Usability study on the Observation of Implicit Shooter Bias Through Virtual Reality

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Abstract

Our current society suffers from racism that constitutes intentional or unintentional inequity and injustice for minorities in many aspects of life. One of these areas studied by social psychologists is racial bias. They use police data to identify discriminatory policing practices and general population-level bias that contributes to disparate use of force directed at Black Americans. To better understand the disparity in the use of force, researchers studied "shooter bias." Shooter bias is the tendency to mistakenly shoot unarmed Black suspects more often than unarmed White suspects and more quickly shoot at armed Black suspects than armed White suspects. To better address and eliminate racial bias from institutions, policies, and systems, we need to identify and measure racial discrimination via novel methods.

Observing how bias affects different subsets of people may offer the ability to avoid biases that lead to potentially negative outcomes. Focusing in on how the demographic information of one individual may affect their implicit bias may give insight into why some shootings occur. The bias observed from the participant when they choose to shoot an avatar gives insight as to the aspect of the variables that affect their implicit bias when the decision to shoot is made. Then in proving that, it can be used to identify and measure such biases and consequently take actions to prevent similar real-life situations.

Through the use of virtual reality simulations the testing for implicit bias can be undergone with the most available control. However, to develop a study within a virtual space requires the foreknowledge that the contents are being observed as intended. The need for a usability study into that which would be used in virtual reality to study implicit bias is necessary as a proof of concept and ensure adequate development. With both qualitative feedback and quantitative data it can be ensured that the virtual environment and its contents are suitable for use within a study on implicit bias in the future.

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Chapter 1

Introduction

The current state of society holds with it a form of racism where intentionally or unintentionally their is a inequity and injustice for minorities in many aspects of life. Using data from surveys, policing activities, and other forms it has shown that within the justice system there is a bias that contributes to the use of deadly force directed toward Black Americans. In the pursuit of attempting to find out the cause behind this researches coined the term "shooter-bias" in 1995 which made the argument that social behaviors were largely influenced by unconscious associations and judgements. This bias is the tendency to mistakenly discharge a weapon on the guise of defence based on the immediate judgements of an individual, usually an armed Black suspects more often than armed white suspects. This term encompasses the speed and frequency of these occurrences in the policing field but can also be used in all facets of prejudgement of individuals.

To address and eliminate these racial biases from current institutions, policies, and systems it is pertinent to be able to identify and measure the racial discrimination. A method is to measure the effect of racial biases by placing the person into a controlled environment (real or virtual) and require them to act under certain circumstances. This method has been done, but a new way to do this is through some immersive virtual environments (IVEs). This is for their flexibility and the ease of portability which causes them to be preferred over real-world scenarios. Through the use of a virtual environment an individual can be subjected to a multitude of scenarios they must act in. The scenarios can be altered and configured to encompass different variables and means, offering alternate insights based on what is being focused on.

The data collected from this form of study can offer the ability to quantitatively view racial

biases in individuals or subsets of people. This may lead to the ability to alter or avoid such biases that lead to negative outcomes in instances where they play a role in the decision making process. Using demographic data of participants and the biases observed it offers an insight as to why some deadly force situations occur. Through the use of a virtual environment observing an individuals bias in a deadly force scenario offers insight as to what variables within the simulation affect their bias most. Then in knowing which variables most affect an individuals bias it can be measured and then actions can be taken to prevent similar instances within the real world.

Thus, within this usability study there will be the validation of different conditions that can be found within a virtual reality study into implicit bias. This is to ensure that the virtual environment and its contents are experienced and interpreted as intended. Through qualitative and quantitative study it can be found and proven that there is validity in certain aspects that are necessary for the study to be undergone. This data can then offer the ability to add modification to the project where required or to prove that what the study is attempting to convey is what is being experienced. Then if no modifications need to be made, that data can be used to reinforce what the study finds, or even possibly when in terms of implicit bias find a similar outcome that should be expected from an actual study.

Chapter 2

Background Research

2.1 Implicit Bias

Shooter bias or implicit bias is not a relatively new concept within a society, but instead have only in the last century been realized as a part of our decision making process. The bias an individual holds whether conscious or unconscious affects how that individual will react when faced with a choice. This bias can be broken down categorically into many facets which allow the dissection of its effect on decision making based on specific factors or situations presented to an individual. The concept has been broken down to the biases of internal matters or the self and biases of external matters like person, place, or thing. Breaking this down allows the possibility to observe just those that are external and how it impacts the decision making process.

The researches who coined the term considered the external judgement similar to a stereotype which is defined as "A stereotype is a socially shared set of beliefs about traits that are characteristic of members of a social category".[1] In there study the trials done to focus on are the ones that observed the implicit stereotype, the implicit race stereotype, and the implicit gender stereotype. The studies were conducted using a means of word association and observations, within the race bias it was found that the White population had a faster response time to White-positive word pairs. In the gender observations were made that essay judgements were made more favorably when credited to male authors over female authors. These two studies began an observation of the implicit biases individuals may experience when subjected to a situation that requires action and they allow for a baseline as to where to begin when observing this today.

2.2 Previous Studies

2.2.1 Factors that effect Shooter Bias

The increased occurrence of the shooting or wrongful deaths of Black Americans has incited an investigation into the aspects of the decision making of individuals who perpetrate these actions. Throughout the past decade there have been recorded occurrences of law enforcement, authority figures, and community members who have committed a deadly force judgement decision against Black Americans. This can be most attributed to their split second decision making or their shooter bias that influenced their decision to shoot. This leads to the necessity to investigate of what influence was their implicit bias on the situation they were presented with and what factors within that situation affected their bias. In knowing these points it can be determined what their bias was and potentially how it could be avoided, however it needs to be outlined the factors that effected their bias of the situation.

In a study where race, neighborhood, and clothing were observed factors the different sets of these variables allowed a look into a participants decision making bias for threat and safety. Two studies were run, the first being that of the effect of neighborhood on an individuals shooter bias, the second being that of the clothing being worn. Within the first study participants were primed by two neighborhoods, one being considered a safe neighborhood and one being considered an unsafe neighborhood. It was found that "comparing across neighborhood primes, participants who were primed with the safe neighborhood, compared to the threatening neighborhood, made more errors with armed Black suspects".[4] It was seen in that the relation between race x object held the same relation within the threatening neighborhood but within the safe neighborhood a relation between environment x race x object was observed. This showed that within a prime of a safe neighborhood participants made more errors with armed Black targets than within the threatening neighborhood prime. However in contrast, the correlation between race, object, and environment, most notably being that in a threatening neighborhood showed an unarmed Black individual was more likely to be shot than a Caucasian.

