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Embodiment and Personalization for Self-Identification with Virtual Humans

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Abstract

Our work investigates the impact of virtual human embodiment and personalization on the sense of embodiment (SoE) and self-identification (SI). We introduce preliminary items to query self-similarity (SS) and self-attribution (SA) with virtual humans as dimensions of SI. In our study, 64 participants successively observed personalized and generic-looking virtual humans, either as embodied avatars in a virtual mirror or as agents while performing tasks. They reported significantly higher SoE and SI when facing personalized virtual humans and significantly higher SoE and SA when facing embodied avatars, indicating that both factors have strong separate and complimentary influence on SoE and SI.

Index Terms: Human-centered computing—HCI design and evaluation methods; Empirical studies in HCI; Virtual Reality;

1 Introduction

Virtual reality (VR) allows altering virtual humans to match a desired use case. While some applications demand virtual humans to behave as autonomous agents, others require them to be user-embodied avatars. Personalizing virtual humans' visual appearance might lead to a higher identification with it and can be useful for applications that require keeping the identity. Both factors can impact a user's SI and SoE towards a virtual human and shape a VR experience.

SoE, the sense of owning, controlling, and being inside a virtual body, is divided into virtual body ownership (VBO), agency (AG), and self-location (SL) [7]. While we describe embodiment as the process of incarnating a virtual human, SoE characterizes the subjective response to this process. It is supposedly driven by the visual perception of a virtual human in visuomotor synchronicity with our real body. Enriching embodiment by further top-down information, such as personalizing the appearance of the virtual human, increases the resemblance to what we expect as our body and what we perceive visually. This might not impact the mainly bottom-up driven sense of AG and SL, but has been shown to increase VBO [6, 12]. Besides SoE, SS and SA are suspected of having a top-down impact on virtual human perception in serious applications [11, 13]. Thus, it appears important to capture the user's SS and SA with a virtual human to determine SI, described as the "process of identifying a representation as being oneself" [5, p.1]. Surprisingly, there seems only little research on SI with virtual humans, although the topic is of great relevance. For our work, we define SS as the degree a user perceives visual similarity with a virtual human, while we describe SA as the attribution of personal characteristics to the virtual human.

While individual effects of virtual human embodiment and personalization are well studied [6, 12, 13], it remains unclear how the interplay between both factors affects a user's VR experience. Whereas measuring SoE is well researched, we are not aware of a measurement tool assessing SI. Therefore, we introduce in our work preliminary questionnaire items to capture SS and SA as subdimensions of SI. We further explore the impact of virtual human embodiment and personalization on SoE and the introduced items.

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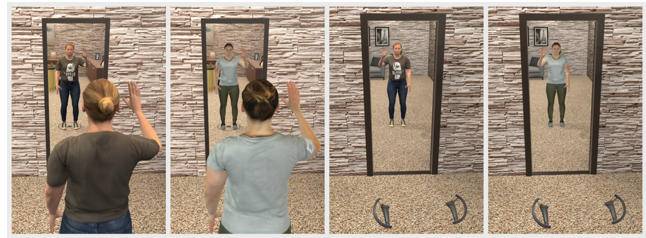

Figure 1: Participants either observed a personalized (far left) and a generic-looking (center left) embodied avatar in a virtual mirror or a personalized (center right) and generic-looking autonomous agent (far right) in an adjacent room without having a virtual body.

2 Materials and Methods

We used a 2×2 mixed design with virtual human embodiment as between-subject factor and personalization as within-subject factor. Participants in VR subsequently faced a personalized virtual human and a generic-looking virtual human in counterbalanced order, either as embodied avatars in the embodiment condition or as agents in the non-embodiment condition. All four conditions are shown in Figure 1. To this end, we generated photorealistic virtual humans for 64 participants (28 male), aged between 18 and 38 ($M = 23.28$, $SD = 3.04$), using the pipeline for fast generation of photorealistic virtual humans introduced by Achenbach et al. [1]. For creating non-personalized virtual humans, we combined the generated 3D model of the personalized virtual human with a gender-matched generic texture of a previously generated photorealistic virtual human. The avatars were realtime animated using a six-point tracking and inverse kinematics (IK) approach adapted from Döllinger et al. [3]. The agent was animated using pre-recorded animation sequences created by using same IK-based system. In each condition, participants first had to perform five body movement tasks adopted from prior work [12, 13]. While participants in the embodiment condition simultaneously observed their own performed body movements on their avatar in a virtual mirror, participants in the non-embodiment condition performed body movements in a different order as the agent to avoid visuomotor coupling while observing the agent in an adjacent room. Since the study was part of a larger project also investigating the body weight perception of virtual humans in dependence on embodiment and personalization, participants performed

Table 1: The table shows all items introduced for the VEQ+.

