Aliens versus Humans: Do avatars make a difference in how we play the game?

Chris Christou*†   Despina Michael*

*GETLab, Cyprus University of Technology,
Limassol, Cyprus.
†University of Nicosia,
Nicosia, Cyprus.
christou.ch@unic.ac.cy, despina.michael@cut.ac.cy

Abstract— an immersive first-person 3D computer game was designed and developed to investigate if the visual characteristics of a player's avatar influences their behavior. Two types of gender-matched biped avatar were used: Normal looking Humanoids and tougher looking Aliens. In the game, players had to block incoming projectiles fired from two canons with their hands. The number of times the players were hit as well as a measure of how hard they hit the projectiles was recorded. Results show differences in these measures dependent on the type of avatar used, in line with previous findings whereby people appear to be influenced by the perceived characteristics of their digital representation.

Keywords—virtual reality; avatar; first-person computer game; immersive VR; body ownership; Proteus Effect; self-perception

I. INTRODUCTION

An avatar is the graphical representation of a participant in a digital simulation. With the development of online virtual communities such as Second Life and multiplayer games such as World of Warcraft in which the participants choose, and even customize, their avatar these graphical entities have become an expression of digital identity. Psychologists have therefore started to probe the effects avatars have on communication and social interaction e.g. [13, 8, 9]. There appear to be two themes: the influence an avatar has on other participants in a virtual setting and the influence the avatar itself has on its owner. Findings from both fields have important implications for the design of digital games. The computer games industry invests substantial amounts of effort and money in designing the central characters of their games and therefore the avatars the players will adopt. Any findings from these two areas of research may therefore have substantial impact on this important aspect of the interactive entertainment industry as well as the academic field of psychology.

A. Avatars in Games

One of the fundamental decisions for a 3D game developer is the choice of perspective for the player and therefore the form taken by the player's avatar. There are two choices: First-person perspectives and third-person perspectives. The former entails the player and avatar having the same vantage point. That is, the player's perception of the world coincides with that of their avatar because the graphical perspective coincides with the avatar's eyes. In the latter, the player sees their avatar from a vantage point outside of their virtual bodies and as such can see the character they are controlling from a distance. One possible benefit of the first-person perspective is that the player can identify more with their character and become more immersed in the virtual scene in which the action takes place. First-person shooters, for example, became a genre of video games in their own right and defined the era of the video games console with notable examples such as Doom, Half-Life and Halo.

Like most games, first-person shooters involve an avatar that is controlled by using either a keyboard or joystick. The player can move through the 3D scene, point and shoot a gun, and view a head up display of their health and ammunition. In traditional computer games the player could not see much of their avatar which was limited to arms, hands or just their weapon of choice. As games evolved the avatar became more important. Indeed, in Massively Multiplayer Online Games (MMOG), a genre of video game in which players play against each other, players choose their avatar and customize them. This endows players with an online personality and the potential to make a statement to their co-players. Furthermore, with the recent release of the Oculus Rift head mounted display (HMD) we expect that avatar characteristics will become even more important. This is because the Rift provides fully immersive viewing. The view of the scene displayed in the HMD is updated according to head movements and therefore players may rotate their heads to see their avatar's arms, legs and even parts of their torso. In this case the sense of identity between the player and their avatar is established even more. The question we may ask is does the appearance of the avatar make any difference to the players' psychology and therefore how they play the game? In the next sections we briefly review two lines of research that suggest that it does.

B. Body Ownership

The phenomenon of body transfer or body ownership derives from the 'Rubber Hand Illusion' [10] in which subjects see a rubber hand located in front of them while their corresponding (real) hand is hidden from view. If participants see their rubber hand being stroked while simultaneously their real hand is stroked in the same way they have the illusion that the rubber hand is their own: so much so that they display anxiety and reflex behaviour when the rubber hand is

threatened with injury. Recent experiments have taken this effect to its logical conclusion by demonstrating the possibility that the whole body of an avatar may be adopted as one's own with similar aversion to threat stimuli [2, 3, 5]. In [5] subjects wore a HMD and faced an experimenter wearing a camera. The camera view was fed to their HMD and the subjects saw their own body while the two synchronously stroked corresponding parts of their bodies. This synchronous visuotactile stimulation led to a strong subjective illusion of being situated in, or owning, the experimenter's body. Objective evidence for this 'body-swapping' was provided by concomitant changes in galvanic skin responses (GSR) when the subject's hands were threatened by the presence of knife. The GSR is a known indicator of heightened stress levels and has been used in the past as the basis for lie-detector tests.