The second study undergone built off the first but instead investigated the correlation between participants' shooting bias and the suspects clothing. The clothing was differentiated by being either threatening or nonthreatening, where the threatening clothing was baggy attire with a headband and baseball cap, and nonthreatening consisting or a button up shirt and tie. The study

was run and found that "Participants were less likely to correctly perceive the armed White target in threatening attire as dangerous and correctly shoot him compared to armed Blacks in threatening attire".[4] This shows that there is a correlation between clothing x race x object in which the threatening attire causes the Black target to appear more dangerous, where fewer errors are made. However, when in the nonthreatening attire the error rates across each race were similar indicating that there is a difference between the clothing factor in the participants implicit bias.

The correlation between race, object, and environment are not the only factors that are observed when investigating shooter bias, but instead are more of a foundation to be built from. The need to understand what and how the factors in a situation affect shooter bias allow for a more accurate depiction of its relation to the decision making process in a potentially deadly encounter. In a two part study, participants were subject to a set of targets being White criminal, Black criminal, White police officer, and Black police officer. They were holding either threatening or nonthreatening objects, where the participant was instructed to shoot when identifying a target with a threatening object. The separation between the two trials is the allotment of response time, where the first trial allowed for 800ms of response time and the second allowed 900ms of response time. When observing race, object, and time they found that "subjects had greater difficulty distinguishing weapons from harmless objects when the weapons were in the hands of simulated Blacks than Whites and subjects were response-biased in the sense of giving the weapon-appropriate response more readily to Black then to White targets".[2] This offers the correlation between race and object but it enters in the observation of time as a factor in which the participants made fewer mistakes when given a slightly longer time for decision. Which allows there to be a new variable when interpreting the bias of an individual, using time as a factor adds an added constraint that has to be observed to get an accurate assessment of bias when presented with a situation.

The factors from other studies allow for an insight as to those that have a role in the decision making process of an individual. Another study undergone added to this to investigate whether skill level or training play a role in a persons implicit bias. There were three tests that took place at the WSU Simulated Hazardous Operational Tasks laboratory in the pursuit of observing various implicit bias amongst different weapons proficiency groups. The first experiment tested a group of individuals which was split between novice and expert level, where expert was split in half by military and police then subsequently run through scenarios to observe the differences in accuracy of the two groups. The second experiment was undertaken to investigate the potential to train a

novice to the level of expert using only simulated deadly force encounters. Then the third experiment was a pilot study in policing operational tasks and deadly force judgement decision making. The factors these experiments employed were that of the environment, the scenario itself, and that the target races were split based on the statistical percentage proportional to that groups involvement in police shootings. These experiments together offer an insight as to how the proficiency of training in deadly force judgement situations affects an individuals ability to accurately asses the situation when confronted. Although this was done through the means of improving the methodological means in which to study shooting bias.

The results of this study offer an insight into the effect of training or skill have alongside someones bias in a deadly force judgement scenario. They are split into three categories to better understand how each group in each test preformed and what was found from that experiment. The first category is the reaction time of the participants in each scenario they underwent, where they found that in each experiment "that participants took significantly longer to shoot Black suspects than White suspects. There was no significant difference in reaction time between shooting Hispanic suspects and White suspects"[3], they took (0.80 s), (0.64 s), and (1.34 s) longer respectively. The second category is the shooting of unarmed suspects, in which only experiment one and three were analyzed due to experiment two having too few errors occur. It was found that in both experiments "participants were less likely to shoot unarmed Black suspects than unarmed White suspects"[3], where they observed a factor of six times in experiment one and a factor of 25 times in experiment two. The third category is failing to shoot an armed suspect, where again experiment two was not analyzed due to too few errors. It was observed that "participants were five times more likely to fail to shoot armed Black suspects than armed White suspects ... participants were equally likely to fail to shoot armed White, Black, and Hispanic suspects."[3], for experiment one and experiment three respectively. This set of experiments using similar variables to others preceding it offers a set of results that are the inverse of what other studies have found although, a form of bias is shown in the results. If the experiment used the same variables but came back with a different result, then there must be something within the experiment that influenced this form of bias. There are a few answers as to why this result was found but it is ultimately left unanswered, most likely the difference resides in the methods of delivering the experiments.

2.2.2 Shooter Bias Beyond the US

Shooter bias is not solely rooted in the racial biases found in the US, but also can be seen in England as well. Similar to most occurrences that incite an interest in the topic of shooter bias, the London bombing was the inciting factor that lead to a investigation into the shooter bias toward the Muslim population. A study was undergone that investigated the implicit bias that could be observed in the subject population against both men and women, as well as both Caucasian and non-Caucasian. These targets were modified from Florida Department of Corrections head shots of inmate, being given a turban or hijab, as well as having a hand in the air with either a threatening object or non-threatening object. Although, one aspect investigated by this study was that these different participant groups had emotional states assigned to them being either happy, neutral, or angry. They found that "participants showed a greater bias to shoot at Muslim targets compared to non-Muslims which confirms the main hypothesis that Muslim appearance facilitates aggressive reactions towards a target. Angry participants also showed a slightly greater bias to shoot than did happy or neutral participants".[8] It was also found that there was a correlation between the participants emotional states in which the more emotional the participant the more bias toward the target, where happy had the highest bias, followed by angry, then neutral. This shows that implicit bias can be observed in different populations despite the composition of those populations or geographical locations being different. As well, it offers the point that subjects mood is also a factor when observing an individuals implicit bias.

2.2.3 How Shooter Bias is Observed

Racial Bias has been observed through both time and location, analyzing racial bias between individuals has become a divided topic when viewed through the lenses of different fields of study. The use of computer based, and virtual reality-based testing is a step forward when assessing an individual's bias in comparison to word or picture based association testing. This topic and method of experimentation have become more popular over the previous years as the societal climate has reached a boiling point for what is deemed shooter bias. A study using a new virtual reality implementation to test participants implicit bias to a situation was deployed which tested target race, socioeconomic status (SES) through clothing, and held object. This experiment was designed to improve upon and investigate the use of virtual reality simulations when testing participants

implicit bias responses. The study found that "Consistent with past desktop-based research, it was found that signals of SES disrupted automatic racial stereotypes, leading participants to be most accurate in their shooting decisions when encountering high SES Black avatars ... by utilizing head and hand motion tracking within VR it was possible to identify a potentially new way of assessing racial bias in shooting behavior".[6] This adds a multitude of new possibilities as to how testing and observations can be made when investigating implicit bias within a population. As well, data consistent with what has been found in previous studies observing implicit bias reinforces that the use of VR is a novel method for the observing of implicit bias.

2.2.4 The Necessity for Usability Testing

The ability for VR to duplicate the results previous studies have found reveals that virtual environments are suitable for the testing of implicit bias. However, with the development of a virtual reality simulation there arises the need for some quality assurance of that simulation in the form of a usability study. This usability testing is what gives the qualitative/quantitative feedback and data that can be used to improve the virtual simulation in future development. It is most common to only use one means of data collection when evaluating an application however, "subjective and objective methods can be considered complementary to each other. Well-formulated subjective usability questionnaires are essential in setting UI courses since they are based on user feedback, while objective analysis confirms UI Evaluation"[5]. The combination of the two are used to assist the other in proving whether the virtual application is effective in the means of which it is trying to convey or accomplish. Which that allows the project the ability to be altered before it is run as to ensure that it is running and being experienced as intended by those undergoing the experiment.

