Towards an Investigation of Embodiment Time in Virtual Reality

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ABSTRACT

Virtual Reality (VR) allows us to embody any possible appearance using avatars. Previous work found that the visual appearance of an avatar can affect the user's behavior – a phenomenon known as the Proteus effect. The illusory feeling of owning a virtual avatar – the body ownership illusion – modulates the Proteus effect. Prior investigations revealed that the time of how long users embody an avatar can affect the extent of the body ownership illusion, however, it is currently unknown whether and how behavioral changes caused by the Proteus effect are moderated by the embodiment time. Therefore, we are planning to conduct a study with 30 participants where we induce the Proteus effect using avatars of different perceived ages to evaluate the effect of embodiment time on walking speed. We hypothesize that the longer users embody an elderly avatar, the slower they will walk in VR. In this proposal, we suggest a study design to evaluate the effect of embodiment time on the body ownership illusion and behavioral changes caused by the Proteus effect in VR.

KEYWORDS

virtual reality, avatars, Proteus effect, virtual embodiment

1 INTRODUCTION AND BACKGROUND

Avatars - virtual characters that represent the user in the virtual environment (VE) - are the the users' virtual body in VR. In immersive VR users can experience the VE from first-person perspective (FPP) via head-mounted displays (HMD). The progress of VR technology allows users to move in VR in a natural and intuitive fashion by precisely tracking the users' limbs and transferring the motion onto the avatar by motion capturing systems. This can result in an illusory feeling of owning the virtual body - the *body ownership illusion*. Hence, users interact via avatars in virtual worlds and experience the virtual body as their own.

Previous work found that users take on the role of the avatar potentially resulting in behavioral, attitudinal and perceptual changes based on the avatar's visual appearance - a phenomenon referred to as the *Proteus effect* [15]. This effect occurs when salient characteristics of the avatar are associated with knowledge and experiences gained by stereotypes and entities. Reinhard et al. [10], for example, showed that embodying older-looking avatars reduces walking speed after exposition in VR. The activated stereotype of older-looking people walking slowly primes the user and unconsciously affects walking speed [10].

Prior research showed that the Proteus effect depends on the extent of the body ownership illusion [1, 9, 17]. Osimo et al. [9] found that avatars have a stronger cognitive impact on the user when moving synchronously with the embodying user than avatars reacting asynchronously to user's motion. Similar was shown by Banakou et al. [1], who found that visumotor asynchrony even extinguishes avatars' effects caused by the body ownership illusion. Beside the synchronicity of stimulation, previous work also suggests that the embodiment time can affect the body ownership illusion [6, 13]. The longer the users embody an avatar, the more intense and stable the perceived body ownership tends to be [13]. This is in line with Tsakiris and Haggard [13], who investigated the ownership of a rubber hand outside of VR. Based on the famous demonstration of the rubber hand illusion [3], the authors utilized visuotactile correlations by synchronously stroking the rubber hand while the real hand is occluded. Results suggest that the longer the participants were exposed to the artificial hand with a maximum exposition time of five minutes the higher was the drift in the perceived position of their hands towards the rubber hand. This indicates a stronger induced illusion that the rubber hand belongs to one's own body.

There is still little known about effects of time on the body ownership illusion and in particular on the Proteus effect. To take advantage of the Proteus effect and its full potential, researchers and designers of VR applications have to know how effects of avatar embodiment on the user behave over time. It has been shown that the Proteus effect can retain after the exposition in VR. Banakou et al. [2] found, for example, that embodying Albert Einstein as a stereotype for superior intelligence can enhance cognitive task performance after the exposition outside of VR. Yee et al. [16] also showed effects of avatar embodiment on real life behavior. Even if the authors found behavioral changes after the VR exposition, they assume fast decay rates of such effects. This is in line with Reinhard et al. [10] who found that avatars' effects could only be shown for the first half of their experiment. These results suggest that the Proteus effect tends to decrease rapidly. It is currently unknown whether the embodiment time of the avatars can affect the extent and the duration of the Proteus effect in and outside of VR. From an HCI perspective, VR designers could deliberately utilize the embodiment time of avatars to enhance the users' performance and VR experience. Considering VR as an intervention technology, e.g. for therapeutic purposes to address mental health problems, the embodiment time could pose an opportunity to amplify the duration of the Proteus effect after the exposition.

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Since effects of time on behavioral changes caused by the visual appearance of avatars have hardly been explored, we want to investigate the effect of embodiment time on the body ownership illusion and the Proteus effect to gain a deeper understanding about the underlying mechanisms. For this reason we propose an experiment where we use avatars of different perceived ages to induce the Proteus effect and to investigate how changes in walking speed and the body ownership illusion develop over time.

