Exploring Agent-User Personality Similarity and Dissimilarity for Virtual Reality Psychotherapy

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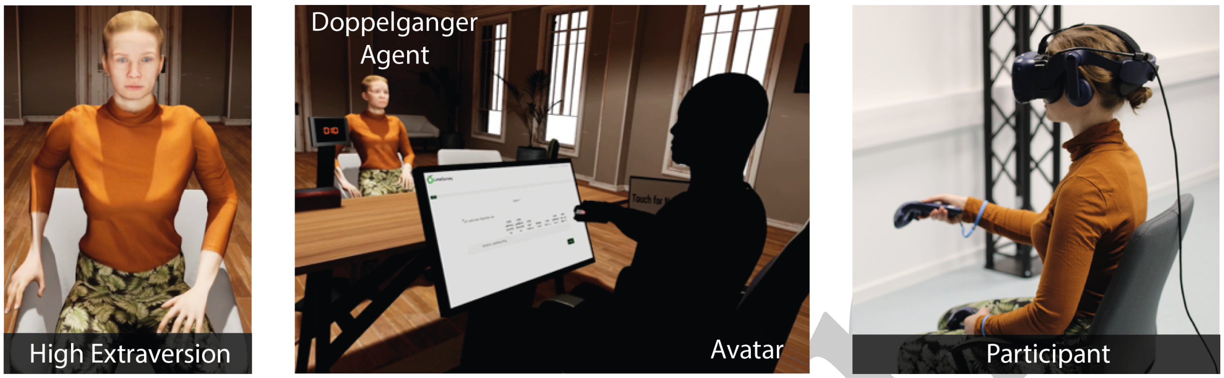

Figure 1: An exemplary participant's Doppelganger animated to show high extraversion (left), the experimental situation including the Doppelganger and the participant's avatar (center), and the participant controlling the avatar's movements (right).

Abstract

Imaginary self-encounters are a common approach in psychotherapy. Recent virtual reality advancements enable innovative approaches to enhanced self-encounters using photorealistic personalized Doppelgangers (DG). Yet, next to appearance, similarity in body language could be a great driver of self-identification with a DG or a generic agent. One cost-efficient and time-saving approach could be personality-enhanced animations. We present a pilot study evaluating the effects of personality-enhanced body language in DGs and generic agents. Eleven participants evaluated a *Photorealistic DG* and a *Generic Agent*, animated in a seated position to simulate four personality types: *Low* and *High Extraversion* and *Low* and *High Emotional Stability*. Participants rated the agents' personalities and their self-identification with them. We found an overall positive relationship between a calculated personality similarity score, self-attribution, and perceived behavior-similarity. Perceived appearance-similarity was affected by personality similarity only in generic agents, indicating the potential of body language to provoke a feeling of similarity even in dissimilar-appearing agents.

Keywords: Virtual reality, personality, body language, agents, self-identification, animation.

Index Terms: Human-centered computing—Virtual reality;

1 Introduction

Self-reflection to increase self-compassion, self-esteem, or self-regulation is a common tool in psychotherapeutic interventions. Virtual reality (VR) takes these methods to a new level by introducing photorealistic personalized virtual humans using full-body 3D scanners (e.g., [21]). Such virtual Doppelgangers (DGs [16]) have a high appearance similarity to the user and can be used as embodied self-avatars or as agents (autonomous computer-controlled entities [10]). However, dissimilar body language might break this virtual DG perception/illusion and affect the efficiency of the psychotherapy. Animating agents to have body language similar to a user without expensive motion capture sessions remains challenging. Recently, a new method was proposed to modify agent animations based on personality traits [13], which have been shown to be connected with body movements [18]. Adapting both appearance and body language (dis-)similarity could open novel ways to create therapeutic scenarios and evaluate virtual human perception. However, how such animations affect the user's perception of and identification with DGs is unclear.

