The Influence of Virtual Reality on the Perception of Artificial Intelligence Characters in Games

Christopher J. Headleand, Gareth Henshall, Llyr Ap Cenydd and William J. Teahan

Abstract Virtual Reality is a technology which is quickly leaving the laboratory and being placed in the hands of the consumer. With many large hardware manufacturers and games development studios investing heavily in the future of the technology, we are starting to see the first VR-based games become available. But will the consumerization of VR hardware change how games developers consider Artificial Intelligence? In this study, we begin by discussing how the perception of an AI-based character may change how a user interacts with it. Based on this survey, we ask the following question: "Do AI characters appear more or less human-like though Virtual Reality, as opposed to typical monitor-based viewing mediums?" We conduct a study where 16 participants play two games (a First Person Shooter (FPS), and a racing game), both played through VR and a monitor (4 games in total). In this study, the participants are told that they will play two games against another human participant, and two against an AI driven character and that they must make a judgement on what they are playing against for each game. However, they actually play against identical AI characters in both viewing instances of the two games. The results show a clear split in assessment for the two games; when the racing game was played through VR, the participants concluded that their opponent was Human; however, when played through the monitor, they concluded they were playing against an AI. However, the opposite trend is apparent when the participants played the FPS game. We conclude the VR does change the way we perceive AI characters; however this change in perception needs to be further investigated.

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1 Motivation

The computing industry recently entered a virtual reality renaissance. The introduction of head mounted displays (HMDs) capable of immersive and comfortable experiences at affordable price points has dramatically reduced the barrier of entry for both home users and researchers.

Emerging VR HMDs are capable of producing the visceral sensation of being inside the simulated world. The depth and quality of this spacial immersion, called *presence*, is the main yardstick that all VR companies use when developing their headsets and experiences. While there are many facets to achieving a deep sense of presence, even the first generation of consumer VR hardware released in 2016 will be capable of producing this phenomenon for sustained periods.

Over the next few years, the industry is predicting an explosion of VR experiences. But what impact will this revolution have on AI research? Some are anticipating that high quality, believable AI will become increasingly important and questions have been raised as to how the appearances and behaviour of virtual characters influence peoples levels of presence, or immersion [5]. As the depth of presence becomes a commonly sought experience, players will be more critical of AI that breaks their sense of immersion. We could assume that this means ‘business as usual’ for AI, and we simply need to keep striving for improvement on the state of the art. But, this does raise the question of whether VR immersion in itself makes a difference to how we perceive AI characters?

A pertinent question for the gaming industry will be whether it is easier to identity an AI character through VR than a traditional monitor. For example, many modern collaborative on-line games seamlessly replace human controlled companions with AI ones if they leave the game, allowing the player to continue without breaking immersion. Virtual characters are now at a stage where it is increasingly difficult to make human/not human distinctions in virtual environments [13], and artificial intelligence is an important component of this façade. If VR had an effect on this, developers may need to reconsider their development choices, or how they implement their AI characters.

This preliminary study is motivated by two research questions: firstly, ”Does virtual reality change the way we perceive non-player characters in-game?”; and secondly, ”Do AI controlled characters appear more or less human-like through this viewing medium?” In essence, we will explore whether VR makes the synthetic behaviour of AI characters more noticeable.

2 Background

How we perceive AI characters within virtual worlds is a pertinent topic in both computer games research and virtual environment applications in general [18]. How AI characters are perceived could have a broad impact on believability, immersion and the usefulness of simulators, training tools and telepresence applications. There is also evidence to suggest that believing an in-game character is human could factor into enjoyment of games. Studies have shown that players will show preference towards team-mates they believe to be human controlled, even if they are actually AI characters[8]. However, what factors affect perception of an in-game character is an open question.

There is evidence to suggest that behaviour and movement are key qualities, with studies showing that people are more comfortable interacting with avatars that move like humans[22]. Studies have also demonstrated that human players will treat in-game characters more favourably if they believe that they are controlled by a human. This extends to noticing positive behaviour (such as sacrifice, or protection) more often [9, 11]. Conversely, if a player believes an in-game character to be a bot (an AI controlled character), they are more likely to assign blame to it [10]. However, an alternate theory is that participants will respond equally to human and computer controlled entities that exhibit similar social behaviour [13], a phenomenon that is sometimes attributed to the CASA (Computers Are Social Actors) theory [12].

