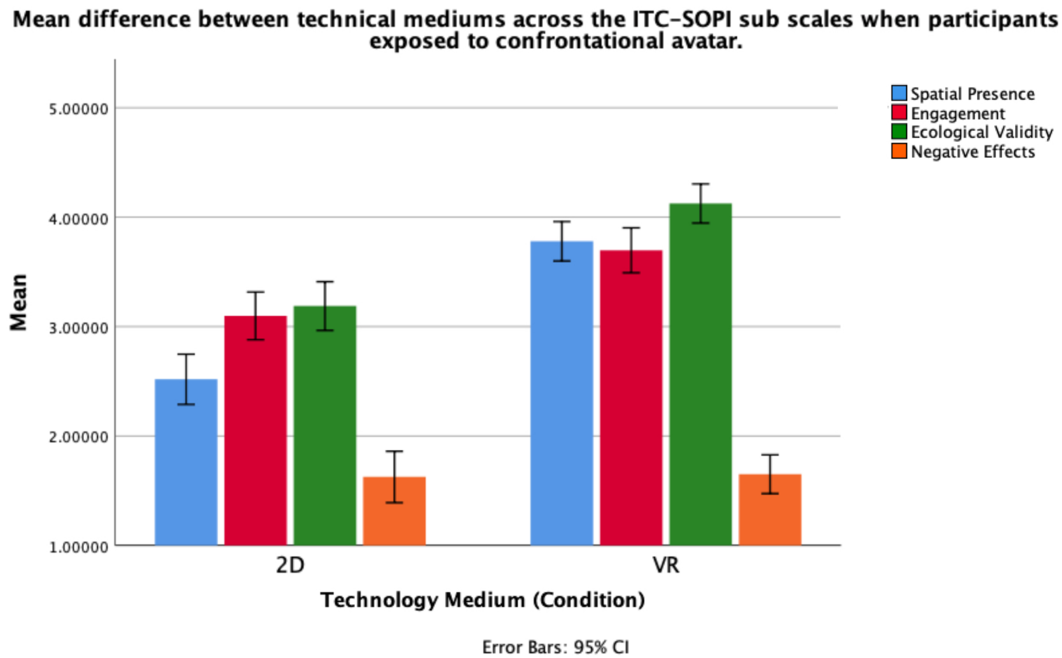


Figure 6.2: Chart of Mean differences between the technological mediums across the ITC-SOPI sub-scales when participants are exposed to confrontational avatar.

As stated in Section 5.1.4, participants in both conditions were provided a demographics questionnaire of which gave an indication of the amount of virtual reality experience each participant had. The demographics questionnaire concluded that 30 out of the 34 2D participants had previous VR experience, of which 30 declared they they used virtual reality occasionally or more. 31 out of the 34 VR participants had previous VR experience, of which 29 out of the 31 declared that they used virtual reality occasionally or more. This suggests that the novelty effect of virtual reality is not affecting the results collected from this experiment.

Each participant in both conditions were interviewed after the exposure to the confrontational avatar. Every participant was asked if they considered the confrontational avatar believable. For the 2D condition, 16/34 participants stated the confrontational avatar was believable, 17/34 participants thought the avatar was partially believable and 1 of the 34 participants did not consider the avatar was believable. Alternatively, for the VR condition, 24 out of the 34 participants that took part declared that they did consider the confrontational avatar was believable, against the remaining 10 out of the 34 participants who believed the avatar was partially believable. These numbers indicate that more of the virtual reality participants considered the confrontational avatar to be believable compared to participants of the 2D condition.

### 6.1.1 Change in State Anxiety.

The results of the study show that participants in both conditions experienced an increase in state anxiety, but participants in the virtual reality condition experienced a greater increase in state anxiety supporting *H3*. Figure 6.1 shows that before the experiment, the mean score of state anxiety for participants in both conditions were almost identical. The graph also displays the difference of the means scores of state anxiety between the two conditions post experiment, where participants completing the VR condition experienced a greater mean state anxiety than the participants in the 2D condition, supporting *H3*.

Participants were interviewed post experiment and asked how the experiment made them feel. When taking into consideration how stressed the confrontational avatar made the participant feel, the responses for 2D participants were varied; ranging from one participant who stated *"I don't think it particularly made me feel anything"* to a more anxious response where another participant stated *"I am going to say anxious. I have been in similar situations, not in a betting shop but where I have seen that kind of body language – and the body language on the animation I suppose – it was very clear about the escalation of the aggression in him"*. Other responses from 2D participants show that there was a change in how participants felt throughout the experiment, where one participant explains *"in earlier stages I felt a lot less uncomfortable, like particularly when he was getting angry at the machine. The first time I myself felt particularly uncomfortable was when he started looking in my direction. And then it amped up a lot when he started walking towards me and getting visibly distressed by it."*. Overall, the participant responses to the first question for the 2D condition suggested that the confrontational avatar had the ability to induce stress as per what Figure 6.1 shows, but compared to the responses of the participants in the virtual reality condition, not to a greater amount of increased feeling of state anxiety, supporting both *H2* and *H3*.

Participants who were exposed to the confrontational avatar in virtual reality responded to the first question with a range of answers, but interestingly, stronger language was used to describe the experience felt by the VR participants. In one example, a participant answers the first question asked with *"Uhh it made me feel anxious, uhm I was aware of the surroundings. Uhh it made me feel tense, as I was being approached. And, I was concerned for the person within the experience. Uhhm I and I felt that I didn't want to be there. Uhh and to get out as quickly as I possibly could, or get behind the table."*, which suggests the strength of intensity of the stress felt by the participant by the stated desire to hide / protect themselves from the confrontational avatar. Several other VR participants acknowledged they felt scared during the experience, again suggesting the higher levels of stress they were experiencing, where another participant stated *"it felt like the whole time was waiting for something to happen"*; that they expected something bad to happen during the experience also suggesting the higher levels of stress the participant was experiencing. Another example from a participant who specified they were *"Quite worried because that's a realistic scenario that could happen. And it felt really real when you were in it – I think I like stepped back slightly when he first came up – which yeah quite odd but that can happen with just a game – certainly wouldn't if you were just doing it on like a computer or something"* of which suggested a physical response by the participant to the confrontational avatar approaching them by stepping away from the aggressor. Going back to Hall's concept of proxemics, what was observed and recorded from the participant in this example could be a reaction to the avatar invading the participant's intimate zone of which would be expected to invoke physiological responses as per recorded in Llobera et al's study (see Llobera et al., 2010).

The comments from participants in both the 2D and VR conditions are backed by the quantitative results shown in Figure 6.1, that participants in the 2D condition did feel an increase of state anxiety, but not as much an increase as participants in the VR condition, thus supporting *Hypothesis 2* and *Hypothesis 3*. The original hypothesis that participants in the virtual reality condition will feel a greater sense of presence and therefore will have a greater change of state anxiety is shown to be true, with presence to be discussed in the next section.

