QATAR UNIVERSITY

COLLEGE OF ENGINEERING

QUANTIFYING EMPATHY IN VIRTUAL REALITY

BY

WALEED BIN OWAIS

A Thesis Submitted to

the College of Engineering

in Partial Fulfillment of the Requirements for the Degree of

Masters of Science in Computing

June 2021

COMMITTEE PAGE

The members of the Committee approve the Thesis of
Waleed Bin Owais defended on 08/04/2021.

Dr.Elias Yaacoub
Thesis/Dissertation Supervisor

Prof.Divakaran Liginlal
Committee Member

Prof.Sumaya Al-Maadeed
Committee Member

Prof.Usama Ali Ebead
Committee Member

Approved:

Khalid Kamal Naji, Dean, College of Engineering

ABSTRACT

Owais, Waleed Bin Masters : June : 2021, Masters of Science in Computing

Title: Quantifying Empathy in Virtual Reality

Supervisor of Thesis: Elias Yaacoub.

We propose a multidimensional model in virtual reality (VR) based intervention to quantify empathy enhancement and promotion of prosocial behavior. A simulation in virtual reality is developed, which can be used as a form of behavioral therapy, thereby facilitating the study of the impact of VR on quantifying empathy. This research investigates which type of virtual reality based intervention has the maximum efficacy in evoking empathy and other allied prosocial behavior. The framework is divided into three niches. The first niche is User-Avatar merging wherein the respondent takes the first person perspective (1PP) of being homeless in an immersive interactive virtual environment. The second is passive interaction wherein the respondent is immersed in a virtual environment and is exposed to simulation but with no interaction. This is done by transposing the viewpoint in third person perspective (3PP), and the third is baseline study group where no virtual reality based intervention was provided. The empirical evidence indicates that there is a significant impact of immersion on empathy and prosocial behavior, and user-avatar merging is the most effective type of VR based immersive intervention to evoke empathy.

DEDICATION

I dedicate this thesis to my parents' for their unwavering, unconditional support and belief in my endeavors and decisions. For being a constant source of motivation and inspiration to succeed notwithstanding the obstacles in life. To my brother who continues to fill in for me in my absence.

ACKNOWLEDGMENTS

“All praise be to Allah (SWT) who is the most beneficent, the most merciful.”

I would like to place on record my heartfelt gratitude to my supervisor, mentor and guide Dr.Elias Yaacoub. Without his guidance and support, this work would not have had been possible.

I would also like to thank Prof.Somaya Al-Maadeed for giving me the opportunity to work in the Virtual Reality lab. Special mention for Dr.AbdelGhani Karkar who acquainted me with VR basics.

I am extremely grateful to every participant who took part in the experimentation process in these trying times. I am equally grateful to the Department of CSE and all my colleagues in the VR lab who helped in the recruitment process.
Last but not the least; I would like to thank all my friends and acquaintances for their support.

The results published in this work are based on the project Quantifying Empathy in Virtual Reality, the experimentation is approved by the QU Institutional Review Board vide letter no QU-IRB 1416-EA/20.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Virtual Reality (VR) is defined as the usage of computer based technology to create a stirring and impelling surrounding to generate a replicated environment [1]. VR generates a simulated world for an end-user giving the illusion as if the person were psychologically present in the computer-generated environment. In this environment, the end users are able to move inside the virtual environment, in addition to interacting with it [1].

It is the ability of a VR to stimulate presence, which is a personal sensation of 'being inside something' that enables the end-users to gauge and understand other perspectives apart from their own. Attributed to the advent of virtual reality, its usage has augmented in different domains such as education, healthcare, entertainment, and others just to mention a few. Mostly, the use of VR comprise of situations where realism is expensive and fraught with complications and danger. The foray of VR into such spheres has increased its popularity. One such realm is the quantification of empathy. Empathy can be defined as an emotional or mental reaction of a person when witnessing the situation from the other person's perspective or vantage point. Extensive research suggests that taking the perspective of someone else is an efficient medium to enhance empathy and promote prosocial behavior [2]. However most perspective-taking tasks are imaginative or verbal. This adds a caveat, as we solely cannot rely on the imagination because of the limited knowledge and contact with a certain social target. This is the reason VR has been touted as the best medium in perspective taking.

The outcome of its usage is phenomenal and the results are overwhelming. Over the past years, tech giants such as Facebook, Sony, HTC and now Microsoft are investing greatly in Virtual Reality.

However, lately, there has been a lot of discussion in the research community concerning the usage of VR as an "empathy machine". There has been a plethora of research vis-a-vis quantifying empathy in VR. Flagship programs of Oculus such as "VR for Good" have been introduced which envisage the usage of Virtual Reality to increase empathy. HTC's "VR for Impact" is another case in point [3], [4]. According to theories such as social presence and media richness, it has been investigated that an experience in VR increases empathy and responsibility. In addition, this further leads to stirring of prosocial behavior. This manifests itself in an improved intent for volunteerism in social causes, in addition to improved resolve to donate money and time [5].

There are people around us who are not privy to the social concerns, and this is where VR comes to play. Environments are designed in such a way that it gives the users a feeling of experiencing a situation from another person's perspective. Research suggests that perspective taking can help manifest empathy and promote prosocial behavior.

It is attributed to this reason that VR has been extensively used over the past few years by various NGO's and global humanitarian organizations. Chris Milk in his famous 2015 Ted Talk described VR as "ultimate empathy machine". This was mainly attributed to the fact that inside a VR environment we have the ability to experience almost everything notwithstanding the limitations of that experience in real life [6].
"Clouds over Sidra" [7] is another case in point. A heartbreaking VR movie about the Syrian refugees that was produced in association with the United Nations (UN). It has the distinction of being the first movie shot for the UN in VR.

Set in Jordan, near the Za'atari camp, which houses hundreds of thousands of Syrian refugees, it revolves around the life of a twelve year old in the refugee camp,

highlighting her daily life in the ragged tent, school and playground in the camp [8]. Xifei Lu remarks that watching the movie is akin to coming to a Syrian refugee camp and witnessing her life by actually being with her.

It was the overpowering reaction to the movie, which facilitated information dissemination about the refugee crisis. It also aided the cause of the Syrian refugees manifold, further validating the usage of VR as an "empathy-machine" [9].

It is against this backdrop that researchers are using various VR intervention techniques to increase empathy and promote prosocial behavior. Immersive VR technology such as Computer Aided Virtual Environment (CAVE) and Head Mounted Display (HMD), establish user's perspective inside the VR environment. This perspective is akin to being on-site, and is touted to have the maximum efficacy than any other immersive media.

1.1 Significance of Immersive Virtual Environment to Increase Empathy

In an immersive virtual environment (IVE) the end-user is under the impression of being psychologically physically present inside a virtual environment [10]. An IVE can be established in two different ways:

1. Computer Aided Virtual Environment also referred to as CAVE, projects the imagery onto a cubical shaped room. The cubical shaped room has translucent walls, ceiling and the floor. Inside the CAVE, the user's position can be tracked using the infrared (IR) cameras. The user can move freely within the demarcated cubical room. Shutter glasses are used to give the user an illusion of depth. These glasses allow the user to see the generated imagery as a 3-D structure [11]. This is depicted in Figure 1.

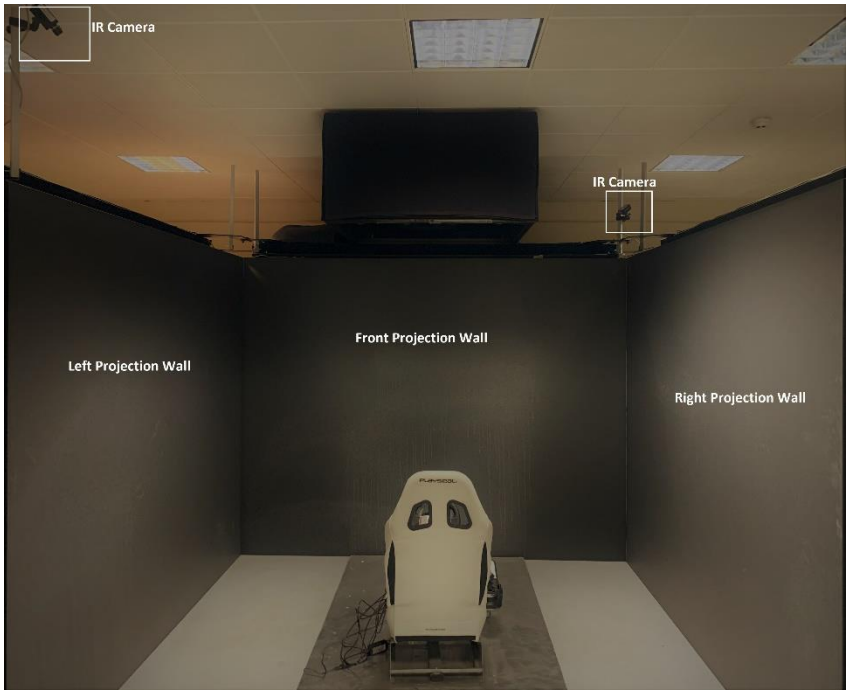


Figure 1. Computer Aided Virtual Environment (CAVE)

2. Head Mounted Display (HMD) is usually part of a headgear. It has a small display optic in front of the eyes that enable the user to see the visual imagery. This HMD is connected to the computer on which the simulation runs. To track the user's position separate IR cameras are used [12]. This is depicted in Figure 2.

Figure 2. HMD and IR cameras attached to a VR ready laptop

The importance of IVE is attributed to the following reasons as per [13] :

- IVE lets us have a precise control over the simulation distribution.
- It allows increasing the thresholds of operating a simulation without having a trade-off with control mechanism.
- There is an upsurge on the influence of experimental research.
- It enables us to simulate situations that are otherwise difficult to be achieved in normal conditions.
- It increases the efficacy in the precision in conduction of experiments
- There is a provision of data gathering with respect to tracking coordinated eye, hand and head movements with increased precision.

1.2 Research Questions

The project envisages the answers to the following research questions:

- Can Virtual Reality be used as an intervention method to increase empathy and prosocial behavior?

- How effective is VR as an intervention method juxtaposed to other conventional methods to evoke empathy and promote prosocial behavior?
- Which mode of VR intervention is most suitable to elicit empathy and promote prosocial behavior for the homeless?

The investigation will mainly revolve to find empirical evidence that find validated answers to the aforementioned research questions.

1.3 Research Objectives

The purpose of this research is to design a multidimensional intervention model in VR and gauge its efficacy in enhancing empathy and promoting prosocial behavior. This research will present a framework in which the targeted categories will be people enduring prejudice attributed to being homeless.

The aforementioned framework will be divided into three proposed niches namely:

User-Avatar Merging: VR based intervention wherein the respondent takes the first person perspective (1PP) of the avatar thereby giving the illusion as if the avatar were its own body, facilitated by active interaction such as controlling the sequence of events etc.

Passive Interaction: VR based intervention wherein the respondent takes the third person perspective (3PP) and is exposed to simulation, although there is no interaction, as juxtaposed to User-Avatar merging. This includes witnessing the simulation.

Baseline group: where no VR based intervention will be provided. The information with respect to the targeted category which is the homeless will be provided orally to the participants. This group will be used as a reference to measure the increase/decrease in empathy with the help of VR intervention.

The research will discuss and debate how efficiently VR can address or contribute in lessening prejudices or predilections people have towards homeless persons and how VR can be used as a behavioral tool to empathize with such people. The objectives that this research will try to accomplish are:

- Explore and quantify the efficacy of Virtual Reality as an intervention tool in alleviating biases.
- Explore and quantify the efficacy of Virtual Reality as an intervention mechanism to increase empathy and promote prosocial behavior among people towards the underprivileged section of society such as homeless people, who are often subjected to prejudice and are attached with numerous social stigmas.
- Compare the efficacy of Virtual Reality based intervention with non-VR intervention.
- Incorporate the use of different metric's to evaluate and substantiate the influence of VR on empathy.

The rest of the manuscript is divided as follows: Section 2 gives background information related to various concepts used in this research. Section 3 outlines the related work. Section 4 describes the methodology used in the experimentation. Section 5 outlines various instruments used in the process of experimentation. Section 6 discusses the results obtained. Section 7 includes a brief discussion. Finally, Section 8 concludes the manuscript and outlines the limitations and envisaged future work.

CHAPTER 2: BACKGROUND

In this chapter, a brief outline of various concepts, techniques and models used in this investigation will be provided. Since the problem that we are investigating lies at the intersection of computer technology and psychology, it is imperative to understand the nuances of these fields.