SL1:	I felt as I was located within the virtual body [4].
SL2:	I felt like I was located out of my body [4].
SL3:	I felt like my body was drifting towards the virtual body [4].
SL4:	I felt like my body was located where I saw the virtual body [2].
SA1:	I felt like the virtual human was me [9].
SA2:	I could identify myself with the virtual human.
SA3:	I had the feeling the virtual human was behaving as I would behave.
SA4:	I felt like the virtual human had the same attributes as I have.
SS1:	The appearance of the virtual human's face was similar to mine [11].
SS2:	The overall appearance of the virtual human was similar to me [11].
SS3:	I felt like the virtual human resembled me.
SS4:	The appearance of the virtual human reminded me of myself.

Table 2: The table shows the descriptive values for each experimental condition as well as p-values of the main and interaction effects (ME and IE) of the ANOVA models. E and NE labels the embodiment factor, P and NP the personalization factor. Double-asterisks highly significant p-values.

		E-P	E-NP	NE-P	NE-NP	ME-E	ME-P	IE
		M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*p*	*p*	*p*
SoE	VEQ Virtual Body Ownership	5.05 (1.21)	4.25 (1.37)	3.85 (1.53)	2.84 (1.20)	$< .001^{**}$	$< .001^{**}$	.497
	VEQ Agency	6.15 (0.75)	5.9 (0.94)	2.84 (1.47)	2.28 (1.26)	$< .001^{**}$	$< .001^{**}$	.166
	VEQ+ Self-Location	4.27 (1.08)	3.72 (1.45)	2.92 (1.44)	2.31 (1.16)	$< .001^{**}$	$< .001^{**}$	.841
SI	VEQ+ Self-Attribution	5.16 (1.06)	4.02 (1.36)	3.96 (1.33)	2.66 (1.33)	$< .001^{**}$	$< .001^{**}$	.578
	VEQ+ Self-Similarity	6.12 (0.66)	4.21 (1.44)	5.75 (0.96)	4.06 (1.73)	.292	$< .001^{**}$	.592

two body weight estimation tasks after the body movement task, following the approach of Döllinger et al. [3]. Participants were informed of all tasks at the beginning of the study. However, those results are not reported here.

After exposure, we assessed the participants' perceived SoE and SI. SoE was captured via the Virtual Embodiment Questionnaire (VEQ) [10]. Since the VEQ provides no items for capturing SL and we are further not aware of a validated tool to capture SI, we extended the VEQ on an exploratory basis with items for SL, SA, and SS. The items presented in Table 1 were either generated by ourselves or taken from different prior work and rephrased to match the VEQ item phrasing. They were presented with the same instructions and captured using the same scale (i.e., 1-7). As all items intend to extend the VEQ, we name the collection *VEQ+*.

3 Results

We calculated 2×2 mixed ANOVAs reported in Table 2, which revealed main effects for both factors, but no interaction effects. Since the VEQ+ has not yet been validated, we performed a reliability analysis, calculating the internal consistency between the items of each factor using Cronbach's α. We found satisfactory internal consistency for SL ($\alpha = .84$), SS ($\alpha = .91$), and SA ($\alpha = .83$).

4 Discussion

We showed a significant increase for all dimensions of SoE when participants embodied the virtual human. Moreover, personalized virtual humans further increased SoE on all dimensions. That is surprising, as previous work only showed an effect of personalization on VBO and not on AG and SL [6, 12], or found no effect of personalization on the appearance of avatars across all dimensions of SoE at all [8]. Interestingly, the manipulation of personalization also affected SoE toward the autonomous agent. It may be that personalization indeed generates SoE towards another person without embodying it as a virtual body. However, another explanation could lie in the design of the non-embodiment condition, as participants had no body of their own. This design choice was made to separate the embodiment and the non-embodiment condition so that in each condition, only one virtual human is visible at a time to avoid confusion among participants when answering the VEQ, whose questions refer to "the virtual body" without emphasizing exactly which body is meant. Whether this observation elicits some SoE towards other virtual humans, or whether it is attributable to the lack of an own body, needs to be addressed by future research.

Regarding SI, we showed that embodiment leads to higher SA of the virtual human characteristics towards the user. This is in line with the assumptions of Wolf et al. [13], who suggested SA as the underlying cause of self-related moderation effects in body weight estimates of virtual humans when being embodied. Concerning the influence of personalization, we found higher SA, and SS scores when facing personalized virtual humans. Personalization impacting SI on both dimensions may indicate greater influence of personalization than embodiment on SI. We further notice that embodiment and personalization seem to complement each other, which is most apparent in the descriptive scores of the SA scale (see Table 2).

Overall, our work showed that personalization and embodiment have a strong separate and complimentary influence on SoE and SI, leading to the highest scores when both are employed together. By introducing questions for capturing SS and SA, we showed that both, embodiment and personalization lead to high SI with a virtual human. The insights are important for the diverse use of virtual humans in serious applications, where appearance and behavior often need to be adapted to the context of an application. While our introduced items can preliminarily serve to extend the VEQ [10], we clearly state that these items have not yet been extensively validated.

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