Gender may also be a factor in perception. Avatars with gender identities have been shown to elicit specific behaviours from humans during interaction. For example, when interacting with characters with a female gender, participants exhibited stereotypical masculine behaviour, and when interacting with male avatars, the participants exhibited feminine behaviours [19]. It is important to note that the participants were not aware of their change in behaviour, meaning that we may not be conscious of how our perception of characters in virtual worlds changes our actions.

We are aware that the appearance of avatars has an impact on interaction [1]. For example, characters wearing outfits with negative social connotations [15] elicit more aggressive intentions and attitudes from participants. But how could other visual factors contribute to our perception of AI characters? To the best of our knowledge, there has not been a study which has evaluated whether changing viewing modality effects the perception of AI characters. Would the increased immersion of VR make synthetic behaviours more obvious to a human observer, or would this change in presence result in a greater perceptual inference of the agent's behaviour, making the façade easier to believe?

3 Method

To explore the research questions, 16 participants (12 Males, 4 Female) were tasked with playing two types of game: a racing game, and a first person shooter (FPS). Both game types were played through two viewing mediums, an Oculus Rift DK2 and a standard PC gaming monitor. Every person played all four games.

Games were played in a mixed order, and it was ensured that the same viewing medium wasn't repeated twice (resulting in 8 possible orders of play). Each order was therefore played by two participants.

Each participant was told that during the four games, they would play two rounds against a human, and two against an AI opponent. They were told that their task in each game was to identify whether the identity of the opponent was an AI or Human.

During the experiment, the participant was in a segregated booth, unable to see other people during the experiment. The beginning of each game included a splash screen which implied the game was connecting to a multi-player server, adding to the façade.

However, regardless of whether the person played through VR or Monitor, their opponent was the same AI (one AI for the racing game, another for the FPS). The purpose of this deception was to ensure that the players were competing against opponents of identical competence and that in-game ability was not used as a flag to differentiate between opponents. This removes one confounding variable from the experiment, and is consistent with the experimental design of studies with similar objectives [8]. By following this approach, we only identify differences in the perception of AI through the two viewing media.

At the end of the experiment, participants filled out a survey. For each of the games, they were asked to make an assessment of the identity of the opponent they competed against. This was done on a 1 to 5 scale, with 1 representing high confidence that the opponent was Human and 5 representing high confidence that the opponent was AI, a score of 3 indicated that the player was unsure either way. The player was then also asked to rate their enjoyment of the game, and a free text response provided the participant with the opportunity to provide qualitative data.

3.1 Ethical Considerations

There are two principle ethical considerations in this study. The first is that the experimental design involves deceiving the participants. However in this case, the harm caused from the deception is minimal, and it was deemed to be the only practical method of achieving the goals of the study.

The second consideration is that video games have been shown to induce motion sickness [21] and that use of the Oculus Rift compounds this nausea in users [4, 3], a condition known as cybersickness. To reduce the risk, we designed both games to adhere to VR best practices[14]. For example, low frame rates are the most common source of sickness, and so we ensured both game types were played on a machine capable of producing a constant 75fps (Frames Per Second), the native frame-rate of the Oculus Rift DK2[20]. Efforts were also made to alleviate motion sickness due to vection [7], including limiting movement speed in the FPS game.

All participants were informed of the risk before they entered the study, and had to read the health and safety information (produced by Oculus) and sign a consent form. Participants were also told that if they felt sick, they could ask to end the study at any time. Additionally, participants was given a short break between each game, and the participants never played two VR games in a row, limiting extended exposure.

4 Test-bed Games

In the following sections, we will explain how both games were implemented, including integration with the Oculus Rift.

4.1 Racing Game

Fig. 1 Players view from inside the car during the game. The original game was played from a 3rd person perspective (outside, behind and above the car). This would have been an unnatural (non-immersed) position to play in VR, so the camera was moved inside the car.