This research provides some clear guidelines as to when body-ownership or body-swapping will take place [2]. These include the participant taking a first-person perspective (the perspective of the body they will own), the presence of concurrent visuotactile stimulation and the synchronicity of movement of the owned body and that of the participant. The latter was demonstrated to good effect by body ownership experiments performed by [4]. They showed that participants demonstrated body-ownership over alien type avatars representing their bodies in a CAVE display even though these avatars had obviously non-human attributes such as a tail. Ownership over the avatars tail was also apparent as long as the movements of the tail were consistent with participant's volitional movements.

Other researchers have looked into whether body ownership influences perception and action in a virtual setting. For example perceptual studies have been carried out to look at the effects of adopting the (relatively smaller) body of a child [6]. It was found that participants in this case overestimated object sizes showing that they were influenced by the reduction in body size relative to the viewed environment. Other research has examined what consequences embodiment in a virtual character may have in the real life [16]. Results of this study showed that prior embodiment in a 'physically' strong looking virtual body influences subsequent endurance lifting of a real weight.

How do these findings affect our question regarding the influence of an avatar on game performance? The body ownership studies establish conditions that maximize the possibility that a player will adopt an avatar as their own but the most interesting aspect is the involvement of non-verbal, subconscious, processes. The galvanic skin response is a measure of sweating through the skin in response to stress and is triggered by the sympathetic nervous system which controls heart-rate, salivation and respiration in 'fight-or-flight' situations. This goes some way in predicting how players will respond once body-ownership is established. Further evidence is provided by the behavioral modification studies characterised by the Proteus Effect [7].

C. The Proteus Effect

Evidence that inhabiting someone else's perspective can change behaviour is available both from real-life surveys as well as virtual-reality experiments. For example [12] used a series of studies to analyse the effects of uniform colour on behaviour in football and hockey league players. Acknowledging that appearance may affect people's mood and outlook, it was hypothesized that the team's uniform colour might influence player's aggressiveness. In a series of experiments they first established that people rated players in black uniforms as more aggressive than players in other uniform colors. Looking at records spanning two decades of games they then found that players wearing black uniforms incurred more penalty points than players wearing other uniform colours. In subsequent laboratory experiments they showed that this was in part due to the players in black perceiving themselves to be more aggressive and thereby acting out on these expectations.

This phenomenon was explained in terms of the Self-Perception Theory [14] which argues that people will infer or assume their attitudes or beliefs as if they we observed from a third-person point of view. In the case of the football players in black, they inferred they were more aggressive and therefore behaved appropriately. Yee & Bailenson [7] refer to the conformance of behaviour on other peoples (or established) expectations as the 'Proteus Effect', a term which we will adopt here. Proteus is derived from the mythical Greek god who could adopt many different forms.

Other real-world studies have provided evidence for the Proteus Effect. For example [17] had groups of people wear different uniforms; nurses' uniforms and Ku Klux Klan robes. In a teacher-student paradigm each group had to give electric shocks to confederate students when they made a mistake. They found that the group with Klan robes gave larger levels of shock when a student made a mistake than those with the nurses uniform demonstrating that they adopted a more aggressive and vindictive stance.

