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BAHÇEŞEHİR UNIVERSITY

BODY OWNERSHIP ILLUSION FOR PROMOTING EMAPTHY-RELATED ABILITIES IN VIRTUAL REALITY: A CASE STUDY

Master's Thesis

ECE KARAHAN

İSTANBUL, 2020

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Thesis Advisor: ASSOC. PROF. DR. BARBAROS BOSTAN

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GAME DESIGN GRADUATE PROGRAM

Name of the thesis: Body Ownership Illusion for Promoting Empathy-Related Abilities in Virtual Reality: A Case Study
Name/Last Name of the Student: Ece Karahan
Date of the Defense of Thesis: 23 June 2020

The thesis has been approved by the Graduate School of _____.

Assoc. Dr. Burak KÜNTAY
Institute Director
Signature

I certify that this thesis meets all the requirements as a thesis for the degree of Master of Arts.

Asst. Prof. Güven ÇATAK
Program Coordinator
Signature

This is to certify that we have read this thesis and we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Arts.

Examining Comittee Members	Signature
Thesis Supervisor Assoc. Prof. Dr. Barbaros BOSTAN	----------
Member Asst. Prof. Çetin TÜKER	----------
Member Asst. Prof. Güven ÇATAK	----------

ACKNOWLEDGEMENTS

This thesis comes true as required with kind support and help of many people. I would like to present my sincere thanks to all of them.

First of all, the summer research internship opportunity I had with The Center for Research and Interdisciplinarity (CRI) in Paris was a great chance for me; which I have so many experiences and opportunity that I personally believe that will bring me lifelong learning and professional development while fostering my personal growth. Therefore, it has been pleasured for me that I was provided with an opportunity to be part of this research internship. I am also quite grateful for having a chance to meet so many wonderful people and professionals from various fields throughout this internship period.

Besides, I would like to express my deeply gratitude to Philippe Bertrand, investigator of BeAnotherLab for taking part in useful decision and giving necessary advices and guidance. Without his kind direction and proper guidance, this project would not have been become reality.

In addition, I would like to express my special gratitude and thanks to Jessica Talley Sagot, life sciences education and technology writer, editor & mentor for imparting her knowledge and advices in this project. In every phase of the project, her supervision and guidance shaped this project to be completed perfectly.

I would also like to express my special gratitude and thanks to Assoc. Prof. Dr. Barbaros Bostan for providing me his constant guidance and regular suggestion as a thesis supervisor throughout my thesis work.

My thanks and appreciations also go to my colleagues; JingYi Liao, Jonathan Kings, Melisande Brie McLaughlin, Subramanian Ramvijji and people who willingly helped me out with their knowledge and advices.

İstanbul, May 2020 Ece KARAHAN

ABSTRACT

BODY OWNERSHIP ILLUSION FOR PROMOTING EMPATHY-RELATED ABILITIES IN VIRTUAL REALITY: A CASE STUDY

Ece Karahan

Game Design Master Program

Thesis Supervisor: Assoc. Prof. Dr. Barbaros BOSTAN

June 2020, 47 pages

Empathy plays crucial role on developing positive interaction between individuals that promotes prosocial behaviours by getting them to experience any situation from another person's perspective. In this regard, the great potential of virtual reality enabling individuals to interactively experience any circumstances and actions by taking part in from the perspective of someone else using a perceptual illusion of body ownership called embodiment put VR in a unique position as an efficient perspective-taking medium; differently from traditional media.

In the consideration of scientific researches conducted on this field, this article proposes to introduce the EVR systems and methods of our VRPT experience called *Behind Her Eyes*, in which aim to evaluate the perception of the sense of presence in virtual reality and the impacts of the feeling of being in the body of another person toward the empathy-related behaviours of individuals. This review offers design and implementation strategies for integrating VR techniques and concepts by bringing a perspective to promote understanding on how to use VR for training empathy-related abilities. The post-experiment interviews about the experiential process of participants who performed the imagine self-perspective taking task showed that they feel more empathetic and connected to the avatar.

Keywords: Virtual Reality Perspective-taking Task, Embodied Virtual Reality, Body Ownership Illusion, Empathy-Related Abilities

ÖZET

SANAL GERÇEKLİKTE EMPATİYLE İLİŞKİLİ YETENEKLERİN GELİŞTİRİLMESİNDE BEDEN SAHİPLİĞİ YANILSAMASI: DURUM İNCELEMESİ

Ece Karahan

Oyun Tasarımı Yüksek Lisans Programı

Tez Danışmanı: Doç. Dr. Barbaros BOSTAN

Haziran 2020, 47 sayfa

Empati, herhangi bir durumu başka bir kişinin bakış açısıyla deneyimlemelerini sağlayarak, bireyler arasında sosyal davranışları teşvik eden pozitif etkileşim geliştirmede önemli bir rol oynamaktadır. Bu bağlamda, beden sahipliği yanılsaması yoluyla bireylerin başka bir kişinin bakış açısına katılarak, onlara herhangi bir koşul ve eylemi interaktif bir biçimde deneyimlemelerini sağlaması bakımından sahip olduğu potansiyel, sanal gerçekliği geleneksel medyadan farklı olarak, etkili bir perspektif alma aracı kılarak onu özel bir konuma getirmektedir.

Bu makale, bu alanda yapılan bilimsel araştırmalar göz önünde bulundurularak, somutlaşmış sanal gerçeklik teknolojisi sistemlerini ve sanal gerçeklikteki varlık hissinin algılanmasını ve başka bir kişinin bedeninde olma hissinin, bireylerin empatiyle ilişkili davranışları üzerindeki etkilerini değerlendirmeyi amaçlayan *Behind Her Eyes* adlı sanal gerçeklik perspektif alma deneyimimizin yöntemlerini tanıtmayı amaçlamaktadır. Bu inceleme, sanal gerçekliğin empati ile ilgili yeteneklerin eğitimi için nasıl kullanılacağına dair bir bakış açısı getirerek, sanal gerçeklik teknikleri ve kavramlarının entegrasyonu üzerine tasarım ve uygulama stratejileri sunmaktadır. Sanal gerçeklikte perspektif alma deneyimini gerçekleştiren katılımcılarla deneyimledikleri süreç hakkında deneyim sonrasında yapılan görüşmeler, onların daha empatik ve kişiyi simgeleyen dijital görüntüye daha bağlanmış olduklarını göstermiştir.

Anahtar Kelimeler: Sanal Gerçeklik Perspektif Alma Görevi, Somutlaştırılmış Sanal Gerçeklik, Beden Sahipliği Yanılsaması, Empatiyle İlişkili Yetenekler

TABLE OF CONTENTS

FIGURES

ABBREVIATIONS

CCTV	:	Closed-circuit Television
EVR	:	Embodied Virtual Reality
HMD	:	Head-Mounted Display
IVE	:	Immersive Virtual Environment
IVR	:	Immersive Virtual Reality
MS	:	Mental Simulation
PI	:	Place Illusion
PSI	:	Plausibility Illusion
VR	:	Virtual Reality
VRPT	:	Virtual Reality Perspective-taking

1. INTRODUCTION

Empathy refers to the ability of viewing the world from the perspective of someone else consisting on emotional reaction upon this perspective and the feelings of concerning others (Davis 1983). The attitudes of individual can be powerfully affected by imagining oneself in different situations through different attitudes (Petrova & Cialdini 2008). The beneficial social interaction among individuals can be elicited with the perceptual and behavioural processes related to the empathy (Preston & De Wall 2002). Recent studies (Blanke et al. 2016; Eisenberg & Miller 1987) indicate that understanding and motivating prosocial behaviours, socially adequate behaviours and social adaptation can be resulted in the higher level of empathy. Taking into account all of these significance and positive impacts on the social interactions; researches, artists and technology development companies have been working on developing innovative methods to promote empathy through various types of empathy interventions.