2 PLANNED EXPERIMENT

Researchers assume that the embodiment time of an avatar can affect the body ownership illusion. However, it is yet unknown whether and how the duration of embodiment influences the Proteus effect. Since previous work found that the induced body ownership illusion can moderate the Proteus effect [1, 9, 17], we hypothesize that the longer users embody a virtual avatar, the more they tend to adopt the salient characteristics of the avatar resulting in a stronger manifestation of the Proteus effect. As prior research revealed that the perceived avatar's age can affect the user's walking speed after leaving VR [10], we want to induce the Proteus effect on the user's walking speed in VR by using avatars of different perceived ages. Thus, we are planning to conduct a study using a within-subjects design with the factor Age with the two levels *young* and *elderly* (see Figure 1), and the factor Time of Measurement with the levels *after 1 minute*, *after 10 minutes* and *after 30 minutes*. Based on findings in research of experience sampling methods [4, 5, 7], we use these three time samples to investigate behavioral changes over time. To reduce order effects we will counterbalance the avatars. To control for confounding variables, important moderators, e.g. the participants' age, their VR experience, the perceived spatial presence in the virtual environment [10], and effects of fatigue and habituation have to be considered. According to findings from previous work, we hypothesize that the longer the participants embody the elderly avatar, the higher the perceived body ownership will be and the slower they will walk in VR.

We will substitute the participant's real body through a young-looking or elderly virtual avatar in VR using a HMD with a wireless adapter to allow participants moving freely within the VR area. The participants will perceive the virtual body and the surrounding environment from FPP with a virtual mirror placed in the virtual environment. Additionally, we will enhance body ownership and agency by visuomotor synchrony with Optitrack motion capturing[1].

We are planning to take several measures to determine the effect of the independent variables on the Proteus effect and the body ownership illusion. To quantify the Proteus effect, we will assess the walking speed of the participants and their physical activity in VR. We will define an area (width: 4.2m, length: 3.9m) in our VR laboratory where participants can move during VR exposure. Since we want to investigate the time course of the Proteus effect based on the embodiment time, we will evaluate the walking speed at three different points in time per avatar: after 1 minute, after 10 minutes and after 30 minutes of embodying the avatar. Hence, we will include two stations at two different positions in the virtual environment where the participants have to alternate between them.

[1]https://optitrack.com/

To disguise the reason for the experiment and to enhance the body ownership illusion, we will include a task of a predefined duration at each station that promotes visuomotor synchrony. To determine the ownership of the avatar, the agency over the avatar and the caused change in the perceived body schema, the participants have to fill in the virtual embodiment questionnaire [11] in VR. To assess the extent of the Proteus effect after the VR exposition, we are planning to use subjective measures like the Proteus Effect Scale [12].

Figure 1: Young (left) and elderly (right) avatar men created for our experiment.

3 HYGIENE MEASURES

According to the hygienic regulations of our country to contain the COVID-19 pandemic, we will follow the policies defined by the government and our institution during user studies. Additionally, we defined and implemented special health and safety measures that have to be followed during the entire experimental procedure. To prepare the VR laboratory for the study, the experimenter has to disinfect the hardware needed for the experiment. Based on recent findings about the sustainability of the coronavirus on surfaces [4, 8], HMDs have to be thoroughly disinfected and have to be locked in a closed plastic box for three days after usage. Since the infectious virus can last on plastic surfaces for about 72 hours [14], the "three-day quarantine" for the HMD should minimize the risk of a transmission of the virus. Similarly, motion capture suits have to be washed with a detergent after each participant, as the coronavirus reacts sensitively towards substances that dissolve fat. Throughout the entire procedure, the experimenter and the participant have to wear face masks and keep a distance of at least 1.50m.

4 CONCLUSION

In this proposal, we suggest a study design to investigate the impact of embodiment time on the body ownership illusion and the Proteus effect. If results confirm our hypothesis, VR designers and researchers have to consider the embodiment time as a relevant factor when inducing effects of avatar embodiment on users. This would suggest a possibility to enhance the Proteus effect by increasing the time of how long users embody the avatar. Since our study only considers age differences across avatars, potential results might not hold for other types of embodiment. Therefore, more studies are needed in future to gain a deeper understanding about the underlying mechanisms of behavioral changes caused by the Proteus effect, and the relationship of body ownership and the embodiment time.

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