In collaborative virtual environments (CVE) where avatars may be created and customised for interacting with multiple other users the avatar expresses the identity of the individual user and we would expect the Proteus Effect to be apparent. Yee & Bailenson [7] reported on two experiments in which the participant's attractiveness and height were manipulated. In the first experiment, subjects were assigned to attractive or unattractive avatars while in a CVE and interacting with a confederate. The confederate was not aware of the condition and saw just a plain avatar. The subjects first viewed themselves in a mirror so they could familiarise themselves with their appearance and then asked to interact with the confederate. The experimenters measured interpersonal distance and self disclosure as dependent variables and found that subjects with attractive avatars would approach the confederate with smaller interpersonal distance and divulge more about themselves than those with unattractive avatars, in accordance with the commonly held belief that attractive people are more friendly and extroverted.
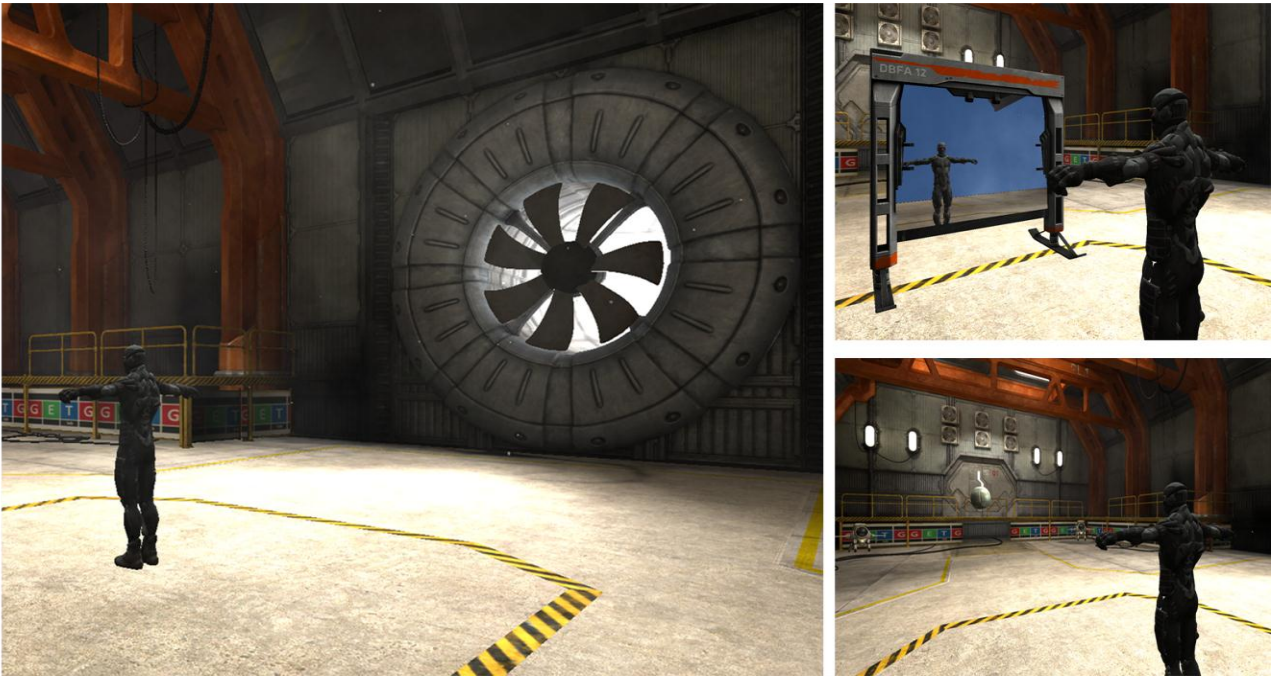
Figure 1. Screen captures from the game. Left: The male alien with a view of the ventilator. Top right: The virtual mirror that is shown at the beginning of each session. Bottom right: The two canons with a view of a projectile in flight.

In a second experiment they manipulated the avatars height as a measure of confidence. Subjects had to negotiate the division of a sum of money between themselves and a confederate. The confederate saw the subject's avatar as the same height whereas the subject saw their avatar as either taller or shorter than the confederate. One player would suggest how to split the sum, and the other could accept or reject the offer, with each getting nothing if offers were rejected. Results showed that subjects with taller avatars negotiated more aggressively than the shorter ones, whereas shorter avatars were twice as likely as the tall ones to accept an unfair division of the sum. Further experiments replicated these findings within a multiplayer CVE and showed a transfer effect into subsequent real-world face-to-face scenarios [8].