2.1 COM-B Behavior Change Model

Before designing any intervention that that results in behavioral change, it is imperative to understand the sequence of events from scratch. This is where COM-B Behavior Change Model and intervention logic model (shown in Figure 3) comes into play.

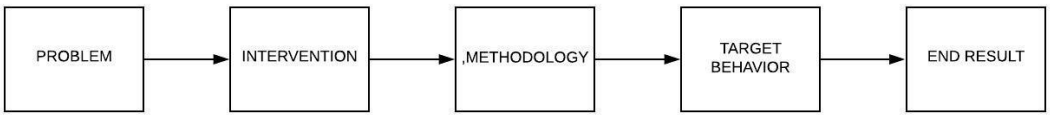


Figure 3. Intervention Logic Model

Based on the chain of events we can understand and gauge the parameters we need to facilitate increase in empathy and promote prosocial behavior. Adapting the intervention logic model [14] we can delineate the following parameters for our investigation as reflected in Table 1.

Table 1. Intervention Logic Model Parameters

Parameter	Research Objective
Problem	Bias, prejudice and lack of empathy for homeless
Intervention	Virtual Reality
Methodology	Validated self-report measurements
Target Behavior	Increase in empathy and prosocial behavior
End Result	Increase in volunteerism, and donation of time and money

Attributed to the COM-B [15] model it has been deduced that for a behavioral change to take place certain parameters need to be taken into consideration.

Capability: This part of the model deals with the physical and psychological aptitude to facilitate a certain change in behavior. Information dissemination that increases the knowledge are included in the psychological aptitude. As aforementioned VR can provide an environment for the same.

Motivation: This includes the motivational capability that augment a behavior change. This can also be facilitated by the use of highly immersive virtual environment by simulating disadvantages associated with a particular scenario.

Opportunity: This refers to the interaction with an environment that enables behavioral change. VR can simulate such environments which may or may not be possible to encounter in real-life.

Thus, it is concluded that VR is appropriate intervention to facilitate a behavioral change.

2.2 Empathy

Empathy is derived from “empatheia”, where pathos refers to suffering. Empathy can be defined as an emotional and mental reaction of a person when witnessing the situation of the other person’s perspective or vantage point [16]. In the field of neuroscience and psychology, empathy can be classified into the following three types:

- Cognitive Empathy: This type of empathy can be defined as the ability to see things from someone else’s perspective. It can be best explained by commonly used phrase “walking in someone’s shoes”. Cognitive empathy leads to motivation and promotes prosocial behavior [17].
- Emotional Empathy: This type of empathy can be best described as an emotional contagion. It is manifested when we feel the same emotion as someone else is feeling. For instance if someone sees a friend crying, they instinctively start crying as well. In a nutshell, this type of empathy enables us to feel others’ emotional state [18].
- Somatic Empathy: This type of empathy is defined as a physical response to other person’s emotive state. It is this type of empathy that manifests itself in the form of helping behavior such as volunteerism, monetary donation etc. [19].

In this research we mainly focus on cognitive empathy as it manifested by taking a perspective of someone else, and since we are investigating the evoking of empathy using various perspective taking exercises, our objects mostly align with Cognitive empathy [20].

2.2.1 Simulation Theory in Empathy

According to this theory, empathy is manifested when we have a first person perspective of the actions and emotions of the other person. “Walking in the other person’s shoes” establishes empathy [21].

This exclusively ascribes to our investigation where we will create a VR based simulation to generate an environment that will enable participants to see things from other people’s vantage point and perspective.

2.3 Approach for testing in Virtual Reality

In accordance to our review [22] which outlined various VR based interventions to elicit empathy, the authors divided VR interventions into three types, shown in Figure 4:

1. Super Human Interaction
2. User-Avatar merging
3. Passive Interaction

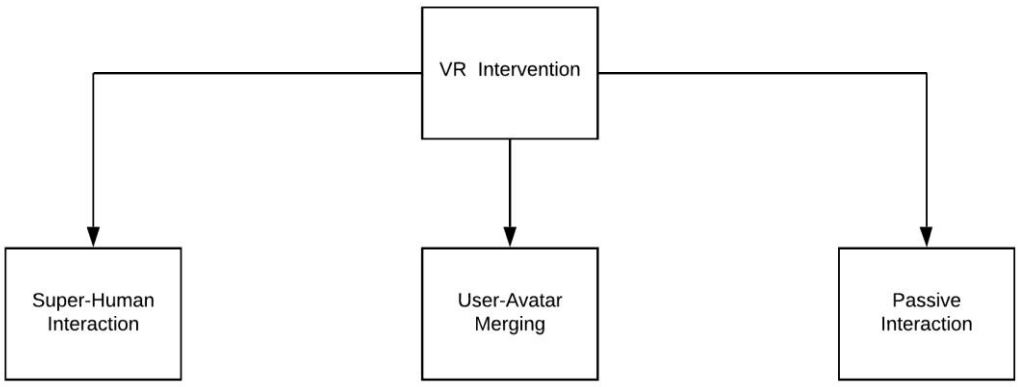


Figure 4: Different types of VR based intervention

2.3.1 Super-Human Interaction

In this technique, a user is provided with a VR intervention in which it enjoys certain super-human capabilities. These capabilities manifest themselves in various forms, for instance changing the sequence of an event or to be acquainted with information, that are super normal in nature. An example of such intervention was given in [23], [24] wherein the participants were capable of having a flashback and changing the point of view (POV). Narrative empathy was manifested in interactive storytelling. Attributed to the change in POV the participant was able to witness a simulation from a diverse vantage point altogether. This coupled with flashback gave the user the discretion to immerse in the simulation with a self-chosen POV to witness a scenario, rather than witness from the vantage point of VR developer. The results indicated that change in POV and enactment of a flashback elicits empathy.

2.3.2 User-Avatar merging (UAM)

This type of VR intervention is also referred to as Body-ownership illusion that is we are under an illusion that we own another body, in addition to our own body. The virtual avatar inside an immersive virtual environment substitutes the first person perspective (1PP), thereby creating the body-ownership illusion. The avatar inside the virtual environment is coordinated with the user's movements. The possession of virtual body via illusion is prompted by visual-motor congruent actions [25]. For instance in Rubber Hand Illusion, the illusory Body-ownership is represented by visual-tactile stimulation. There are numerous examples of investigations that have used User-Avatar merging to measure empathy. For instance, in [26] the respondents in the investigation were given a first person perspective (1PP) of a character imprisoned in

Guantanamo Bay. Although there were no self-report measures to quantify empathy or other prosocial behavior, many participants reported feeling anxiety and discomfort. In addition, many conveyed emotive correlation with the virtual prisoner.

2.3.3 Passive Interaction (PI)

In this type of VR intervention, a participant is immersed in a virtual environment but with limited or no interaction. In Passive Interaction, a third person perspective (3PP) is established for the user. This is in sharp contrast to UAM where the user gets the body-ownership illusion attributed to establishment of first person perspective (1PP). This type of VR intervention is the most widely used. The stimulant in this type of intervention is mostly 360̊ degree movies, non-interactive simulation.

Plethora of investigation has been done to quantify the impact of Passive Interaction on behavioral change, empathy enhancement and promoting social behavior. The targeted niches mostly in case of PI have been war-victims, refugees and autistic children, among others.

By investigating the three paradigms, it was concluded that UAM and PI will be most suitable for our targeted niche which is the homeless. By establishing a first person perspective of being homeless in UAM, to establishing a third person perspective in PI of witnessing someone else being homeless, UAM and PI are most suitable. The reason why Super Human interaction was excluded was because we found it imperative to establish realism, and in most cases of Super Human interaction, the problem is fixed at the end. This would have had been conflicting to our investigation, since we want the user to experience the suffering, anguish and distress that is ascribed to being homeless.

Summary

In this chapter, a holistic overview was given about various VR and psychology paradigms. The psychological models validate that VR can be used as a type of intervention to facilitate behavior change, enhance empathy and promote prosocial behavior. In addition, it was discussed as to why User-Avatar merging and Passive Interaction are most suitable frameworks in immersive virtual environment to provide intervention to enhance empathy for homeless people.

CHAPTER 3: RELATED WORK

In this chapter, research that has been done thus far in using VR as an intervention tool to enhance empathy will be discussed. Attributed to the fact that the field of quantifying empathy using VR is quite nascent, there is a dearth of research in this facet. We have reviewed almost all the scholarly, peer reviewed studies that have used VR as a conduit to enhance empathy and promote prosocial behavior.

In [27] emotional story-telling was used in VR. The logical conclusion of the story was derived from the user input. That is, the user had the discretion to choose one of the many vantage points of a same story. As per the authors, this imbibed a sense of super naturalism in the respondents giving them the illusion that they had control over how a particular scenario would end. This resulted in behavioral change of the participants and promoted prosocial behavior. Another example in this regard is [24]. In this investigation, the concepts of flashback and change of point of view (POV) were used. The objective was to manifest interactive storytelling in such a manner than it elicits empathy. Attributed to the change in POV the participant was able to witness a story from a several vantage points. This coupled with flashback allowed the participant to select its own POV to witness a scenario in VR rather than witness from the vantage point of VR developer. The flashback made the respondent privy to certain things which are otherwise concealed in real-life scenarios. The results indicated that change in POV and enactment of a flashback elicits empathy.

As per the outcome of a research in [28] , the authors concluded that perspective taking exercises in VR have an impact in enhancing empathy in real life, but added a caveat, that the subject of the perspective taking exercise should be based on realism, which is in contrast to the findings in super human interaction.

In a study [29] that investigated the impact of usage of VR as an intervention

tool to enhance empathy among people for colorblind, VR intervention was compared with traditional perspective taking exercise, and it was concluded that VR was an effective medium to enhance empathy as compared to non-VR intervention. It further added that behavioral change embodied in VR intervention indeed showed its impact in real life, which was validated that participants who were given VR intervention made twice the efforts to help people who are colorblind as compared to those participants who did not receive VR intervention.

To raise awareness about bullying and to showcase the psychological impact it has on a victim, [30] simulated a virtual classroom. It showcased a foreign student getting bullied by his classmates. The respondent was given a choice to see the perspective of the bullied student and that of a teacher. The overall results of the experiment concluded that majority of participants' empathy was enhanced as was validated by various self-report measurements taken pre and post experimentation. In [31] the authors juxtaposed narration based perspective taking with Virtual Reality based perspective taking, and concluded that VR based perspective taking drives empathy and other allied prosocial behavior.

Another experiment that used VR intervention to enhance empathy was [32]. This investigation created a virtual simulation that enabled the participants to see things from the perspective of a prisoner in Guantanamo Bay. Even though no self-report measures were recorded post intervention, many of the respondents reported discomfort and unease, and conveyed an emotional relation with the prisoners.

In addition, VR based intervention has been used to improve the understanding of certain psychological disorders such as panic attacks. In [33] various simulations showcased what a person experiences when he/she is undergoing a panic attack. The objective of the investigation was to check the viability of VR intervention for empathy

enhancement. This was successfully validated in the results, which showed that participants had an empathy enhancement, increased understanding and sensitivity for people who undergo panic attacks.

Empathy is of utmost importance in the field of healthcare, in fact it is considered as one of the pillars in healthcare [34]. As per research, healthcare professionals who are empathetic facilitate reduction in anxiety in their patients and also make the patient more comfortable in confiding. However, there is a burnout associated with medical profession [35] , that is, with the passage of time there is an ebb in empathy. To this end, investigators in [36] created a VR intervention for medical students, simulating an old person with high degree of ailments. The results indicated that VR intervention made the medical students more empathetic with respect to old age patients, mostly having hearing and vision impairment. This was echoed in [37] as well, where students of dental science were provided with VR intervention to treat a virtual patient. It was concluded that participants who received VR intervention were found to be more empathetic, and devoted more time to their patients than the participants who did not receive VR intervention.

In [38] the respondents witnessed a 360° VR movie about a young refugee living in a camp. The investigation concluded that participants who viewed the VR content in HMD reported feeling more empathetic than the participants who viewed the same content in a 2D environment. Likewise, in [39] the participants who viewed a movie of horror genre in a VR environment reported more emotional response than the participants who watched it in 2D. This further corroborates the fact that there is a positive correlation between VR intervention and evoking emotiveness. To acquaint people with what autistic children endure and feel, investigators in [40] stimulated a passive VR environment that consisted of severe mixture of sounds and visual imagery

of how an autistic child views things. The investigation concluded that majority of participants (87%) displayed visible-emotion, and anxious facial expression (79%). The results were validated with statistical analysis.