### 6.1.2 Presence.

Figure 6.1 shows that participants in the VR condition experience a greater change in state anxiety than participants in the 2D condition. Considering the hypothesis *H1*, and Figure 6.2 of which shows the means of the four sub scales of the ITC - Sense of Presence Inventory for participants in both conditions, it is found that participants in the VR condition experience a significantly higher sense of spatial presence, thus supporting *Hypothesis 1*. This is backed up by comments from participants in both conditions. For example, two participants who completed the 2D condition stated *"I wasn't fully immersed so I knew it wasn't, like I couldn't be harmed in the sense."*, and *"It didn't really make me feel anything – it's just kind of – I was stood in front of the TV. And I didn't feel like I was in it - I was just watching TV"*. Both of these quotes suggest the participants involved had a reduced sense of presence, and when compared to comments from VR participants, of which one of the participants felt *"Like I was actually there."*, it is understandable that Figure 6.2 shows a higher sense of spatial presence in favour of the VR condition. Similar to the change of state anxiety, there were examples of some participants who did not report hypothesised responses. Interestingly, one 2D participant said *"it made me feel a little bit 'taken-a-back' when the guy was in your face. Uhhmm, kinda had to look away a little bit cause I was so close to the screen – he felt a bit close to me. So I looked to the side a little bit. I wasn't directly having that eye contact with the avatar's face."*. This participant reports that they reacted in such a way as if to suggest the avatar caused a response by invading the personal / intimate zones when considering proxemics; that potentially the participant felt present enough for physical responses to the avatar invading their intimate zone to have occurred. This suggests that participants in the 2D condition still had a sense of presence, of which is backed up by the mean value of spatial presence reported by the 2D condition participants of 2.64 (out of 5).

Although it is shown in Figure 6.2 that there is a significantly increased feeling of spatial presence reported by participants of the virtual reality condition, the comments from participants in both conditions stating what features potentially helped to break presence could explain why even with the significantly increased sense of spatial presence reported in the VR condition, the mean value of 3.74 is not closer to the maximum value of 5. Our results also back up the suggestion by Diemer et al. that participants exposed to a virtual reality scenario that elicits emotional response will have a stronger reported sense of presence (see Diemer et al., 2015).

Post experiment, participants were asked if there was anything to make the confrontational more believable. This question provided the opportunity for participants in both conditions to specify features of the avatar they thought needed to be improved, providing insight into what features of the avatar potentially contributed to a break in presence. What became apparent is that many of the participants on both conditions commented on the animations of the avatar. Participants commented on the animations and graphics of the face and head, with comments such as *"No lateral neck movement"* and *"his mouth moving weren't quite in sync"*, with other participants commenting on the appearance of the body with comments like *"He looked far too skinny – err and also moustache twindling and the way he walked was a bit wonky – other than that he was believable"*. These comments from participants in both conditions show the importance of ensuring that the fidelity of an application is as high as possible is important; animations need to look realistic and not 'buggy', and the visuals must be as photo-realistic as possible. Several participants commented on the graphics, with responses to the final question asked to them including *"Errm, the scene in general possibly. Higher resolution graphics – more details that kind of thing – other than that I think it's fantastic – very accurate"*, suggesting the visuals of the applications prevented the participants from feeling as present as they potentially could have, similar to how participant's felt in the study by Slater et al. (see Slater, Rovira et al., 2013).

During the development of the application, as stated previously the application focused on ensuring that the virtual environment and confrontational avatar was as believable as possible. This was to ensure the level of plausibility illusion experienced by participants was as high as possible. Slater et al. concluded that graphical issues and features of the agent developed in their study (such as lack of lip-sync animations) contributed to the reduction in plausibility illusion reported by participants in their experiment. (See Slater, Rovira et al., 2013). In our study, we aimed to mitigate this reduction in plausibility illusion reported by implementing facial animations and lip-sync, as well as focusing on ensuring the behaviours and motion of the confrontational avatar was as realistic as possible. The comments from the participants vary, with some participants identified previously suggesting we were successful in mitigating the risk of reduction of plausibility illusion experienced by participants in Slater et al.'s experiment. Although, as evident by other comments by participants, there is still work to be done. Future developments investigating participant response to avatars should focus on ensuring the graphics of the avatar are higher quality and appear more photo-realistic than the model developed in this experiment. Extra consideration should also be directed at ensuring the animations / motion capture are as smooth and not 'buggy' as possible to ensure plausibility illusion remains high.

### 6.1.3 Was it believable?

As discussed in the literature review, an application that has a purpose to replicate real life scenarios needs to ensure that it is as believable as possible, in terms of both fidelity (how much the virtual environment emulates the real world) and how realistic the actions and scenarios presented are. One of the studies discussed in the literature review emphasises the importance of ensuring that an avatar and the virtual environment it is present in is as close to real life as possible. The study by Slater et al. concludes that the "credibility" of the scenario in their experiment needed to be improved, with participants of that study commenting on the fact that features of the environment and the avatar was not plausible; commenting on the view that the environment did not look like a London Pub for example. (see Slater, Rovira et al., 2013). From the start of the development, there was a focus on ensuring that the application, the environment and confrontational avatar was as believable as possible with the equipment and technical skills of the researcher that were available.

Post experiment, participants were asked to fill out the ITC - Sense of Presence

Inventory of which one of the sub scales the questionnaire measure is Ecological Validity; where the sub scale measures how close the participant would feel if they were exposed to the same stimuli in real life. Figure 6.2 shows a mean score of 4.11 out of 5 for the virtual reality condition, of which is significantly higher than a mean score of 3.34 out of 5 for the 2D condition. These scores show that participants in the virtual reality condition felt as if the scenario and environment caused them to react closer to as they would do in a real-life scenario than participants of the 2D condition. This is supported by comments recorded from participants on both sides in the post experiment interview. One VR participant comments on the graphics and environment by stating *"I think the character was perfectly believable. The graphics were probably 90 per cent of the way to being perfect – but I think the actual character and what it was there to represent was pretty much spot on to what I have seen in many shops."*. Furthermore, another VR participant responds to the first question asked with *"I used to work in that environment and it was very very realistic. So it took me back and as a former referee I am used to that level of confrontation – but it – a little bit shocked, a little bit nervous."*. These comments from participants of the VR condition suggest that we were able to produce an avatar and scenario that could be considered believable and associated with aggressive behaviour conducted by individuals found in betting shops. Other comments from participants in both conditions back up the previous discussion that an application with reduced technical glitches, and improved graphics on both the environment and the avatar would help to make the character (and scenario) more believable.

After the experiment, the participants in both conditions were interviewed and asked if they considered the confrontational avatar believable, of which the results of that question are present in Section 6.1. It is proposed that the majority of participants in both conditions considered the avatar to be believable as the behaviours and actions shown are generalisable to the real world. There were minimal responses that suggested that participants have been previously exposed to such behaviour in real life in betting shops, yet a majority of participants considered the actions of the confrontational avatar to be believable. Perhaps the actions demonstrated by the confrontational avatar are comparable with other common scenarios where confrontation and aggression is prevalent, such as pub and club environments. This suggests that this proposed approach of training staff in betting shop environments could be transferable to other industries and professions where employees have to effectively deal with confrontational customers.

