Avatar Embodiment Realism and Virtual Fitness Training

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ABSTRACT

In this paper we present a preliminary study of the impact of avatar realism on illusion of *virtual* body ownership (IVBO), when using a full body virtual mirror for fitness training. We evaluated three main types of user representation: realistic and non-realistic avatars as well as no avatar at all. Our results revealed that same-gender realistic human avatar elicited a slightly higher level of illusion and performance. However qualitative analysis of open questions revealed that the feeling of power was higher with non-realistic strong-looking avatars.

Index Terms: H.5.1 [Information Systems]: Artificial—Augmented and Virtual Realities

1 INTRODUCTION

Physical inactivity is the cause of numerous health problems such as overweight, increased risk of cardiovascular disease, non-clinical depression or diabetes [3]. Lack of time and energy are often mentioned by people who do not engage in physical activity [4]. One approach to motivate people is to rely on *exergames*, a combination of physical exercise and digital games [12]. Nowadays, a great number of popular games promote an entertaining approach for increasing physical activity *(e.g.,Wii Fit Plus, Just Dance, Dance Revolution, Kinect Sports, Your Shape: Fitness Evolved, EA Sports Active)*. Numerous systems have been developed around gaming and VR platforms to make monotonous or painful exercises more motivating [13]. Virtual or augmented mirrors, large display reflecting user's image in a artificial environment, have been successfully used for rehabilitation [7], accurate sport training [2] or fitness-based games [9]. One of the major benefits of such Virtual training is their ability to motivate and encourage adherence to training schedules [1] while increasing enjoyment [9].

At their core, these games or VR applications rely on physical embodied interaction using a motion tracking system and a graphical representation of the user's body. Most of them relies on a realistic virtual user representation, using either a 2D or 3D silhouette outlining the actual user's body shape, and/or a realistic human avatar replicating user's movements.

We believe that the feeling of embodiment over a non realistic avatar visualized in a *virtual* mirror will provide a novel type of VR training platform and could enhance the training experience. Therefore, in this paper we present the first steps towards the exploration of avatar realism on user experience and performance in the context of a virtual fitness training application.

2 VIRTUAL BODY OWNERSHIP AND MOTIVATION

The Illusion of Virtual Body Ownership (IVBO) appears when users feel virtual body parts to be their own. A first-person perspective of an avatar in an immersive VR setting can trigger strong

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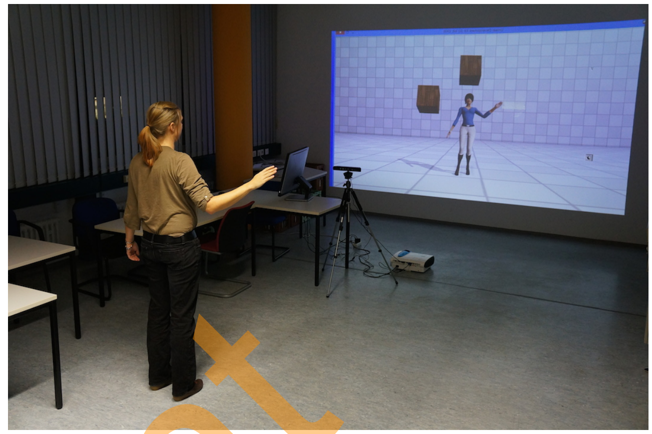

Figure 1: **System Overview - *Virtual Mirror* Display**. Participants saw virtual avatars from a third-person mirror perspective synchronized with their real body movements in space and time.

IVBO effects, even though the virtual body differs considerably from the real person's body [10]. Mirrors are usually placed inside the virtual environment to allow users to get acquainted with their new virtual appearance [10]. An important effect of this illusion is to strongly, quickly and subconsciously influences user's behaviour and feelings [5]. The illusion of owning a body which appears stronger or fitter than our real one, could theoretically have a strong positive impact on the overall experience and maybe increase enjoyment, engagement and so performance. Therefore, a first step for this research is to investigate if people accept a virtual body when seeing an altered reflection of them using a semi-immersive *virtual* mirror metaphor, especially when their avatar is not human or extremely different compared to their body.