To implement the racing game, we used two projects available freely through the Unity asset store. The first *Car Tutorial* [23] is a complete package including a track and a physics driven player car. We augmented this package with the AI car from *The Vehicle Physics Toolkit(VPT)* [2] package, which is also freely available. The underlying physics of both AI and player controlled cars were based on the same model [23].

The AI car follows a predetermined path along the center of the virtual racetrack. A variable in the AI car script determines how much it can deviate from that path before it needs to correct. Varying this value allows us to produce a relatively realistic driving style. The path itself is constructed from a series of game objects linked together to form a complete circuit. Within the VPT package, breaking zones are placed throughout the track so that the AI car will slow down at sharp corners.

A reset function was also added so that any AI or player controlled car crashes would result in the car resetting its position to the middle of the road after two seconds.

The majority of racing games have a natural rhythm, with players regularly changing position and overtaking each other, rather than one player dominating the race. This is a commonly sought after mechanic by game designers, and is usually achieved by applying a rubberbanding function that speeds or slows down the AI car if too far behind or ahead. The same mechanic tends to naturally arise in similarly-skilled player controlled games due to driver error etc. Rubberbanding was implemented into our game for the same reason, ensuring that the AI was constantly battling the player for position regardless of the player's ability.

The original camera position followed above and behind the car (third person perspective). This camera angle was not suitable for VR as it is both unnatural and likely lead to nausea [16]. The camera was moved to be inside the car, providing a much more natural perspective. Being surrounded by the car's interior also helps to reduce nausea as it provides a static frame of reference.

4.2 First Person Shooter

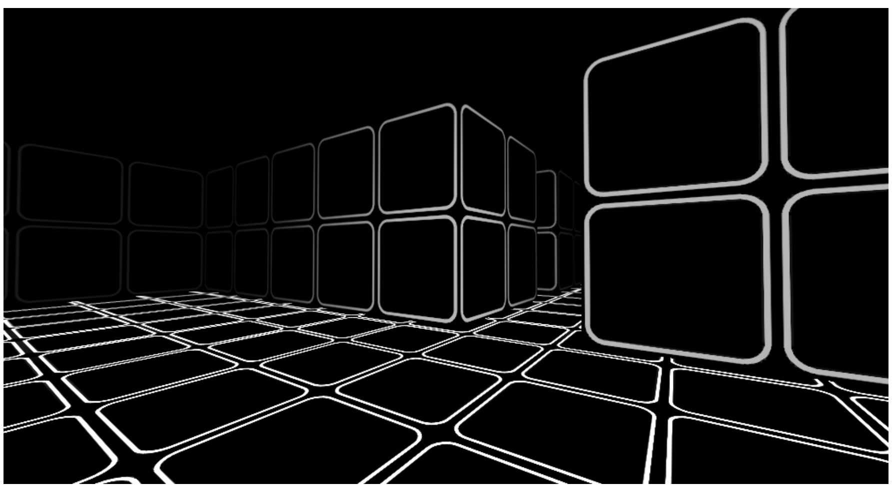

Fig. 2 The player's view within the FPS maze. This is randomly generated using the RMCM algorithm.

The FPS game required the player to explore a randomly generated maze and destroy an opponent. To generate the environment, we implemented the RMCM algorithm [6] in Unity. Each environment (which can be seen in figure 2) was 50 units square, with one unit equal to the diameter of the enemy and the player's avatar colliders.

The player and the opponent were placed at opposite corners of the environment. The player and the opponent both controlled an identical character implementation (which can be seen in figure 3), ensuring equivalent speed and manoeuvring ability. The two entities in the game were armed with the same simulated weapon, and had the same number of lives.