Interestingly, participants from both conditions mention throughout the interviews other ways they think would make the application more believable or realistic. One 2D participant suggested that making the avatar appear more drunk in behaviour could have made the avatar more believable as *"alcohol obviously makes people act like that more – so I think that would add to it"*. Another 2D participant answers the final question with *"I was just thinking maybe more like physiological things, so like having a bit of sweating – a bit of getting red or errm kind of wiping his brow or errm kind of – I don't know like really clasping like his wrists or punching his hand or something a bit more – rather than just punching the screen"*. Furthermore, a VR participant states *"Errrm well I suppose it depends on how big a reaction you're trying to get from your subjects – there are other sort of physiological er changes in his behaviour that you could add in short of actual physical assault – like making himself look bigger with his arms out and things like that"*. These comments suggest that improvements to behavioural animations and appearances would help make the avatar more believable. Furthermore, similar to responses in Slater et al's study (see Slater, Rovira et al., 2013), participants in both conditions commented on the introduction of more interaction between the participant and the avatar, with one participant stating the following as an improvement to how believable the avatar is: *"Yeah, I think that is the only thing having some level of response mechanisms so that the avatar can respond to the users – if not voice recognition then certain movement like him falling backwards."*. This introduction of greater interactivity in the application has the potential to improve how believable the scenario is to participants, where having the avatar respond to voice or movements will potentially help the participant feel as if they are talking to a real individual, rather than being just an observer. One VR participant goes on to further state that *"by taking the pressure off your, your subjects by telling them that they can not interact er it removes from them all the er added responsibility and fear and nervousness that comes with* *that. Errm if you told your subjects that they had to make a choice of which when you know they couldn't handle any more they would sort of push the avatar away or something like that – err you would have errm that extra load on your subjects that would create an additional depth of nervousness and reaction – particularly – I mean they're a member of staff – they're there to keep the place safe errm and by saying to your subjects you're not to do anything – you can't interact, you're taking a big load off"*. This comment suggest that not having the responsibility expected of a member of staff working in a betting shop potentially takes away some of the stress the participant could of experienced, of which this would be interesting to test further.

As discussed previously, similar studies have faced issues with how believable the avatar and scenario is having an effect on the responses participants provide. From the start of development, the realism and how believable the scenario is was a priority. The involvement of Dr Adrian Parke, an expert in Gambling Behavior and aggression, creating the scenario and continuously providing feedback, along with having Dr Andrew Westerside, an academic and practitioner from the School of Fine and Performing Arts, playing the part of the confrontational avatar whilst being motion captured resulted in a believable avatar that was successful in causing an increase of state anxiety in participants. This is backed up by the results of the ITC-SOPI showing the high levels of Ecological Validity reported, especially in the VR condition backing up the conclusion that the scenario was believable, albeit with a number of flaws of which has been reported previously.

The consideration of proxemics was also important in this study, to ensure that participants in both studies had a normalised distance away from the confrontational avatar and that the avatar did not appear 'massive' as reported in Section 4.7. This process of ensuring the avatar appeared equal distance away from the participants in both conditions is one that we have found no other study had considered in this context, specifically confrontational avatars and comparing the anxiety they induce between virtual reality and a 2D display. This consideration of proxemics, and the method to ensure a normalised distance between the confrontational avatar and participant in both conditions is unique and help produce an avatar that was perceived as believable in both conditions.

Much of the focus of the development was ensuring that the confrontational avatar and the virtual environment was as believable as possible, and the results of the ITC-SOPI sub-scales for Spatial Presence and Ecological Validity along with comments from participants in both conditions suggest we were successful in producing an environment and confrontational avatar that was believable, albeit with some flaws as identified previously.

## 6.2 Discussion

### 6.2.1 Implications on Training.

The study that was conducted yielded results that show that virtual reality as a medium elicits a greater change of state anxiety (stress) whilst maintaining a higher level of spatial presence, ecological validity and engagement compared to the 2D medium. These results show that virtual reality technology has the potential to elicit emotional responses to a stressful stimuli close to that of which someone who experiences the same stimuli in real life would feel, as shown by the ecological validity results. Due to the relatively high levels of ecological validity in the VR condition, it suggests there is a case to use VR technology as a training tool for betting shop staff to use to help teach the staff to successfully identify potential aggressors before they start to act aggressively and to provide experiential training so the staff are able successfully train to de-escalate aggressive situations and / or protect themselves and other members of public from confrontational customers.

What also proved interesting was the results of the negative effects sub scale. The insignificant difference of the the negative effects sub scale show that although the participants feel more present in the VR condition, there is not an increase in negative effects compared to the 2D condition. There is no difference to the negative effects the participant feels between the two conditions, and so according to the results of this study there is no further risk of experiencing negative effects such as dizziness, tiredness, disoriented etc. when compared to using the 2D medium.

With these points in mind, and the high level of mean spatial presence and ecological validity reported by participants in the VR condition, the investigation of virtual reality technology as a medium to provide experiential training to betting shop staff is recommended. Further work could be commenced (of which will be discussed in more detail in Section 6.2.4), knowing that participants have a strong sense of spatial presence and ecological validity compared to the 2D medium which opens up the possibility to produce a functional virtual reality application that has a purpose to train betting shop staff on how to deal with confrontational customers.

### 6.2.2 Inter-disciplinary Workflow.

During the development of the methodology and application that was produced for the study, an inter-disciplinary workflow was undertaken. This inter-disciplinary workflow began at the start of this project, with initial meetings with Dr Adrian Parke from the School of Psychology to discuss aggressive incidents in betting shops to motion capture being recorded in the School of Sports and Exercise Science featuring performances from Dr Andrew Westerside from the School of Fine and Performing Arts. This workflow spanned until the creation of the application that was used in the study. The workflow was conducted as we recognised that we in Computer Science did not have the skills and expertise required to produce all assets needed for the application, and so we mitigated this by inviting experts from other disciplines to provide the expertise needed.

The main benefit of this workflow was the production of a believable and realistic confrontational avatar. Without the expert advice from Dr Adrian Parke, in the form of continuous feedback on the production of the confrontational avatar and the creation of a script that contained a believable scenario story line, the avatar would not have behaved in such a manner that was comparable with real world incidents in betting shops. Furthermore, without the support from Dr Franky Mulloy and the technician team of the School of Sports and Exercise Science, a method of which to capture real world movements and behaviours from our actor would not have been possible, of which would of most likely resulted in inadequate animations that would have had to been hand-animated or stitched together using pre-existing animations. The motion capture helped produce animations that were considered realistic and believable by participants in both conditions, and although there were some glitches with the motion captured animations, the resulting animations were bespoke and able to contribute to elicit stress in the participants. Finally, the involvement of Dr Andrew Westerside as the actor brought all the pieces together; a well written script and scenario had an experienced actor to perform the confrontational avatar using motion capture equipment. Organising a time that all parties were available to complete a motion capture session was the biggest disadvantage of the inter-disciplinary workflow, and did contribute to the development of the application taking longer than expected.

The continuous involvement from Dr Adrian Parke and Dr Andrew Westerside proved invaluable; where having input from our Actor proved beneficial. The method to involve a professional actor was also conducted by Slater et al. (see Slater, Rovira et al., 2013), although it is not mentioned if they involved the actors in the production outside of the performing. Dr Westerside was involved with the production of confrontational avatar, with contribution more than just performing; Dr Westerside was involved with the research team in reviewing each iteration of the motion capture after it was applied to the confrontational avatar model. The regular feedback from our actor helped drive the production process of the confrontational avatar.