This point becomes more pertinent when observing implicit bias as the recognition of race, gender, object, and other variables are paramount to the outcomes that should be expected from this form of study. In the sense that one wrong identification on any of those variables has the potential to skew the data and offer an incorrectly laid conclusion from the data. The usability testing will offer the ability to ensure that misidentifications are not an issue and can be used to reinforce what is found later in the study as it develops. Although, multiple usability studies should be run at each major alteration of the projects development as it is not known how the alteration may affect the outcome previously found. These forms of tests when observing identifications, which can be semi-subjective when looking person-to-person offer the ability to have assurances that the final test

will run as intended. In a virtually simulated environment "it has to be emphasized that even the simplest form of usability testing is mandatory in a VR system implementation...if the interaction and virtual environment itself is transparent and intuitive, consistent with perception, knowledge, and previous experiences"[5]. The consideration that all aspects within a virtual environment have to be assured, the usability study into those facets of the virtual simulation with means outlined previously should provide the feedback necessary for assurances in the usability of the application being presented for study.

Chapter 3

Proposed Problem

3.1 Problem with Previous Studies

There have been a myriad of methods brought forth to observe implicit bias among a population and with that also the testing of many factors that influence an individuals decision when presented with a situation. The current means available to test individuals on their implicit bias has evolved in such a way that makes previous means unnecessary. There lies an inherent set of problems with the previous studies that when observing multiple a pattern can be seen which illuminates what needs to be altered in order to be able to create a more defined experiment. These problems usually occur based on the time the study was given, the availability of technological aids, and the essential questions that were being asked. Refining these points further the problems that face the previous studies lies within the medium they were administered, the variables that were being tested for, and the population that was sampled for the study. In determining how these problems can be corrected is the essential way to refine the studies and their findings.

3.1.1 Population

The populations that are observed among the previous studies mostly share various similarities in terms of their demographics and that is where the main issue can be found from the population. In table 3.1 it shows a breakdown of the populations observed in the previous studies into implicit bias. Simple patterns become obvious when set side by side, as 60% of the studies

use more female participants than male participants. As well, the mean age of participants from all studies is 23.416 years of age, where only 20% of the studies have a mean age outside of the low 20's age range. Then within the demographics, 40% did not report their demographic information on their participants, where the rest vary greatly in their majority and minority populations. These imbalances within the testing populations for the studies is a major issue when observing implicit bias, this is due to the nature of bias. As a social group each one will have a set of biases, so each major age group, each sex, and each demographic would exhibit a slightly different bias from the social group they occupy.

Table 3.1: Population Data for Each Study

Study	Population	Mean Age	Demographic
Study 1 [2]	55 Male 46 Female	21.8[0]	Data Not Provided
Study 2 [3]	74 Male 28 Female	31	91 Caucasian 7 Hispanic/Latino 2 Black
Study 3 [4]	48 Male 88 Female	21.8[0]	35 Caucasian 78 Asian/Asian American 17 Hispanic/Latino 6 Other
Study 4 [6]	42 Male 55 Female 2 Non-Binary	23.08	80 Caucasian 9 Asian/Asian American 8 Hispanic/Latino 3 Black 1 Multi-Racial
Study 5 [8]	31 Male 35 Female	19.4	Data Not Provided

3.1.2 Testing Variables

When going over the previous works, within the sets of variables used to test for the impacts on implicit bias there can be seen a set of commonalities between studies. Depicted in table 3.2 the pattern of the variables being tested in each study is apparent, the given baseline can be seen. All the previous studies use the race and object variables as those are the original variable that were observed when testing was completed on paper. However, as the ability to administer more

[0]The study references participants as "Undergraduate Students", the average age range of undergraduate students is 21.8 years of age.

complex tests developed, in addition to the greater understanding of implicit bias the possibility to incorporate more variables into the testing became possible. Beyond that, the other variables show how each individual study looked at going a step further in observing which have a direct interaction with an individuals implicit bias in a situation. Although there is something that is missing in them, since most of the studies are trying to enforce the idea that the participant, being a plainclothes or uniformed law enforcement officer, it lacks the actual set of tools they would commonly use. Across all the studies the participant is given either a gun or the choice to shoot/not-shoot within some scenario but they are never given any other means of subject control. The ability to choose submission weapons correct for the scenario is an aspect that has not been tested for yet, even though it is known that police carry more than just a sidearm.

Table 3.2: Variable Data for Each Study

Study 1 [2]	Study 2 [3]	Study 3 [4]	Study 4 [6]	Study 5 [8]
Race	Race	Race	Race	Race
Object	Object	Object	Object	Object
Time	Skill	Clothing	Clothing	Clothing
		Environment		

3.1.3 Testing Medium

The medium the testing is run through holds a large role in the outcome of the tests, while all mediums have merit. When the attempt is made to observe phenomena from real situations and stripped down to paper some of the aspects of what act on the situation are lost. When initially looking into the topic of implicit bias the use of paper testing and word associations was used to observe the correlation between an individuals bias with word combinations this can be seen in the analysis done by (Greenwald & Banaji 1995 [1]). Once the correlations between individuals and their bias was observed the need for further testing became necessary. The need to administer the testing in a way that was as real to life as possible was the logical path to be followed which lead researchers to computer simulation of these scenarios. These forms of scenarios can be similar to the paper tests like what is seen in the study conducted by (Unkelbach, Forgas, & Denson 2008 [8]), where digital pictures were displayed on a screen for the participants to observe. However, this change does not further the realism of the scenarios being investigated and instead is in a sense a

streamlined version of what has been done already.

The transition over to a digital medium was an important step in furthering the ability of testing individuals in the scenarios observing implicit bias as it allows for the development of more complex methods and scenarios. A testing method that can be considered akin to a game, or the gamification[1] of the testing process. These types of testing procedures are the ones that can be seen in the study done by (Greenwald, Oakes, & Hoffman 2003 [2]), where a flash game-like application was used to test the participants on their implicit bias. The need to develop further continued still and the next step was the use of specialized programs to develop the tests within found in (Kahn & Davies 2017 [4]) where the use of specialized programs was necessary to develop their gamified scenarios for testing. This was completed through the use of the Psyscope program for one of their studies, then DirectRT for the second study. These gamified versions of the testing produced a set of valuable data but the ability for a more realistic scenario method had become possible across a different set of means.