To address this, we conducted a preliminary study comparing the effects of personality-enhanced body language and appearance dissimilarity on personality ratings and self-identification with agents (s. Fig. 1 for an overview). Participants rate the personality of a *Photorealistic DG* and a *Generic Agent*, animated to match the personality traits of *High Extraversion (HE)*, *Low Extraversion (LE)*, *High Emotional Stability (HS)*, or *Low Emotional Stability (LS)*. Our contribution is threefold. (1) We expand a system to create body language (dis-)similarities between users and anthropomorphic agents. (2) We outline a study design to examine the effects of personality-enhanced animations on self-identification. (3) We present preliminary results showcasing the potential of personality-enhanced animations.

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2 Related Work

There are several possibilities for creating virtual humans with varying degrees of appearance dissimilarity. Cheymol et al. [4] offer an overview of characteristics defining such dissimilarities at either an atomic or a holistic level. Striving for a maximized appearance similarity, recent developments in photorealistic virtual human personalization aim for a close congruence at a relatively efficient time and cost [2], fostering high self-identification [14]. Opting for agents over embodied self-avatars adds a new dimension to creating (dis-)similarities. Creating body language similarity might facilitate plausibility and increase the identification with an agent on a subtle level [12]. On the other hand, body language dissimilarity holds vast potential for virtual self-encounters. Exemplifying adjustments in body language could help modify self-perception and adapt self-expression. It could further facilitate self-distancing [11], an essential step in therapeutic self-reflection. Conversely, inappropriate body language representations could lead to a disassociation with the DG or indulge the risk of negative experiences [9].

2.1 Body Language in Agents: Adapting Personalities

In the design of agent animation systems, personality and its effect on body language are a frequent topic. Neff et al. [15] found that self-adapting movements in agents reduce emotional stability ratings, while higher gesture rates and specific edits in gesture performance increased extraversion ratings. Smith and Neff [17] investigated the effects of hand position, movement speed, or arm swivel on agent personality ratings. They found significant differences for all personality traits. In a comprehensive framework, Sonlu et al. [18] linked the Big Five personality traits (extraversion, agreeableness, conscientiousness, emotional stability, and openness) with body language across dialog and speech, facial expressions, and body movements. They note that openness and conscientiousness require dialogue and voice for effective portrayal, while extraversion, agreeableness, and neuroticism suit systems without speech. Based on this framework, Lugrin et al. [13] implemented a non-verbal personality behavior model for VR agent animation, allowing the expression of individual Big Five traits. They found a distinction in ratings between high and low extraversion and high and low emotional stability among desktop-presented generic agents. Our study adds to these results by elevating them to a VR environment and exploring how personality similarity or dissimilarity links to self-identification.

2.2 Agent Perception: The Role of Appearance

Being confronted with a DG agent potentially has not only positive effects. Compared to a generic virtual human with less appearance similarity, a DG might increase appearance-related self-consciousness, negatively affecting self-assessments [6]. The DG's appearance might thus trigger negative self-esteem by highlighting perceived shortcomings and accentuating the disparities between one's actual self and personal expectations [6], ultimately leading to an adverse change in self-esteem. Moreover, embodying personalized avatars, compared to generic ones, can lead to more eeriness and a withdrawal from physical sensations [5]. Using an agent with high body language similarity yet lacking any appearance similarity may be a solution to help maintain self-esteem and self-identification, ultimately enhancing the efficiency of a VR therapy tool. Participants may perceive self-identification with an agent that has an entirely different appearance but exhibits a high level of personality similarity through their body language [7]. Overall, it remains unknown how agent appearance and behavior integrate into a perception of similarity and self-identification and whether any combination of both can benefit psychotherapy relying on self-encounters in VR.