The inter-disciplinary team that worked together to produce the confrontational avatar was successful in producing a believable and realistic scenario, that received a lot of praise from participants in both conditions. This team addressed issues other researchers have faced in similar research projects, to ensure the confrontational avatar produced would be well suited for the experiment conducted.

### 6.2.3 Limitations.

Although the results of the study supported the original hypotheses, there were some limitations to the research design and the believablility of the confrontational avatar and virtual environment the participants were exposed to. Regarding the application participants were exposed to, it was mentioned by some participants in both conditions that the graphics of the confrontational avatar affected perceptions of believability, where other participants suggested that improved graphics and animations would have increased the experience and believability of the experiment (as discussed in Section 6.1.3), with comments from participants such as *"Errrm I guess like some of the movements seemed a bit like more like jolty than like in real life – like it didn't seem as fluid slightly – that was it"* and *"Higher resolution graphics – more details that kind of thing – other than that I think it's fantastic – very accurate"* as a response to the final question asked in the post-experiment interview. Referring back to the discussion of fidelity in Section 2.2, previous research explains the importance of ensuring character models are as life-like as possible, and to have any feature of an avatar that does not represent real world people (such as graphical issues pointed out by participants of this study) risk affecting Place Illusion and Plausibility Illusion, which could result in a reduction of the feeling of presence. This was a limitation, and so it would be suggested that in future work the use of higher graphical quality models would benefit the outcomes of future experiments.

The use of motion capture itself can be argued as a limitation as well. Although motion capture provided the bespoke animations that were successful in producing an affective response in the participants, it limited the interaction the participants experienced. Participants were instructed to remain in the same spot, on the cross, and not to move from that point throughout the experiment. This was so that the participant could experience the confrontational avatar as it was designed; where if the participant moved from the cross, the animation would play as it has been developed and the confrontational avatar would perform his aggressive behaviour toward empty space. The participants had to remain in the same position, so that the motion capture would work as intended, resulting in a more scripted and controlled experience which limited how interactive the experience was. The participants were also unable to speak or communicate with the avatar either verbally or physically, of which would limit the plausibility of the scenario similarly to the results of the study conducted by Slater et al. where the researchers conclude that "the plausibility of the experience would be greatly improved through more interactivity". (Slater, Rovira et al., 2013). A method of which to incorporate the realistic behaviours recorded with motion capture and allow interactive actions to occur (such as physical and verbal communication of which had realistic responses) would be recommended for future work to allow for an application that will potentially facilitate higher levels of plausibility illusion.

Finally, the length of the sequence was suggested to be too short, with comments from participants such as *"..and the experience being longer but it was really really good I think"* and *"Errr perhaps an end to the story – but I think that it was to shock the player at that point and not to finish a story"*. With the overall experience being just under three minutes, the exposure to the confrontational avatar could have been longer. Although this poses questions itself and would need to be investigated; would people become accustomed to the experience in a longer scenario and would that have an effect on participant's results? Would the longer experience be less effective if the participants became accustomed to the scenario?

### 6.2.4 Future Work.

The results of this study show that virtual reality as a technology medium elicits a greater change in state anxiety (stress) due to facilitating a greater sense of presence compared to 2D technology. In this study, looking at how participants react to a confrontational avatar in a betting shop, we show that virtual reality is better suited to elicit real responses to confrontational customers, opening up potential for future work on the development of a virtual reality training application to help betting shop staff prepare for incidents involving confrontational customers. This future application will need to consider points discussed in Section 2.5, where experiential training is explored. The training application would need to be successful in transferring knowledge to it's users and so the application would also need to consider concepts such as pedagogy, and a methodology that correctly investigates if participants are able to learn from the training provided and successfully recall said training. The training application will need to successfully impart current training information provided to workers of betting shops and if produced effectively could potentially bring the benefits to betting shop workers as mentioned in the literature review, such as an effective training solution that is able to train workers how to efficiently deal with confrontational customers without having to hire actors / spaces for de-escelation training (of which could potentially benefit betting shops financially and logistically). Other benefits of this proposed training application include the use of "scenario scaffolding", previously mentioned in the literature review is used in a study by Carlson and Caporusso, of which could be used to create multiple scenarios for betting shop workers to train with by re-using scenario dynamics and environments. (See Carlson and Caporusso, 2018). A realistic virtual reality training application that is successful in imparting training knowledge as well as the feelings of anxiety that betting shop workers face when dealing with confrontational customers could potentially become an effective training solution to betting shop employees that assists with dealing with confrontational customers.

# Chapter 7

# Conclusions

This thesis presents our study that investigated how participants react to confrontational avatars in virtual reality and 2D display conditions, focusing on the state anxiety and presence reported by the participants who completed the experiment. An application was produced with a focus on ensuring a high level of believability. An inter-disciplinary team was assembled to produce a confrontational avatar using motion capture technology; from an expert in aggression in gambling writing the scenario script, to a practitioner from the School of Fine and Performing Arts acting out the confrontational avatar whilst being motion captured, the process to create a believable and realistic avatar was in depth to avoid issues faced by researchers in other studies investigating confrontational avatars. Additionally, a method of which to ensure that the distance between the confrontational avatar in both conditions was normalised was completed; a consideration not present in the limited related studies comparing virtual reality and 2D display technology.

The results of the study conclude that participants in both conditions reported a significant increase in state anxiety from baseline values recorded with the State-Trait Anxiety Inventory, but participants in the virtual reality condition experienced a significantly greater increase in state anxiety compared to participants in the 2D condition when exposed to a confrontational avatar in a virtual betting shop environment. The study also investigated the self-reported feeling of presence by participants in both virtual reality and 2D display conditions and concludes that participants in the virtual reality condition reported a higher score on all sub-scales of the ITC - Sense of Presence Inventory (with significant increases in the Spatial Presence, Engagement and Ecological Validity sub-scales) compared to participants in the 2D display condition. Based on the results of the experiment, we can propose that virtual reality is better suited as a technology medium to be used as a training solution to assist betting shop workers with training to effectively deal with confrontational customers.

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# Appendix

## Medical Screening Form

Participant ID:

# Medical Screening Form

We operate this study according to the University of Lincoln School of Computer Science Health and Safety Guidelines for Virtual Reality (VR) equipment. However, before you take part, it is important to determine whether you have any conditions which might impair your ability to use the VR equipment safely or otherwise pose harm to your person.

Please circle either ‘yes’ of ‘no’ to answer the following questions. If you need any help of wish to ask for further clarification, please ask:

| | |
|---|---|
| Do you suffer from Epilepsy, or a similar condition which may be triggered by flashing lights of visual stimulus? | **YES/NO** |
| Do you suffer from any significant uncorrected problems with your vision, such as tunnel vision? (this excludes the requirement for glasses or contact lenses). | **YES/NO** |
| Are you pregnant? | **YES/NO** |
| Do you suffer from any conditions (e.g. related to mobility) which could cause you to be unduly injured by bumping into objects, or people, of by falling to the floor? | **YES/NO** |
| Do you suffer from any other condition which you think might affect your ability to use the VR? | **YES/NO** |

Please do ask if you would like to discuss anything relating to these questions.