The use of virtual and Augmented reality (VR & AR) environments have come to be the most realistic methods of recreating these real life situations within a controlled environment. Within the study by (James, Vila, & Daratha 2012 [3]), the use of an AR environment was the medium they chose to run their testing through. This environment was set up at the WSU Simulated Hazardous Operational Tasks lab, within they had 2 simulators which is an enclosed environment with sound deadening, where there is a 7m x 5m shooting range which ends with a 3.5m x 2m screen. The handguns given to participants were specially made Glock model 21s which were outfitted with infrared lasers which when contacting the screen at the end of the range would register a shot. It should be noted that this is similar to the simulators commonly used to train law enforcement officers on, more so the North Carolina Department of Justice, Justice School uses the PriSim simulator by Cubic, though little information is available on their simulator. However the competitor simulator Virtra has a myriad of information available and are similar to the WSU simulators except that they use three screens and have more flexibility in what can be used to interact with the scenario. The intractability of these simulators is what helps them to be closer to real world occurrences where implicit bias may be seen. The Virta sim beyond that of WSU's can have inter-actors such as: sidearms, assault weapons, control weapons, and even flashlights all of which allow the sim to be as

[1]Merriam-Webster dictionary defines gamification as: the process of adding games or game-like elements to something (such as a task) so as to encourage participation.

realistic and interactive as possible.

The next step to a virtual reality sim is the latest in the medium of study to encapsulate as much as possible a realistic sense of being within the simulation. This can be seen in the study by (Peck, Good, & Seitz 2021 [6]), where a VR headset was used to administer the scenarios in which the participants needed to respond. This virtual reality sim allows for a greater number of record-able data points along with nuanced actions from the participants that would not have been able to have been observed previously. The new data points are that of hand and eye tracking as well as body posture, the physical presence and actions an individual expresses when subjected to a scenario, and the previous variables used. As this is a newer implementation on this medium for testing there lacks the ability for an adequate comparison to others of similar design. Although, some points can be drawn from the implementation and what was found from the study to make a deduction as to where they may improve. Through the deduction the testing mediums are not the closest to reality as they could be yet, as each suffer their own set of flaws. The main of which lie within the scenarios themselves for each AR and VR implementations, while the medium is some of the most advanced so far to be developed, the use of older or non realistic scenarios even when gamifiying the implementation is what causes them to require some improvement.

3.2 Solution

The outlining of what can be considered the problems with previous studies allows the ability to pinpoint what actions or means may be able to remedy those issues. There are certain steps to be taken that will allow for a more accurate and more flexible set of tests and means of testing moving forward. If the points of change are made there should be seen an alteration between the results found in the new study when compared to previous studies. That is in which they should be more accurate than previous in terms of analyses of bias within social groups or social subgroups of people. In doing this a further understanding of the interaction between an individual their biases on a situation may become more clearly observable.

3.2.1 The Population Problem

The population problem has the simplest solution in that the aspects of what needs to be changed is easily controlled. Considering that implicit bias is exhibited within a social group

based on the biases the social group has against something, it would be pertinent to have an evenly split participant group. It has been seen that the biases between social groups do differ slightly, so an evenly split population sample would allow for a more accurate analysis and breakdown into the results of the study. This split of the observable population however needs to be split even across race, gender, and age to allow for more accurate responses when looking into a specific set of groups/subgroups and how they respond. This is more so important due to the fact that the majority of populations observed previously favored an age range, gender, and race. The necessity to observe the implicit bias of certain groups of people when speaking on stereotyping and racial profiling is an important factor as it may lead to differences in bias between genders, age ranges, and races. Then that could lead to the ability to better understand where the majority of negative biases lie, what influences them, and then so how they may be able to be controlled or altered.

3.2.2 The Variables Problem

The variables problem is not the most pertinent problem as with each new variable tested of the base variables for testing offers a new insight into its relation to bias. Although, there is a variable set that has not been tested yet despite direct correlation to the inciting incidents that spark investigation into implicit bias. The variable set that needs to be investigated on top of the baseline is that of weapon power and its influence on an individuals shooter bias. The set of weapons carried by police officers occasionally varies due to a number of factors but strictly there is usually a standard set of weapons that one would carry or have access to that should be tested against. This means the testing of an electronic control weapon, chemical control weapon, sidearm, and heavy assault weapon. These means all tools available to an officer have yet to be investigated and in most studies the choice boils down to shoot/don't shoot usually referring to a sidearm. The relation between the weapon power and bias may reveal some information on how the type of protective means an individual has at their disposal in combination with their biases affects their decisions in the simulation. Then with this information it may be possible to better arm law enforcement officers with proper weaponry to reduce the likely-hood of potential deadly force encounters.

3.2.3 The Medium Problem

The medium problem is one that has not been adequately explored yet, in that there has not been enough investigation with it to pinpoint an exact issue. Instead the main medium issues outlined lie within the method the studies used the medium along with the scenarios that were used in combination. The use of an immersive virtual environment allows for the illusion of real world scenarios while contained within a controlled environment over that of augmented reality. That illusion is one of the main aspects that makes virtual reality the best medium of implementation for exploring aspects of implicit bias. Within an immersive virtual environment there are several characteristics that show if it can be considered realistic one being sensorimotor action in which an action by the individual has the corresponding action within the sim, such as turning their head or moving their hands. The illusions of realism stem from the concept of place illusion and the concept of plausibility illusion. They are defined as "place illusion (PI) is the type of presence that refers to the sense of 'being there'... plausibility illusion (Psi) is the illusion that what is apparently happening is really happening (even though you know for sure that it is not)"[7]. The combination of sensorimotor actions, place illusion, and plausibility illusion is what allows the new virtual reality simulation to be considered realistic as it was designed with these aspects in mind.

The scenarios that the previous studies used were those that fit the medium however with the concept of gamification and the ability for the program to randomly generate combinations the majority of previous scenarios become outdated. Scenarios such as those on paper or those administered through a computer are not necessary, but the need to create ones similar to the real life videos used in the AR simulation is closest to what needs to be done for realism. The scenarios used in the previous study which used VR had a gamified set of scenarios that only placed an individual in front of a target or in a group which pulled away from being realistic. An example set of scenarios designed for this implementation is outline in Appendix A.1, as well a few commercial scenarios were used in the design for this implementation. These outline where the participant will be in the virtual environment while also showing how the sim will be interacting with them in a timeline of events or storyboard-like fashion. The use of real world scenarios to generate the VR based sims is the most effective means of gaining a realistic testing set as it is the best way to enforce realism by using true scenarios.

Chapter 4

Methodology

The collection of data was completed through the means of a usability study. This study was administered to participants from a proctor while they were in the virtual environment and required them to answer questions based on what they were viewing and their thoughts. The qualitative and quantitative data are divided based on what the question asked for or required the participant to do.