Many comprehensive studies (Ahn et al. 2013; Batson et al. 2009; Batson et al. 1997; Batson et al. 1988) conducted on this field have indicated that imagining oneself from their perspective can be effective way in order to promote empathy-related abilities and prosocial behaviours. The ability of VR for eliciting presence; which refers to the subjective feeling of the users related to be inside VE, provides users to deeply understand the perspectives of others than their own (De la Peña *et al.* 2010). From this point of view, virtual reality was described as ''*the ultimate empathy machine*'' by Mike Chris; as he explained in his Ted Talk (2015) that:[1]

> *"You're sitting on the same ground as [Sidra]. And because of that, you feel her humanity in a deeper way. You empathise with her in a deeper way. I think that we can change minds with this machine.*
>
> *VR is going to play an incredibly important role in the history of mediums. All of these mediums require what we call "suspension of disbelief," because there's a translation gap between the reality of the story and our consciousness interpreting the story into our reality."*

[1] TED: Ideas worth spreading, https://www.ted.com/talks/chris_milk_how_virtual_reality_can_create_the_ultimate_empathy_machine, (29 Sep. 2018)

These experiences place people into an immersive virtual environment created through computer generated displays; where people can move around without constraint by interacting with their surroundings in order to show them what it would be like to viscerally experience any situation from another person's perspective. In this way, the perceptual input of the users from the real physical environment was replaced with the perceptual input from the virtual environment (Ahn et al. 2016), which makes them to feel like what being seen as their actual surroundings inside a virtual environment. In this regard, the increasing interest on VR as an empathy-related learning medium has led to raise the production of IVEs; which were designed with the objective of promoting empathy.

By being inspired by embodied researches, the international research group from a variety of fields by working together interdisciplinary collaboration with The Center for Research and Interdisciplinarity (CRI) had created an immersive virtual reality perspective-taking experience called *Behind Her Eyes*; integrating several EVR methods with different technological sets to induce the body ownership illusion by using visually, tactilely, and aurally multi-sensory stimuli; on the purpose of promoting empathy-related behaviours in IVR. In the considerations of previous studies which suggest that perspective taking tasks in virtual reality can be used as an effective measure in order to increase the sentiments regarding toward others such as empathy and prosocial behaviour, this review article will present here the several EVR methods of our perspective-taking task; in which we evaluated the effectiveness of VRPT and the use of immersive virtual environment toward taking the perspective of someone to increase empathic abilities of individuals.

2. LITERATURE REVIEW

2.1 PRESENCE AND PLAUSIBILITY IN VIRTUAL REALITY

The virtual reality enables individuals to experience the feeling of being in an alternate world taking place within an environment depicted through computer generated graphics by using head-mounted displays (HMD) which disconnects the users from seeing the real world. M. Slater (1999) describes this state of consciousness and sensation of being there within a virtual environment as *''presence''*. The notion of presence and immersion has been considered as two central concepts for scientific researches conducting on the virtual reality and became a subject of many other research fields including computer science, medicine, psychology, military, entertainment, art, cognitive science, philosophy, and ethics during recent decades. (Lombard et al. 2009).

2.1.1 Sense of Presence

Virtual reality enables individuals to sensorially and psychologically experience the feeling defined as presence consisting of being in the world which was generated by computer generated displays through the outside of their real physical body. Presence refers to *''the state of consciousness and psychological sense of being in the virtual environment.''* (Slater & Wilbur 1997). Sanchez-Vivez and Slater (2005, p. 74) defined the presence in virtual reality as the extent of how people realistically give reactions within a virtual environment where can be taken the reaction from the low-level to the high-level of physiological, emotional and behavioural reactions. In recent years, many researches about presence have been conducted for instance (Heeter 1992; Held & Durlach 1992; Loomis 1992; Sheridan 1992; Steu 1992; Barfield & Weghorst, 1993). The main idea of these researches is that virtual environment should allow individuals to experience their virtual surroundings specified by the displays as more engaging reality than the actual physical world and consider their surroundings as somewhere that

can be visited rather than images that are seen (Slater & Wilbur 1997). The sense of presence is closely related to the degree of how virtual environment functionally and visually matches the real physical world (Waller et al. 1998). Slater and Wilbur (1997, pp. 603-613) argued that behaviours in the virtual environment should correspond to the behaviours that could occur in a daily reality within similar situations. Therefore, presence necessitates that participants associate with the virtual body that they can identify their own movements with its movements and the virtual body is connected with their body in virtual environment.

2.1.2 Immersion and Sensorimotor Contingencies

According to Tang et al. (2004), *''while presence refers to user's individual experience, immersion refers to the technical capabilities of a system to provide an adequate sensorial information to the perceptual system.''* The feeling of immersion, whether physical or psychological in nature, enables users a sense of belief of leaving from the real world and being in the virtual environment in present time (Sadowski & Stanney 2002). An IVR system provides the ability in order to perceive through natural sensorimotor contingencies (Slater 2016). The term of sensorimotor contingencies is used to describe the movements that carried out in order to be able to perceive such as moving the head and eyes to change the viewing direction (Noë 2004; Regan & Noë 2001). Slater (2016, p. 74) stated that *''We need to use our whole body in a natural way in order to perceive. Perception is related to the whole-body movement''* and he also submitted that the main technological goal of VR is *''to realize perception through such natural sensorimotor contingencies to the best extent possible.''*

2.1.3 Place and Plausibility Illusion in Virtual Reality

According to Slater (2009), the illusion that gives individual a feeling of being in a virtual environment depicted can be created by using a system supporting SCs which bears a resemblance to the real physical environment. In VR environment, with the body movement of individual in natural way, the brain's perceptual system perceives

what being seen as her actual surroundings, in spite of the fact that she/he knows she/he is not actually there. This subjective illusion of the sense of being there in a virtual environment refers to as telepresence or presence in the literature (Held & Durlach 1992). However the term of place illusion was also used to define this type of presence in order to avoid confusion of the different alternative meanings attributing to the word presence and is defined by Slater (2009) that *"It is the strong illusion of being in a place in spite of the sure knowledge that you are not there."* According to Slater (2009), Psi is a different concept related to presence and stated that *''While PI is about how the world is perceived, the Psi is about what is perceived.''* Psi represents the illusion that what is happening which was depicted in VR environment is actually occurring in spite of knowing for sure that it is not actually taking place. The evidence of many experiments revealed that the essential component of Psi is that the events; depicted by the VR display on which you don't have a direct control have a direct refer on you. Slater and Sanchez-Vives (2016, p. 74) stated that:

> *''While PI is constrained by sensorimotor contingencies of the VR system, Psi relates to the credibility of the scenario. In both cases, users know that they are not "there" and that the events are not happening, but they feel as if they are leading them to adopt behaviours as if they were really inhabiting.''*

M. Slater (2009) argues that place illusion and plausibility can lead to realistic behaviour in immersive virtual environments.