## Demographics Questionnaire

Participant ID:

Demographics Questionnaire

Please take some time to complete this Demographics Questionnaire to help us understand your experience with Virtual Reality. Please don't hesitate to ask if you would like to discuss anything relating to these questions.

Q1: Have you used Virtual Reality before? Please Circle. YES / NO

Q2: If YES, how often? Please Circle.

Never / Occasionally (one or twice a month) / Often but less than 50% of days / 50% or more of days / Every day.

## State-Trait Anxiety Inventory

**SELF-EVALUATION QUESTIONNAIRE** STAI Form Y-1
**Please provide the following information:**

Name________________________________________Date_____________S_____

Age__________________ Gender (*Circle*) **M** **F** T_____

**DIRECTIONS:**

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

| | NOT AT ALL | SOMEWHAT | MODERATELY SO | VERY MUCH SO |
|---|---|---|---|---|
| 1. I feel calm | 1 | 2 | 3 | 4 |
| 2. I feel secure | 1 | 2 | 3 | 4 |
| 3. I am tense | 1 | 2 | 3 | 4 |
| 4. I feel strained | 1 | 2 | 3 | 4 |
| 5. I feel at ease | 1 | 2 | 3 | 4 |
| 6. I feel upset | 1 | 2 | 3 | 4 |
| 7. I am presently worrying over possible misfortunes | 1 | 2 | 3 | 4 |
| 8. I feel satisfied | 1 | 2 | 3 | 4 |
| 9. I feel frightened | 1 | 2 | 3 | 4 |
| 10. I feel comfortable | 1 | 2 | 3 | 4 |
| 11. I feel self-confident | 1 | 2 | 3 | 4 |
| 12. I feel nervous | 1 | 2 | 3 | 4 |
| 13. I am jittery | 1 | 2 | 3 | 4 |
| 14. I feel indecisive | 1 | 2 | 3 | 4 |
| 15. I am relaxed | 1 | 2 | 3 | 4 |
| 16. I feel content | 1 | 2 | 3 | 4 |
| 17. I am worried | 1 | 2 | 3 | 4 |
| 18. I feel confused | 1 | 2 | 3 | 4 |
| 19. I feel steady | 1 | 2 | 3 | 4 |
| 20. I feel pleasant | 1 | 2 | 3 | 4 |

**SELF-EVALUATION QUESTIONNAIRE**

**STAI Form Y-2**

Name________________________________________________Date________

**DIRECTIONS**

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel.

| | ALMOST NEVER | SOMETIMES | OFTEN | ALMOST ALWAYS |
|---|---|---|---|---|
| 21. I feel pleasant | 1 | 2 | 3 | 4 |
| 22. I feel nervous and restless | 1 | 2 | 3 | 4 |
| 23. I feel satisfied with myself | 1 | 2 | 3 | 4 |
| 24. I wish I could be as happy as others seem to be | 1 | 2 | 3 | 4 |
| 25. I feel like a failure | 1 | 2 | 3 | 4 |
| 26. I feel rested | 1 | 2 | 3 | 4 |
| 27. I am "calm, cool, and collected" | 1 | 2 | 3 | 4 |
| 28. I feel that difficulties are piling up so that I cannot overcome them | 1 | 2 | 3 | 4 |
| 29. I worry too much over something that really doesn't matter | 1 | 2 | 3 | 4 |
| 30. I am happy | 1 | 2 | 3 | 4 |
| 31. I have disturbing thoughts | 1 | 2 | 3 | 4 |
| 32. I lack self-confidence | 1 | 2 | 3 | 4 |
| 33. I feel secure | 1 | 2 | 3 | 4 |
| 34. I make decisions easily | 1 | 2 | 3 | 4 |
| 35. I feel inadequate | 1 | 2 | 3 | 4 |
| 36. I am content | 1 | 2 | 3 | 4 |
| 37. Some unimportant thought runs through my mind and bothers me | 1 | 2 | 3 | 4 |
| 38. I take disappointments so keenly that I can't put them out of my mind | 1 | 2 | 3 | 4 |
| 39. I am a steady person | 1 | 2 | 3 | 4 |
| 40. I get in a state of tension or turmoil as I think over my recent concerns and interests | 1 | 2 | 3 | 4 |



## ITC - Sense of Presence Inventory

# BACKGROUND INFORMATION

**Age:** ............. ____________years **Sex:**............ Male ☐ Female ☐

**Occupation:**.... ________________ **Nationality:** . ____________________

**Rate your level of computer experience** (tick one)**:**
- None.......................................................... ☐
- Basic .......................................................... ☐
- Intermediate ................................................ ☐
- Expert.......................................................... ☐

**Rate how often you play computer games** (tick one)**:**
- Never .......................................................... ☐
- Occasionally (once or twice/month) ........ ☐
- Often but less than 50% of days.............. ☐
- 50% or more of days .............................. ☐
- Every day..................................................... ☐

**Rate your average <u>weekly</u> TV viewing** (tick one)**:**
- 0-8 hours ...................................................... ☐
- 9-16 hours .................................................... ☐
- 17-24 hours .................................................. ☐
- 25-32 hours .................................................. ☐
- 33-40 hours .................................................. ☐
- 41 hours or more.......................................... ☐

**Education** (tick <u>highest</u> qualification achieved)**:**
- None ................................. .................. ☐
- CSE/O-level/GCSEs (or equivalent)........ ☐
- A-level (or equivalent) ............................ ☐
- City & Guilds ........................................... ☐
- Diploma...................................................... ☐
- Degree ....................................................... ☐
- Professional qualification........................ ☐

**What is the TV size you watch the most?** (tick one)**:**
- Small/portable (14'' or less) ......................... ☐
- Medium (15-28'') ......................................... ☐
- Large (more than 28'')................................. ☐

**How would you rate your level of TV/film production knowledge?** (tick one)**:**
- None .......................................................... ☐
- Basic.......................................................... ☐
- Intermediate............................................... ☐
- Expert ........................................................ ☐

**Have you viewed stereoscopic (3D) images using polarised glasses (e.g. IMAX 3D) before?**

Yes ☐ No ☐

**Have you used an experimental virtual reality system before (beyond a consumer computer/arcade game)?**

Yes ☐ No ☐

**How would you rate your <u>knowledge</u> of how 3D images are produced?** (tick one)**:**
- None.......................................................... ☐
- Basic .......................................................... ☐
- Intermediate ................................................ ☐
- Expert.......................................................... ☐

**How would you rate your <u>knowledge</u> of virtual reality (i.e. how it works)?** (tick one)**:**
- None .......................................................... ☐
- Basic.......................................................... ☐
- Intermediate............................................... ☐
- Expert ........................................................ ☐

**Code** (researcher use only)**:** _______

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## PART A

**Please indicate HOW MUCH YOU AGREE OR DISAGREE with each of the following statements by circling just ONE of the numbers using the 5-point scale below.**

| (Strongly disagree) | (Disagree) | (Neither agree nor disagree) | (Agree) | (Strongly agree) |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