3 Methods

Our study outline includes a 2×4 within-subjects design. Our independent variables are appearance similarity (*Photorealistic DG* vs. *Generic Agent*) and personality-enhanced body language (*HE*, *LE*, *HS*, and *LS*). Fig. 2 shows an exemplary DG and a generic agent in postures from the four body language conditions. We expect a high level of appearance and personality similarity to induce a higher sense of self-identification between the user and an agent. We also hypothesize that agents with a low appearance similarity but a higher level of personality similarity will generate higher self-identification. We measure self-identification in terms of appearance-similarity, self-attribution, and behavior-similarity [7].

3.1 Personality-Enhanced Agent Animation System

We use a custom animation system for virtual humans with personality-specific body language, as introduced by Lugrin et al. [13], which the authors provided for our use. This system features sitting animations representative of the four personality types in our study. We modified and adapted the system to our needs. In particular, we modified the gaze control mechanism. For HE, agents glance away briefly before returning their gaze to the user. For LE, we implemented the inverse behavior. Agents with this trait only look at the user's eyes for one second before shifting their gaze to a different target. Additionally, we developed a method to switch an agent's personality dynamically during the application and incorporated blinking animations to enhance realism and avoid an uncanny valley effect.

Figure 2: Exemplary doppelganger and the generic agent showing different personality-enhanced behavior animations.

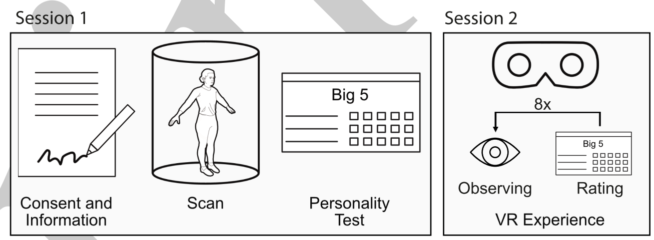

Figure 3: Overview of the experimental procedure. The period between session 1 and session 2 was five to seven days.

3.2 Agents Conditions

The study includes two types of agents consisting of virtual humans controlled by our personality animation system: a male agent from Adobe Mixamo characters, representing our *Generic Agent* condition, and the participant's DG, representing our *Photorealistic DG* condition (Fig. 2). The DGs are created in the local university's embodiment lab using a 3D photogrammetry full-body scanner. The resulting models are fully rigged and textured. To match our animation system's restrictions, we adjust them slightly in Blender. We parent the leg bones to the lowest spine bone and transfer the weight from the lowest spine bone to the middle spine bone to allow for better compatibility with the skeleton of the generic agent. To enhance the DGs' lifelike appearance, we change their eyes' UV mapping to align with Epic Games' MetaHuman's Eyes Material. As the skeleton of the Photorealistic DGs differs from that of the generic agents, we re-target the animations. We use a Control Rig created with the Unreal Engine's Control Rig Plugin.

3.3 Participant's Avatar

The virtual representation of a human body in VR plays a crucial role in shaping the overall experience and its impact on individuals. For instance, it increases presence [19] and plausibility [12] and reduces mental workload [20]. In addition, various therapeutic virtual self-encounters presuppose the embodiment of virtual humans that deviate from the patient in appearance [1, 16].

However, determining the ideal appearance for an avatar can be challenging, particularly when encountering a Doppelganger. To avoid potential effects of avatar appearance on the participants' self-perception and , thus, potentially on how they rate their DG, we designed a neutral avatar using a completely unlit texture on a standard human body shape (see Fig. 1, center). Previous studies have shown that users adapt their behavior to expectations and stereotypes associated with their avatar's appearance (Proteus effect [22]). In addition, people reliably associate what virtual humans wear (outfit color, design, and type) with their personality traits [3]. Our unlit avatar design aims to eliminate any potential influence of clothing, appearance or body shape on participants' self-perception and DG perception. The avatar is visible from a first-person perspective, matches the participants' seated position, and replicates their head, hand, and arm movements via an upper-body inverse kinematic. The length of the avatar's arms is adjusted to match the participant's arms during a fast calibration process at the start of the experiment.