4.1 Population

The usability study consisted of a small population of 20 individuals who participated, due to a limited time frame to collect data the population was aimed at only 10 but double was collected. The sample population was drawn from community members of Oak Island, Southport NC. The population was had no split in terms of the race of participants, all participants reported that they were of White/Caucasian descent. There was a range within the populations age bracket where (Mean = 32.05, Standard Deviation=12.006), as well the gender was split 55% male and 45% female. Within the population only 20% of respondents reported using a virtual reality device before participating in the study. The participants were found through the means of a promoter at local points of interest within each town, where they were able to get individuals interested in participating. The full population statistics can be found in table 4.1, where the data is broken down more clearly.

Table 4.1: Statistical Population Breakdown

Category	Split	% Population
Race & Ethnicity	White	100%
Sex	Male	55%
	Female	45%
Age	15-24	20%
	25-34	45%
	35-44	15%
	45-64	20%

4.2 Procedure

Participants would come in and sit down, if there were more than one the excess would be asked to wait in a room beyond the ability to hear or see the current test. For each participant the necessity to alter equipment was undergone if necessary, that for glasses wearers or eye position. Then the participant was given a moment to acclimate to being in VR and that of their hand positions/posture. The test subject would then be instructed what to expect within the study. Then the participant would spawn in the environment surrounded by black walls, which were used in between tests to allow a moment of rest and for entities to be loaded/unloaded. This is where the test begins and the questioning would start.

The walls would drop and they would then be asked as few question on the environment and their virtual hands. They would also be informed on how they can move and look in the environment beyond their sensorimotor control. Once responses were collected, they would then be asked to return to their spawn, marked with a black cube and the next test was generated. The participant would be faced with four objects on pedestals and asked to identify each item from left to right. Once their data was collected, the walls came up and the next set was generated. A set of four avatars was loaded and the participant had to identify aspects or characteristics of them and report back. Again, once this was done the walls came up and the next set was loaded. The next set of questions came in the form of a set of tests, where the participant would look at an avatar

and try to identify characteristic of them similar to the previous questions and identify what object they were holding. This was done at a distance to keep in line with the distance the real application would most likely have used. This was run a total of eight times with different models although 2 sets being similar to check against false positives. Once this was complete a wrap up question was asked and the participant was finished.

4.3 Simulation

Figure 4.1: Simulated Testing Environment

The virtual reality simulation being used for the usability study has several parts that come together to make the whole. The environment is that of a "T" shaped neighborhood simulating daytime, equipped with houses, props, and other world building elements for realism. Within this environment there are a set of avatars, objects, and combinations of those which were used for testing. As well, there is a rig that was used to simulate the individual within the virtual environment. There are also temporary items like the walls used to hide the player or the marker at their starting location, though they are not a permanent fixture. A sample of the environment with some of the objects used for identification can be seen in figure 4.1. In this space these elements combine to make up the testing processes, appearing and disappearing as necessary when they are required. Along each

section of street that branches from the intersection is a different set of tests, where the left holds the avatar and item identifications, the center holds item identifications, and the left holds avatar identifications.

Chapter 5

Iterations

The project underwent several iterations as it developed through the means of ideas, challenges, and modifications. This forced the need for many changes over its development and in some occasions backtracking to earlier versions. However, the current state is one that will add merit to the overall whole as the investigation continues beyond this study.

5.1 Original Idea

The original aspiration of the study was planned to be a modification of the study conducted by (Peck, Good, & Seitz 2021[6]). This would include subjects within a virtual environment, confronted with an avatar and then having to decide whether or not to shoot. The means to go beyond the previous study was planned to be by the means of a more realistic environment, a separate set of variables, and hopefully a subset within the population being that of law enforcement. The variables that were planned to be tested were two genders, three races, three attires, three environments, and two objects. An environment that is more in line with the set of experiment proposed is the one that is currently being used, although there is also another environment that was made to represent a low socioeconomic status neighborhood. Although, some of these variables would be altered or removed as development progressed, the addition of new or different ones would take their place in subsequent iterations.

5.2 First Iteration

The first iteration of the project had a subset of the variables from the original plan. The use of the Oculus Quest II virtual reality device was set, and a semi-functional rig was in place. This iteration comprised of the environment with a set of models loaded in it, with a set of interact-able objects. However, the rig being used only had ray inter-actors instead of hands and most objects/avatars were not interact-able. This version was semi-working and was joined by another environment used for the testing objects and assets to allow them to be used without adversely impacting the main project. It was in this iteration the limitations of some of the software was realized as well as the ability to easily work within them. The acquisition of working models for some of the objects needed for the simulation were collected during this time and then tested in the separate environment. The avatar models that were being used were also set to be remade for the next iteration to better fit the environment and visibility. In the end this iteration was assessed and changes were set to be made for the next, as well as the addition of some other means of control and data collecting points. Assets for this section can be seen in Appendix B.

5.3 Second Iteration

In the second iteration of the project it was decided that the HTC Vive would be better suited for the project due to it having eye tracking capability. This came as development with the Oculus became more problematic, as the rig the participant would be using during the sim had issue with its virtual hands. However, the implementation of this would not come to fruition as the necessary development could not be undergone at the time as access to the device was limited. Although, at this point another alteration was made and that is where the point to look at weapon fire power came into play and its possible role in implicit bias. Throughout this iteration there were stagnant portions where work was difficult to implement whether due to environmental or digital factors. However, the redesign of the avatars was completed in this iteration and with this iteration they had different clothing options to signify threatening versus non-threatening apparel. It was also in this iteration that the redesign of the environment to include a low socioeconomic version was created. This was done by modifying the existing environment and both adding and removing models to make the environment appear to be of lower economic standing.

5.4 Final Iteration

In the end of development with the issues faced it was decided the best means for the project to continue was to alter what it was currently into the form of a usability study. This would allow it to be continued later and give some feasible data to use as its development continues and what direction or modifications may be necessary. Its current state is the high socioeconomic standing environment with a working virtual reality rig, with avatars, and models. These can be seen in Appendix B, the animation of the hands was one of the biggest feats for this section. This was a large difficulty, partially brought on by the Unity software, due to the inability to edit animations within the inspector window. There was also the creation of a basic movement system which would allow the rig to move given input from the Oculus's controllers, where the right controlled turning and the left controlled forward/backward, left/right movement. Then with those in combination, the design of how the usability study would be run caused alteration to the scene. The addition of all the usable objects and the usable avatars was added to the scene for an individual to identify. Also a set of avatars holding objects was created, six in total to test the identification at a distance similar to how the original study was planned to be ran. Then there was also added a set of temporary objects to assist with testing, that of a black spawn marker and a black set of walls to hide the participant when necessary. The combination of all of these within the environment meant the project was at a point where it was ready for the usability study to be conducted.