---

**<u>AFTER</u> MY EXPERIENCE OF THE DISPLAYED ENVIRONMENT…**

1. I felt sad that my experience was over ......................................................1 2 3 4 5
2. I felt disorientated.......................................................................................1 2 3 4 5
3. I had a sense that I had returned from a journey........................................1 2 3 4 5
4. I would have liked the experience to continue ..........................................1 2 3 4 5
5. I vividly remember some parts of the experience......................................1 2 3 4 5
6. I'd recommend the experience to my friends. ...........................................1 2 3 4 5

## PART B

**Please indicate HOW MUCH YOU AGREE OR DISAGREE with each of the following statements by circling just ONE of the numbers using the 5-point scale below.**

| (Strongly disagree) | (Disagree) | (Neither agree nor disagree) | (Agree) | (Strongly agree) |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

---

**<u>DURING</u> MY EXPERIENCE OF THE DISPLAYED ENVIRONMENT…**

| | | | | | |
|---|---|---|---|---|---|
| 1. I felt myself being 'drawn in'. | 1 | 2 | 3 | 4 | 5 |
| 2. I felt involved (in the displayed environment). | 1 | 2 | 3 | 4 | 5 |
| 3. I lost track of time. | 1 | 2 | 3 | 4 | 5 |
| 4. I felt I could interact with the displayed environment | 1 | 2 | 3 | 4 | 5 |
| 5. The displayed environment seemed natural. | 1 | 2 | 3 | 4 | 5 |
| 6. It felt like the content was 'live'. | 1 | 2 | 3 | 4 | 5 |
| 7. I felt that the characters and/or objects could almost touch me. | 1 | 2 | 3 | 4 | 5 |
| 8. I enjoyed myself. | 1 | 2 | 3 | 4 | 5 |
| 9. I felt I was visiting the places in the displayed environment | 1 | 2 | 3 | 4 | 5 |
| 10. I felt tired. | 1 | 2 | 3 | 4 | 5 |

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| (Strongly disagree) | (Disagree) | (Neither agree nor disagree) | (Agree) | (Strongly agree) |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

---

**<u>DURING</u> MY EXPERIENCE OF THE DISPLAYED ENVIRONMENT…**

11. The content seemed believable to me........................................................1 2 3 4 5

12. I felt I wasn't *just* watching something. .....................................................1 2 3 4 5

13. I had the sensation that I moved in response to parts of the displayed environment ..................................................................................................1 2 3 4 5

14. I felt dizzy. ...................................................................................................1 2 3 4 5

15. I felt that the displayed environment was part of the real world. ...............1 2 3 4 5

16. My experience was intense. ........................................................................1 2 3 4 5

17. I paid more attention to the displayed environment than I did to my own thoughts (e.g., personal preoccupations, daydreams etc.). .................1 2 3 4 5

18. I had a sense of being in the scenes displayed...........................................1 2 3 4 5

19. I felt that I could move objects (in the displayed environment). ................1 2 3 4 5

20. The scenes depicted could really occur in the real world...........................1 2 3 4 5

21. I felt I had eyestrain. ...................................................................................1 2 3 4 5

22. I could almost smell different features of the displayed environment. ......1 2 3 4 5

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| (Strongly disagree) | (Disagree) | (Neither agree nor disagree) | (Agree) | (Strongly agree) |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

**<u>DURING</u> MY EXPERIENCE OF THE DISPLAYED ENVIRONMENT…**

| | | | | | |
|---|---|---|---|---|---|
| 23. I had the sensation that the characters were aware of me. | 1 | 2 | 3 | 4 | 5 |
| 24. I had a strong sense of sounds coming from different directions within the displayed environment | 1 | 2 | 3 | 4 | 5 |
| 25. I felt surrounded by the displayed environment | 1 | 2 | 3 | 4 | 5 |
| 26. I felt nauseous. | 1 | 2 | 3 | 4 | 5 |
| 27. I had a strong sense that the characters and objects were solid | 1 | 2 | 3 | 4 | 5 |
| 28. I felt I could have reached out and touched things (in the displayed environment). | 1 | 2 | 3 | 4 | 5 |
| 29. I sensed that the temperature changed to match the scenes in the displayed environment. | 1 | 2 | 3 | 4 | 5 |
| 30. I responded emotionally | 1 | 2 | 3 | 4 | 5 |
| 31. I felt that *all* my senses were stimulated at the same time. | 1 | 2 | 3 | 4 | 5 |
| 32. The content appealed to me. | 1 | 2 | 3 | 4 | 5 |
| 33. I felt able to change the course of events in the displayed environment. | 1 | 2 | 3 | 4 | 5 |

| (Strongly disagree) | (Disagree) | (Neither agree nor disagree) | (Agree) | (Strongly agree) |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

**<u>DURING</u> MY EXPERIENCE OF THE DISPLAYED ENVIRONMENT…**

| | | | | | |
|---|---|---|---|---|---|
| 34. I felt as though I was in the same space as the characters and/or objects... | 1 | 2 | 3 | 4 | 5 |
| 35. I had the sensation that parts of the displayed environment (e.g. characters or objects)were responding to me. .................................... | 1 | 2 | 3 | 4 | 5 |
| 36. It felt realistic to move things in the displayed environment..................... | 1 | 2 | 3 | 4 | 5 |
| 37. I felt I had a headache…............................................................................. | 1 | 2 | 3 | 4 | 5 |
| 38. I felt as though I was participating in the displayed environment…........... | 1 | 2 | 3 | 4 | 5 |

<u>If there is anything else you would like to add, please use the space below:</u>

**<u>PLEASE CHECK THAT YOU HAVE ANSWERED ALL THE QUESTIONS</u>**

**<u>THANK YOU VERY MUCH FOR YOUR TIME AND PARTICIPATION</u>**

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## Participant Brief Form

**Participant Information Sheet – Study 1**
**(Draft Version 7 / Final version 1.0: 11/10/2019)**

UNIVERSITY OF LINCOLN

**Title of Study:** Confrontational behaviour in virtual reality: a study of user response.
**Name of Researcher(s):** Arthur Jones
**Contact Details of the Researcher(s) are given at the end.**

Ethics Reference: 2019-Feb-0239

We'd like to invite you to take part in our research study. Joining the study is entirely up to you, before you decide we would like you to understand why the research is being done and what it would involve for you. One of our team will go through this information sheet with you, to help you decide whether or not you would like to take part and answer any questions you may have. We'd suggest this should take about 45 minutes.

**What is the purpose of the study?**

This project aims to investigate the use of Virtual Reality and 2D Technology as a medium for invoking emotional reactions to confrontational avatars. This particular study is investigating how individuals emotionally react to specific scenarios in Virtual Reality and 2D technologies and investigates the level of presence the participants feel.

The study will be conducted on campus in accordance to the School of Computer Science Health and Safety guidelines on the use of Virtual Reality.

**Why have I been invited?**

You are being invited to take part because you are above the age of 18. We are inviting 96 participants and would like you to take part. There are no benefits to you in taking part, other than to contribute to the outcomes of the project.

**Do I have to take part?**

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason. This would not affect your legal rights.

**What will happen to me if I take part?**

As the participant, you will be expected to be involved with this study for around 45 mins on one agreed date. Before the experiment, you will be asked to complete a questionnaire. During the study, you will be asked to complete one experiment. It will either be a Virtual Reality experiment or will be the same scenario, but completed on a 2D set-up. Half of the participants will complete the 2D Video set-up and half the Virtual Reality set-up. During the experiment, you will be asked to observe the behaviours and actions of confrontational behaviour performed by an avatar. After the completion of each experience of the application in 2D or VR, you will be asked to complete a number of questionnaires. Audio recording equipment will be used to record the participant's answers in a post experiment semi-structured interview.