2.2 PERCEPTUAL ILLUSION OF BODY OWNERSHIP IN EVR

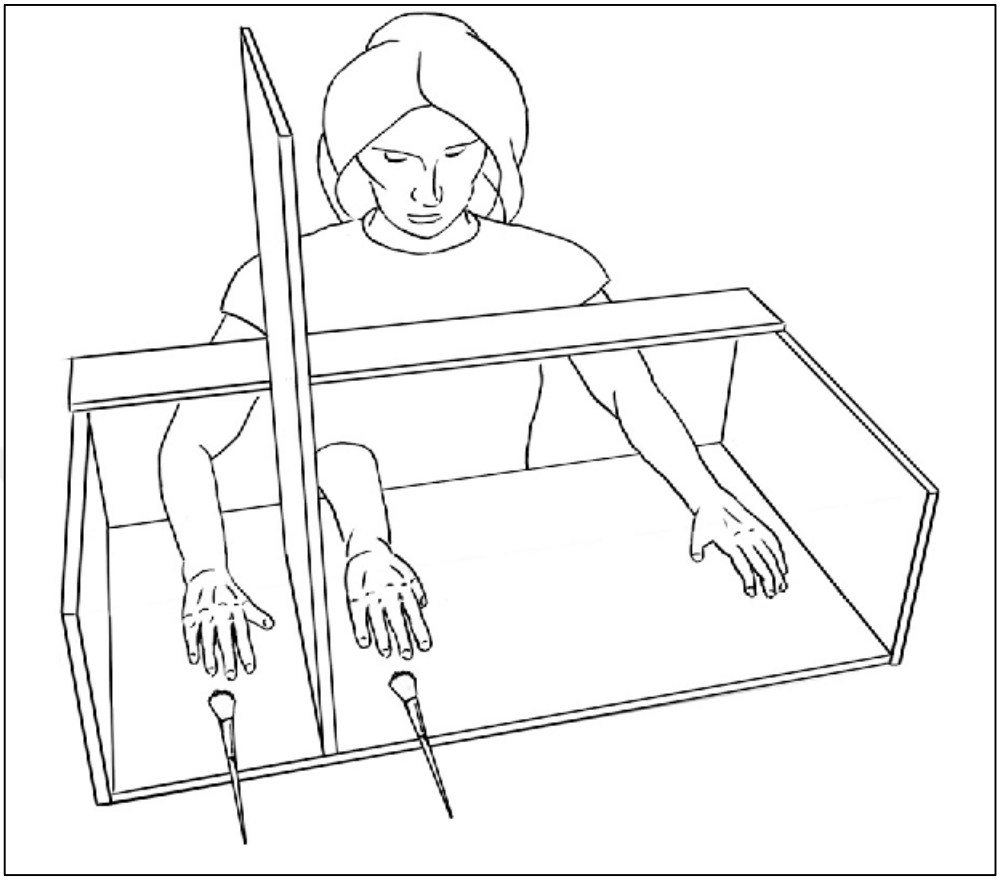
Virtual reality has a great ability to produce stimulant by enabling individuals to deliver embodied experiences that surpass the sense of physics and supposition about the world (Riva et al. 2016). From a psychological aspect, Riva (2009) described the virtual reality as an embodied technology which has a potential in order to be able to manipulate the feeling that makes them believe to be and act in the world (Riva et al. 2014). Immersive virtual reality systems often lead participants to behave as though their virtual surroundings which they are experiencing are real (Slater & Sanchez-Vives 2005). The state of a sense of presence is used to refer to this phenomenon (Bystrom et al. 1999). The virtual body can be seen as if nearly reflecting the movement of their own

body of participants who are immersed with the sense which the displays enclose and involve them. In that way, as they can move their own body, the visual information provided from the virtual reality systems nearly reflect what their proprioception makes them feel. In this regard, Slater and Sanchez-Vives (2005) suggest that the key aspect of immersive VR systems is the ability of using in-built motor knowledge in order to access the virtual environment.

2.2.1 Background: Rubber Hand Illusion

It has been shown that a foreign object can be categorized as a part of human body representation through synchronous multisensory stimulation such as tapping and stroking over the fake and corresponding part of the real body. One of the most famous examples of this phenomenon is the Rubber Hand Illusion. The rubber hand illusion which was first demonstrated by Botvinick and Cohen (1998) is a sort of simple illusion where participants were induced that they behave as if a rubber hand is a part of their own body. In experimental setting, the rubber hand is placed in a proper position on the table in front of a person and the real hand of the subject is placed in a parallel position with a rubber hand and hidden behind the screen (Figure 2.1). The experimenter is synchronously stroking a person's hidden real and visible rubber hand together so the subject sees the fake rubber hand being touched but feels their actual hand being touched. Thus, subject starts to be induced that the fake hand is actually the real part of their body. *''The rubber-hand illusion has been used extensively as an experimental paradigm in research aimed at understanding the mechanisms behind our sense of embodiment* (e.g., Longo et al 2008), *personal impressions of body-ownership and self-consciousness* (e.g., Lenggenhager et al. 2007; Ehrsson et al. 2004), *or self-other merging* (e.g., Paladino et al. 2010).'' The recent studies (Petkova & Ehrsson 2008) have also shown that the whole-body illusion which is similar to the rubber hand illusion can be induced by using a head-mounted display showing stereo real-time video imagery.

Figure 2.1: Overview of experimental setup



Source: de Haan, A., Van Stralen, H., Smit, M., Keizer, A., Van der Stigchel, S. and Dijkerman, H. (2017). No consistent cooling of the real hand in the rubber hand illusion. Acta Psychologica, 179, pp.68-77.

2.2.2 Full Body Ownership Illusion

Body ownership refers to *''the feeling that the body and bodily sensations are self-attributed.''* (Blanke 2012; Tsakiris 2010; Gallagher 2000). The Rubber Hand Illusion has been used as an adaptive technique of the sense of embodiment in order to investigate the process that forms a basis for the body ownership experience (Tsakiris 2010). Botvinick and Cohen (1998) showed the possibility of inducement over the ownership illusion of a rubber arm, even though it doesn't look like the person's real arm, through using a suitable synchronous multisensory stimulation.

Similarly, the full body illusion can be produced through using the same fundamental principles of synchronous multisensory stimulation. In the experiment that was carried out by Lenggenhager et al. (2007), the head-mounted displays that was connected to the video cameras that films their back from behind them were used to stream visual real-time video images to subjects so they view the live video image of their body (as a virtual body), while they were stroked with a stick from their real back. They felt this stroking on their back while seeing it in the virtual body representation that they saw in front of them either simultaneously or not. Subjects had the experience of the illusion of being drawn forward on the body represented through video images that they saw in front of them but felt on their own back as a consequence of experiencing this synchronous visual-tactile stimulation on the back of their body. It was mnetioned by Lenggenhager et al. (2007, pp. 1096-1099) that:

> *''The illusion of self-identification with the virtual body (i.e., global ownership, the feeling that "the virtual body is my body") and the referral of touch ("feeling the touch of the stick where I saw it touching my virtual body") were both stronger when subjects were stroked synchronously than when they were stroked asynchronously''*

In the related study of Ehrsson (2007), subjects were seated and saw themselves from their behind through HMD. The experimenter stroked the subjects on their chest and subjects could see the movement of stick either synchronously or asynchronously with the stroke underneath the video cameras behind them. Through visual tactile stimulation on their chest, subjects had the experience of the feeling that the stick which they saw in the virtual location of their chest was stroking their real chest and the virtual body which they are looking at was the body of someone else. In both cases, the out-of-body illusion has not been observed with asynchronous visual-tactile stimulation.

The experiment carried out by Petkova and Ehrsson (2008) aimed to demonstrate the possibility of inducing the full body ownership illusion of an artificial body using experimental setup consisting of seeing a body other than oneself from a first-person perspective, while the subject was exposed to synchronised visual and tactile stimulation. In order to be able to provide the first-person perspective of the other body,

participants wear a set of head-mounted displays which were connected to two CCTV cameras assembled on the head of a male manikin and recording the events from the eye level of manikin. In this way, participants saw the manikin's body from the perspective of its head by looking through HDM instead of expecting to see their own body. The experimenter strokes the body of participant with a rod which is not seen by participants while they synchronically stroke the body of manikin which is in the view of the participant. Synchronous visual-tactile stimulation on the body of a subject and seen from the first-person perspective on the body of manikin elicit a body ownership illusion which subjects experience the feeling that the manikin's body is their own body. Asynchronous stimulation has not been observed to elicit a body ownership illusion.

2.2.3 Proprioception and Immersive Virtual Reality

The aim of the immersive virtual reality is often to transfer participants into a virtual environment where they experience situations and actions by taking part in. The main concern of such applications is to induce participants for the illusion of being in the environment which is depicted through IVR (Brooks 1999) and actually assessing and improving the sense of being there and the ability to act there which is generally referred to as presence is one of the major challenges (Sanchez-Vives & Slater 2005; Sheridan 1992). The significant scientific and practical issues in the researches on IVR have been created through the issues of being and acting there with technological necessities. One of the important aspects defining the IVR is the systems which enable to immerse participants into the virtual environment (Bystrom et al. 1999). Two of these IVR technology systems to display are physically surrounding displays and head-mounted displays; which cover up the real body of participants and in this way enable a virtual body to be substituted. The assertion that a virtual body is a crucial component of HMD-based IVRs which has a major impact on the participants has been argued for a long time (Heeter 2003; Slater et al. 1998). It has been indicated that the presence responses of participants can be impacted by the amount of their use of virtual body. According to Slater and Steed (2000), participants who need to use their virtual body to

interact with the objects to activate them have higher sense of presence as compared with those who simply need to press the button. It has been argued by Slater et al. (1995) and later Usoh et al. (1999) that participants report a higher sense of presence after experiencing mimicking walking in the immersive virtual environment which produces match among the vision and proprioception.