3.1 Envisaged Contribution

To the best of the knowledge of the author, there has been no investigation where the use of VR intervention has been investigated from a multimodal perspective, which is juxtaposition of various paradigms that we have outlined such as User-Avatar merging and Passive interaction. It is imperative to identify with suitable empirical evidence which mode of VR based intervention is most suitable to elicit empathy and promote prosocial behavior. In addition, most of the investigations that have been described in this section ascribe to either of the paradigms.

In the limitations chapter of [31] the authors have explicitly mentioned about the need to check the role of interactivity with non-interactive process, which is what we refer to as User-Avatar merging and Passive Interaction respectively.

Herein we present empirical evidence with respect to multimodal comparison of two paradigms in VR intervention. In addition, research suggests that the level of familiarity with Virtual Reality may influence the outcome, as most people are overwhelmed with technology. To this end, we will use the concept of dual immersion, that was introduced and recommended by [41] which means that participants who are not acquainted with VR should be immersed at least twice, but none of the work aforementioned have used this concept. Table 2 provides a summary of the related work.

Table 2. Summary of Related Work

Type of VR intervention	**Targeted niche**	**Reference**	**Empirical Analysis**
Super Human Interaction (SHI)	Emotional story-telling	[24],[22],[28]	Post
Passive Interaction(PI)	Colorblind	[29]	Pre and post
User Avatar Merging (UAM)	Bullying	[30] ,[31]	Pre and post
PI	Prisoners	[32]	No
UAM	Psychological disorders	[33]	Pre and post
UAM	Healthcare	[34],[35],[36]	Post
UAM or PI	Refugees/Homeless	[38], [39]	Pre and post
PI	Autism	[40]	Pre and post

CHAPTER 4: METHODOLOGY

Here we have a design: T x S: (where T {T1, T2, no tech} represents the set of technologies and S {homeless scenario1, homeless scenario2, verbal representation} represents the contexts being simulated).

A study was conducted to compare the effect of different types of immersion within (VR) and investigate its impact on empathy and allied prosocial behavior vis-à-vis homeless people. The different types of immersive intervention include the User-Avatar Merging and Passive Interaction. In the User-Avatar merging, the participants were immersed in an interactive virtual environment wherein a first person perspective (1PP) [42] of a homeless person was established. In the Passive Interaction, the participants witnessed a non-interactive (no user input) simulation, which led to transposing the respondents viewpoint to a third person perspective (3PP) [43] of a homeless person. There was no interaction (user input) with the simulation in the Passive Interaction as juxtaposed to User-Avatar merging.

A baseline study was also conducted wherein no VR based intervention was provided. The baseline group was only given a brief verbal introduction vis-à-vis homeless people. The intuition behind briefing the participants in G1 was to acquaint them to a small degree of information so that they would answer the questionnaires with ease. The primary reason for the establishment of G1 was to gauge the level of empathy people generally have for homeless people and to find the degree of variation between VR and non-VR intervention.

The baseline study group will hereafter be referred to as the Control Group (G1) and the Experimental Group (G2) consists of the respondents who received the two types of VR based intervention as reflected in Table 3.

Table 3. Group Divisions in the experimentation

Group	VR Intervention	Sample Size
Control Group (G1)	No	13
Experimental Group (G2)	Yes	28

The experimental group (G2) is further bifurcated into G2.1 and G2.2 that refer to the User-Avatar merging and Passive Interaction respectively shown in Table 4.

Table 4. Experimental Group Bifurcation

Group	Type of VR Intervention
G2.1	User-Avatar Merging
G2.2	Passive Interaction

4.1 Method

The experimentation and the procedures were approved by the Qatar University's Institutional Review Board vide letter number QU-IRB 1416-EA/20. The participants signed a consent form indicating their approval to voluntarily participate in the experiment and publish the results anonymously.

4.2 Participants

The recruited participants were above the age of 18. The notification with regards to participation was sent via emails, social media and in addition, a flyer was posted outside the Virtual Reality Lab where the experiment was conducted. There was no bar with respect to eligibility vis-à-vis age or gender, except being above the age of 18. Participants who replied in affirmative were asked to come to the Virtual Reality Lab of Qatar University. The participants were also provided with a google map to locate the lab seamlessly.

A total of 45 participants gave their written consent to voluntarily participate in the experiment. Of the 45, 4 participants were unable to complete the experiment attributed to motion sickness and thus the intervention was stopped immediately. No results were recorded in this scenario. Not all participants were native speakers of English but all of them were comfortable in answering in English with ease. Moreover, to ensure that participants did not feel fatigue in filling the self reported measures, the scores were pre-printed and the participants had to merely encircle the score.

The absolute sample (n = 41) consisted of the following attributes:
23 men (56.09%) and 18 women (43.9%) participated. The range of ages was between 19 and 41. The mean age was 26.4 and the standard deviation was 4.91(M= 26.4, SD = 4.91). The participants were mostly undergraduate and graduate students enrolled in a public university.

4.3 Design and procedure of the experiment

The participants were assigned randomly to the Control Group (G1) and to the two subgroups G2.1 and G2.2 of Experimental Group (G2).

4.3.1 Development of Simulation

The simulation was developed in Unity 2019.4.20f and Oculus SDK was used. The development was done in C#. Some of the assets used in the simulation were downloaded from the Unity asset store and made VR compatible.

4.3.2 Scenario of the simulation

The VR simulation begins inside a room. Throughout the course of simulation, a voiceover orients the participant from the beginning to the end. Initially the participant finds himself inside a room. The voiceover directs the participant to locate the radio. The participant moves inside the room using the two oculus touch controllers. As the user locates the radio, the proximity sensor around the radio is activated and the user is directed to turn on the radio by using the hands.

When the user presses the button to turn on the radio, the news bulletin is on which mentions about a large number of people being laid-off because of the pandemic.

As the participant is registering the news bulletin, the voiceover informs the participant about unread voicemails. The participant locates the telephone and presses the voicemail button. The voicemail is of a person who happens to be the boss of the participant. He regrettably informs the participant that attributed to the pandemic and recent economic downturn the participant is being laid off. After this, the voiceover directs the participant to move towards the table. The participant finds a document, which happens to be an eviction notice. The voiceover informs the participant that attributed to non-payment of dues (house rent); the room needs to be vacated immediately. After that, the participant is asked to pack the things in a bag and head to the door to exit the room.

After exiting the room, the participant finds himself in a car. The voiceover informs the participant that there have been strict warnings by the local police to the

public to not sleep in their cars as the cases of homelessness were increasing.

The participant is able to drive by placing his virtual hands on the steering and the sensors record the hand movement to steer the car left or right. The voiceover directs the participant to drive to a secret location where the car can be parked and the participant can spend the night in the car. As the participant was driving, flashing green-colored signs were used to give directions to the desired location. After the participant reaches the desired location (an area demarcated by a flashing red sign), he is instructed to park the car there. After the passage of few seconds, a police siren is heard and a police patrol car approaches. The participant is informed that the police have impounded the car.

In the last scene of the simulation, the participant is without a car, on a street all by himself with his belongings. The participant is warned about thieves that may try to take away the belongings. As the participant is moving in the street he sees other homeless people around. Some try to attack him and take away his belongings. The participant is instructed to run in an alley by using the controllers. It is at this moment that the simulation ends followed by a few textual messages regarding homelessness.

Some ideas for the storyline of the simulation were adapted from a documentary titled Hotel 22 [44].

4.3.3 Procedure for Experimental Group G2.1

As aforementioned G2.1 is the subtype of the experimental group G2 also referred to as the User-Avatar merging. The total number of participants in G2.1 was (n = 14). In this group before immersion, each participant was asked to fill a pre-immersion questionnaire. After that, an intervention was provided to the participants by immersing them in an interactive virtual environment which is the simulation

aforementioned. The participants experienced the first person perspective (1PP) of what it means to be homeless. The participants were seated on a chair, and an Oculus Rift CVI was used as an apparatus.

Oculus Rift CV1 [45] was used for immersion, which consists of a head mounted display (HMD), two touch controllers and two sensors which track the participants head and hand movement (orientation and translation) inside the simulation. The two hand-held Oculus wireless touch controllers provide the hand-presence inside the simulation giving the respondent the illusion as if it were his own hands. The hands seen inside the simulation translate according to the respondents hand movements.

The HMD has a resolution of 1080 x 1200 pixels and runs at 90 Hz. The inbuilt headphones of the HMD were used for the audio. The two sensors tracked the participant's movement inside the simulation. The specifications of the laptop on which the simulation was run were Intel(R) Core(TM) i7-4720HQ CPU @ 2.60GHz 2.60 GHz, the OS used was windows 10 and graphics-card used was NVIDIA GEFORCE 1060.

To configure the HMD, sensors and the touch controllers Oculus software was used. The tracking area was calibrated before every immersion to give the participant a seamless VR experience. The tracking was set within a radius of 200 cm from the chair on which the participant sat. Figure 5 shows all the parts of the Oculus Rift that were used. The participants were given a briefing session with regards to the use of controllers for movement. The participant in Figure 5 has given a written consent for the use of this picture. It is imperative to mention that participants who didn't have a prior VR experience hitherto, were immersed in a random VR simulation to familiarize them with the technology and reduce the overwhelming side effects of VR.

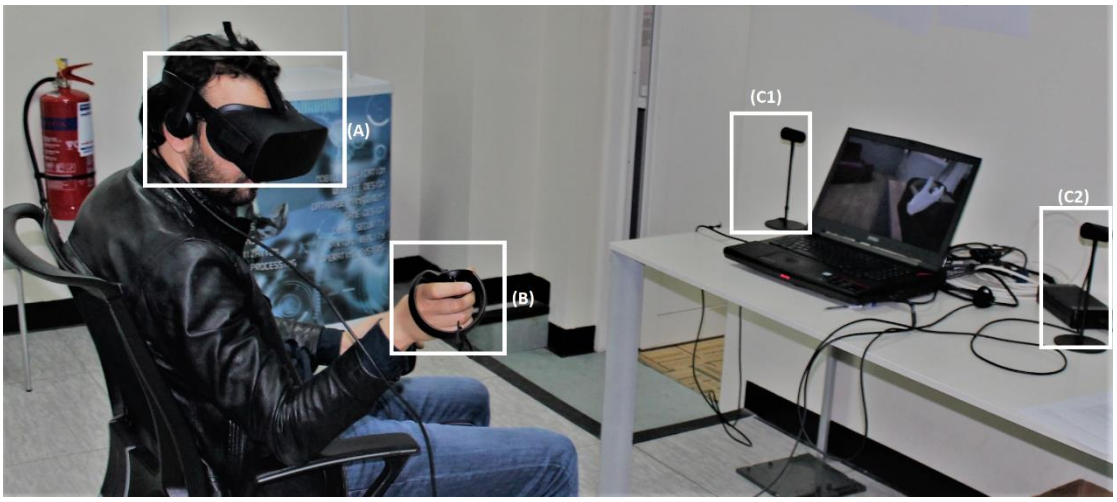


Figure 5. User-Avatar merging (A) Oculus Rift CV1 HMD (B) Right touch controller (C1 and C2) Left and Right Sensors.

Figure 6 below shows the various scenes during the User-Avatar merging immersion.

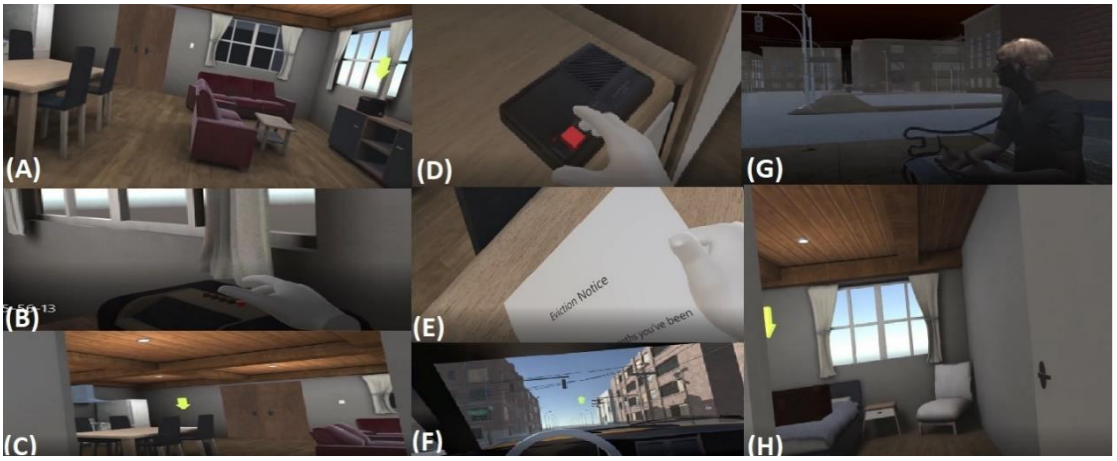


Figure 6. Different scenes in User-Avatar merging labelled from A to H

The scenes labelled from A through H depict the following as shown in the Table 5.