These two lines of research (the body ownership studies and the Proteus Effect) provide evidence that players will be influenced by the avatar that serves as their digital self in computer games. To provide further evidence for this we designed a first-person game in which we could immerse players within an action game and where we could systematically change their avatars in order to see if this influenced non-verbal responses. Although the experiments of [12] demonstrated non-verbal behavioural modification they were based on retrospective data. The current experiment sought to vary avatar appearance in a systematic way to establish a link with non-verbal responses.

II. EXPERIMENT

A. Overview

We designed a game in which a single player had to defend themselves against a barrage of incoming projectiles (metal balls) fired from two canons. Players were immersed in the game by wearing a HMD and had to hit incoming balls with just their hands to deflect them from hitting their body. Each player played one turn of the game with a gender-matched human avatar and one with an alien avatar. The order of assignment of human and alien avatar was alternated from player to player.

We measured the number of times they were unsuccessful in deflecting the projectiles (body blows) as a performance measure and the relative impact velocity with which they hit the projectile as a behavioural measure. The latter was used as it was readily derived from the physics engine of the game and also because it correlates with impact force. Our rationale was that if the avatars' appearance influenced the players we would see a difference in one or both of these measures. Specifically, the aliens were chosen to look tougher than the humans and players, in perceiving this aspect of their avatars, may exhibit more aggressive play which might be revealed by our two objective dependent variables.

B. Technical Setup

The experiment was performed using a single PC equipped with an Nvidia GeForce GTX 770 graphics card. Immersive viewing was achieved with an Oculus Rift HMD at a resolution of 1280x800 pixels and 60Hz refresh rate displaying stereoscopically disparate images to each eye. The Rift HMD has the advantage of being more lightweight compared to older systems and, additionally, the visor completely covers the user's field of view ensuring immersion in the virtual scene.

Players body movements were tracked by a Microsoft Kinect sensor placed approximately 2.4m from the player. The sensor captured depth data from the scene at 30Hz from which a skeletal frame of the player was extracted. This skeletal frame was used to control the limbs of the avatars used in the game.

Figure 2. The avatars used in the game. Avatars were 'rigged' with skeletons which facilitated their animation during the game. These skeletons were identical between conditions: that is, gender-matched human and alien avatars contained the same skeleton to control for any advantage of bone length.

Player's rotational head movements were tracked by motion sensors on the Rift HMD.

We used the Unity3D game engine to create an application which loaded geometries and controlled gameplay. Real-time motion capture was achieved by integrating the Kinect sensor with Unity3D using a plugin developed by Rumen Filkov [1]. The Oculus Rift was also integrated with Unity3D by a proprietary wrapper which handled viewing updates from head-movements and stereoscopic display of the scene in the HMD.

The game also provided background sounds and auditory feedback with audio speakers positioned to the left, right and in front of the player. Unity3D provides rudimentary localized sound whereby players are able to identify sound sources coming from their left and right including the sound of the canons firing the projectiles. This served as a priming cue that the projectiles would be fired from one direction or the other.

In order to improve the sense of immersion and encourage body ownership over the player's avatar we included a large mechanical air fan in the laboratory that coincided with the position of a virtual ventilator in the virtual game environment (see Fig. 1).

C. Avatars and Environment

The avatars used in the experiment are shown in Fig. 2. The humanoid avatars are modified models obtained from the Poser Pro software library (James and Jessi). The main modifications made to these characters was adjustment of sizes (so that all avatars were approximately the same size) and polygon reduction to ensure performance was as fast as possible while preserving realism. In general, we ensured both the humanoid

and alien characters consisted of approximately the same number polygonal elements (~22k polygons) to limit performance differences.

The design of the alien avatars is from the 'Nanosuit' worn by the main character in the first-person shooter game Crysis and were obtained from a public domain 3D content library. Again, modifications were carried out to equalize overall sizes. Further modifications were made to the hands to create fist-like hand poses.

The 3D character meshes contained an internal skeleton called a rig that is used to control the movement of the characters' body and limbs. This rig was applied in 3DS Max and exported to Unity3D. The four avatars used in this game contained identical skeletal rigs in order to ensure performance differences were not caused by differences in limb length etc. The height and build of all avatars was therefore similar. This had the potential to diminish observed effects however we wanted to ensure that any differences in the objective measures were because of appearance rather than some other extraneous source.