2.2.4 Body Ownership Illusion in Virtual Reality

Recent studies have shown that these types of perceptual illusions of body ownership can be generated in immersive virtual reality over the virtual body which was seen from the first-person perspective. The results of these studies reveal that substantial behavioural and conceivably cognitive changes which depend on the appearance of the virtual body can be resulted in the full body ownership illusion. According to Slater et al. (2013), this could have a great importance on many applications such as learning, education, training, psychotherapy and rehabilitation which use IVR. Immersive embodied virtual reality with whole body ownership illusion refers to the method which was adapted from Rubber Hand Illusion in order to generate perceptual illusion in virtual environment (Maselli & Slater 2013; Petkova & Ehrsson 2008). It has been observed that the illusion occurred with a much lesser extent through a flat video projected hand on a table top (Ijsselsteijn 2006).

The experiment of Slater et al. (2008) demonstrated that the rubber hand illusion has the same extent function in virtual reality as in the original Botvinick and Cohen paper, with the difference of the arm and seen stimulus touching the virtual hand that were virtually represented. In the experimental setup, the image of virtual arm was projected on a stereo power wall and virtually seen like projecting out of the participant's real body generated an ownership on the virtual arm. The experimenter strokes a hand of the subject using tracked wand which was represented as a virtual ball that stroking synchronously or asynchronously the corresponding virtual arm. In this study, they showed that the body ownership illusion can be generated in an immersive virtual

environment by providing subjective, behavioural and physiological evidence (Slater et al. 2008). It has been observed that the illusion occurred with a much lesser extent through a flat video projected hand on a table top (Ijsselsteijn 2006). In the article entitled *''Virtual hand illusion induced by visuomotor correlations''* by M. V. Sanchez-Vives et al. (2010), it was demonstrated that the body ownership illusion over the hand virtually represented can be induced by the synchronous visual motor actions between synchronous movements of the real and the virtual hand but it does not occur when the movement was asynchronous.

It has also been demonstrated that the full body ownership illusions towards an avatar occurred. Normand et al. (2011) carried out an experiment by using immersive virtual reality in order to investigate whether the illusion of a dramatically increased belly size in immersive virtual reality can be induced through multisensory stimulation in the belly area with first person perspective. Throughout the experience, participants experienced to see a virtual body having an inflated belly which substitutes their own body from a first-person perspective in VR environment through head-mounted display. Experimenter synchronously stroke their real own belly using a rod which was also seen as a congener within a synchronous condition where stroking movements were synchronous with what participants feel and see in the VR. The results of the experiment show that the body representation towards larger belly size can be temporarily produced changes through the virtual body substituting the body in virtual environment through first person perspective with synchronous multisensory stimulation.

Another experiment which was conducted by Kilteni et al (2013) where participants performed to play a virtual West-African Djembe hand drum in an immersive virtual environment which was registered with a physical drum, through a virtual body that substitutes their own body, demonstrates that the body ownership illusion over the virtual body can be induced through seeing a virtual body from a first person perspective and receiving spatiotemporally congruent multisensory and sensorimotor feedback related to the physical body. The findings of the experiment show that the

substantial behavioural and possibly cognitive changes which depend on the appearance of the virtual body can be led to the whole body ownership illusions, which could be significant for many applications *'such as learning, education, training, psychotherapy and rehabilitation'* by using immersive virtual reality (Kilteni et al. 2013).

2.2.5 Behavioural Correlations of Body Ownership

It has been comprehensively shown that body ownership illusion has a variety of behavioural connections depending on experimental setup. One of the research (Kilteni et al. 2013) shows that the post-experiment performance of participants in a certain task is affected by the experience of body ownership through an artificial body which is different from the real body. For instance; in the experiment which was conducted by H. Farmer et al. (2012), a modified version of the Rubber Hand Illusion was used by placing black rubber hand instead of white one with Caucasian participants. The result of the experiment has shown that participants who had strongly experienced body ownership illusion showed a tendency to less racial prejudice after the illusion than before. The results of the experiment conducted by Longo et al. (2009) where participants who experienced rubber hand illusion in a way to perceive the rubber hand as being more similar to their real own hand, are relevant to this issue.

In a similar way, it has been known that several behavioural outcomes such as in improving presence and predictions on distance are constituted by the body representation in immersive virtual reality (Mohler et al. 2010; Slater et al. 2010). Actually, the subject of using the potential of immersive virtual reality on the body swapping was used in the informal experimentation conducted by Jaron Lanier et al in the early times of virtual reality (Jaron 2010). However, the subject of body swapping in immersive virtual reality might causes to the behavioural alterations is not a new concept and there was a path breaking work which has been called the Proteus Effect (Yee & Bailenson 2007). The emotional situation of participants in their social interactivity was affected by how their appearance that they have is in immersive virtual

reality (Bailenson et al. 2008). It has been shown that there is an impact on the racial prejudgement of participants who observe themselves as an avatar with different race (Groom et al. 2009). A concept which is closely related to this impact is called 'virtual doppelgangers' in which participants observe their alternate self-reflection that is carrying out an activity, which was designed for the purpose of inducing behavioural changes on the participants (Hershfield et al. 2014; Ahn 2011; Fox & Bailenson 2009; Fox et al. 2009; Bailenson et al. 2008). There could be a relationship between the embodiment in virtual reality and the notion of self-presence which refers to the impact of the experience with virtual body over someone's self-identity (Lee 2004). Within this context, the recent studies over body ownership illusion, which those are the experiment conducted by Slater et al. in which virtual fat body was given to thin men (Slater et al. 2010) and the other experiment conducted by Normand et al. (2011); in which female body was given to the male participants in virtual environment, successfully revealed the inducement of body ownership illusion on the participants through virtual body which is entirely different from their own body.

2.3 USING PERCEPTUAL ILLUSIONS TO PROMOTE EMPATHY-RELATED ABILITIES

Empathy refers to an ability to understand someone's emotions (Hoffman 2001). It has been shown that empathy enables individuals to increase their understandings and encourage prosocial behaviours (Ahn et al. 2013; Batson & Ahmad, 2009). When it is considered on its the importance and impacts upon the social interactions of intergroup; researches, artists and technology development companies have been trying to find out innovative methods in order to promote empathy through different sort of empathy interventions.

2.3.1 Empathy and Prosocial Behaviour

The relationship between empathy and prosocial behaviour has become a subject of experimental surveys for decades. Empathy is defined by J. Decenty (2010) as *''an*

interpersonal social experience that involves affective resonance, cognitive appraisal and emotion regulation, which together enhance prosocial interactions.'' The term of empathy is used to define the ability and tendency to share and understand someone else's inner states (Zaki & Ochsner 2012), involved various psychological factors (Zaki 2017), which is a compulsory element for effective social interaction (Hoffman 2001). Perspective-taking refers to the action of *''attributing mental situations to others and reasoning about how situations relate to them''* (Gopnik 1992). Empathic concern is an effective motivational way to enhance the welfare of other individual (Zaki & Ochsner 2012). These various empathic components are affected by prosocial behaviours. The prosocial behaviour is predicted by experience sharing (Hein et al. 2010; Krebs 1975). Besides this, avoidance behaviour can also be motivated by sharing others' distress and it prevents helping behaviour (Davis et al. 1999; Batson 1991). In a similar way, the prosocial behaviour towards individuals can be enhanced by encouraging them to metalize about a target (Sturmer et al. 2005) and the eventual prosocial behaviour are predicted by brain activity that is related to metallization (Waytz et al. 2012). The empathy level of people comparatively consistent, however it is also influentially affected by states by motivating or preventing their empathetic responses (Hooker et al. 2009; Lundqvist & Dimberg 1995). Thereby, empathy and prosocial behaviour can be intentionally enhanced or reduced.