**Will my taking part in the study be kept confidential?**

All data collected from you during this study (including video and audio recordings) will be stored digitally in a secure location approved by the University of Lincoln for this purpose. It will be stored semi-anonymously; labelled using a unique identifying number. Which links your number to your name will be held digitally in a separate location, so we can identify your data if (and only if) you later decide to withdraw from the study. All of your data will be destroyed after a period of 5 years from completion of the study.

**Privacy notice**

The University of Lincoln is the lead organisation for this study. The university's Research Participant Privacy notice https://ethics.lincoln.ac.uk/research-privacy-notice/ will explain how we will be using information from you in order to undertake this study and will be the data controller for this study. This means that we are responsible for looking after your information and using it properly.

We will keep identifiable information about you for 5 years from completion of the study.

**What will happen if I don't want to carry on with the study?**

Your participation is voluntary and you are free to withdraw at any time, without giving any reason, and without your legal rights being affected. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally-identifiable information possible.

**What will happen to the results of the research study?**

The results will be published in the final submission required for the Masters of Computer Science by Research.

Anonymised results from the ITC-SOPI Questionnaire will be shared with researchers at Goldsmiths University.

**Who is organising and funding the research?**

This research is being organised by the University of Lincoln.

**What if there is a problem?**

If you have a concern about any aspect of this study, you should ask to speak to the researchers who will do their best to answer your questions. The researchers contact details are given at the end of this information sheet. If you remain unhappy and wish to complain formally, you can do this by contacting ethics@lincoln.ac.uk.

If you feel that we have let you down in relation to your information rights then please contact the Information Compliance team by email on compliance@lincoln.ac.uk or by post at Information Compliance, Secretariat, University of Lincoln, Brayford Pool, Lincoln, LN6 7TS.

You can also make complaints directly to the Information Commissioner's Office (ICO). The ICO is the independent authority upholding information rights for the UK. Their website is ico.org.uk and their telephone helpline number is 0303 123 1113.

**Further information and contact details**


Primary Researcher: Arthur Jones; 14537186@students.lincoln.ac.uk

Primary Supervisor: Wayne Christian; wchristian@lincoln.ac.uk




## Participant Debrief Form

**Participant Debrief Sheet**
**(Draft Version 4 / Final version 1.0: 17/01/19)**

UNIVERSITY OF LINCOLN

**Title of Study:** Confrontational behaviour in virtual reality: a study of user response.
**Name of Researcher(s):** Arthur Jones

**Contact Details of the Researcher(s) are given at the end.**

We'd like to thank you for taking part in our research study. This research will provide crucial information and broaden our understanding of how individuals react to confrontational behaviour in a Virtual Reality and a 2D Video.

**What was the aim of the study?**

The data we have collected will indicate how participants emotionally react to confrontational individuals in these two experiences. The data collected will help to determine if the use of Virtual Reality will invoke higher emotional reaction over the use of traditional 2D Video Experience training or not, to allow for recommendations that could be used in the development of Virtual Reality training applications of which aim to train individuals on dealing with confrontational customers.

**Questions and withdrawing**
If you have any further questions about the study, please feel free to ask the researcher before you finish or alternatively contact the researcher or their supervisor at any time on 14537186@students.lincoln.ac.uk. If you wish to withdraw your data please also contact the researcher or supervisor on 14537186@students.lincoln.ac.uk with your unique participant number. In cases where your participation was anonymous please contact ethics@lincoln.ac.uk with your unique participant number. Please note you will only be able to withdraw up until the point of data analysis.

**Further help and support**
If you have any ethical concerns regarding the current research, your treatment as a participant or your involvement in the study please feel free to contact ethics@lincoln.ac.uk.

If you have been affected by any of the issues raised by taking part in this study the following organisations may be able to provide help and advice:

**Student Wellbeing**: Email – studentwellbeing@lincoln.ac.uk

Phone – 01522 886400

**Samaritans Support Line**: 116 123

**Police Victim Support Line**: 08 08 16 89 111

Confrontational behaviour in virtual reality: a study of user response. Debrief Sheet Draft 4
Version 1.0 17/01/19

## Study / Instructions Script

# Study Script - VR vs 2D

Study Resources

- Forms
  - Participant Information Sheet.
  - Consent Form.
  - Medical Form.
- Training
  - How to use the HTC Vive.
  - Discussion of what the participant is to do in the experiment.
- Questionnaires
  - Demographics Questionnaire.
  - 2 x STAI State.
  - 1 x STAI Trait.
  - 1 x ITC-SOPI.

Important Notes

**Recruitment**: Participants should be over the age of 18, not pregnant, not susceptible to bumps and falls and have uncorrected vision issues.

**Independent Variables should be altered:** Odd numbered participants should be exposed to the confrontational avatar in Virtual Reality, where as even numbered participants should be exposed to the confrontational avatar using the 2D Interactive set-up.

**Observations and procedures:** Participants using the vive should be observed and told to remain on the determined cross. Participants using the 2D set-up should be told to remain on the determined cross.

Full Study Script

The conductor of the experiment should take extra care to follow this script accurately.

**Introduction**

"Welcome, and thank you for participating in this study. My name is [conductor name] and I will be running this study with you today. Firstly, we will run through some information about the study and what you will be expected to do. Please feel free to ask questions at any point"

*FOR VR PARTICIPANTS*

"This study makes use of the HTC Vive, to immerse you into a Virtual Reality environment. I will walk you through how to use the HTC Vive in a little while, but first, I need to ensure that you do not have any medical conditions that may affect your ability to use the equipment. Therefore, can I ask you to read and fill out this form?"

*HAND **MEDICAL FORM** TO PARTICIPANT* - "Feel free to ask any questions regarding the form".

*PARTICIPANT COMPLETES MEDICAL FORM*

***IF THE PARTICIPANT ANSWERS YES TO ANYTHING*** - "I am sorry to inform you that since you have indicated that you have a condition that might affect your ability to participate, we will not be able to run this study with you today, but thank you for your time!".

*FOR 2D PARTICIPANTS*

"This study makes use a computer and monitor to immerse you into an environment. I will walk you through how to use the equipment in a little while, but first, I need to ensure that you do not have any medical conditions that may affect your ability to use the equipment. Therefore, can I ask you to read and fill out this form?"

*HAND **MEDICAL FORM** TO PARTICIPANT* - "Feel free to ask any questions regarding the form".

*PARTICIPANT COMPLETES MEDICAL FORM*

***IF THE PARTICIPANT ANSWERS YES TO ANYTHING*** - "I am sorry to inform you that since you have indicated that you have a condition that might affect your ability to participate, we will not be able to run this study with you today, but thank you for your time!".

**Consent**

"In order to participate in this study, I need to gain your informed consent as I need to ensure that you understand what is going to happen in this study and that you agree and consent to participation, The following information sheet details your rights regarding the study, the data we wish to collect, how the data will be used and stored etc."