The environment in which the game took place (Fig. 1) was adapted from a publicly available model from the Unity3D asset store. Modifications were made to the environment model to reduce the overall polygon count. We also added a virtual mirror for the familiarization stage described below. This mirror consisted of 1024x1024 pixel surface and was created by a 'live feed' from a virtual camera in front of the player's avatar. The output from the virtual camera was converted to a texture on the system GPU and applied to the mirror surface during each frame update.

The virtual environment contained a large industrial ventilator fan to the right of the avatar. A particle system was used to model the flow of dust and debris emanating from the fan. This, in combination with the real mechanical fan which was placed in a corresponding position in the laboratory provided visuotactile stimulation facilitating immersion and thus increasing the likelihood that participants adopted the avatars' body as their own. The virtual ventilator also had sound objects attached to it adding to the industrial background sounds audible throughout the game.

D. Game Design

The game involved a simple task of the player protecting themselves from an incoming barrage of projectiles. Players were instructed to use their hands to hit and deflect the balls and prevent them from hitting their bodies.

The balls were fired from two canons positioned to the left and right of the player and at a distance of 10m. The virtual distance of the canons on either side of the sagittal plane of the avatar was symmetrical (approx. 4.5m). The canons fired toward the location of the player on a random basis. The trajectory of the balls was dependent on an initial constant impulse in a direction determined by the virtual position of the player. The balls were influenced by gravitational effects and prior calibration guaranteed that the player would be hit unless they took appropriate action.

Ellipsoidal collision detectors in both of the avatars hands allowed Unity3D to detect collisions with the balls. These collision detectors were identical in position and size for all four avatars used. On impact, the balls were deflected with a force commensurate with the relative velocity of the ball and the avatar's hand. This relative velocity was derived from the Unity3D physics engine and was stored as one of the dependent variables of the game (see below). On impact the balls could then be seen to bounce back into the scene in a direction relative to the impact.

A large ellipsoidal collision detector was also placed around the avatar's body. When a ball collided with this detector this was counted as a body-blow and an audible human 'pain' sound was triggered to provide players feedback that they had been hit by the ball.

E. Procedure

Participants signed consent forms and filled in a pre-test questionnaire to assess their game playing habits before being given written instructions.

After the HMD was fitted and basic visibility tests performed, the players saw their avatar reflected in front of them in a virtual mirror for 20 seconds in order to familiarize themselves with their appearance. During this familiarization period the players were instructed to feel free to move their limbs and look around. Their movements during this time were reflected in the virtual mirror.

We used a within-subjects design to test the efficacy of the avatars in this experiment. The experiment consisted of two parts. Subjects were alternately assigned to a gender-matched Alien or Human character as their first avatar in the first part and the other avatar in the second (to counter order effects).

Each part of the game was identical and consisted of four repeated sessions. In each session the mirror appeared first, followed by its disappearance and the onset of 20 shots fired from the canons.

At the end of each part of the experiment participants removed the HMD and filled out a 5-point Likert style questionnaire relating to their subjective experience of immersion within the environment and ownership over the particular avatar used.

F. Data Collection

The experimental data consisted of the two questionnaires (one for each avatar) and the data stored from Unity3D. The Unity3D data consisted of the number of body-blows suffered and the relative impact velocity. The latter was stored only when a collision was detected between the avatars hand and the ball after it was shot from the canon. These values were averaged and stored with the total number of body-blows in a data file at the end of each session of the game.

G. Participants

In total 48 unpaid participants volunteered, 13 were female and 35 male. The median age was 25.5 years. According to a pre-test assessment questionnaire the vast majority (91.7%) said they used computers on a daily basis. When asked if they played computer games the majority (33%) said they played at least a few times a week and 25% said they played every day. Only 8.3% said they never played. When asked if they had experience with virtual reality the majority (75%) said they had little or no experience and 6% said they used VR on a weekly basis. The latter were participants drawn from colleagues within our department. None of the participants however were aware of the purpose of the experiment or the dependent variables that were being measured during the game.