3 EXPERIMENT

As depicted by Figure 1, participant were facing a large screen display (2.5 m width *x* 2 m height) acting as both, a window to a virtual environment and, a mirror reflecting their image in the form of an 3D avatar.

The participant's body motion and movement were replicated in real-time to their virtual body, using Microsoft Kinect and a modified version of the Unreal Game Engine 3. The task consisted of a simple game of touching flashing targets. As illustrated by figure 1 targets were represented by three large cubes disposed around the user. During one game round, participants had 30 seconds to touch a maximum number of cubes using their virtual body's hands. The cube to touch was highlighted with a animated yellow texture. There was only one cube activated at a time. Once touched by the user, a sound and an animation were played while another one was randomly activated.

We adopted a repeated measures design with, as within-subjects factor, the realism of the virtual body. The within-subject actor was composed of six conditions represented by six distinct avatars. We evaluated three main types of user representation: Realistic, Non-Realistic and No-Avatar, divided into six avatars: normal adult male

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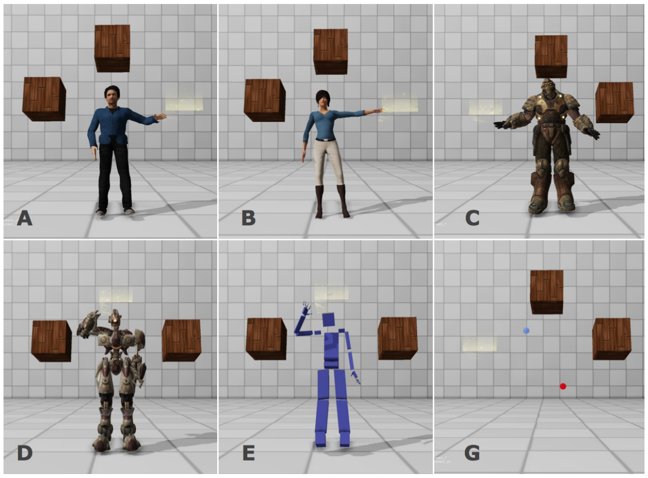

Figure 2: **Avatars**. Each participant experienced six different representations: realistic human adult male (A) and female (B), warrior (C), robot (D) and block man (E) and two-spheres-only avatar(G)

and female humans, a giant warrior, a humanoid robot, a simplified human shape (block-man) as well as a condition with no avatar but two-sphere, serving as control group. The figure 2 illustrates the different avatar conditions. Each participant experienced all avatars in a random order with breaks in between to relax and answer questionnaires. The following measures were collected in this study:

1. **IVBO Questionnaire**: A questionnaire was designed to subjectively measure the IVBO based on [11, 10, 6, 8]. It was composed of 12 closed questions and 3 open questions.

2. **Task Performance**: The performance was measured through the number of blocks touched in 30 seconds.

4 Results & Discussion

A total of 24 participants were involved in the experiment (16 males and 8 females), with an average age of 26 years old ($SD = 8.02$). For each avatar categories, we aggregated and compared all dependent variables across participants. Our main results are summarized in table 1. As expected, there is significantly less IVBO ($p = .012$) and performance ($p = .029$) in the *No-Avatar* condition (two-spheres-only avatar) compared to all other avatars. Whereas the IVBO of the realistic avatars ($M = 2.74$, $SD = 1.07$) were significant higher ($p = .047$) than unrealistic ones ($M = 2.39$, $SD = 0.94$). Regarding realistic human avatars, same gender avatar performance ($M = 38.29$, $SD = 5.95$) was significantly higher ($p = .021$) than the other gender ($M = 35.25$, $SD = 7.21$). The feeling of ownership was highly also significant better ($p = .002$) when owning a same gender body ($M = 3.14$, $SD = 1.26$) than owning a different one ($M = 2.35$, $SD = 1.19$). In the meantime, we observed no significant difference ($p = .271$) in terms of performance between realistic and non-realistic avatars. Participants did not perform significantly better with the stronger-looking giant soldier and robot avatars ($M = 36.08$, $SD = 6.91$) than with the other avatars ($M = 36.54$, $SD = 6.16$). However, the analysis of the open questions provides interesting indications regarding the impact of non realistic avatars. To the question: *Have you felt stronger with certain avatars, and why ?*, 10 out of 13 participants providing a response, mentioned that stronger-looking avatars made them feel stronger: *"because the look of the robot and the warrior gave me the feeling that my movements were more powerful"*, *"because the avatar looks more massive, more fit"*,*"because the avatar transfers a stronger feeling to me"*.