3.4 Virtual Environment

The virtual scene comprises a simple room with a table, a clock, and two screens. A large touchscreen in front of the participant displays the questionnaire, and a smaller screen serves as a "next agent" button. A virtual chair marks the participant's position, similar to the physical chair they sit on during the experiment. The agents are positioned opposite the participant across the table (Fig. 1, center).

3.5 Technical Setup

The VR setup operates on Unreal Engine 4.27.2 and runs on a Windows 10 PC with an i7-9700K CPU, 32GB RAM, and an RTX 2080 Ti GPU. It utilizes an HTC Vive Pro HMD with 1140×1600 resolution per eye and a 90 Hz rate, along with four Lighthouses and two motion controllers for hand tracking. Surveys are conducted via LimeSurvey on a university PC (session 1) or through a web browser directly integrated into VR (session 2).

3.6 Measures

We assess personality using the Ten Item Personality Inventory (TIPI) [8] both for the personality of the participants and the agents. The TIPI consists of five dimensions matching the Big Five personality traits. It is assessed in ten items on a 7-point Likert scale from 1 (does not apply at all) to 7 (fully applies). In addition, we calculate a personality similarity score using the absolute value of the difference in personality ratings between participants and agents. We reversed the result and calculated a mean value including all TIPI dimensions, resulting in a range between 0 (no similarity) and 6 (maximum similarity).

To assess self-identification, we use three questions from the extended Virtual Embodiment Questionnaire VEQ+ [7]: (1) "The overall appearance of the virtual human was similar to me" (appearance-similarity, adapted from self-similarity), (2) "I could identify myself with the virtual human" (self-attribution), and (3) "I felt the virtual human was behaving as I would behave" (behavior-similarity, adapted from self-attribution). They are assessed on a 7-point Likert scale, from 1 (disagree strongly) to 7 (agree strongly).

3.7 Procedure

The study consists of two sessions (Fig. 3). Initially, participants consent, undergo a body scan for their digital double, and fill out a demographic survey and the TIPI on a PC. In the subsequent session,

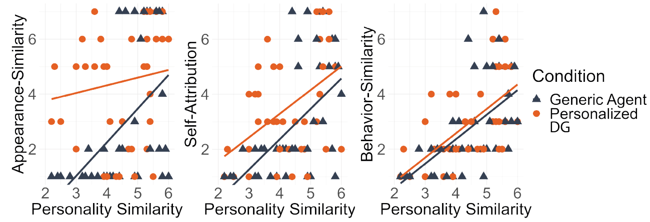

Figure 4: Relationship between personality similarity scores and self-identification ratings.

participants are seated in the lab and calibrate their avatar before evaluating it. They observe each agent for 30 seconds, then rate its personality and their self-identification with it, using in-VR on-screen questionnaires. The sequence of agent presentations, varying in appearance and personality body language, is randomized across two blocks.

4 Preliminary Evaluation

For our pilot test, we recruited participants via the local university's study portal, with participants receiving course credits as compensation. Our exclusion criteria were (1) known photosensitivity, (2) uncompensated visual impairments, and (3) high simulator sickness prevalence. Fourteen undergraduate students participated. Three were excluded because of technical issues, resulting in 11 participants (9 female, 2 male) with a mean age of $M = 21.18, SD = 1.40$ years. Two participants had no experience with VR, eight had been in VR one to ten times, and one had been in VR more than 20 times. Four participants had prior experience with DGs.

Table 1 overviews our descriptive results. We calculated repeated measures correlations using the *R* package *rmcorr* to gain insight into a potential relationship between personality similarity and self-identification. On an alpha level of .05, we found a significant correlation between personality similarity and self-attribution, $r(76) = 0.44,\ p < .001,\ 95\%\ CI\ [0.24, 0.60]$, and between personality similarity and perceived behavior-similarity, $r(76) = 0.60,\ p < .001,\ 95\%\ CI\ [0.43, 0.72]$. We did not find a significant correlation between personality similarity and perceived appearance-similarity, $r(76) = 0.22, p = .057,\ 95\%\ CI\ [-0.01, 0.42]$. Fig. 4 gives an overview of the three variables.