Table 1. Shows the median, interquartile ranges and Wilcoxon Matched Pairs comparisons between questionnaire responses after Alien and Human avatar trials

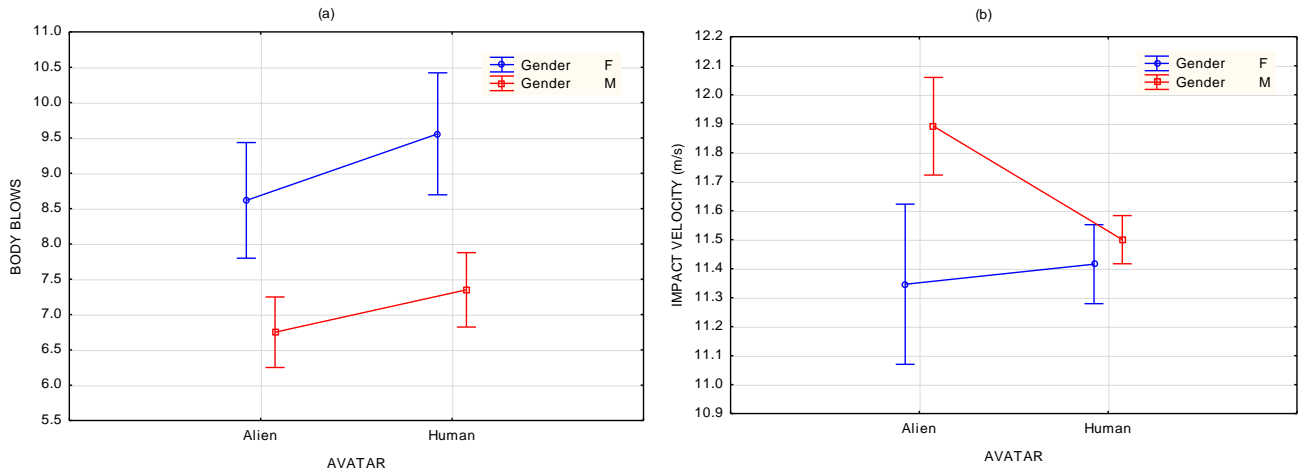|	Alien		Human		
Question	Median	IQR	Median	IQR	P value
Q1. I felt that the body that I saw was my own.	4	1.0	4	0.5	0.18
Q2. I felt that the body I saw moved with my movements.	4	0.0	4	0.0	0.98
Q3. I felt that I was in the environment that I saw.	5	1.0	4	1.0	0.31
Q4. I felt that I saw the environment through a screen.	2	0.5	2	0.0	0.76
Q5. I felt that the body that I saw belonged to someone else.	2	1.0	2	1.0	0.51

Figure 1. Performance results for the 48 participants. (a) The mean number of body blows for Alien and Human avatars as a function of gender. (b) The mean relative impact velocity for Alien and Human avatars. Error bars show the standard error of the mean.

III. RESULTS

We consider first the questionnaires used to assess the players feeling of owning the avatar body in the game and also their sense of immersion within the scene. This was measured on a Likert scale with values of 1 representing the highest level of disagreement with each question and 5 representing the highest level of agreement. Median values and interquartile ranges are shown in Table 1. The data shows that the feeling of body ownership (assessed by questions 1 and 2) was high with a median score of 4. This was also the case for the feeling of immersion. There were no significant differences in these measures between human and alien avatars and this is shown by a Wilcoxon Matched Pairs test carried out on scores for alien and human avatars for each question (see p-values shown in the last column of Table 1).

Fig. 3 shows mean body blows (a) and relative impact velocity data (b). The first behavioral measure we consider is the number of body blows: the average number of times the ball struck the ellipsoidal collision detector surrounding the avatar's body. Results for male and female players are shown separately in Fig. 3(a) which reveals a clear separation based on gender with male participants more successful in protecting themselves from incoming balls. It should be stressed however that the two samples sizes are different with respect to gender. A within-subjects repeated measures analysis of variance (ANOVA) was conducted to compare the effect of avatar type on the number of body blows in ALIEN and HUMAN avatar conditions. We also considered gender as a between-subjects factor. There was a significant effect of AVATAR on number of body blows [$F_{(1,46)}=5.4$, $p<0.025$]. The gender of the participants (and therefore their avatar) was also significant [$F_{(1,46)}=4.8$, $p<0.05$]. The interaction between GENDER and AVATAR was not significant [$F_{(1,46)}=0.27$, $p=0.6$].