2.3.2 Perspective-taking Tasks and VR

Perspective-taking tasks where subjects are expected to put themselves into someone's shoes to understand how it would be like to be them under particular situations has been extensively became a subject in the literature and have an effective impact on developing the empathy on perceivers' feeling for particular social objectives. It has been shown that perspective-taking does not only enhance empathy for particular people but also ensure to develop empathy on the whole stigmatized groups (Batson et al. 1997). To give an example to this, the experiment which was carried out by Batson et al. (1997) has shown that subjects who were expected to put themselves into a member of a stigmatized group, such as person who was diagnosed with AIDS or a convicted felon, submitted more affirmative behaviours on not only particular member of a

stigmatized group but also on entire stigmatized group. In the literature it has been suggested that there are several distinctive impacts based on the type of perspective-taking that is used. For instance, past researches (Batson et al. 2003; Batson et al. 1997) have shown that the empathy and renunciative motivation towards helping can be induced by imagine-other perspective-taking tasks which subjects are given instruction to think about how another one would feel about specific circumstance. Beside this; the empathy, personal distress and an egoistic motivation to help can be induced by imagine-self perspective-taking tasks which subjects are given instruction to think about how they would feel if they were in a circumstance of someone else. The research conducted by Lamm et al. (2007) has also shown that there is distinctness in the neural mechanisms which are enabled while imagine-self vs imagine-other perspective-taking tasks were being used. Batson et al. (1997) argued that in the case that the aim of the perspective-taking task is to raise the motivation of helping, using an imagine-self perspective-taking task may be more influential than imagine-other approach. Despite the fact that there is a general opinion on this issue that perspective-taking results in positive consequences under specific situations (Batson et al. 1997), this may also result in not only negation over positive consequences but also lead to raise the stereotypes of others (Tarrant et al. 2013). Beside this, this may lead individuals to accuse people from stigmatized group for their respective circumstances, even when they are not in the wrong (Batson et al. 1997) and produce negative impacts on competitive environments. For instance, it has been shown in the research which is carried out by Pierce et al. (1986-94) that taking the perspective gave cause to competitor for more unethical attitudes.

2.3.3 The Impacts of Perspective-Taking on Empathy-Related Responses

Immersive virtual environment enables users to experience the feeling of being somewhere through interactive and immersive computer-generated displays differently from the physical world where they are in. According to Ahn et al. (2016), the perceptual input from the real physical world is blocked out by the systems in VR and replaced it with perceptual input from the virtual surrounding of the user. These abilities of VR, which enable users to vividly experience any circumstance through the

high level of immersion and the feeling of presence as though it happened to them from different perspectives (Ahn et al. 2016) put VR in unique position as an efficient perspective-taking tool which is different from traditional media. Various researches in recent years have examined the possibilities on how traditional perspective-taking exercises can be enhanced and transferred into the virtual world through using computer generated environment where subjects can interactively experience within VR, which is also known as IVE. The virtual reality perspective-taking (VRPT) enables individuals take on the perspective of other individual through the use of immersive virtual environment. It is foreseen that social psychologists will be able to accomplish a great variety of methodological problems such as ‘’the experimental control-mundane realism trade-off, lack of replication, and unrepresentative sampling’’ through transferring these exercises into virtual reality (Blascovich et al. 2002).

Transferring perspective-taking into virtual reality also enables individuals to provide the experiences being induced which would difficult to create in physical world such as having different skin colour or gender, being at a different age than the actual age or even living in the body of an animal. To give an example to this, throughout the experiment that was carried out by Groom et al. (2009), subjects experience he embodied perspective taking through avatar having different skin tone. In another experiment conducted by Bailenson et al. (2016), participants embodied an elder person in an immersive virtual environment. The experiment conducted by Slater et al. (2010) enables the male subjects to substitute a life-sized virtual human female body as their own body through a first-person perspective. Researches can also have subjects of experiencing the ownership of virtual animal’s body in virtual environment (Ahn et al. 2016).

According to Macrae and Bodenhaused (2000), when users are performing perspective-taking task in VE, they are in need of less mental sources in order to generate particular circumstance and environment as they are all computer-generated displays, so users only tend to act and give reaction throughout the experience. This ability places perspective task in VR into an advantage position, in comparison with traditional perspective taking by the reason of fact that users don’t have to put faith in their

prejudices. There is a lack of experimental control which happens during the imagination process of the users throughout the traditional perspective-taking task. However, in opposition to this, perspective-taking task in VR also provides methodological benefits because it enables all users to serve completely same experience (Blascovich et al. 2002).

Embodied cognition theory submitted that cognition has an interactive relation with body and mind (Barsalou 2010); which occur within the context of particular environment (Wilson 2002). Recent studies (Oppezzo & Schwartz 2014; Williams & Bargh 2008) have shown that the user's performance can be enhanced by physical movement while fulfilling cognitive tasks, the perceptions and attitudes of users can be affected by the physical experience of specific surrounding. VR enables participants to move and form interactions with their environment as though they were actually there by the way of combining body movements and controllers. These abilities enable users to collect spatial information about their virtual surroundings through using their same perceptual systems which they use to collect the spatial information about the real physical world. In addition to this, recent studies (Blanke 2012) have also shown that more certain mental presentment about the physical environment occurs as a result of collecting more perceptual information. Thereby, the ability of users on engaging with and using their movement within VR allow them to improve their cognition resulting from additional information which users can collect through their physical movement (Brisswalter et al. 2002) and may have a positive impact on empathy and prosocial behaviours.

In comparison with traditional media for perspective-taking exercises, some studies (Yee & Bailenson 2009) suggest that IVEs can have a powerful impact upon the individual behaviours. Some researchers support the claim that VPRT is an efficient medium in order to encourage helping behaviour (Ahn et al. 2013), decrease implicit prejudice (Banakou et al. 2016; Maister et al. 2013; Peck et al. 2013), counter change racial in-group prejudice (Hasler et al. 2017), improve financial planning (Sims et al. 2015) and reduce prejudice (Oh et al. 2016). Other studies (Schutte et al. 2017) support that the empathy-related responses can be enhanced through virtual reality and the

analyses that were obtained from past studies reveal that the intervention is more effective upon people who has a low level of empathy before the intervention (Ahn et al. 2013). However, there is lack of direct evidence to show that empathy is a mediator for the relationship between virtual reality and increased cooperation.

2.3.4 Overview of Experiments: Training Empathy Related Abilities in EVR by Using Body Ownership Illusion

Petrova and Cialdini argued in the article named *'Evoking the imagination as a strategy of influence'* (2008) that imagining oneself in different circumstances with different consideration has an influential impact on someone's attitudes and behaviours. According to Galinsky and Moskowit (2000), saliently trying to see the situations through the perspective of outgroup member and imagining oneself as this person enables to decrease stereotypes about this outgroup. Using of neural processes which is generally used to evaluate oneself is encouraged through assuming other people's perspective (Ames et al. 2008), which provides an overlapping upon positive attitudes and behaviours of the individuals towards the model. Blascovich et al. (2002) support the argument that immersive virtual reality technologies have a great potential to use them as methodological means in order to researching and analysing the issues of social influence.

Groom et al. (2009) carried out an experiment in which they studied on the impact of the race of a perspective-taking avatar with black and white and its representation with imagined and embodied upon people's implicit racial prejudice in an immersive virtual environment. They aimed to indicate how the race of the subjects make an interaction with the race and representation of an avatar and determine whether racial prejudice could be decreased. The results of the experiment show that experiencing the embodied perspective taking through avatar having different skin tone in an immersive virtual environment have an impact on the users to change their implicit racial bias outside the virtual environment. Throughout the VR experience with embodied perspective taking, it has been observed that the model race has an impact on varying the implicit racial bias of participants. On the other hand, the VR experience with imagined perspective taking, there is no remarkable differences observed between participant and avatars

having black and white skin tone. The findings of experiments also show that the impacts of avatar race maintain outside the virtual environment. Participants who experienced the embodiment of avatar having black skin tone in IVE show a tendency to greater implicit racial bias outside the IVE in comparison with those who experienced the embodiment of avatar having white skin tone. It was mentioned by Groom et al. (2009, pp. 1-18) in the article that:

> *''These findings have important implications for strategies to reduce racial prejudice and provide new insights into the flexibility of racial identity and racial attitudes afforded by virtual technologies.''*

Another experiment which was conducted by Oh et al. (2016) examines whether there is a mitigative influence of perspective taking upon the negative effects on ageism under threat, if it has such an effect, if this effect would have more efficacious on the participants who experienced the embodiment of an elderly person in an immersive virtual reality in comparison with those who were involved in a traditional perspective taking through mental simulation (MS). Throughout the experience, participants have seen themselves into the body of an elderly avatar with their matched gender in the embodied virtual environment condition. Past studies show that embodied perspective taking in an immersive virtual reality is an effective tool in order to overcoming the negative effects on ageism under threat which was presented outside of intergroup contact in comparison with mental simulation. However, the findings of this experiment offer an evidence that the embodiment of perspective taking in an immersive virtual environment have potential to provide greater advantage upon the mental simulation in overcoming intergroup threat for participants who have a situation which make taking the perspective of an outgroup member difficult for them (Oh SY et al. 2016).