Table 5. Scene labelling index for Figure 6

Label	Description
A	User locates the radio
B	User switching on the radio using his fingers
C	User locating the table
D	User pressing the button on the answering machine
E	User grabbing the eviction notice
F	User driving the car
G	User seeing other homeless people in the streets
H	User locating the bag inside the room

The average running time of the simulation was 12 minutes. After the completion of the simulation, the participants were asked to fill in various questionnaires that will be discussed in detail in the next chapter.

4.3.4 Procedure for Experimental Group G2.2

G2.2 is a subtype of Experimental Group (G2) also referred to as Passive Interaction. The total number of participants in G2.2 was (n = 14). In this group before immersion, each participant was asked to fill a pre-immersion questionnaire as was done in G2.1. After that, an intervention was provided to the participants by immersing them in an interactive virtual environment, which is the simulation aforementioned. The participants experienced a third person perspective (3PP) of what it means to be homeless. The participants were seated on a chair, and an Oculus Rift CVI was used as an apparatus.

In this experiment, the participants did not use touch controllers because there was no need of a user input. The participant witnessed the simulation. The

scenario of the simulation was same as that of G2.1, the only difference being the absence of user input. The participant used the HMD to turn the head and to focus on things as and how required. Figure 7 shows all the parts of the Oculus Rift that were used. The participant in Figure 7 has given a written consent for this picture to be used. It is imperative to mention that participants who didn't have a prior VR experience hitherto, were immersed in a random VR simulation to familiarize them with the technology.

Figure 7. Passive Interaction (A) Oculus Rift CV1 HMD (C1 and C2) Left and Right Sensors

The average running time of the simulation was 9 minutes. After the completion of the simulation, the participants were asked to fill in various questionnaires that will be discussed in detail in the next chapter. Figure 8 shows the chain of events for experimentation with G2.

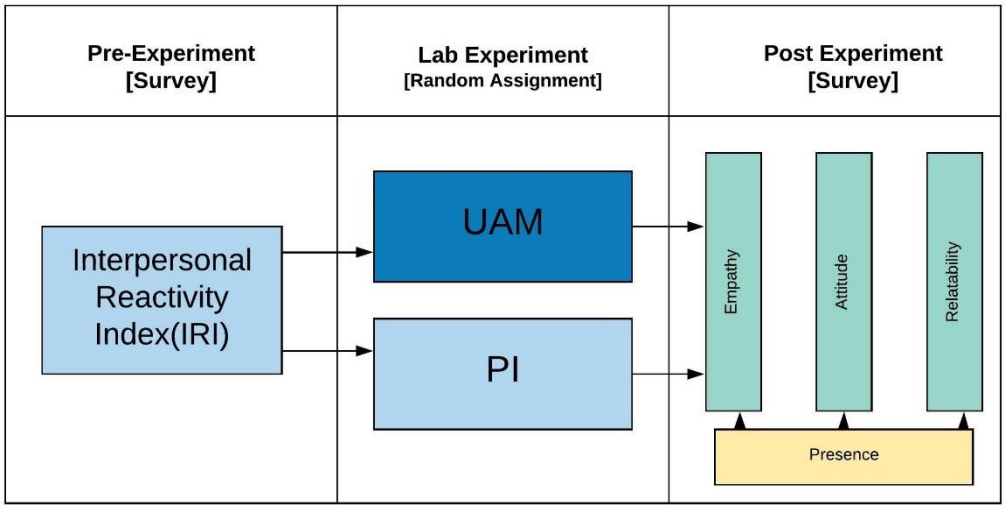


Figure 8. Chain of events for Experimetal Group

4.3.5 Procedure for Control Group G1

The control group did not receive any VR based intervention. The total number of participants in G1 was (n = 13). Participants were given a brief verbal introduction session about homeless people, and the impediments such people face in their daily lives. The intuition behind briefing the participants in G1 was to acquaint them to a small degree of information so that they would answer the questionnaires with ease. The primary reason for the establishment of G1 was to gauge the level of empathy people generally have for homeless people.

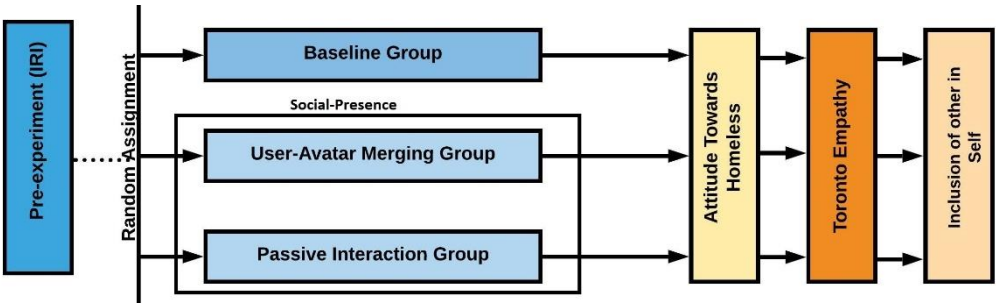


Figure 9. Methodology

Figure 9 represents the schematic representation of the methodology used in the design of the experimentation.

Summary

In this chapter, we gave a holistic view vis-à-vis various types of groups used in the investigation. We also delineated the design and the procedure for the experiment for each group, including the scenario of the simulation and the apparatus used.

CHAPTER 5: MEASUREMENTS

In this chapter a brief overview of the various scales/self-report measures used in the pre-test and post-test scenarios is discussed. All the scales used in the experimentation are provided in Appendix: A. For all the scales, the overall Mean (M), Standard Deviation (SD) and Cronbach's alpha (α) was calculated. This is in addition to the statistical analysis done for G1, G2.1 and G2.2.

The Cronbach's alpha (α) was calculated [46] to gauge the internal consistency/reliability of the scale. The value of the Cronbach's alpha (α) can be interpreted [47] from Table 6.

Table 6. Cronbach's alpha (α) interpretation

Value	Interpretation
0.91 - 1.00	Excellent
0.81 - 0.90	Good
0.71 - 0.80	Acceptable
0.61 - 0.70	Fairly acceptable
0.51 - 0.60	Poor
Less than 0.5	Unacceptable

The equation to calculate Cronbach's alpha (α) is given below

$\alpha = \frac{k}{k-1} \times (1 - \frac{\sum_{i=1}^{k} \sigma_y^2}{\sigma_x^2})$, where k = number of items, σ_y^2 = sum of variance of individual items, σ_x^2 = variance of total score of each subject. All the instruments that were used in the experimentation are one of the most widely used instruments based on the number of citations and have been validated across various demographical cultures using exploratory factor analysis (EFA), confirmatory factor analysis and test-retest reliability. As such, all these instruments are highly reliable.

5.1 Interpersonal Reactivity Index

The Interpersonal Reactivity Index (IRI) [48] is a scale that consists of 28 items. It has four sub-scales namely Perspective Taking (PT), Empathetic Concern (EC), Personal Distress (PD) and Fantasy Scale (FS).

All the four sub-scales consist of seven items each answered on a 5-point Likert Scale. The Likert Scale [49] ranges from "Doesn't describe me well" to "Describes me well". The questions are answered as A, B, C, D and E scored as 0, 1, 2, 3 and 4 respectively. Some questions are reverse coded.

The IRI is used to quantify the variation in empathy and the ability to be able to see things from other's vantage point. The scale was validated in [50].

Some of the questions in the scale are "I often have tender, concerned feelings for people less fortunate than me" and "I sometimes try to understand my friends better by imagining how things look from their perspective". Table 7 reflects the Mean, Standard Deviation and Cronbach's alpha (α) for the four subscales of IRI.

Table 7. Parameters of IRI

Subscale	Mean	Standard Deviation	α
EC	3.18	0.83	0.71
PT	2.43	0.90	0.80
FS	2.56	1.03	0.72
PD	2.18	0.98	0.74

The Cronbach's alpha (α) of all the subscales was above the required acceptable threshold. This scale was used as the pre-test scale for G2.1 and G2.2. In a later chapter, it will be described how the IRI was utilized to determine the success of random

assignment into various groups.

5.2 Attitude towards the Homeless

The Attitude towards the Homeless [51] is a 7-item scale used to quantify the attitude towards the homeless people. The 7-items are answered using a 7-point Likert scale ranging from “Strongly Agree” to “Strongly Disagree” recorded as 1 and 5 respectively. Item-1 and Item-7 were reverse coded. Some of the questions in the scale are “Homeless people do not choose to be homeless” and “Homelessness is a self-inflicted state”. The greater the score in this scale the more is the positive attitude towards the homeless people. The scale was validated in [52].

The Table 8 reflects the Mean, Standard Deviation and Cronbach’s alpha (α) for the Attitude towards the homeless scale.

Table 8. Parameters of Attitude towards the homeless

Mean	Standard Deviation.	α
3.6	0.93	0.92

The Cronbach’s alpha (α) of Attitude towards the homeless is excellent and thereby highly reliable.

5.3 Social Presence Scale

This 6-item scale is used to determine the participant’s ability to relate to virtual

objects inside the immersive virtual environment [53]. The answers determined the degree of the strong/weak feeling with which the participants felt that they were actually present in the virtual environment. This scale tests how successful the immersion was. This scale is answered using a 5-point Likert scale ranging from “Not at all” to “Very strongly”. The greater the score, the greater is the level of immersion. Some of the questions included in the Social Presence Scale are “To what extent you felt you were in the same room?” and “To what extent did you feel you could get to know someone that you met only through this system?”. It is imperative to mention that attributed to the fact that this scale measures the level of immersion in an immersive virtual environment, it was only used in the Experimental Group (G2) and not in Control Group (G1) as there was no immersion in the latter. The scale was validated in [54].

The Table 9 reflects the Mean, Standard Deviation and Cronbach’s alpha (α) for the Social Presence scale.

Table 9. Parameters of Social Presence Scale

Mean	Standard Deviation.	α
3.54	0.76	0.72

The Cronbach’s alpha (α) of Social Presence scale is acceptable.

5.4 Inclusion of the Other in the Self

The Inclusion of the Other in the Self [55] is a 2-item graphical representation of understanding and connectedness.

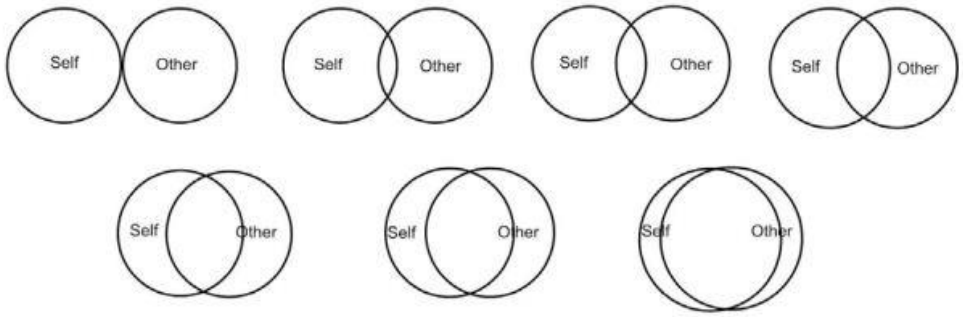


Figure 10. Inclusion of the Other in Self Scale

Each item has two concentric circles whose area of intersection varies from null to maximum. The area of intersection determines the degree of relationship that the participant felt with the homeless person. Greater the area of intersection, greater is the closeness.

The second item represents the relationship of the participant with the homeless community. The participant was asked to circle the diagram which best describes the relationship with the other homeless person and with the homeless community as a whole. Each Venn-diagram has a score between 1 to 7 (1 = no intersection at all, maximum intersection). Greater the score, greater is the feeling of closeness. The scale was validated in [56].

The Figure 10. Inclusion of the Other in Self Scale shows a graphical representaion of an item in the Inclusion of the Other in Self Scale. Overall Mean and

Standard Deviation for IOS was calculated. There was no need to determine Cronbach's alpha (α), because unlike other scales used, IOS does not have a Likert scale. Table 10. Parameters of Inclusion of the Other in Self Scale shows overall Mean and Standard Deviation for the Inclusion of the Other in Self Scale.