The second measure was the relative velocity of the tracked collision detector on the avatars hand with respect to the ball on impact. A similar repeated measures ANOVA was carried out with the dependent variable being the relative impact velocity

and AVATAR as within-subjects factor. We also considered GENDER as a between subjects factor. The results showed that AVATAR was not significant in this case [$F_{(1,46)}=0.92$, $p=0.34$] and neither was the effect of gender [$F_{(1.46)}=2.7$, $p=0.1$]. Although the interaction between AVATAR and GENDER was also not significant [$F_{(1.46)}=1.9$, $p=0.18$] it is clear from the Fig. 3(b) that there is a difference in performance between male and female participants, especially when their avatar was alien. We therefore separated the data for males and females and performed separate paired sample t-tests comparing impact velocity for Alien and Human conditions. For male participants, there was a significant difference in impact velocity for Alien (M=11.9, SD=1.15) and Human (M=11.5, SD=0.3) avatar conditions; $t(34)=2.33$, $p=0.04$. For females, there was no significant difference for Alien (M=11.34, SD=0.24) and Human (M=11.41, SD=0.81) avatar conditions; $t(12)=-0.29$, $p=0.78$.

I. DISCUSSION

This experiment was designed to test whether in an immersive computer game the players' avatar affected their performance. Based on previous research on Body Ownership and the Proteus Effect it was hypothesized that there might be differences in immersive gameplay depending on the characteristics of the avatar used.

Our post-test questionnaires (completed by players after each condition) provide subjective evidence that participants felt both immersed in the virtual environment in which they played and also adopted the virtual avatar body as their own. The sense of ownership was felt equally well for both human and alien avatars and the sense of immersion was equally strong for both types of avatar. This feeling of embodiment was important in our experiment in that it allowed players to assume the characteristics of the avatar being used. This in turn allowed us to measure differences in performance and attribute them to the visual characteristics of the avatar.

Having established subjective evidence for participants sense of avatar embodiment we looked to the performance and

behavioural data recorded during game-play. The results for body hits were the more clear-cut of the two measures used and show that even though each participant played the same game but with different avatars they suffered fewer body blows when their avatars had the stronger, tougher characteristics of the Nanosuit than when they appeared human. One explanation (in line with the Proteus Effect) would be that players felt stronger and more confident when they adopted the alien avatar and this confidence reflected itself in players deflecting incoming shots more often. However, this difference may relate specifically to the avatars hands and be explicable in terms of embodiment. The aliens had tough fist-like poses whereas the humans had bare out-stretched fingers. When playing with human avatars our participants may have been conscious of the possibility of damaging their hands and were therefore more reticent to strike the balls leading to more body blows. The collision detectors were identical for both human and alien hands and therefore the difference in performance is directly related to the visual appearance of the hands. Another possibility, also related to the hands, is that player changed their hitting strategy in each case. In the case of the alien avatars they may have chosen to punch the balls whereas with a human avatar they chose to deflect them with the palm of the hands, with one strategy being more successful than the other.

The other measure we recorded was the relative impact velocity. We hypothesized that the stronger looking alien avatars might elicit more aggressive behaviour by players which would, in turn, result in greater deflection forces applied to the incoming balls. Although we did not have access to the actual forces calculated by the physics engine we did have access to the relative impact velocity which we used as a relative measure of force. The results indicated no overall significance of the effect of avatar when male and female data was combined. However on separating results of males and females we found that the males performed as predicted by the Proteus Effect whereas for females there was no effect of avatar. Either the males were more prone to assume an aggressive character than females or they we more prone to the Proteus Effect in general. It may be objected that the latter is not plausible considering the results for the body blows but these may be entirely explained in terms of embodiment (participants' aversion to damaging their hands). One shortcoming here, which restricts a fuller comparison between males and females, is that relatively fewer women volunteered to participate. Further studies are therefore needed to explore this interesting issue.