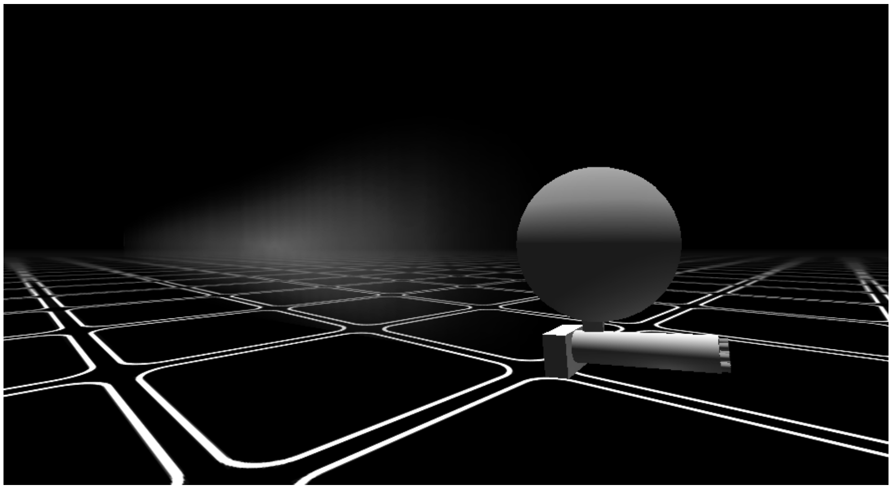

Fig. 3 The opponent character in the FPS game. The character was a simple sphere with a turret weapon. As the character moved around the scene, it left a decaying blue trail behind since in early experiments we discovered that even in small mazes, it was difficult to locate the opponent character. The player avatar also had a blue trail, although this was not used by the AI for tracking.

The AI was controlled by a simple finite state machine operating in one of three states:

Wander In the wander state, the AI randomly explores the environment, sensing the world ahead of it with a vision cone of 120°. The vision range is limited only by occlusion from walls in the environment. As the character moves into a new room, it will detect any exits it can see, select one at random and steer towards it. If it does not see an exit directly ahead, it explores the room using a wander steering behaviour [17].

Engaged If the player enters the opponent's vision cone, the AI enters the engaged state. In this state, it will move towards the player firing its weapon. The AI stops moving forward if the player is within a 'close range' vision cone, where the length of the close range vision cone is equal to the diameter of the enemy and the player's character collider.

Seek If the AI is in the engaged state, and the player exits its vision cone, it enters a seek state. The seek state causes the AI to turn and move towards the last point at which it saw the player. Once there, if it has not seen the player again (activating the engaged state), it returns to the wander state.

Each time the player was shot, a small health bar provided the player with a visual indicator of the damage. The game was a single round ending with either the player or opponent being destroyed.

4.3 Headset and Input Device

We used the same camera position and field of view for the VR and monitor versions of both games. A standard Unity camera was used to render for the monitor versions, while the VR versions used the stereoscopic camera implementation provided by Oculus that renders a separate image for left and right eyes.

The Oculus Rift DK2 is capable of tracking the player in 3D space using an infrared camera that tracks the headset's position. This allowed the player to lean around in the VR car game, but not in 2D monitor version. While this could have a small impact on performance, we deemed positional tracking to be an integral part of VR as it has an important effect on both nausea reduction and immersion.

As half of the four experiments were run on the Oculus Rift, the games were controlled using a gamepad (specifically the Microsoft Xbox gamepad). Once the headset is on, the participant is unable to see the keys of a keyboard, so a tactile controller is more suitable.

5 Results

The results show a clear split between the monitor and VR based games. However, what makes the results particuarly interesting is that the split is inverted for the two game types.

In the VR racing game, players typically reported that the opponent was Human. The mean result for all the racing games played through VR is 2.56, placing the average player opinion between human and undecided. This is an inconclusive score by itself, but the mode score of 2 provides further insight into the perception of the players. We can also observe an obvious bias towards the players reporting the opponent as human controlled in the distribution of scores (seen in figure 4).

When playing the racing game through a monitor, the players typically reported that the opponent was an AI. The identification here was more statistically obvious, with a mean score of 4 and a mode of 4 (13 of the 16 participants voted that they believed the character was AI).

However, we observe an inverse trend in the FPS game. While playing the game in VR, the majority of participants reported that the opponent was AI controlled (mean score of 3.68 and a mode of 4). This falls into a similar distribution to the AI reporting in the racing game, but through the alternate viewing medium (VR rather than Monitor).

When the participants played the FPS game through the monitor, they trended towards reporting that the opponent was human controlled. As with the racing game, this was reported with significantly less confidence than the reporting of the AI character (mean score of 2.43 and a mode of 1).