Our preliminary results reveal intriguing first insights. First, they tend to confirm our expectations. We observed an overall positive relationship between personality similarity and a sense of behavior-similarity and self-attribution, suggesting the potential to affect self-identification in similar and dissimilar agents. Interestingly, on a descriptive note, the sense of appearance-similarity seems to correlate with personality similarity only when using generic agents (see Fig. 4, left). This result indicates stability in the sense of appearance-similarity of DGs. However, it hints at the potential to evoke a sense of appearance-similarity via body language even with agents with a dissimilar appearance. Further, on a descriptive level, participants seem to have recognized the four personality traits within both appearance conditions. Overall, our results indicate an effect of agent body language on self-identification and personality perception. This promising result shows the efficiency and potential of personality-enhanced animation systems. However, further data is necessary to validate these observations.

5 Conclusion

We introduced a personality-enhanced body language animation system as a novel approach for therapeutic VR self-encounters. We conducted a preliminary evaluation to investigate how simulating agents with similar or dissimilar personalities to participants affected

Table 1: Descriptive results. (HE = High Extraverison, LE = Low Extraversion, HS = High Emotional Stability, LS = Low Emotional Stability)

		Generic Agent				Photorealistic DG			
		HE	LE	HS	LS	HE	LE	HS	LS
		M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
TIPI Personality Rating	Extraversion	5.32 (1.62)	2.14 (0.81)	3.55 (1.59)	2.41 (1.20)	4.55 (1.42)	2.27 (1.23)	3.00 (1.45)	2.27 (0.93)
	Agreeableness	3.77 (1.37)	5.32 (0.75)	5.09 (1.34)	4.14 (1.19)	4.50 (1.64)	4.91 (1.46)	4.64 (1.94)	3.27 (1.17)
	Conscientiousness	5.05 (1.31)	4.36 (1.21)	4.91 (1.28)	3.82 (1.33)	5.68 (0.93)	4.64 (0.74)	4.95 (1.13)	4.14 (0.87)
	Emotional Stability	5.14 (1.38)	4.23 (0.98)	4.50 (1.75)	2.68 (1.19)	5.32 (0.96)	3.05 (1.17)	4.32 (1.44)	3.41 (1.53)
	Openness	4.27 (0.93)	3.55 (0.69)	4.32 (1.37)	3.50 (1.10)	4.41 (1.30)	3.27 (1.03)	3.82 (1.45)	3.05 (0.72)
Personality Similarity		4.84 (0.79)	4.37 (0.72)	4.67 (1.13)	3.76 (1.17)	5.16 (0.69)	4.01 (1.13)	4.44 (1.00)	3.68 (0.93)
Self-Identification	Self-Similarity	2.73 (2.76)	2.64 (2.38)	2.91 (2.66)	2.73 (2.57)	4.91 (1.70)	4.45 (1.75)	4.45 (2.30)	3.82 (2.27)
	Self-Attribution	3.00 (2.32)	2.45 (1.69)	3.36 (2.25)	2.45 (1.86)	4.18 (1.60)	3.45 (1.75)	3.91 (2.17)	2.73 (1.95)
	Behavior-Similarity	2.91 (1.70)	2.27 (1.10)	3.55 (1.92)	2.18 (1.33)	3.55 (1.29)	2.45 (1.21)	3.55 (2.02)	1.91 (0.83)

their perception of a virtual agent with the same appearance (Doppelganger) and a virtual agent with a different appearance. Our results indicate that personality-driven animations could be a powerful tool to affect agent perception by increasing or decreasing self-identification. Our future work will try to replicate our findings with a larger and more diverse sample, including a generic agent matching the gender, body type, and outfit of the participant.

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