Researches (Ahn et al. 2016) can also have subjects experience to live the body of an animal in virtual environment. The results of the experiment support the predictions that perspective taking of an animal can be simulated in IVEs by digitally producing sensory information and enable to promote the feeling of mutual attachment between nature and person. It was reported that the ownership of virtual animal's body was felt by participants and they experienced the mental merging with nature. Besides this, it was also indicated that participant experienced the embodied animals' experience in IVEs in

more sensory-rich way comparing with watching the video of the same experience. The reason was stated by Ahn et al. (2016, pp. 7-38) in the article named *'The effect of embodied experiences on self-other merging, attitude, and helping behaviour'* that:

> *''Because IVEs offer a wider array of sensory information than video, allowing users to see, hear, and feel environmental damage, participants perceived greater spatial presence and felt that their experiences as an animal were more genuine than watching a video of the same experience.''*

This experiment demonstrates that IVR's enables direct experience to positively engage individuals with environmental problems.

3. METHODOLOGY

The referred literature has shown that VRPT experiences can have an impact on increasing the prosocial behaviour toward individuals. By being inspired by embodied researches, our international interdisciplinary research group collaboratively working with The Center for Research and Interdisciplinarity (CRI) had developed VRPT experience called *Behind Her Eyes* by integrating several EVR methods with different technological sets to induce the body ownership illusion by using visual and tactile multi-sensory stimuli; on the purpose of promoting empathy-related behaviours of individuals in VR. Throughout the experience, participants perform an imagine self-perspective taking task with an immersion experience by using HMD from a first-person point of view; where they see themselves through the perspective of a woman, with an experience that have taken place in her everyday life. In our VRPT condition, we aim that participants are expected to imagine what it would be like if they became a woman and experienced what it was like to being sexually harassed from the first-person perspective inside VR; created by using computer generated images through combining 360-degree video with CGI animation and Leap Motion controller. In consideration of scientific researches conducted on this field, in this section, this review aims to describe the tools and methods of our pilot project *Behind Her Eyes* and offers design and implementation strategies for integrating different techniques and concepts that can be used in VR for training empathic skills of individuals.

3.1 PARTICIPANTS & PROTOCOL OF INTERACTION

Initially, 15 participants were recruited among student of Interdisciplinary Research Center (CRI) by making an announcement that was sent to the students of CRI Summer School via e-mail. Before the experiment, all participants were asked to read the information sheet which describes the details about the experiment, and confirm their attendances. All participants read and signed an informed consent form. The equipment and experimental content were introduced to the participants and they were equipped with a set of HMD as well as headphone before the start of the experiment. Throughout

the VR experience, participants have completed all the necessary steps of the experiment and they were invited to the interview after the end of the experiment.

3.2 EQUIPMENTS

The physical configuration of the experiment is shown in the Figure 3.1. In this experimental installation, participants can see the virtual scenes through using HTC Vive HMD; where the leap motion is connected in front of to provide fully immersive views in the virtual environment. The HTC Vive HMD is connected to the computer with the USB cable, which converts the normal computer scenes to the VR format and displayed them on its screen. Meanwhile, the hand movements of the users can be identified through hand-tracking system of Leap Motion device and displayed in the virtual world, and so they can interact with the objects in VE by using their actual hand movement. The Leap Motion device was used in our experimental setting for the purpose of tracking the hand movements of the users by detecting the distance and the infrared camera which calculate the location of the hands; which increases the immersion of the experience.

Figure 3.1: Equipment used for VRPT condition

With the combination of the head motion capturing and the hands tracking devices, the HMD system can update the screen in real-time by tracking in accordance to the hand and head movements of the user, thus the fully immersive experience can be obtained by the participants. The virtual environment was created by capturing from the real world through Samsung Gear 360-degree video camera.

3.3 METHOD

The aim of the experiment is to evaluate the perception of the sense of presence in virtual reality and the impact of the feeling of being in the body of another person on empathy-related behaviours of individuals. The immersion of the person was provided in VE, which was created by capturing from the real world through 360-degree video camera. In this experimental setting, set of HMD; where the Leap Motion is attached to and headphone were used to provide immersion for participants in order to make them feel themselves in the body of another person by giving them a vision of the avatar's hand controlled by them whereby they can move their head and hands in natural way in VR. Thereby, participants can experience leaving the reality of physical world and immersing themselves virtually into the digital body of an avatar. Throughout the experience, they are asked to carry out a perspective taking task in VE. For the reason that the main objective of our VRPT experience Behind Her Eyes is to promote empathy by dealing with the issues of gender equality, it is significant for participants to feel themselves in the body of a real person. For this purpose of the experiment, a real person was simulated through a virtual avatar which was realistically modelled and rendered. The main concern of the experiment is to demonstrate the inducement of the illusion of immersion in the body of another person and evaluate subjective effects of the experience on individuals' considerations about gender equality. The experiment consists of seeing the body of someone from a first person's point of view while immersed into the virtual environment. The participants were submitted to the experience and asked to answer the questionnaire.

3.4 EXPERIMENTAL SETUP AND THE BODY OWNERSHIP ILLUSION

In this experimental installation, participants were asked to sit on a chair in front of a physical table and entered an immersive virtual reality through a headphone and set of HMD with a leap motion controller attached to the front of it controlled by them mimicking the participant's actual hand movements to give him/her a display of the avatar's hand in VR, in order to create the illusion of self-identification with the virtual body of an avatar. During this process, participants perform an imagine self-perspective taking task in VR. The audible and nominal directives appearing in the scene allow to give instructions to participants in order to inform them to seated or remain standing and directed in the IVE and also help them to concentrate on the experiment all along the process. Between the transitions of each scene, the screen was turned off and on again. The experience was designed to follow the conditions below:

a. Exploration: Subjects were given a time to accord to their virtual environment by performing some simple movements to help them to associate their physical hand movements with the movement of avatar's hands that they saw in the scene, which allows them for the body transfer. Thus, the participants saw the avatar's hand in visuomotor synchronicity, where they expected to see their own hands. This stage lasted for 1 minute. After being closely acquainted with the virtual environment, the narrative begins.

b. Interaction with the environment: In order to induce perceptual illusion in VE, our experimental setting offers a way to create spatial interaction experience centred on the sense of touch by evoking the feeling of tactile sense through hand-tracking system of leap motion device displaying the orientation of participant's real hand movements; which enables them to make choices that will bring out variations in the plot and interact with the objects in the virtual environment. To achieve this in our experimental setting, the real phone was carefully placed in the table in the real physical environment to be in the same place as the virtual phone in VE (Figure 3.2). Through the VR technological equipment and Leap Motion device, participants can interact with this object while experiencing the actions in VR by controlling the hands of properly rigged

humanoid avatar character through a first-person perspective using their own hand movement. Thus, when participants touched either with their virtual body, they would feel the subjacent corresponding real object and with this feeling of tactile sense and they can also perceive realistic tactile stimuli while interacting with the objects in VE; which increases the immersion of the experience.

Figure 3.2: Experimental setup to induce body ownership illusion

The studies also indicate that in order to be able to provide the sense of presence in VR, this is considerably important that the virtual environment visually and functionally matches the real physical world (Waller et al. 1998). Therefore, the virtual environment was created by capturing from the real world through 360-degree video camera and all 3D models depicted in the virtual scene which will be interacted by participants were modelled in such a way that they have a close resemblance to the real objects through 3D computer generated software. The virtual hand of an avatar was realistically modelled and textured to simulate a real hand; participants can freely control these virtual hands with their own hand movements without seeing the body of an avatar, while immersed into the virtual environment.

c. Association with the virtual body: In order to support the argument Slater and Wilbur (1997) that ‘’*Behaviours in the virtual environment should correspond to the behaviours in a daily reality’’*, we’ve created our VE; where participants can explore their surroundings with their body movement in natural way by interacting with the objects in their virtual surroundings through hand-tracking system of leap motion device attached to the front of HMD. This enables them to freely control the virtual hands of properly rigged humanoid avatar character in VE by mimicking their actual hand movements. In this way, we aimed that they can perceive what being seen as their actual surroundings through their natural body movement. This situation allows participants to correlate with the avatar identifying their own movement with the movement of virtual body in VE. Controlling the virtual hand in visuomotor synchronicity allows participants to interact with their own body through the first-person perspective of an avatar. This experiment consisted of seeing a virtual hand depicted in the scene from the first-person point of view. The visual appearance of an avatar would not be seen and the avatar’s hand was noticeably feminine in appearance. The avatar’s hand is shown in detail in Figure 3.3 from first-person point of view.