Table 10. Parameters of Inclusion of the Other in Self Scale

Mean	Standard Deviation.	α
4.31	0.55	-

5.5 Toronto Empathy Questionnaire

The Toronto Empathy Questionnaire (TEQ) [57] is a 16-item scale used for assessment of empathy having robust psychometric properties. The items are answered using a 5-point Likert Scale ranging from "Never" to "Always". Some of the items on the scale are "I get a strong urge to help when I see someone who is upset" and "I have tender, concerned feelings for people less fortunate than me". The answers are scored from 0 to 4 (0 = Never, 4=Always). Greater the score, greater is the quantification of empathy and of traits such as being sympathetic, tender or considerate. Some items such as Item-2, Item-7 were reverse coded [58]. This scale was validated in [59]. The Table 11. Parameters of the TEQreflects the overall Mean, Standard Deviation and Cronbach's alpha (α) for the TEQ.

Table 11. Parameters of the TEQ

Mean	Standard Deviation	α
2.81	0.97	0.71

The Cronbach's alpha (α) for the TEQ is above the acceptable threshold. The TEQ is further subdivided into four groups that can be used to determine the following prosocial traits shown in Table 12. TEQ Sub-grouping.

Table 12. TEQ Sub-grouping

Items	Prosocial behavior
1, 4	Stimulate same emotions
3, 6, 9, 11	Sympathetic arousal
2, 14, 16	Altruism
13	Helping ability

Summary

In this chapter, we discussed the parameters of various scales that were used in pre-test and post-test scenarios across the Control Group (G1) and Experimental Group (G2). Cronbach's alpha (α) which determines the level of reliability for each scale was also measured. The overall Mean and Standard Deviation for each scale was also measured.

CHAPTER 6: RESULTS

To quantify the results Mean, Standard Deviation across the three groups was compared and contrasted. The account for how significant the impact of condition was on the outcome variables, analysis of variance (ANOVA) was calculated. The data analysis was done using the R programming language [60]. Also, to account that the random assignment across the three groups G1, G2.1 and G2.2 was successful ANOVA was calculated on the population variables of the IRI across the four sub-scales. In addition, correlation among outcome variables was also measured.

6.1 Analysis for IRI (Population)

ANOVA measurement across the four subscales of the IRI confirmed that there was no major variance among the various participants clustered under the three groups. This validated that random assignment to the three groups was successful. For Perspective Taking we recorded $F(2,41) = 0.59$, p-value = 0.7 , for Fantasy we recorded $F(2,41) = 0.86$, p-value = 0.5, for Empathetic Concern the parameters recorded were $F(2,41) = 1.10$, p-value = 0.36 and for Personal Distress $F(2,41) = 1.10$, p-value = 0.34.

The alpha (level of significance) was set at 0.5 and as can be seen the p-value obtained is greater than the level of significance. As such, we did not reject the null hypothesis (H_0) which means that all the group means are equal, and that there are no statistical difference across the three groups.

As can be noted, there is no significant differences in the ANOVA parameters across the four subscales. This validates the fact all the participants were almost uniform with respect to their epithetical traits pre-intervention. Thus, our random assignment was successful.

6.2 Outcome Variables

The outcomes variables include the IOS, Attitude towards the Homeless, the TEQ and the Social Presence scale. The Mean and Standard Deviation for all the outcome variables was calculated. ANOVA [61] was conducted on all the outcome variables which conformed to our hypothesis that

a) the Experimental Group (G2) will have higher efficacy in evoking empathy for homeless as compared to the Control Group (G2)
b) the User-Avatar merging (UAM) is more effective than the Passive Interaction (PI)

6.2.1 Attitude towards the Homeless

The Mean and Standard Deviation across the three groups were calculated as reflected in Figure 11.

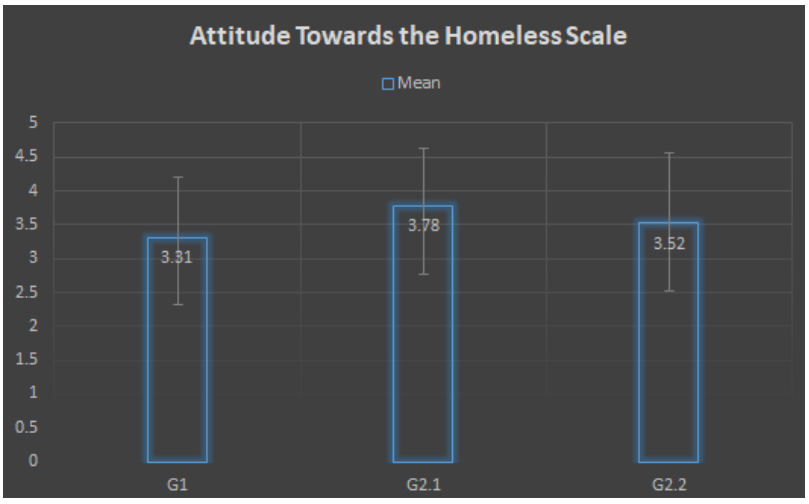


Figure 11. Mean and SD for Attitude Scale

The graph shows that more positive attitude towards the homeless was recorded in the UAM, followed by PI and G1 recorded the lowest amongst the three. To gauge how significant was the impact of the each condition we conducted ANOVA. F(2,41) = 3.27, p-value = 0.03 (which is less than the level of confidence 0.05). Thus, it indicates that there was a substantial impact of the type of grouping conditions, and that participants in the UAM type of intervention recorded more positive attitudes towards homeless.

6.2.2 Toronto Empathy Questionnaire

As was done in the previous scale, Mean and Standard Deviation across the three groups were calculated as reflected in Figure 12.

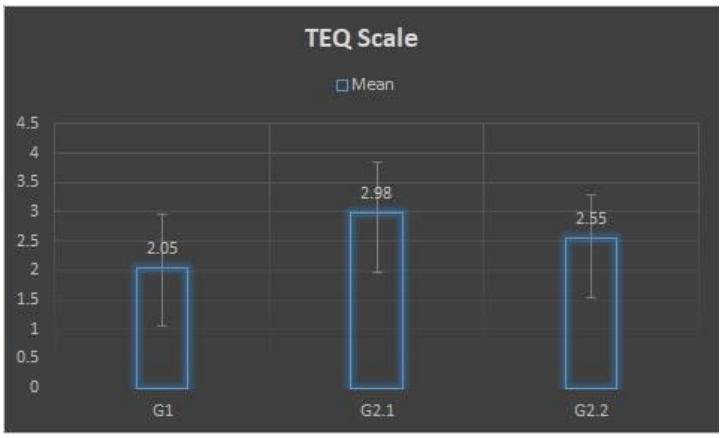


Figure 12. Mean and SD for TEQ Scale

The graph in Figure 12 shows that more participants in the UAM elicited more empathy, compassion and sympathy for the homeless followed by PI and G1 recorded

the lowest amongst the three (conforming to the hypothesis). To gauge how significant was the impact of the each condition we conducted ANOVA. F(2,41) = 1.42, p-value = 0.024 (which is less than the level of confidence 0.05). Thus, it indicates that there was a substantial impact of the type of grouping conditions, and that participants in the UAM type of intervention evoked more empathy towards homeless.

As discussed before the TEQ has various subgroups, which can be used to quantify allied prosocial behavior. Item-13 in the TEQ is used to quantify the helping-behavior. Thus, this item was analyzed separately.

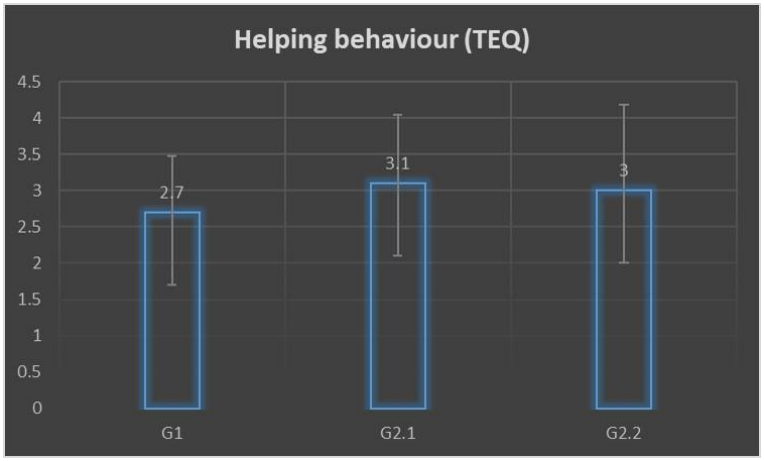


Figure 13. Helping behaviour in TEQ

The analysis conformed to the trend seen hitherto. The participants in the UAM group exhibited more helping behavior followed by the participants in the PI group as shown in Figure 13. Participants in the G1 where no intervention was provided showed the lowest helping behavior.

Item-5, item-14 and item-16 of the TEQ scale are used to quantify the altruistic prosocial behavior, which is the selfless concern for other human beings. The results determine that although there is no significant difference in altruistic behavior across the three groups, but UAM group showed highest altruism among the three. This is reflected in Figure 14

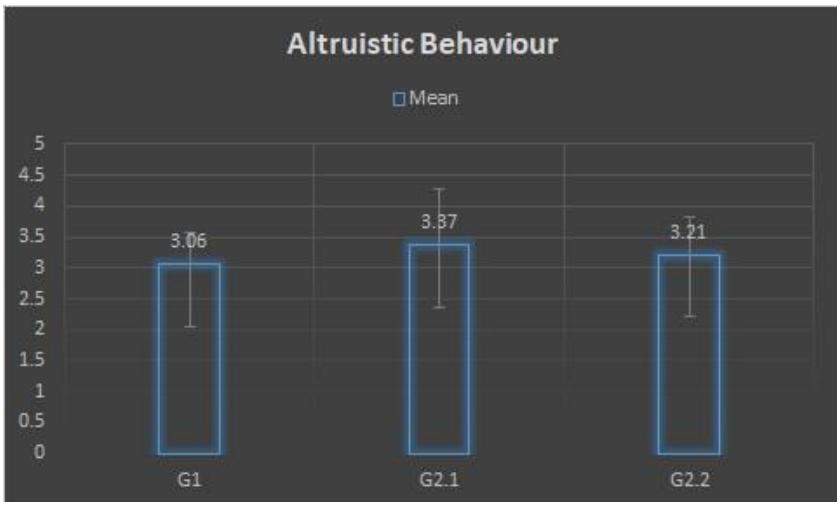


Figure 14. Altruistic Behaviour (Mean and SD)

6.2.3 The Social Presence Scale

The Social Presence scale is used to quantify the degree to which the participants felt like actually being present in the virtual environment. Analysis was done only on the two subgroups of Experimental Group (G2) as there was no immersion in the Control Group (G1). Mean and Standard Deviation was calculated as reflected in Figure 15.

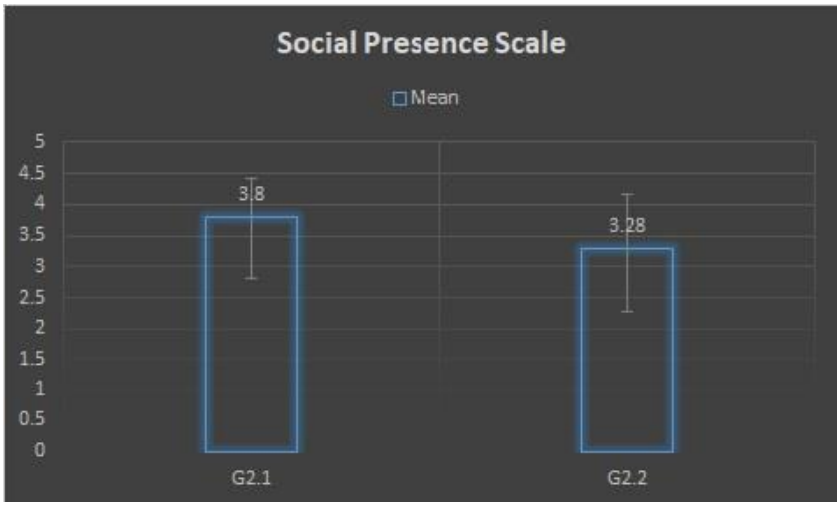


Figure 15. Mean and SD for Social Presence Scale

The graph in Figure 15 shows that more participants in the UAM felt more being inside the virtual environment than the PI. To gauge how significant was the impact of the each condition we conducted ANOVA. $F(1,28) = 8.76$, p-value = 0.003 (which is less than the level of confidence 0.05). Thus, it indicates that there was a substantial impact of the type of immersive intervention and that participants in the UAM type of intervention felt more being inside the virtual environment as compared to the participants in PI.