Chapter 6

Results

6.1 Data collection

The questionnaire that was used for the data collection was proctored for each individual who participated in the study, and instruction was given only when required to inform about functionality. This was done because 80% of the population had not be exposed to or was familiar with a virtual reality device before participating in this study. Each testing period took approximately 27.4 minutes on average for each participant, some times were omitted in the average as they recorded time the survey was open waiting for the next respondent. The respondents were also given as much time as needed to answer the first set of questions and those allowed the participant to move around and interact with the environment. There were loose time restrictions on the last set of questions given, as well as movement restrictions so the participant would not walk up to the avatar and object they were identifying and the identification would be done as true to the intended simulation as possible. The questionnaire was given verbally to the participants while they were in the virtual reality simulation, the proctor could view their perspective while the test was running and could assist when needed to orient the individual or instruct them where to go.

6.2 Usability Studies

In the process of the projects development the need for a usability study became apart, as it was necessary to know how well the current state of the simulation would be perceived by

participants. This study was divided into four categories with both qualitative and quantitative data being given by the participant. The survey questions used in the usability study can be found in Appendix C, where they are outlined fully. The questions were used to asses the participants opinions on certain aspects of the simulation and their ability to identify objects/avatars within. The latter of the two being done so at a distance as to be as true to the intended simulation as possible. The qualitative questions used a one through five scale to rate the participant's opinion where 1 was considered "Not Realistic" and 5 being "Very Realistic". The remaining questions were instead recorded answer, but for clarity will be scored using percentages of the total population with letter abbreviation for some terms.

6.2.1 Environment, Usability, & Feel

The questionnaire's section that was on the environment and the feel of the simulation gave some interesting feedback, the data found can be seen in table 6.1. This is the ability to see how people viewed the environment and and their virtual self, as well in the last question of the set where the sim could possibly improve moving forward. The overall environment and its feel of realism was found to hold an average of 3.55 on the scale. This is an informative statistic as it shows the necessity to improve on the environment through suggestion/feedback given in the last question. The virtual hands used within the simulation along with their animation and interactivity had an average rating of 3.95. This offers the insight that the virtual hands used were realistic enough to feel like true hands from varying aspects of sensorimotor controls. Those together show that the environment should be a means of focus as the project continues to develop. This is to increase the realism of that which will aid in the place illusion of participants in future studies in virtual environments.

Table 6.1: Results for Environment, Usability, & Fell

Environment, Usability, & Feel	Avg
Environment Rating	3.55
Hand/Usability Rating	3.95

6.2.2 Object & Avatar Identification

The object and avatar identifications offer some valuable information as to the perception of the participants and the presentation of those entities within the simulation. The object identification

saw 100% accuracy over 80 entries for the shotgun, pistol one, pistol two, and the cell phone which can be found in table 6.2. This leads it to be believed that the objects within the simulation are realistic enough that they can be accurately identified even by those who have minimal weapons knowledge. The avatar identification saw a 100% accuracy when observing the aspect of gender of the avatars. This shows the avatars used were realistic or visually descriptive enough that their genders could be easily identified by those who participated in the study. The race of the avatars was the aspect that saw the first error, an error rate of 1.25% where avatar 2, a Black female was misidentified as of Indian descent. Avatars 1, 3, and 4, had 100% accuracy for all participants which can be found in table 6.3 shows these avatars in their current state are obvious enough that their demographics can be identified. However, avatar 2 who had the error may require some change to be more apparent of its demographics moving forward. It is important that the race and gender identifications be completely accurate, as when they are applied the misidentification may lead to inaccurate data when observing shooter bias within the simulation. This is due to their being different biases toward different races, the bias towards what was perceived in the study as Indian descent may be different than that of Black descent, which is where the inaccuracy may arise.

Table 6.2: Object Identification

Object	Accuracy
Object 1 (Shotgun)	100%
Object 2 (Pistol 1)	100%
Object 3 (Pistol 2)	100%
Object 4 (Cell Phone)	100%

Table 6.3: Avatar Identification

Avatar	Aspect	Response
Avatar 1 (W M)	Gender Race	100% Male 100% White
Avatar 2 (B F)	Gender Race	100% Female 95% Black 5% Indian
Avatar 3 (B M)	Gender Race	100% Male 100% Black
Avatar 4 (W F)	Gender Race	100% Female 100% White

6.2.3 Identification Trials

The data that most closely resembles what was planned for the original study was the trials at the end of the questionnaire which ran through race, gender, and object identification from a distance. This was completed over eight tests, where two were repeats to check for false positives. Within the table 6.4 the data from the trials can be found where the matching trials are (T2 & T5) and (T3 & T7), the rest are unique to each trial. The demographic based responses from the

participants mirrored what was found in the avatar identification tests in table 6.3. This is a well made reinforcement that the avatars within the simulation are ones that have easily identifiable demographic characteristics. The only error seen is one that also matches the earlier identification tests, which also reinforces that participant, even though incorrectly reporting, could still identify the same avatar from a distance as the same race as was done previously. The accuracy in the demographics portion of this test bolsters the argument for them which also reinforces the idea that they are adequate for use in the study moving forward.

Table 6.4: Results for Avatar Race, Gender, & Object

Accuracy								
Trials	T 1 (W F Ph)	T 2 (B M Pi)	T 3 (W M Pi)	T 4 (B F Pi)	T 5 (B M Pi)	T 6 (W F Pi)	T 7 (W M Pi)	T 8 (B F Ph)
Race	100% White	100% Black	100% White	100% Black	100% Black	100% White	100% White	95% Black 5% Indian
Gender	100% F	100% M	100% M	100% F	100% M	100% F	100% M	100% F
Object	95% Phone 5% Pistol	100% Pistol	90% Pistol 5% Phone 5% Empty	95% Pistol 5% Phone	90% Pistol 10% Phone	90% Pistol 10% Phone	90% Pistol 5% Phone 5% Empty	95% Phone 5% Pistol

The object aspect of the trials revealed an interesting set of responses to be analyzed, especially when considering the duplicate trials that were given. The object aspect saw a total error rate of 6.875%, where the was actually a greater error rate with White avatars (4.375%) over Black avatars (2.5%). Even though this usability study is not specifically looking into implicit bias, and instead just the usability of the sim, it is notable that it found similar results that some of the previous studies found. This is where the sample population resulted in a higher error rate toward White avatars, 3.75% of responses showed the misidentification of a threatening object as a non-threatening object with White avatars. This is higher than what was found in Black avatars where an error rate of 1.875% of responses were misidentifying a threatening object for a non-threatening object. The trials where non-threatening objects were held both exhibited a single occurrence where the non-threatening object was misidentified as a threatening object.