It is perhaps unsurprising that where participants reported that they believed the opponent was an AI (Monitor for the racing game and VR for the FPS), they responded with higher confidence. The AI designed for both the games was relatively

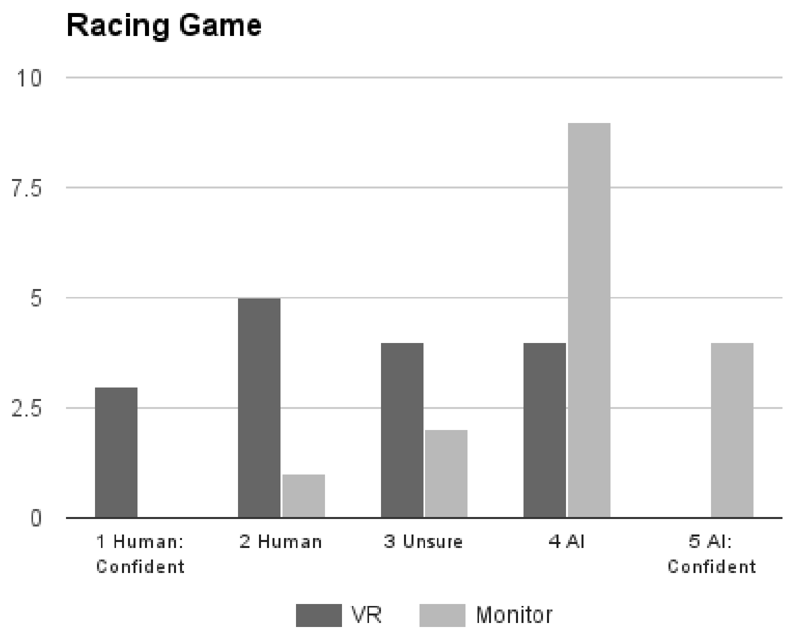

Fig. 4 The participant's assessment of their opponents identity for the First Person Shooter game. When played in VR, the majority of participants trended towards believing that their opponent was human controlled (mean score of 2.56 and a mode of 2). However, when playing the game through the monitor, the participants were more likely to report a belief that the opponent was AI controlled (mean score of 4 and a mode of 4).

simple and contained little sophistication or artificial stupidity to make it respond more like a human controlled character. However, as the participants voted with relatively strong conviction in these cases, it is interesting to see participants trending towards reporting that their opponent was human controlled in the alternative viewing medium (even though this was with less confidence).

We also asked the players to rate their enjoyment of each of the four games. We were expecting to see a correlation between the games where the participant believed they were playing against a human and higher enjoyment. No such correlation existed, with the games that received the highest rating being the ones played in VR. However, we do not assume that this trend necessarily means that players will enjoy VR games more than their monitor based equivalent. The majority of the participants had not played games through VR before the study. As such, the novelty of the new viewing medium likely contributed to the enjoyment results we have reported.