6.2.4 The Inclusion of Other in Self Scale

The Inclusion of Other in Self scale measures the feeling of connectedness and understandability for the average homeless person and the homeless community as a whole. Mean and Standard Deviation were calculated.

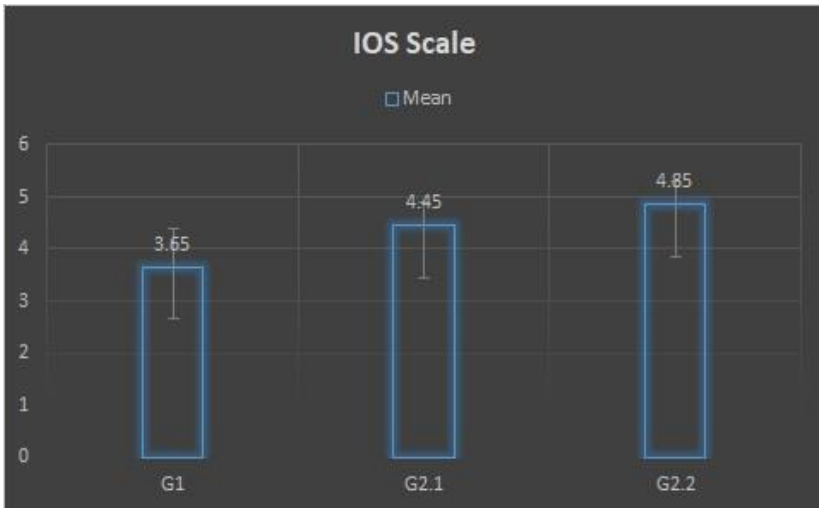


Figure 16. IOS Scale Mean and SD

As per the trend in the Figure 16, participants in the PI showed more connectedness and understanding for the average homeless person and the homeless community. This partly conforms to the hypothesis that the participants in the Experimental Group (G2) that received VR intervention will exhibit higher scores than the participants in the Control Group (G1) that received no VR intervention.

To quantify the significance of the condition across the three groups ANOVA was conducted. $F(2,41) = 3.61$, p-value = 0.03 (which is less than the level of confidence 0.05). Thus, it indicates that there was a significant impact of the type of intervention provided across the groups.

There is a deviation in the second part, which as reflected in the Figure establishes the fact that participants in PI were more understanding than in UAM. Although this seems to be a deviation from the expected trend but there is a lucid explanation for that. This will be discussed in-depth in the forthcoming chapter.

It is also imperative to mention that a large number of participants showed signs of discomfort mostly during the UAM intervention during the scenes such as car impounding and receiving the information about being laid off.

Summary

In this chapter a holistic analysis on the data was performed, by juxtaposing the data from each of three groups with the other. This was done by the calculation of Mean and Standard Deviation. In order to further validate the impact of immersion across the three conditions ANOVA was performed which validated the hypothesis. The analysis on the IRI scale reflected that there was no significant deviation across the basic empathetic traits amongst the three groups thereby validating the fact that the random assignment into the three groups was successful. Table 13 reflects the Mean and SD of all the scales.

Table 13. Summary of Mean and SD across the three groups.

Scale	G1		G2.1		G2.2	
	Mean	SD	Mean	SD	Mean	SD
Attitude	3.31	0.91	3.78	0.84	3.52	1.05
TEQ	2.05	0.94	2.98	0.88	2.55	0.75
Presence	-	-	3.8	0.62	3.28	0.89
IOS	3.65	0.75	4.45	0.45	4.85	0.45

CHAPTER 7: DISCUSSION

The self-reported measurements clearly indicate that the baseline group, which received no VR based intervention, was the least effective in evoking empathy and other prosocial traits among the participants. Likewise, the positive attitude towards the homeless people, which is bereft of biases, predispositions and prejudice, was seen more significantly in the participants that received the VR intervention. In fact, the impact of VR intervention was very significant as was validated by the ANOVA. In addition, the positive traits concerning prosocial behavior was more prominent in the UAM group. UAM group actively interacted with the simulation in the first person perspective (1PP), as juxtaposed to the PI group, in which, although VR intervention was provided but there was no user interaction, as in the user had no control over the sequence of events. This is in sharp contrast to the UAM in which the participants had full control of the movements within the simulation and could move and interact as per their discretion.

When it comes to traits such as empathy, compassion and sympathy the participants, which did not receive VR intervention, reported less empathy and compassion as compared to the group that received VR intervention. This conforms to Chris Milk's famous words when he referred to VR as the "ultimate empathy machine" [6].

Further, the participants that received the UAM intervention reported feeling more empathetic and compassionate than the participants that received the passive intervention. This is aligned with our idea that it is not only the use of VR intervention that elicits empathy, but also the type of VR intervention has a significant impact on the quantification of empathy. Further, the various traits that are measured by the TEQ

were analyzed such as helping behavior and altruism, it was reported that participants who received VR intervention showed more helping behavior as compared to the participants who received no VR intervention. This helping behavior can be interpreted that such participants will be more keen to help, donate time and money, and volunteer in causes vis-à-vis homeless people. Also, helping behavior was more prominent among participants who received UAM intervention, again conforming to our construct that the type of VR intervention

Among various factors that drive the prosocial behavior is altruism. We can speculate that participants with prominent altruistic behavior will feel a moral obligation to volunteer or donate to causes related to homelessness. In this investigation it was found that participants who received VR intervention recorded more altruism that the participants who did not receive the intervention. Although there were less significant difference across the three groups but the UAM group showed the most prominent behavior among the three groups.

The entire discussion gyrates around the fact that the type of VR intervention causes a significant impact on the outcome variables such as attitude, empathy etc. Thus, it was imperative to investigate the impact of the two types of intervention. The results indicate that there was a highly significant impact of the type of immersion on the presence inside the virtual environment. Participants who were given the UAM type of intervention reported the that they felt more present in the simulation as if it were happening in real as compared to the participants who received the PI intervention. This explains the difference in all the outcome variables of the self-report measures vis-à-vis UAM and PI, and explains the prominence in parameters measured by UAM than the PI.

The IOS scale was used to measure outcome variables such as closeness and

connectedness. The participants who received the VR intervention reported feeling more connected and close to the homeless as compared to the participants that received no VR intervention. However, within the VR intervention the results showed that PI group felt closer and connected to the homeless post intervention. This deviates from the results that were recorded for the rest of outcome variables. To account for this deviation we would like to juxtapose the altruistic behavior shown by the participants with the IOS outcome variables shown in Figure 17.

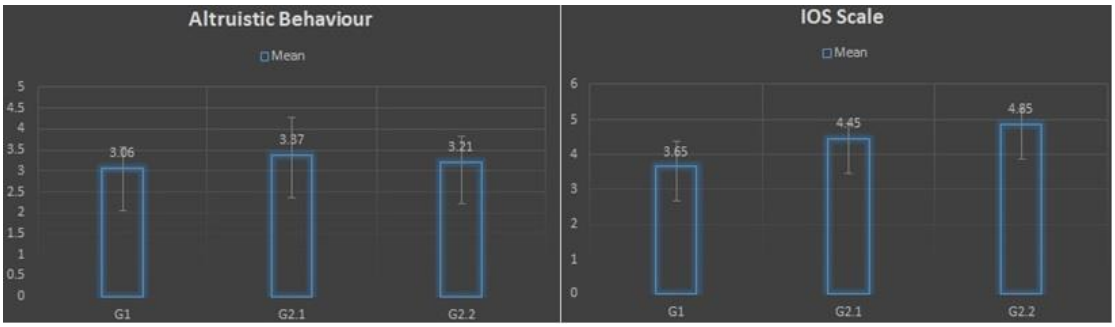


Figure 17. Relation between IOS and Altrusim

In the self-report measures for the IOS, the participants were asked to report how they felt about the homeless person present in the simulation. It is imperative to mention that in the UAM attributed to first person perspective (1PP), it was the participant himself who was homeless as compared to the PI intervention where the homeless person was seen in a third person perspective. It should be noted that there was no significant difference in the altruism behavior post intervention for the control group (although both the groups showed prominent altruistic behavior) which manifested in the participants feeling more concerned or connected to the "other" person and not to themselves.

CHAPTER 8: CONCLUSION AND FUTURE DIRECTIONS

A Virtual Reality based intervention was proposed to evoke more empathy and other allied prosocial conduct such as helping behavior, volunteerism, altruism and eliciting attitudes that are more positive. The targeted category was chosen to be homeless people who endure a lot of prejudice, and are attached with social stigmas. The VR based intervention was used to emphasize on the efficacy of VR in addressing and contributing towards assuaging prejudices or biases society has towards stereotyped classes such as homeless people and its efficacy as an intervention tool to empathize with, and to understand the people persecuted. The participants who received the intervention established the first person perspective (1PP) and a third person perspective (3PP) of being homeless. The investigation found that VR based intervention elicited more empathy and prosocial behavior as compared to the group that received no VR intervention. In addition, it was found that participants who received interactive intervention, also called User-Avatar merging showed more prominent empathy and other prosocial traits than the participants who were immersed in an non-interactive intervention also referred to as Passive Interaction. Thus, we conclude that although VR based intervention is more effective that an a non-VR based intervention, but an interactive immersion, in which the user controls the sequence of events such as in UAM in our simulation, has more efficacy in evoking empathy than immersing in a non-interactive immersion.

We recommend that UAM model be used by global bodies, non-profit organizations and NGO's in their fund-raisers or other public events. This model will be instrumental to garner more monetary support and to increase the intention of institutions or individuals to volunteer for social services, to disseminate awareness

regarding homelessness and to alleviate biases and predispositions among people and ultimately make the world a better place to live.

8.1 Research Expected Impact

On the accomplishment of all the objectives, we can use the effective intervention tool (of the two types of VR intervention) in different ways, as it will lead to increased empathy thereby facilitating an increased prosocial behavior.

Various global bodies, non-profit organizations, NGO's et al. can use this model in their fund-raisers or other public events. This model will be instrumental to garner more monetary support and to increase the intention of institutions or individuals to volunteer for social services, to disseminate awareness regarding homelessness and to alleviate biases and predispositions among people.

8.2 Future Directions

We envisage the following future work for this project

- Since the quantification was done by self-report measures pre and post experimentation, in future we would like to use electrophysiological monitoring such as EEG to quantify and validate the results and to record electrical activity in the brain, mostly in the prefrontal sites of the brain as it is associated with sadness and withdrawal symptoms [62]. A concept of mirror system in humans is speculative in nature and has been found in the premotor cortex, the supplementary motor area, the primary somatosensory cortex, and the inferior parietal cortex [63].
- It would be interesting to incorporate Neurofeedback, where based on physiological data (EEG), the course of the simulation changes [64].

- We would also like to use Machine Learning to incorporate eye tracking and neurofeedback.
- Since the social target that was chosen for this investigation was homelessness which did not fall under the ambit of Super Human interaction, in future we would like to develop VR simulation that cater to all the paradigms in the VR intervention.
- We would also like to increase the sample size for the experimentation in the future endeavors.
- We would also like to stage a fundraiser with a local NGO and quantify the number of participants who would register to volunteer or donate money.

8.3 Limitations

One of the limitation in the experiment is the limited sample size. Although the results we obtained were statistically significant and we can infer generic information regarding empathy enhancement and promotion of prosocial behavior from the results, an increased sample size would validate the inferential statistics with greater efficacy. Another limitation of the design is that the richness of the experience that the participant is subjected leads to differences. Ideally the richness of the experience across the three conditions should have had been same but since this is infeasible in our case as difference in intervention model will lead to a difference in the experience, this poses a limitation.

In addition, as some parts of the simulation were adapted from a western movie, the population in our study was able to connect to it this can be ascribed to the following reasons:

The primary reason of being homeless in this simulation was laying off of the avatar because of the global pandemic and this has been a global phenomenon. The connectivity was also successful as reflected by the empirical evidence. Although this was adapted from a western movie, it is a general phenomenon as to what causes homelessness and its possible ramifications.