A necessary set of duplicate trials were included within the questionnaire to ensure that any responses were accurate and not false positives/negatives. Trial two/five consisted of a Black male with a pistol which saw a notable discrepancy, where on the latter of them two misidentifications were made, where the pistol was identified as a phone. This could show that there may be some issue that at that distance it was hard to identify or possibly misidentifying due to the last occurrence of

a non-threatening object being many trials before. This set of reinforcement trials are the outlier as the next set does not exhibit the same trend that these did. Trial three/seven consisted of a White male with a pistol, which both saw errors, with a 1.25% error rate. The notable aspect is with the responses in combination with the errors, where 90% of respondents identified the correct threatening object. However 5% of respondents saw a non-threatening object in both occurrences, as well 5% of respondents saw no object in the avatars hand. This second set with identical responses show that despite the errors, the identification of the avatars and items was accurate to their perception and there were no discrepancies. This leads to the possibility that this set of responses show that with modification the misidentifications can be remedied in further study but will be reviewed in the Limitations section.

Chapter 7

Conclusion

The study originally aimed at investigating the effect of weapon power on an individuals shooter bias, though that was not the end product the usability study instead revealed useful results. These which have both reinforced what has been seen in previous study and that of what will become of the current study. The investigation into the factors that have some effect on an individuals shooter bias can be best seen in a virtual environment simulation. Through the usability study the place and plausibility illusion of the participants made for a fairly realistic experience. The results of which gave enough information to show that the current state it one that is usable to the extent that it is still beyond that of what has come before it.

This information that has been collected and analyzed was done so for the study moving forward to have a well defined base to build from, as well as qualitative and quantitative feedback on what it would have been using. The necessity for this form of data is pertinent when developing a study such as this as it has allowed the ability to conclusively state whether or not in reality or virtual reality that is, would be effective in the investigation into implicit bias. Therefore in its current state the virtual reality simulation is done so in a way that could be used study implicit bias, although, there are many aspects in which it could be further developed to increase the illusions and then so allow for more accurate data.

7.1 Limitations

There are a few limitations of the study that should be outlined for clarity and understanding, especially so when looking at the feedback from the last question of the questionnaire. The sample population used consisted of singular ethnicity, those of White descent, where other races may have had slightly different views than those who participated in the study. As well, The hardware used to run the study and the simulation was of an older generation so there were some performance issues. In most cases this was not a very noticeable problem however the sim had to be rendered multiple times on a select amount of occasions to remedy poor performance before allowing a participant to begin. The points of improvement question offered a few issues that can be remedied in later development and the responses fall into three groups. The first group outlines that the neighborhood needed more ambience some interactability or some aspect that reduces the sterility of it, in the sense that it should feel "lived in". The second group follow a previous point that noticed micro-stuttering, due to the tethered nature of the Oculus device and other hardware related influences, essentially improved hardware would make the simulation more smooth. The third group had an interesting point to be made as the the position of the object the avatars were holding. It was suggested by them that have the object held head on made it difficult in some instances especially due to the distance from them, however animations of the avatar and their posturing with the object should remedy that point.

7.2 Future Work

As the project has developed it has been intended to be continued beyond this study. The main development of the final product can be seen in the Iterations section and lies in between the second and final iterations. The main points that should be focused on however is the project plans to be migrated over to the use of the HTC Vive instead of the Oculus. This is so there will be the possibility for hand/eye tracking and allow for a look at an individuals sight line and posture while investigating implicit bias. The future of this work will look into those two data collecting points as well as the ones intended to be investigated originally, as well as weapon fire power. It is hoped that the study will continue using the information found within the usability study and the points found where other studies lacked to create a virtual reality simulation to study implicit bias in a controlled environment realistic enough to give the illusion of reality.

Appendices

Appendix A Scenarios Design

A.1 Designed Scenario

Within the Environment (HSES or LSES) the participant will be positioned at point 1 outlined by blue within Figure 1. This is where the spawn, position 2 is the spawn point of the Avatar that will interact with the participant. The participant may move up slightly to the green position, the avatar will walk and turn the corner to the orange position. Once both entities are in their respective zones, at an area defined as the decision point, the participant will have little more than a few seconds to assess and decide on what they are going to do. In which case they will either shoot or not shoot the avatar that has approached them. Then another scenario will be loaded up and undergone.

Figure 1: Top down view of environment with entity locations

There is a slight amount of distance between the participant and the avatar that is being used per sim. This is to keep the avatar at such a distance that the held object is not entirely obvious to the participant. Another form of obstruction may be used, such as, pulling something out of a pocket, pulling something from back, etc. The amount of time per sim should be about 5-10 seconds. This allocates a few seconds for the entities to move into place, the avatar to preform their action and then a small time for the participant to decide.

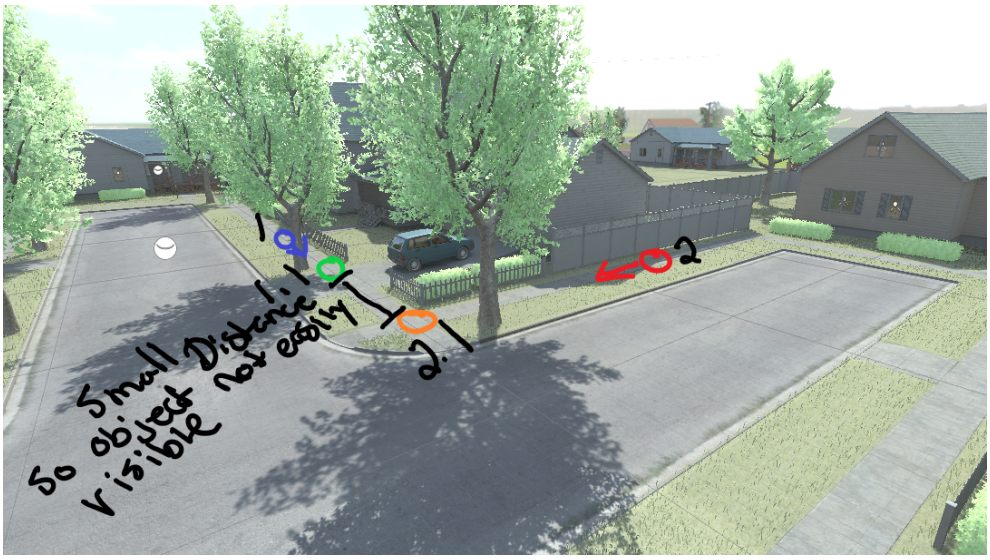

Figure 2: Perpendicular view of environment with entity Movements

From the participants perspective it is shown what they will be able to see once placed into the sim. The distances that are moved are outlined; the avatar being rendered will spawn behind a fence to keep its loading hidden from the participant. This is also useful to ease the avatar into view instead of immediately being presented with them. The car provides as a slight obstruction as the avatar moves, which may obstruct some participants views until they have rounded the corner. This is so the participant has as little time as possible to make their decision.

Figure 3: Participant view of environment with entity movements

Appendix B Asset Stages

This Appendix goes over some of the initial and final stages of the assets used in the simulation, as well as a brief description discussing the reasoning or necessity to do so.