*HAND **PARTICIPANT INFORMATION SHEET** TO PARTICIPANT" - "Please read this Participant Information Sheet, and if you have any questions at all, please don't hesitate to ask."

*WAIT FOR PARTICIPANT TO READ PARTICIPANT INFORMATION SHEET*

*ONCE PARTICIPANT HAS READ AND SIGNED, READ THE FOLLOWING TO THE PARTICIPANT:*

"May I draw your attention to the section of the Participant Information Sheet that explains what will happen to you. It states "During the experiment, you will be asked to observe the behaviours and actions of confrontational behaviour performed by an avatar". Due to the nature of the study, I have to read out and draw your attention to that section, and check with you that you are still happy to partake. Are you still happy to be involved with the study?"

IF YES, CONTINUE, IF NO - "Thank you for your time".

"Now, please look at and read this consent form if you wish to participate".

*PROVIDE **CONSENT FORM** AND A PEN, PARTICIPANT SIGNS THE FORM*

"Thank you. I will now give you a quick run down of what you will be doing. You will first fill out a number of questionnaires, of which I will go into more detail of why you are completing them when I hand them to you. Once these questionnaires have been completed, you will begin the experiment. Once the experiment is completed, you will fill out some more questionnaires and the study will finish with a post semi-structured interview."

*PROVIDE **DEMOGRAPHICS QUESTIONNAIRE** TO PARTICIPANT*

"Can you please fill out this Demographics Questionnaire, which will allow us to understand your experience with Virtual Reality."

*PROVIDE **BACKGROUND INFORMATION** SECTION OF **ITC-SOPI** TO PARTICIPANT*

**STAI State and Trait Anxiety Sub-scales.**

"Before we proceed, could you please complete this questionnaire which allows us to collect information from you regarding how you are feeling at this moment and generally in terms of anxiety. You will be completing the STAIT questions at the end of the Study."

*PROVIDES PARTICIPANT **THE STAI*** - "Thank you".

**Training and Set-up**

*FOR VR PARTICIPANTS*

"For the experiment that you will be partaking in today, you will be immersed into a Virtual Reality environment and your task will be to keep watch of the virtual characters and make a mental note of the behaviours you witness of which we will discuss after the experiment in the debrief."

“Before we can achieve this, we will go over how the Virtual Reality Headset works. Today we are using the HTC Vive, of which tracks your head movements using the two light boxes you can see, to create a play space where you move in, When you walk towards the edge of the play space, a light blue grid will appear. You should not see this as during the experiment, as you will need to remain in the same spot (the grey cross on the floor).”

“The Headset will go on your head. You can tighten it by adjusting the wheel at the back of the Headset, as demonstrated here”

“If at any point you begin to feel dizzy, or ill, please let me know and we will stop the study. Is that okay?” *WAIT FOR RESPONSE*.

“I will also talk to you about the wire connected to the Vive headset. There is a potential that the cable may become wrapped around yourself during the experiment. If that happens, carefully spin in the opposite direction to untangle yourself. If you are unable to untangle yourself, let me know and we will stop the experiment.”

“I will be outside of the play area during the experiment.”

*DEMONSTRATE TIGHTENING MECHANISMS*

“We will now put the Headset on and introduce you to a Virtual Reality Environment”

*HELP PARTICIPANT WITH HEADSET, START LOADING SCREEN*

“Now you are in a Virtual Reality Environment, feel free to walk around and look around for a couple of minutes, ensuring you walk to the edge of the play space to be shown the blue grid. Please also take note of your body in VR also.”

*AFTER 2 Mins, ASK THE PARTICIPANT TO TAKE HEADSET OFF AND DIRECT TO STARTING CROSS*

“We are now ready to start the experiment”

*FOR 2D PARTICIPANTS*

"For the experiment you will be partaking in today, you will be immersed into a 2D interactive environment and your task will be to keep watch of the virtual characters and make a mental note of the behaviours you witness of which we will discuss after the experiment in the debrief interview. We also ask you to stay standing on the White Cross located in front of the Television, and ask you not to move from that spot."

"Before we can achieve this, you will need to know how the set-up works. The application is running off a PC. When the application is started, you will see a first person view appear on the Television.

"We are ready to start the experiment"

**Experiment**

"So, now you know what you have to do in the experiment, and you are all set-up to start, I will now ask you to start the experiment. Once the experiment is complete, I will ask you to complete two questionnaires, and will interview you on the experiment, where we will discuss the observations you have made on the avatars in the virtual environment."

"During the experiment, you will be role-playing as a Betting Shop employee, who's responsibility includes to ensure that the customers are observed and looked after. You will not be able to interact with the avatar, but as discussed previously, you will need to observe and make mental notes of the behaviours and actions that you will witness".

"Any questions?"

"If you are ready to start, we can now begin. Once you are immersed into the environment, I will not communicate with you until you have completed the experiment."

"If you are ready, please step onto the cross, and put the headphones on [and headset if VR]. You will first be immersed into an environment that will allow you to get use to the controls and movement, then after a couple of minutes, you will be immersed into the study environment; the Betting Shop."

*FOR VR PARTICIPANTS*

“We ask you to observe your virtual body as soon as the experiment starts. Once you have observed your virtual body, please then proceed to focus on the task asked of which is to observe and make mental notes of the behaviours of the confrontational avatar”

*ENSURE SET UP IS COMPLETE FOR VR / 2D, ENSURE HEADPHONES ARE ON PARTICIPANT*

*LOAD UP BASELINE ENVIRONMENT*

*OBSERVE PARTICIPANT DURING EXPERIMENT*

“Well done, you have completed the experiment. Now could you please complete the **State Anxiety sub scale** questionnaire, and then once you have finished that, the **ITC-SOPI** questionnaire.”

*WAIT FOR PARTICIPANT TO FINISH QUESTIONNAIRES”

“Thank you for finishing those questionnaires. We will now finish with an interview”.

*CONDUCT INTERVIEW QUESTIONS*

Q1. How did the experiment make you feel? (Open ended question)

Q2. Did you think that the avatar was believable? YES / NO / PARTIALLY.

Q3. Why did you think that? (Open ended question)

Q4. Is there anything that you believe would make the character more believable in your opinion? (Open ended question).

Thank you for answering those questions for me. There is one last thing I will ask you. This concerns social media. Have you before taking part in this experiment saw any material related to this experiment on the Twitter Social Media platform?

YES - Thank you for taking part in the study, unfortunately I will be unable to use your data.

NO - Thank you for answering that.

**Conclusion**

“Thank you very much for taking the time to participate in this study. You can keep the information sheet which outlines what the study was all about and provides some contact information which you can use to retract your data from the process should you see any reason to”

*PROVIDE INFORMATION SHEET* “Before you leave, would you like to provide me with any feedback or ask me any questions about your participation in today’s study?”

“Is there any comments you would like to add regarding the study?”

*WAIT FOR PARTICIPANT TO LEAVE*

*ADD PARTICIPANT ID TO ALL FORMS*

*STORE PHYSICAL FORMS BOTH CONSENT AND QUESTIONNAIRES SEPARATELY*

*SCAN AND STORE DIGITAL COPIES OF PARTICIPANT FORMS*

*WRITE CONDITION ON QUESTIONNAIRES (I.E VR or 2D).*