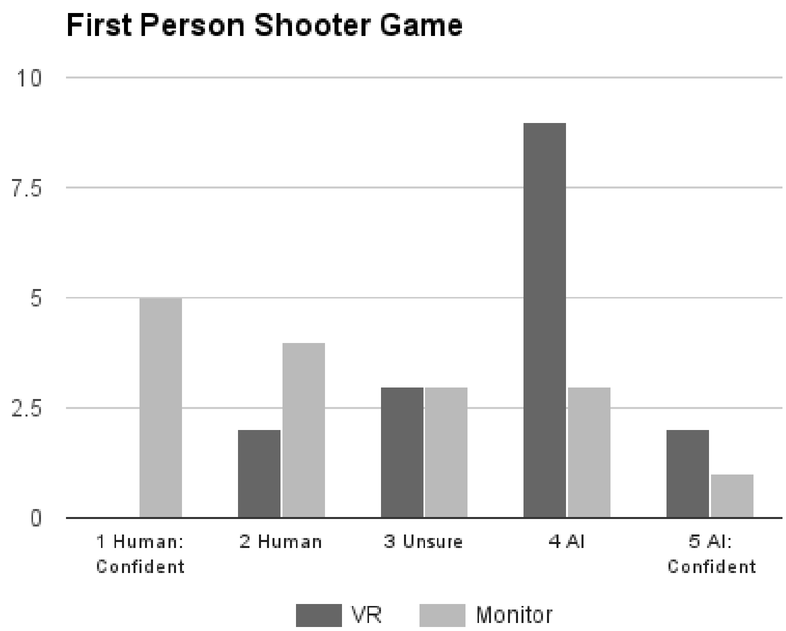

Fig. 5 The participant's assessment of their opponent's identity for the First Person Shooter game. When played in VR, the majority of participants trended towards believing that their opponent was AI controlled (mean score of 3.68 and a mode of 4). However, when playing the game through the monitor, the participants were more likely to report a belief that the opponent was human controlled (mean score of 2.43 and a mode of 1).

We also captured data regarding who won the game, the player or the opponent. In the racing game, a win was recorded if the player completed two laps in the shortest time. In the FPS, a win was recorded if the player successfully destroyed the opponent before they themselves were destroyed.

As can be seen in figure 6, the player was not particularly successful in either game (6 wins recorded in the racing game, 1 win in the FPS). We assume that this was because the participants were not provided with the opportunity to practice the game before the study, and conversations with participants after the experiment adds evidence towards this suspicion. However in the racing game, it did appear that the player performed moderately better through VR. We gained further insight through the free text response. In eight of the games, the player reported that the game was easier in VR, with several mentioning that the ability to look around freely was a positive experience.

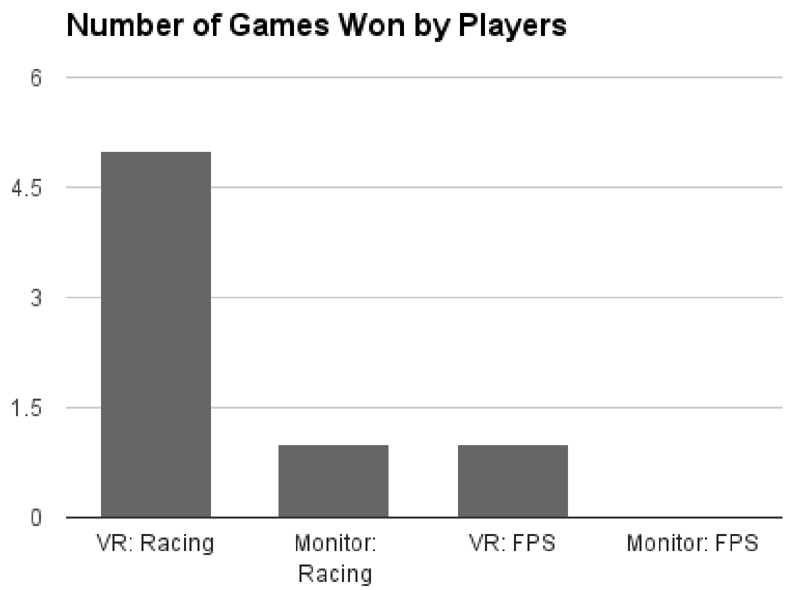

Fig. 6 Number of player wins for each of the four game instances.

6 Conclusion and Future Work

The important conclusion to draw from this study is that the level of immersion provided through Virtual Reality appears to clearly impact how we perceive AI characters. Despite the study being undertaken with a relatively small number of participants, the results show a clear split in the player's perception of their in-game opponent.

We anticipated that the results for both game types would be the same, demonstrating that VR either makes AI characters more or less obvious to a human player; clearly, from our results, this is not the case. This study indicates that there is likely a link between the way a game is played, and how VR affects the player's perception of the world. Further studies need to explore this in greater detail. Future work will be to implement a much larger study with more participants engaged in a broader spectrum of games.

Perception through virtual reality could have clear implications for the future development of Artificial Intelligence in games. It appears that VR could have the effect of making AI characters more or less human-like during play, and this will impact how we design them. If prolonged presence is the ultimate goal of VR, it is clear that AI will have a significant role to play.

One further consideration is that the Rift Dk2 hardware does not invoke a sense of presence in most people beyond fleeting moments. It will be interesting to see how hardware capable of deeper and more prolonged presence (like the consumer Rift and HTC Vive) will affect the results.

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