B.1 Weapons Assets

The weapon assets used were initially decided just be enough to be realistic which can be seen in figure 4. As development continued and the refinement of what "fire power" was going to be defined as it left the project for the need of semi-realistic weapons that would be convincing enough to mimic that of a peace officers toolkit. The final assets are where they were changed, the majority change lie with the weapons as they now are more akin to that of real world weapons, and the phone went through a change going with a black model. This change can be seen in figure 5.

Figure 4: The set of original object assets

Figure 5: The set of current object assets

B.2 Avatar Assets

The models underwent a large change, the original models being used can be seen in figure 6 and they initially were made just to demonstrate the different races. As the project developed the need for multiple sets were necessary, this being a set for high socioeconomic status and low socioeconomic status models. This clothing definition created eight models from the original four that were being used for demonstration. The high socioeconomic set can be seen in figure 7, with the low socioeconomic set being seen in figure 8.

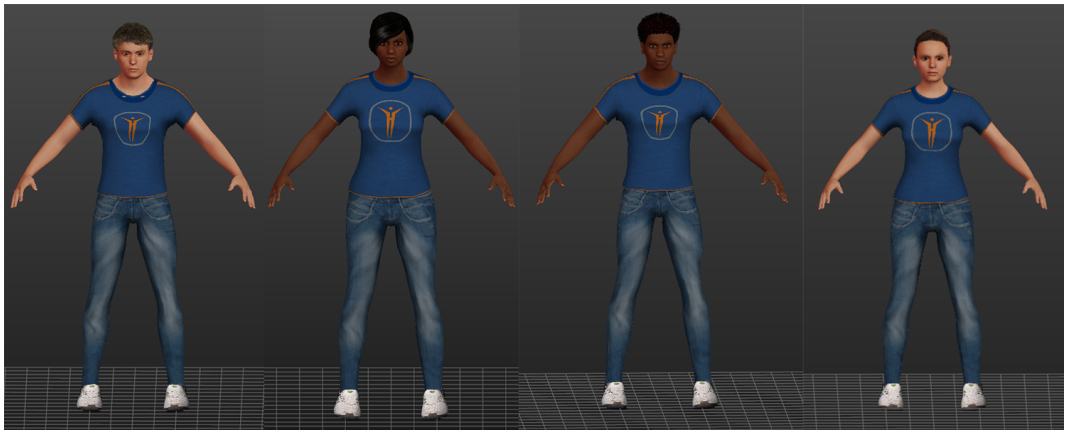

Figure 6: The set of original avatar models

Figure 7: The current set of High socioeconomic avatar models

Figure 8: The current set of Low socioeconomic avatar models

B.3 Environment Assets

The environment that was used as the high socioeconomic neighborhood did not see any change over the development of the project. However, from that environment was designed a low socioeconomic environment that is intended to be used as the project continues. The high socioeconomic environment can be seen in figure 9, then the altered version can be seen in figure 10.

Figure 9: The current high SES neighborhood

Figure 10: The current low SES neighborhood

Appendix C Questionnaire

C.1 General Information, Environment, Usability, & Feel

The last question in this set was given at the end of the survey to cover feedback on all sections.

- What is your race?

  White, Black or African American, American Indian or Alaskan Native, Asian,

  Native Hawaiian or Pacific Islander

- What is your gender?

  Male, Female, Non-Binary/Other, Prefer not to say

- How old are you?

- Look Around. How would you describe the environment you are in?

  (Not Realistic) 1 2 3 4 5 (Very Realistic)

- Look at your Hands. Describe the feel of those?

  (Not Realistic) 1 2 3 4 5 (Very Realistic)

- Is there anything you would like to say based on what you have seen or experienced?

C.2 Object Identification

This set of questions are open ended and depends on the participants perception of the object.

- Look at Object 1, Can you Identify what it is?

  Phone, Pistol 1, Pistol 2, Shotgun

- Look at Object 2, Can you Identify what it is?

  Phone, Pistol 1, Pistol 2, Shotgun

- Look at Object 3, Can you Identify what it is?

  Phone, Pistol 1, Pistol 2, Shotgun

- Look at Object 4, Can you Identify what it is?

  Phone, Pistol 1, Pistol 2, Shotgun

C.3 Avatar Identification

This set of questions are open ended and depends on the participants perception of the avatar.

- Look at Avatar 1, can you identify the race and gender?
- Look at Avatar 2, can you identify the race and gender?
- Look at Avatar 3, can you identify the race and gender?
- Look at Avatar 4, can you identify the race and gender?

C.4 Identification Trials

This set of questions are open ended and depends on the participants perception of the avatar with the object.

- Look at Avatar 1, can you identify the race, gender, and the object they are holding?
- Look at Avatar 2, can you identify the race, gender, and the object they are holding?
- Look at Avatar 3, can you identify the race, gender, and the object they are holding?
- Look at Avatar 4, can you identify the race, gender, and the object they are holding?
- Look at Avatar 5, can you identify the race, gender, and the object they are holding?
- Look at Avatar 6, can you identify the race, gender, and the object they are holding?
- Look at Avatar 7, can you identify the race, gender, and the object they are holding?
- Look at Avatar 8, can you identify the race, gender, and the object they are holding?

Bibliography

[1] Anthony G Greenwald and Mahzarin R Banaji. Implicit social cognition: attitudes, self-esteem, and stereotypes. *Psychological review*, 102(1):4, 1995.

[2] Anthony G Greenwald, Mark A Oakes, and Hunter G Hoffman. Targets of discrimination: Effects of race on responses to weapons holders. *Journal of Experimental Social Psychology*, 39(4):399–405, 2003.

[3] Lois James, Bryan Vila, and Kenn Daratha. Results from experimental trials testing participant responses to white, hispanic and black suspects in high-fidelity deadly force judgment and decision-making simulations. *Journal of Experimental Criminology*, 9(2):189–212, 2013.

[4] Kimberly Barsamian Kahn and Paul G Davies. What influences shooter bias? the effects of suspect race, neighborhood, and clothing on decisions to shoot. *Journal of Social Issues*, 73(4):723–743, 2017.

[5] Dorota Kamińska, Grzegorz Zwoliński, and Anna Laska-Leśniewicz. Usability testing of virtual reality applications—the pilot study. *Sensors*, 22(4):1342, 2022.

[6] Tabitha C Peck, Jessica J Good, and Katharina Seitz. Evidence of racial bias using immersive virtual reality: Analysis of head and hand motions during shooting decisions. *IEEE Transactions on Visualization and Computer Graphics*, 27(5):2502–2512, 2021.

[7] Mel Slater. Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1535):3549–3557, 2009.

[8] Christian Unkelbach, Joseph P Forgas, and Thomas F Denson. The turban effect: The influence of muslim headgear and induced affect on aggressive responses in the shooter bias paradigm. *Journal of Experimental Social Psychology*, 44(5):1409–1413, 2008.