RELATED WORK PUBLISHED BY THE AUTHOR

- Owais, W. B., & Yaacoub, E. (2020, February). Quantifying Empathy in Virtual Reality: An Outline. In 2020 IEEE International Conference on Informatics, IoT, and Enabling Technologies (ICIoT) (pp. 457-462). IEEE.
- Owais, Waleed Bin, and Elias Yaacoub. "On Accommodating VR Traffic for mHealth Applications in Rural Areas with Limited Impact on IoT Traffic." 2020 IEEE International Conference on Informatics, IoT, and Enabling Technologies (ICIoT). IEEE, 2020.
- Journal paper titled “Augmenting Virtual Reality with EEG and Nuerofeedback: A Survey” by Waleed Bin Owais, Elias Yaacoub and Somaya Al-Maadeed. (Accepted with a minor revision in Virtual Reality & Intelligent Hardware)

REFERENCES

[1] G. C. Burdea and P. Coiffet, *Virtual reality technology*. John Wiley & Sons, 2003.

[2] C. D. Batson and N. Y. Ahmad, "Using empathy to improve intergroup attitudes and relations," *Soc. Issues Policy Rev.*, vol. 3, no. 1, pp. 141–177, 2009.

[3] D. J., "Vive To Spend $10 Million on VR Projects That 'Create Positive Impact," 2017.

[4] "VR for Impact.," *HTC*, 2017. .

[5] R. D. Johnson and M. Keil, "Internet-Enabled Audio Communication: A Richer Medium For Students Feedback?.," 2002.

[6] C. Milk, "How virtual reality can create the ultimate empathy machine," *TED Talk*, 2015. https://www.ted.com/talks/chris milk how virtual reality can create%0Athe ultimate empathy machine?language=en (accessed Oct. 29, 2019).

[7] H. Kool, "The ethics of immersive journalism: A rhetorical analysis of news storytelling with virtual reality technology," *Intersect Stanford J. Sci. Technol. Soc.*, vol. 9, no. 3, 2016.

[8] T. H. Zaghloul, "Reflecting on urban resilience based on analyses of al-Zaa'tari Camp for Syrian refugees in al-Mafraq, Jordan," 2018.

[9] M. Shuayb, N. Makkouk, and S. Tuttunji, "Widening access to quality education for Syrian refugees: The role of private and NGO sectors in Lebanon," *Cent. Leban. Stud.*, 2014.

[10] L. Freina and M. Ott, "A literature review on immersive virtual reality in education: state of the art and perspectives," in *The international scientific conference elearning and software for education*, 2015, vol. 1, no. 133, pp. 10–

1007.

[11] M. R. Mine, “Virtual environment interaction techniques,” *UNC Chapel Hill CS Dept*, 1995.

[12] J. P. Rolland and H. Hua, “Head-mounted display systems,” *Encycl. Opt. Eng.*, vol. 2, 2005.

[13] T. D. Parsons, “Virtual reality for enhanced ecological validity and experimental control in the clinical, affective and social neurosciences,” *Front. Hum. Neurosci.*, vol. 9, p. 660, 2015.

[14] J. Dirksen, D. DiTommaso, and C. Plunkett, “Augmented and Virtual Reality for Behavior Change,” *eLearning Guild St. Rosa, CA, USA*, 2019.

[15] S. Michie, L. Atkins, and R. West, “The behaviour change wheel,” *A Guid. to Des. Interv. 1st ed. Gt. Britain Silverback Publ.*, pp. 1003–1010, 2014.

[16] R. Elliott, A. C. Bohart, J. C. Watson, and L. S. Greenberg, “Empathy.,” *Psychotherapy*, vol. 48, no. 1, p. 43, 2011.

[17] A. Smith, “Cognitive empathy and emotional empathy in human behavior and evolution,” *Psychol. Rec.*, vol. 56, no. 1, pp. 3–21, 2006.

[18] A. Mehrabian and N. Epstein, “A measure of emotional empathy.,” *J. Pers.*, 1972.

[19] I. Messina, A. Palmieri, M. Sambin, J. R. Kleinbub, A. Voci, and V. Calvo, “Somatic underpinnings of perceived empathy: The importance of psychotherapy training,” *Psychother. Res.*, vol. 23, no. 2, pp. 169–177, 2013.

[20] A. Raine and F. R. Chen, “The cognitive, affective, and somatic empathy scales (CASES) for children,” *J. Clin. Child Adolesc. Psychol.*, vol. 47, no. 1, pp. 24–37, 2018.

[21] I. Ravenscroft, “What is it like to be someone else? Simulation and empathy,”

Ratio, vol. 11, no. 2, pp. 170–185, 1998.

[22] W. B. Owais and E. Yaacoub, "Quantifying Empathy in Virtual Reality: An Outline," 2020, doi: 10.1109/ICIoT48696.2020.9089565.

[23] C. Gentry, *A fully homomorphic encryption scheme*, vol. 20, no. 9. Stanford university Stanford, 2009.

[24] B.C. Bae, S. Jang, D.-K. Ahn, and G. Seo, "A vr interactive story using pov and flashback for empathy," in *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 2019, pp. 844–845.

[25] M. Slater, D. Pérez Marcos, H. Ehrsson, and M. V Sanchez-Vives, "Inducing illusory ownership of a virtual body," *Front. Neurosci.*, vol. 3, p. 29, 2009.

[26] P. Bertrand, J. Guegan, L. Robieux, C. A. McCall, and F. Zenasni, "Learning empathy through virtual reality: multiple strategies for training empathy-related abilities using body ownership illusions in embodied virtual reality," *Front. Robot. AI*, vol. 5, p. 26, 2018.

[27] S. Beckhaus, A. Lechner, S. Mostafawy, G. Trogemann, and R. Wages, "alVRed–Tools for storytelling in virtual environments," *Int. Statustagung Virtuelle und Erweiterete Realität, Leipzig, Ger.*, 2002.

[28] A.V. Loon, J. Bailenson, J. Zaki, J. Bostick, and R. Willer, "Virtual reality perspective-taking increases cognitive empathy for specific others," *PLoS One*, vol. 13, no. 8, pp. 1–19, 2018, doi: 10.1371/journal.pone.0202442.

[29] S. J. Ahn, A. M. T. Le, and J. Bailenson, "The effect of embodied experiences on self-other merging, attitude, and helping behavior," *Media Psychol.*, vol. 16, no. 1, pp. 7–38, 2013.

[30] K.E. Stavroulia and A. Lanitis, "Enhancing Reflection and Empathy Skills via Using a Virtual Reality Based Learning Framework | Stavroulia | International

Journal of Emerging Technologies in Learning (iJET)," vol. 14, no. 07, pp. 18–36, 2019, [Online]. Available: https://onlinejour.journals.publicknowledgeproject.org/index.php/i-jet/article/view/9946.

[31] F. Herrera, J. Bailenson, E. Weisz, E. Ogle, and J. Zak, *Building long-term empathy: A large-scale comparison of traditional and virtual reality perspective-taking*, vol. 13, no. 10. 2018.

[32] N. De la Peña *et al.*, "Immersive journalism: immersive virtual reality for the first-person experience of news," *Presence Teleoperators virtual Environ.*, vol. 19, no. 4, pp. 291–301, 2010.

[33] V. Russell, R. Barry, and D. Murphy, "Have experience: an investigation into vr empathy for panic disorder," in *2018 IEEE Games, Entertainment, Media Conference (GEM)*, 2018, pp. 1–9.

[34] M. Hojat, D. Z. Louis, V. Maio, and J. S. Gonnella, "Empathy and health care quality." SAGE Publications Sage CA: Los Angeles, CA, 2013.

[35] M. S. Krasner *et al.*, "Association of an educational program in mindful communication with burnout, empathy, and attitudes among primary care physicians," *Jama*, vol. 302, no. 12, pp. 1284–1293, 2009.

[36] E. Dyer, B. J. Swartzlander, and M. R. Gugliucci, "Using virtual reality in medical education to teach empathy," *J. Med. Libr. Assoc.*, vol. 106, no. 4, pp. 498–500, 2018, doi: 10.5195/jmla.2018.518.

[37] S. Tettegah, K. Taylor, E. W. Whang, S. Meistninkas, and R. Chamot, "Can virtual reality simulations be used as a research tool to study empathy, problems solving and perspective taking of educators? Theory, method and application," in *ACM SIGGRAPH 2006 educators program*, 2006, pp. 35-es.

[38] N. S. Schutte and E. J. Stilinović, “Facilitating empathy through virtual reality,” *Motiv. Emot.*, vol. 41, no. 6, pp. 708–712, 2017, doi: 10.1007/s11031-017-9641-7.

[39] A. Kim, M. Chang, Y. Choi, S. Jeon, and K. Lee, “The effect of immersion on emotional responses to film viewing in a virtual environment,” in *2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 2018, pp. 601–602.

[40] V. Camilleri, M. Montebello, A. Dingli, and V. Briffa, “Walking in small shoes: Investigating the power of VR on empathising with children’s difficulties,” *Proc. 2017 23rd Int. Conf. Virtual Syst. Multimedia, VSMM 2017*, vol. 2018-Janua, pp. 1–6, 2018, doi: 10.1109/VSMM.2017.8346253.

[41] K. Carey, E. Saltz, J. Rosenbloom, M. Micheli, J. O. Choi, and J. Hammer, “Toward measuring empathy in virtual reality,” *CHI Play 2017 Ext. Abstr. - Ext. Abstr. Publ. Annu. Symp. Comput. Interact. Play*, no. October, pp. 551–559, 2017, doi: 10.1145/3130859.3131325.

[42] M. Slater, B. Spanlang, M. V Sanchez-Vives, and O. Blanke, “First person experience of body transfer in virtual reality,” *PLoS One*, vol. 5, no. 5, p. e10564, 2010.

[43] H. Galvan Debarba, S. Bovet, R. Salomon, O. Blanke, B. Herbelin, and R. Boulic, “Characterizing first and third person viewpoints and their alternation for embodied interaction in virtual reality,” *PLoS One*, vol. 12, no. 12, p. e0190109, 2017.

[44] E. Lo, *Hotel 22*. USA, 2014.

[45] P. R. Desai, P. N. Desai, K. D. Ajmera, and K. Mehta, “A review paper on oculus rift-a virtual reality headset,” *arXiv Prepr. arXiv1408.1173*, 2014.

[46] J. M. Bland and D. G. Altman, “Statistics notes: Cronbach’s alpha,” *Bmj*, vol.

314, no. 7080, p. 572, 1997.

[47] M. Tavakol and R. Dennick, “Making sense of Cronbach’s alpha,” *Int. J. Med. Educ.*, vol. 2, p. 53, 2011.

[48] M. H. Davis, “Individual differences in empathy: a multidimensional approach.,” 1980.

[49] G. Albaum, “The Likert scale revisited,” *Mark. Res. Soc. Journal.*, vol. 39, no. 2, pp. 1–21, 1997.

[50] A. M. H. Siu and D. T. L. Shek, “Validation of the interpersonal reactivity index in a Chinese context,” *Res. Soc. Work Pract.*, vol. 15, no. 2, pp. 118–126, 2005.

[51] H. E. Lester and H. M. Pattison, “Development and validation of the attitudes towards the homeless questionnaire,” *Med. Educ.*, vol. 34, no. 4, pp. 266–268, 2000.

[52] J. B. Kingree and W. F. Daves, “Preliminary validation of the attitudes toward homelessness inventory,” *J. Community Psychol.*, vol. 25, no. 3, pp. 265–288, 1997.

[53] K. L. Nowak and F. Biocca, “The effect of the agency and anthropomorphism on users’ sense of telepresence, copresence, and social presence in virtual environments,” *Presence Teleoperators Virtual Environ.*, vol. 12, no. 5, pp. 481–494, 2003.

[54] M. Kang, H. Choi, and S. Park, “Construction and validation of a social presence scale for measuring online learners’ involvement,” in *EdMedia+ Innovate Learning*, 2007, pp. 1829–1833.

[55] A. Aron, E. N. Aron, and D. Smollan, “Inclusion of other in the self scale and the structure of interpersonal closeness.,” *J. Pers. Soc. Psychol.*, vol. 63, no. 4, p. 596, 1992.

[56] S. Gächter, C. Starmer, and F. Tufano, “Measuring the closeness of relationships: a comprehensive evaluation of the’Inclusion of the Other in the Self’scale,” *PLoS One*, vol. 10, no. 6, p. e0129478, 2015.

[57] R. N. Spreng, M. C. McKinnon, R. A. Mar, and B. Levine, “The Toronto Empathy Questionnaire: Scale development and initial validation of a factor-analytic solution to multiple empathy measures,” *J. Pers. Assess.*, vol. 91, no. 1, pp. 62–71, 2009.