Table 1: **Results** where R = Realistic, NR = Non-Realistic, NA = No-Avatar, SG = Same Gender, DG = Different Gender

Categories	*variable*	*p-value*
NA vs Others	$\Downarrow$ Performance	.029
NA vs Others	$\Downarrow$ IVBO	.012
R vs NR	$=$ Performance	.271
R vs NR	$\Uparrow$ IVBO	.047
SG vs DG	$\Uparrow$ Performance	.021
SG vs DG	$\Uparrow$ IVBO	.002

5 Conclusion

We observed that all avatars elicited an IVBO, with a slight increase of performance and acceptance towards avatars with an higher degree of resemblance with the user (i.e. realistic human avatar of same gender). However, non-realistic but stronger looking avatar appears to elicit a feeling of power, which is interesting for fitness training applications. Further work is needed to investigate these first observations in more depth. Our next step is to replicate this experiment with a higher-quality motion tracking system, and for both fully-immersive and semi-immersive environments.

References

[1] F. Anderson, M. Annett, and W. Bischof. Tabletops in motion: The kinetics and kinematics of interactive surface physical therapy. In *CHI '12 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '12, pages 2351–2356, New York, NY, USA, 2012. ACM.

[2] F. Anderson, T. Grossman, J. Matejka, and G. Fitzmaurice. Youmove: Enhancing movement training with an augmented reality mirror. In *Proceedings of the 26th Annual ACM Symposium on User Interface Software and Technology*, UIST '13, pages 311–320, New York, NY, USA, 2013. ACM.

[3] S. Biddle and N. Mutrie. *Psychology of physical activity: Determinants, well-being and nterventions (2nd ed.)*. 2008.

[4] L. R. Boschman. Physical activity with digital companions. In D. S. Tan, S. Amershi, B. Begole, W. A. Kellogg, and M. Tungare, editors, *CHI Extended Abstracts*, pages 1065–1068. ACM, 2011.

[5] K. Kilteni, I. Bergstrom, and M. Slater. Drumming in immersive virtual reality: the body shapes the way we play. *IEEE transactions on visualization and computer graphics*, 19(4):597–605, 2013.

[6] K. Kilteni, R. Groten, and M. Slater. The sense of embodiment in virtual reality. *Presence: Teleoperators and Virtual Environments*, 21(4):373–387, 2012.

[7] E. Molla and R. Boulic. A two-arm coordination model for phantom limb pain rehabilitation. In *Proceedings of the 19th ACM Symposium on Virtual Reality Software and Technology*, VRST '13, pages 35–38, New York, NY, USA, 2013. ACM.

[8] J.-M. Normand, E. Giannopoulos, B. Spanlang, M. Slater, and M. Giurfa. Multisensory stimulation can induce an illusion of larger belly size in immersive virtual reality. *PLoS ONE*, 6(1):e16128, 2011.

[9] M. Rice, M. Wan, M.-H. Foo, J. Ng, Z. Wai, J. Kwok, S. Lee, and L. Teo. Evaluating gesture-based games with older adults on a large screen display. In *Proceedings of the 2011 ACM SIGGRAPH Symposium on Video Games*, Sandbox '11, pages 17–24, New York, NY, USA, 2011. ACM.

[10] M. Slater, B. Spanlang, M. V. Sanchez-Vives, O. Blanke, and M. A. Williams. First person experience of body transfer in virtual reality. *PLoS ONE*, 5(5):e10564, 2010.

[11] W. Steptoe, A. Steed, and M. Slater. Human tails: ownership and control of extended humanoid avatars. *IEEE transactions on visualization and computer graphics*, 19(4):583–590, 2013.

[12] Virtualware. Virtualrehab., 2014.

[13] D. Wollersheim, M. Merkes, N. Shields, P. Liamputtong, L. Wallis, F. Reynolds, L. Koh, et al. Physical and psychosocial effects of wii video game use among older women. *International Journal of Emerging Technologies and Society*, 8(2):85–98, 2010.

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