Figure 3.3: A first person view of the avatar of the participant within the virtual environment.

d. Synchronous multi-sensory stimulation: In the article, Lenggenhager et al. (2007) reveal that *‘’the illusion of self-identification with the virtual body and the referral of*

touch were both stronger when subjects were stroked synchronously than when they were stroked asynchronously.'' Therefore, in our experimental setup, participants were stimulated by touch provided by experimenter. Experimenter controls the scene from computer where the older man places his hand on her thigh in order to provide synchronous visual-tactile stimuli to the participants (Figure 3.4). Whenever participants are stroked her/his virtual back and thigh in VR, experimenter synchronically stroke the same area of their real body. Thus, participants could see the virtual thigh being stroked in the virtual environment, while feeling her/his real one being stroked in the synchronous mode.

Figure 3.4: Synchronous multi-sensory stimulation

3.5 NARRATIVE DESIGN

In this VRPT condition, participants experienced the narrative events within VE described above. The VRPT experience consisted of four scenes taking place four different locations described in the narrative. Each scene includes an interactive perspective taking task where participants can make choices and see the consequences of those choices in real-time. Throughout the experience, participants can interact with

certain objects in the virtual environment. The choices made by participant were created in a way that they don't affect the length of the overall VR experience. The narrative begins with participants sitting in her desk where her computer open in front of her in her bedroom that was created through recording 360-degree video in order to look like an actual bedroom. Subject suddenly receives a phone call from a friend who wants to invite her to the meeting with their friends in the bar. They answer this call by picking up the phone standing on the desk with physical hand movement through hand-tracking system of Leap Motion device. After hanging up the phone, they look to the two outfits appearing on the scene. One in the short summer dress which her friend asked her to wear, another is a simple pair of pants and a blouse. They were expected to choose one. Participant is now standing at a bus stop in the late afternoon, wearing the outfit which she has chosen. Across the street, a man and woman are having an argument. Their voices are raised and tones tense but not quite yelling, trying to avoid any unwanted attention. She begins to leave, crossing the street and getting nearer to participant. He crosses after her and reaches for her arm. He holds her wrist and she is backed to a wall. The brawl goes on. Participants are expected to choose to intervene or to remain a passive viewer. The choices of participant lead to multiple different endings within the experience. Participant is now sitting alone at a table with four spots set. A waitress comes around the bar and approaches her. She asks her if she started with a drink while she is waiting for her friends. Participant is expected to choose water or drink. An older man is sitting at the bar in front of his drink and looks over to her then smiles. Eventually, he orders a second before finishing the first. He coughs and continues watching her. Eventually, he walks towards her, with two drinks and sits down beside her, ask why don't her let him offer her this drink. He gives her his second drink. Participants are expected to say yes or no. The man leans in more, eventually touching her shoulder. He places his hand on her thigh. Afterwards, her friend arrives. She pushes him away. The restaurant turns to watch. Another male arrives. The waitress eventually intervenes and makes the man leave though he protests. She goes to escort him back out. Her friends sit, people eventually go back to their own business but whispers are heard. She returns to the bar, clearing the man's glasses from the table. Her friend asks her if she want to stay or go. In the last scene, she is waiting for the tram alone in the tram station in the late night.

3.6 POST-EXPERIMENT INTERVIEW

After the experiment and removal HDM, interviews were conducted immediately and participants were invited to complete post-experiment questions about their experience. Each participant was asked to answer the same questions which serve to evaluate the body ownership illusion, the sensation of being in the body of an avatar and how this experience changed their perspective on sexual harassment.

4. RESULTS & DISCUSSION

This study mostly focused on evaluating the perception of embodiment illusion in virtual reality and the impacts of the feeling of being in the body of another person on empathy-related behaviours of individuals by demonstrating the inducement of the illusion of immersion in the body of woman and evaluating subjective effects of the experience on individuals' considerations about gender equality.

From the post experiment interview about experiencing the embodiment of our perspective-taking task in VR, we observed that the perspective-taking task had an affirmative impact on that participants felt more empathetic and connected to the avatar which was sexually abused in our VRPT experience; which supports the argument has been revealed by some of researches (Batson et al. 2003; Batson et al. 1997) that ''*the empathy, personal distress and an egoistic motivation to help can be induced by imagine-self perspective-taking tasks which subjects are given instruction to think about how they would feel if they were in a circumstance of someone else.''* The participants were asked to answer if the experience helps them to feel empathy with a woman now. Some participants voluntarily reported their impressions such as: *''It gave me real feelings of a problem faced by women in their daily life''*, *''It has sensitivized me towards some of the problems and the issues faced by women in this society and helped me realize that as a society we still have a lot to work for helping women lead a normal life''*, *''It helps us realize the challenges faced by woman and it is something which society as a whole should work on''*. One of the participants who were asked to answer how much your view changed on the subject after the experience declared that *''The experience went into my way of seeing things''*. It is also noteworthy that one of the participants who asked him to answer if he witnessed such events in real life, what his response would have been answered that *''I felt like to do really something when the guy is harassing girl on road''*. Jessica Talley Sagot who is life sciences education and technology writer, editor & mentor described her thoughts about the VR experience as follows:

''A VR experience that captures a universal yet personal journey on the provocative subject of violence against women. I found myself asking questions I hadn't considered, which balanced discussion of what makes a singular experience so devastatingly uncomfortable for women.''

The results of the post-experiment interviews shows that evoking the feeling of visual-tactile stimuli increased the immersion of the experience, which supports the argument of Lenggenhager et al. (2007) that *''the illusion of self-identification with the virtual body (i.e., global ownership, the feeling that "the virtual body is my body") and the referral of touch ("feeling the touch of the stick where I saw it touching my virtual body") were both stronger when subjects were stroked synchronously than when they were stroked asynchronously''.* In order to support this argument, the experimental setting was created by evoking the feeling of tactile sense in such a way that participant could have the experience of body ownership illusion by simultaneously feeling the stroke on their own body while seeing it in the virtual body representation that they saw in front of them as a consequence of experiencing this synchronous visual-tactile stimulation on their body provided by experimenter. One of the participants voluntarily reported that ''*The scene with the older man places his hand on my thigh was really inducing fear and nervousness too.''.* Another one declared that*: ''In the bar scene, the man came and sat next to me. I saw the man put his hand on my leg. At that time, I realized that someone really touched my leg and back. This was an unexpected experience for me. I think this made the actions more real in VR.''*

In order to support the argument of Slater and Wilbur (1997) that ''*Behaviours in the virtual environment should correspond to the behaviours in a daily reality.'',* we created our VR environment where participants can explore their surroundings with their body movement in natural way by interacting with the objects in their virtual surroundings through hand-tracking system of leap motion device attached to the front of HMD. In this way, we aimed to enable participants to perceive what being seen as their actual surroundings through their natural body movement. In order to induce perceptual illusion in VR, we create spatial interaction experience in our experimental setting by evoking the feeling of tactile sense in such a way that participants can see that there is an object in the virtual environment that they can interact with, they could also simultaneously feel the realistic tactile stimuli by touching the subjacent corresponding

real object that was properly placed in a same place in the real physical environment. After the post-experiment interviews, most participants declared that evoking the feeling of tactile sense throughout the experience increased the immersion of their experience. Participants voluntarily reported their impressions such as: *''This is not my first experience in VR but I had never participated such a VR experience before where I can control the avatar with my own movement.'', ''It was very interesting experience to use my hand movement in virtual environment which made the experience fun for me.''.* The one who were asked them to answer if there is anything you wish had happened or you had done differently in the VR experience Behind Her Eyes shared her thought as follow:

> *''Feeling the sense of touch while touching the virtual objects intensified the realism in VR. But I can criticize that everything in my surroundings in VE looks so realistic like in the real world, but it was obvious that the avatar's hands were digital, which creates a mismatch in the realism of the environment. Maybe it would be more compatible if everything was modelled in 3d to overcome this mismatch ''*

Our observations from the post-experiment interviews about the procedure of VRPT experience of Behind Her Eyes suggested that the methods we used can promote a vivid body ownership illusion of immersion towards a digital avatar that the participant can have the feeling of being in the body of another person and gave us a chance to evaluate subjective impacts of the participant about this experience. It is important to point out that the participants were asked to answer if they feel close the person who they experienced the body swap with throughout the experience and how much they felt like you experienced the story from someone else's point of view. Some participants declared that *"It was very interesting to experience the difficulties of woman from their own perspective.'', ''I would really encourage my male friends to do this to experience the fear and shame we can feel.'', I would say that it's a realistic reconstitution of what a girl feels when she is hitting on or when she is alone in the dark on the street''.*

In the consideration of the post-experiment interviews towards the experiential process of participants during the VR experience of Behind Her Eyes, it has been observed that our VRPT enabled participants vividly experience the perspective of other person through the high level of immersion and the feeling of presence by promoting the sense of their embodiment towards virtual body representations in VR and also have an

affirmative impact on feeling empathy with a woman and changing their view on sexual harassment. Daniel Assayag who is a FabLab manager shared his thoughts about the VR experience as follows:

> *''This experience make you feel the inacceptable presence of one that steps upon your intimate space. Virtual universe, offer the possibility for the viewer to live that moment without the terrible consequences. This VR interactive show is a direct uppercut, that wires your brain to the understanding of what women are put through every day in our over-sexualised societies.''*

5. CONCLUSION

The procedures of creating the illusion of being in the body of another person through full body ownership illusion; which is also referred to as embodiment illusion has been extensively studied by a wide variety of disciplines in VR, psychology and neuroscience. In these experiments, it has been observed that participants can experience the perceptual illusion of body ownership over a different body or body parts of a digital avatar or plastic mannequin, which these interventions might have an affirmative impact on their attitudes and behaviours in real life. In one of those researches using virtual reality, participants who had strongly experienced body ownership illusion showed a tendency to less racial prejudice after the illusion than before. Some of these studies put excessive emphasis on using the great potential of EVR for promoting empathy and motivating prosocial behaviours. Empathy has a crucial interpersonal and societal role for building positive interactions between individuals, which is also related with promoting prosocial behaviours. Empathy is associated with perspective-taking which enables individuals to more deeply understand perspectives other than their own and respond appropriately to the situations, which can lead better society by promoting individuals to care more about each other.

By combining scientific researches and experiments which have been conducting on this field, the motivation of the project of Behind Her Eyes is to create an embodiment virtual reality experience by inducing perceptual illusion through combining VR technologies, which allows individuals to experience what it was like to being sexually harassed through taking the perspective of a woman. This experience enables individuals to see themselves in a body of an avatar while interacting their virtual environment with realistic visual-tactile stimuli. The aim of the experiment is to evaluate the perception of the sense of presence in virtual reality and the impact of the feeling of being in the body of another person on empathy-related behaviours of individuals.

As described originally by the Rubber Hand Illusion, ''*Synchronous multi-sensory stimulations over a body part can extent to ownership over the entire body*.'' In this regard, when visuo-tactile stimuli are provided synchronously on the artificial and own body part, participants perceive the artificial body part to be their own and that the tactile stimulation on the artificial body part is the source of their sensations. Slater et al. (2008) also suggest that synchronous touches are important factors in order to induce the body ownership illusion in virtual environment. Similarly, we decided to produce the full body illusion in VR by using the same fundamental principles of synchronous multisensory stimulation. In order to provide this in our experimental setup, subjects had the experience of the illusion of being stroked on the body representation that they saw in front of them but felt on their own body as a consequence of experiencing this synchronous visual-tactile stimulation. Participants can also perceive realistic tactile stimuli while interacting with the objects. They could simultaneously feel the tactile sense by touching the corresponding objects that was properly placed in a same place in the real world as the object in virtual environment.

Research has experimentally shown that the embodiment illusion may be enhanced by the appearance and control of the avatar. It is possible to elicit embodiment illusion in VR with avatars not only consisting of lookalike gender or race but also different gender. In this regard, VR provide us a great ability to create an experience from the perspective of a woman; which would not possible to create in the real physical world such as having different gender. The responses of participants after our VR experience supports the argument of Slater that male participants can feel the ownership over a virtual female avatar. Besides that, it has also been shown that in order to be able to provide participant the sense of immersion in VR, this is considerably important that the virtual environment visually and functionally matches the real physical world. Enabling participants to perceive the avatar in a similar way to how they perceive real physical world, the external appearance of the body part was simulated through a virtual avatar which was realistically modelled and rendered and the virtual environment was captured from the real world through 360-degree video camera. In order the perceive and interact with VR environment with their body movement in natural way, the technological equipment which we used enable participants to interact with their virtual surroundings

using their actual hand movement through hand-tracking system of leap motion device displaying the orientation of participant's real hand movements which controls the hands of properly rigged humanoid avatar character. Philippe Bertrand who is an investigator of BeAnotherLab stated his thoughts about our VR experience as follow:

> *''Behind Her Eyes explores the potential use of immersive videos in VR to help society to overcome the culture of gender violence. Beta-tests in Paris have shown an interesting emotional impact in males, what may be significant to expand individual's consciousness and change negative social behaviours. The prototype points out to a promising continuation of this research on how to use different perspective illusions in VR to enhance men's empathic abilities regarding sexual harassment.''*

In this article, we presented our VRPT named Behind Her Eyes and its integration of EVR methods being developed with the aim of improving empathy-related skills of individual through target-specific perspective-taking task in immersive virtual environment. We expected that it would offer a guideline for utilizing VR techniques that can be used to develop the empathy-related trainings. We believe that future research that will conduct on these techniques would bring different perspective on developing new methods that could have a great impact for promoting the society to be more empathic.

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APPENDENCIES

APPENDIX A: POST-EXPERIMENT INTERVIEW QUESTIONS

1. What is your age?
2. What is your highest level of education?
3. How many VR experiences have you had (via mobile, desktop/laptop, or console)?
4. Have you ever experienced sexual harassment or assault? If so, please describe your thoughts about that experience in a few words?
5. Describe your thoughts about this VR experience?
6. How did this VR experience Behind Her Eyes make you feel?
7. Do you feel close the person you experienced the body swap with throughout the experience?
8. Do you think that you were immersed, while experiencing the story?
9. To what extent did it feel like you were physically present in the story?
10. How much did you feel that you were in the scene depicted?
11. How much did you feel like you experienced the story from someone else's point of view?
12. Did you have fun interacting with the experience?
13. Did you have fun interacting with virtual environment?
14. What was more powerful to you in the experience?
15. In the first scene, what outfit did you choose and why?
16. During the second scene, what was your biggest concern when choosing to intervene or not? If you witnessed such events in real life, do you think that would have been your response?
17. Does the experience help you to feel empathy with a woman now?
18. Did this topic change in its level of personal importance to you after experiencing Behind Her Eyes?
19. After experiencing Behind Her Eyes, how much did your view change on the subject?
20. Did this experience change your perspective on sexual harassment? If yes, in what way?
21. How long did the experience feel to you?
22. How likely are you to share this story with your friends or family?
23. Is there anything you wish had happened or you had done differently in the VR experience Behind Her Eyes?

CURRICULUM VITAE

Name Surname **:** Ece Karahan

Place and Date of Birth **:** Zonguldak, 1992

Foreign Languages **:** English, French

Primary Education **:** TED Zonguldak College Foundation Private Primary School

Secondary Education **:** TED Zonguldak College Foundation Private High School

Bachelor's Degree **:** Bilkent University, B.Sc. Interior Architecture and Environmental Design, 2015

Name of Institute: Social Sciences Institute

Name of Master's Program: Game Design

Working Life:

- Logic Artists, 3D Prop & Environment Artist (2019 -)
- Centre de Recherches Interdisciplinaires, Research Intern (2018)