[58] G. H. Weems and A. J. Onwuegbuzie, “The impact of midpoint responses and reverse coding on survey data,” *Meas. Eval. Couns. Dev.*, vol. 34, no. 3, pp. 166–176, 2001.

[59] R. H. Xu, E. L. Wong, S. Y. Lu, L. Zhou, J. Chang, and D. Wang, “Validation of the Toronto Empathy Questionnaire (TEQ) Among Medical Students in China: Analyses Using Three Psychometric Methods,” *Front. Psychol.*, vol. 11, p. 810, 2020.

[60] I. L. Dryden and K. V Mardia, *Statistical shape analysis: with applications in R*, vol. 995. John Wiley & Sons, 1AD.

[61] H. Scheffe, *The analysis of variance*, vol. 72. John Wiley & Sons, 1999.

[62] M. Gold, D. E. Redmond Jr, and H. Kleber, “Clonidine blocks acute opiate-withdrawal symptoms,” *Lancet*, vol. 312, no. 8090, pp. 599–602, 1978.

[63] C. Heyes, “Where do mirror neurons come from?,” *Neurosci. Biobehav. Rev.*, vol. 34, no. 4, pp. 575–583, 2010.

[64] T. Baumgartner, L. Valko, M. Esslen, and L. Jäncke, “Neural correlate of spatial presence in an arousing and noninteractive virtual reality: an EEG and psychophysiology study,” *CyberPsychology Behav.*, vol. 9, no. 1, pp. 30–45, 2006.

APPENDIX A: SELF REPORT MEASUREMENT SCALES

Attitude Towards Homeless

Date:_____

Below is a list of statements. Please read each statement carefully and rate how frequently you feel or act in the manner described. Circle your answer on the response form. Please circle the number that most closely represents your views. There are no right and wrong answers to these questions.

		Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	Homeless people do not choose to be homeless	1	2	3	4	5
2	Nearly all homeless people are drug addicts	1	2	3	4	5
3	Homeless people are victims	1	2	3	4	5
4	Homeless people are rude	1	2	3	4	5
5	Homeless people are aggressive	1	2	3	4	5
6	Homelessness is a self-inflicted state	1	2	3	4	5
7	Homelessness is not a health issue	1	2	3	4	5

Date:_____ Interpersonal Reactivity Index

The below statements investigate about your thoughts. For each question, indicate how well it describes you by choosing the appropriate letter on the scale.
A, B, C, D, or E. When you have decided on your answer, fill in the letter next to the item number.
READ EACH ITEM CAREFULLY BEFORE RESPONDING.
Answer as honestly as you can

		Doesn't describe me well (A)	B	C	D	Describes me well (E)
1	I daydream and fantasize, with some regularity, about things that might happen to me.					
2	I often have tender, concerned feelings for people less fortunate than me.					
3	I sometimes find it difficult to see things from the "other guy's" point of view.					
4	Sometimes I don't feel very sorry for other people when they are having problems.					
5	I really get involved with the feelings of the characters in a novel.					
6	In emergency situations, I feel apprehensive and ill-at-ease.					
7	I am usually objective when I watch a movie or play, and I don't often get completely caught up in it.					
		Doesn't				Describes

Date:_____ Interpersonal Reactivity Index

		describe me well (A)	B	C	D	me well (E)
8	I try to look at everybody's side of a disagreement before I make a decision.					
9	When I see someone being taken advantage of, I feel kind of protective towards them.					
10	I sometimes feel helpless when I am in the middle of a very emotional situation.					
11	I sometimes try to understand my friends better by imagining how things look from their perspective.					
12	Becoming extremely involved in a good book or movie is somewhat rare for me.					
13	When I see someone get hurt, I tend to remain calm.					
14	Other people's misfortunes do not usually disturb me a great deal.					
15	If I'm sure I'm right about something, I don't waste much time listening to other people's arguments.					
16	After seeing a play or movie, I have felt as though I were one of the characters.					
		Doesn't describe				Describes me well

Date:_____ Interpersonal Reactivity Index

		me well (A)	B	C	D	(E)
17	Being in a tense emotional situation scares me.					
18	When I see someone being treated unfairly, I sometimes don't feel very much pity for them.					
19	I am usually pretty effective in dealing with emergencies.					
20	I am often quite touched by things that I see happen.					
21	I believe that there are two sides to every question and try to look at them both.					
22	I would describe myself as a pretty soft-hearted person.					
23	When I watch a good movie, I can very easily put myself in the place of a leading character.					
24	I tend to lose control during emergencies.					
25	When I'm upset at someone, I usually try to "put myself in his shoes" for a while.					
26	When I am reading an interesting story or novel, I imagine how I would feel if the events in the story were happening to me.					
		Doesn’t describe me well				Describes me well

Date:_____ Interpersonal Reactivity Index

		(A)	B	C	D	(E)
27	When I see someone who badly needs help in an emergency, I go to pieces.					
28	Before criticizing somebody, I try to imagine how I would feel if I were in their place.					

Date:_____ Social Presence Questions

The below statements investigate about your thoughts. For each question, indicate how well it describes you by circling the appropriate number on the scale.

		1(Not at all)	2	3	4	5(Very strongly)
1	To what extent did you feel able to assess your partner's reactions to what you said?—Able to assess reactions, not able to assess reactions.	1	2	3	4	5
2	To what extent was this like a face-to-face meeting?—A lot like face to face, not like face to face at all.	1	2	3	4	5
3	To what extent was this like you were in the same room with your partner?—A lot like being in the same room, not like being in the same room at all.	1	2	3	4	5
4	To what extent did your partner seem "real"?—Very real, not real at all.	1	2	3	4	5
5	How likely is it that you would choose to use this system of interaction for a meeting in which you wanted to persuade others of something?— Very likely, not likely at all.	1	2	3	4	5
6	To what extent did you feel you could get to know someone that you met only through this system?—Very well, not at all.	1	2	3	4	5

TEQ

Date:_____

Below is a list of statements. Please read each statement carefully and rate how frequently you feel or act in the manner described. Circle your answer on the response form. Please answer each question as honestly as you can.

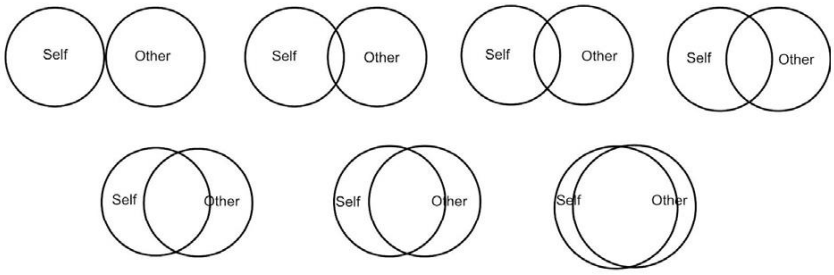
		Never	Rarely	Sometimes	Often	Always
1.	When someone else is feeling excited, I tend to get excited too	0	1	2	3	4
2.	Other people's misfortunes do not disturb me a great deal	0	1	2	3	4
3.	It upsets me to see someone being treated disrespectfully	0	1	2	3	4
4.	I remain unaffected when someone close to me is happy	0	1	2	3	4
5.	I enjoy making other people feel better	0	1	2	3	4
6.	I have tender, concerned feelings for people less fortunate than me	0	1	2	3	4
7.	When a friend starts to talk about his\her problems, I try to steer the conversation towards something else	0	1	2	3	4
8.	I can tell when others are sad even when they do not say anything	0	1	2	3	4
9.	I find that I am "in tune" with other people's moods	0	1	2	3	4
10.	I do not feel sympathy for people who cause their own serious illnesses	0	1	2	3	4
11.	I become irritated when someone cries	0	1	2	3	4
12.	I am not really interested in how other people feel	0	1	2	3	4
13.	I get a strong urge to help when I see someone who is upset	0	1	2	3	4
14.	When I see someone being treated unfairly, I do not feel very much pity for them	0	1	2	3	4
15.	I find it silly for people to cry out of happiness	0	1	2	3	4
16.	When I see someone being taken advantage of, I feel kind of protective towards him\her	0	1	2	3	4

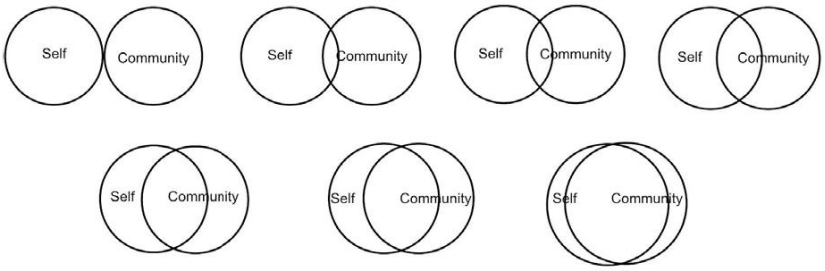
Date:_____ Inclusion of Other in the Self (IOS) Scale

Instructions: Please circle the picture below that best describes your relationship.

Answer Format: Circle a diagram

Scoring: Respondents choose a pair of circles from seven with different degrees of overlap. 1 = no overlap; 2 = little overlap; 3 = some overlap; 4 = equal overlap; 5 = strong overlap; 6 = very strong overlap; 7 = most overlap. The number chosen is the respondent's score.




Self
Community
Self
Community
Self
Community
Self
Community
Self
Community
Self
Community
Self
Community


جامعة قطر
QATAR UNIVERSITY
Institutional Review Board
(IRB)
APPROVED

Questionnaire to be Filled before the Experiment

You are requested to fill this questionnaire before starting the experiment. You are only urged to answer in a truthful and honest manner. You are not required to answer questions that you prefer not to answer.

Gender: ☐ Male ☐ Female

Date of Birth: ___/___/_____

Education Level (Baccalaureate, BS, MS, PhD, etc.): _____

Current Occupation: _____

Vision: ☐ Normal vision ☐ Corrected vision ☐ Impaired vision

Mental Condition: did you suffer from previous mental disorders? ☐ Yes ☐ No

Medical Condition: did you suffer from previous cardiac disorders? ☐ Yes ☐ No

Meditation Experience: Have you practice meditation (e.g. Yoga) before?

☐ Yes, I practice meditation regularly ☐ Only occasionally ☐ Never

I certify that the above information is true to the best of my knowledge.

_____

_____ _____

Your Signature Today's Date

جامعة قطر
QATAR UNIVERSITY
Institutional Review Board
(IRB)
APPROVED

APPENDIX B: IRB APPROVAL

November 9th, 2020

Dr. Elias Yaacoub
College of Engineering
Qatar University
Phone: +974 4403 4251
Email: Elias@qu.edu.qa

Dear Dr. Elias Yaacoub,

Sub.: Research Ethics Expedited Approval
Project Title: "Quantifying Empathy in Virtual Reality"

We would like to inform you that your application along with the supporting documents provided for the above project, has been reviewed by the QU-IRB, and having met all the requirements, has been granted research ethics **Expedited Approval** based on the following category(ies) listed in the Policies, Regulations and Guidelines provided by MOPH for Research Involving Human Subjects. Your approval is for one year effective from November 9th, 2020 till November 8th, 2021.

1) Present no more than minimal risk to human subject, and
2) Involve only procedures listed in the following category(ies).
Category 4: Collection of data through noninvasive procedures.
Category 7: Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Documents Reviewed: 02_QU-IRB Application Human Subject-V3_Bilingual_Feb2019_Empathy_Yaacoub_Owais_V2.0, 01_QU-IRB Checklist_Empathy_Yaacoub_OwaisV2, 04_Research_Proposal_Empathy Yaacoub_Owais, Consent_Form_v2.0, Questionnaire00_Participant_Information, Questionnaire01_Attitude_towards_homeless, Questionnaire02_IRA, Questionnaire03_SocialPresence, Questionnaire04_The_Toronto_Empathy_Questionnaire, Questionnaire05_Inclusion of Other in Self, QU-IRB Review Forms, responses to IRB queries and updated documents.

Please note that expedited approvals are valid for a period of **one year** and renewal should be sought one month prior to the expiry date to ensure timely processing and continuity. Moreover, any changes/modifications to the original submitted protocol should be reported to the committee to seek approval prior to continuation.

Your Research Ethics Expedited Approval Number is: **QU-IRB 1416-EA/20**. Kindly state this number in all your future correspondence to us pertaining to this project. In addition, please submit a closure report to the QU-IRB upon completion of the project.

Best wishes,
Dr. Ahmed Awaisu
Chairperson, QU-IRB

Institutional Review Board
(IRB)
Office Of Academic Research