In summary our results provide evidence for non-verbal behavioural differences in performance based on the visual appearance of the avatar adopted by the player in a first-person action game. It is hypothesized that these differences are the result of embodiment (the feeling of owning the avatar body) and the Proteus Effect (an inference of persona). Previous laboratory tests of the Proteus Effect have used subjects' verbal responses in social interaction scenarios to assess its influence. Our results show a modification in behavior revealed in non-verbal responses and therefore extend previous findings in this field. Furthermore, because we used a computer game scenario, these results have direct significance to the design of video game characters.

REFERENCES

[1] Kinect Wrapper for Unity3D by RF Solutions (Rumen Filkov) http://www.assetstore.unity3d.com/#/content/7747

[2] A. Maselli and M. Slater, "The building blocks of the full body ownership illusion", Frontiers in Human Neuroscience, vol. 7, no. 83, pp. 1-15, 2013.

[3] M. Slater, B. Spanlang, M. Sanchez-Vives, and O. Blanke "First person experience of body transfer in virtual reality", PloS ONE 5:e10564.doi:10.1371/journal.pne.0010564, 2010.

[4] W. Steptoe, A. Steed and M. Slater, "Human Tails: Ownership and control of extended humanoid avatars", IEEE Transactions on Visualization and Computer Graphics, vol. 19, no. 4, pp. 583-590, 2013

[5] V. I. Petkova and H. H. Ehrsson, "If I were you: Perceptual illusion of Body Swapping", PloS ONE, vol. 3, no.12, 2008.

[6] D. Banakou, R. Groten, and M. Slater, "Illusory ownership of a child body causes overestimation of object sizes and implicit attitude changes", PNAS, vol. 110, no. 31, pp. 12846-12851, 2013.

[7] N. Yee and J.N. Bailenson, "The Proteus Effect: The Effect of Transformed Self-Representation on Behavior", *Human Communication Research*, vol. 33, pp. 271-290, 2007.

[8] N. Yee, J. N. Bailenson, and N. Ducheneaut "The Proteus Effect: Implications of transformed digital self-representation on online and offline behavior", Communication Research, vol. 36, no. 2, pp. 285-312, 2009.

[9] N. Yee and J. N. Bailenson, "The Proteus Effect: Implications of transformed digital self-representation on online and offline behavior", Communication Research, vol. 36, no. 2, pp. 285-312, 2009.

[10] M. Botvinick and J. Cohen, " Rubber hands 'feel' touch that the eye sees", Nature, 391(6669), pp. 756-756, 1998.

[11] J.-E.R Lee, C.I. Nass and J.N. Bailenson, "Does the mask govern the mind? : Effects of arbitrary gender representation on quantitative task performance in avatar-represented virtual groups", *Cyberpsychology, Behavior, & Social Networking*, in press.

[12] M.G.Frank and T. Gilovich, "The dark side of self- and social perception: black uniforms and aggression in professional sports.", J Pers Soc Psychol. 54(1), pp.74-85, Jan 1988.

[13] N. Yee, J. N. Bailenson, M. Urbanek, F. Chang, and Dan Merget. "The unbearable likeness of being digital: The Persistence of Nonverbal Social Norms in Online Virtual Environments", CyberPsychology & Behavior. February 2007.

[14] D. J. Bern, "Self-Perception Theory", In L. Berkowitz (Ed.), Advances in Experimental Social Psychology, New York: Academic Press, vol. 6, pp.1-62, 1972.

[15] R.S., Rosenberg, S.L., Baughman, J.N. Bailenson, "Virtual Superheroes: Using Superpowers in Virtual Reality to Encourage Prosocial Behavior", PLOS One., 8 (1), 2013, pp. 1-9.

[16] D. Michael and M. Slater, "Embodiment in a Strong Virtual Body Influences Weight Lifting Endurance". 8th FENS Forum of Neuroscience 2012,Barcelona, Spain, 2012.

[17] R.D. Johnson & L.L. Downing, "Deindividuation and valence of cues: Effects of prosocial and antisocial behavior". Journal of Personality & Social Psychology, 37, 1979, pp. 1532-1538.