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My avatar makes me feel good? The effect of avatar personalisation and virtual agent interactions on self-esteem

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ABSTRACT

The theory of Objective Self-Awareness (OSA) and related studies suggest that embodiment of personalised avatars may induce self-awareness and influence self-esteem. Additionally, the Computers Are Social Actors (CASA) paradigm suggests that humans may mindlessly respond to computers in ways that are similar to human interactions. Based on those assertions, it is plausible that virtual embodiment of a personalised avatar and interactions with a virtual agent can shift self-esteem. However, those effects on self-esteem have not been thoroughly examined in past studies. To address these research gaps, a 2 (avatar personalisation: personalised vs. non-personalised avatar) × 2 (virtual agent interaction valence: positive vs. negative) between-subjects experiment was conducted using a Virtual Reality (VR) simulation (N = 171). Findings from the study showed that there was no effects of avatar personalisation and virtual agent interaction valence on state self-esteem change. However, the pairwise comparisons present some preliminary indications that avatar personalisation and positive interactions with a virtual agent may facilitate improvements in state self-esteem altogether. Implications of the study findings are discussed.

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Virtual reality; human–computer interaction; avatars; virtual interactions; well-being; personalisation

1. Introduction

Self-esteem plays a substantial role in one's psychological well-being and daily functioning. It is generally defined as the way individuals evaluate their self-worth, value, or importance (Blascovich and Tomaka 1991). Self-esteem has been argued to permeate various facets of life and exists as a relatively stable characteristic, termed as *global* or *trait self-esteem* (Brown and Marshall 2006; Leary and Baumeister 2000). Studies have found that individuals with higher levels of global self-esteem tend to experience more positive emotions, higher levels of life satisfaction, and stronger interpersonal relationships (Harris and Orth 2020; Joshanloo 2022; Myers and Diener 1995). Conversely, individuals with lower levels of global self-esteem are more likely to experience anxiety and depression (Cheng and Furnham 2003; Sowislo and Orth 2013), and engage in undesirable behaviours such as problem eating, alcohol use, and risky sexual behaviour (Ethier et al. 2006; McGee and Williams 2000; Zimmerman et al. 1997). Given that self-esteem can influence individuals' psychological well-being and life functioning, it is important to examine factors that may impact self-esteem.

Even though global self-esteem may be more resistant to change, accrued alterations in state self-esteem may improve global self-esteem over time. Literature on self-esteem suggests that while self-esteem may exist as a trait that is less malleable to change, one's self-esteem can fluctuate from time to time, similar to a barometer. This form of self-esteem is termed as *state self-esteem*, which suggests that individuals' evaluations of their self-worth may be subject to momentary changes (Brown and Marshall 2006; Heatherton and Polivy 1991; Heatherton and Wyland 2003). Some studies have found relatively strong positive associations between state self-esteem and global self-esteem (e.g. Heatherton and Polivy 1991; Waller and MacDonald 2010). Additionally, studies have demonstrated that multiple exposure to an intervention or stimulus (e.g. clinical interventions aimed at enhancing self-esteem) may improve global self-esteem, along with changes in state self-esteem (Heatherton and Polivy 1991). Hence, this study focuses on individuals' changes in state self-esteem, considering that state self-esteem is more susceptible to fluctuations, and accrued changes in state self-esteem can influence global self-esteem.

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.

1.1. Virtual embodiment

Virtual Reality (VR) presents individuals an avenue to undergo virtual embodiment, enabling them to experience avatars of different physical characteristics and engage in simulated interactions that may influence self-esteem. The term *avatar* is generally defined as graphical representations of human users in digital spaces (Horstmann, Gratch, and Krämer 2021; Trepte and Reinecke 2010), while *virtual embodiment* involves assuming the body of an avatar and controlling it in a virtual environment (Bailey, Bailenson, and Casasanto 2016). In one study, individuals with disabilities experienced improvements in global self-esteem after undergoing a series of virtual simulations in *Second Life* (Nosek et al. 2016). These simulations mirrored real-life interactions, including self-care activities and peer interactions. Another study found that individuals who embodied avatars more attractive than their actual selves experienced positive changes in appearance self-esteem following the virtual simulation (Leung, Ng, and Lau 2021). Additionally, studies have suggested that users may experience stronger internalisation of avatars' attributes through virtual embodiment, rather than mere observation (e.g. Yee and Bailenson 2009). Altogether, these findings provide some indications that virtual embodiment may facilitate the internalisation of avatar attributes and influence individuals' self-esteem. However, further research is needed to examine how factors associated with virtual embodiment contribute to changes in self-esteem.

1.2. Research gaps, study objectives, and implications

Advancement in digital technologies have enabled users to generate and embody avatars that are personalised according to their actual facial image (e.g. Radiah et al. 2023; Zollhöfer et al. 2011). Studies that examined the effect of viewing and/or embodying avatars tailored according to one's facial image have found that these personalised avatars can influence users' emotions and body satisfaction (e.g. Park 2018; Radiah et al. 2023; Ridgway 2018), as well as digital experiences, such as body ownership and presence (e.g. Döllinger et al. 2023a; Waltemate et al. 2018). Yet, it remains empirically unclear how viewing and embodying such personalised avatars affects users' state self-esteem. Hence, the first objective of this study is to examine how virtual embodiment of a personalised avatar mapped with one's facial image can influence users' state self-esteem.

It is important to note the distinction between personalisation and customisation. *Personalisation* refers to tailored content that is driven by a system, while *customisation* refers to the agency for users to tailor content according to their own preferences (Sundar and Marathe 2010). In this study, the term *personalised avatar* will be used to describe the avatar that is tailored according to one's actual facial image, given that users will not be able to adjust the appearance of the avatar based on their own preferences.

Further research is also needed to understand how the valence of interactions with virtual agents can influence one's state self-esteem. VR simulations tend to involve interactions with *virtual agents*, defined as autonomous computer-controlled agents (Horstmann, Gratch, and Krämer 2021). These virtual agents may assume various roles (Guimarães et al. 2020), such as companions or interactants. The extant literature suggests that humans may elicit psychological responses similar to human-human interactions when interacting with computers (e.g. Krämer 2008; Krämer et al. 2013), and the valence of interactions with computer systems can potentially influence one's psychological states (e.g. Burgers et al. 2015). However, more work is needed to examine how positive and negative interactions with human-like virtual agents in VR may affect users' self-esteem. Hence, it is imperative to examine the effect of both avatar personalisation and the valence of interactions with other characters in VR on users' changes in state self-esteem altogether.

The implications of this study are twofold. On a theoretical level, findings from this study can extend understanding of how users experience changes in state self-esteem after viewing and embodying an avatar tailored according to their actual facial images. It also contributes to understanding how the valence of interactions with virtual agents during virtual simulations impact users' state self-esteem, and how these factors interact to influence changes in state self-esteem. On the practical level, findings from this study can inform future VR and avatar design considerations to maximize the benefits and mitigate potential harm of these digital experiences on users' self-esteem.

2. Theoretical background

2.1. Theory of objective self-awareness

The *theory of Objective Self-Awareness (OSA)* can be drawn upon to understand how personalised avatars can direct individuals' attention towards themselves. The OSA theory posits that humans experience *objective self-awareness*, defined as consciousness directed towards one or more aspects of the self when the self is presented or perceived as an object (Duval and Wicklund 1972; Ickes, Wicklund, and Ferris 1973). For instance, studies have found that individuals who completed a task in the presence of a camera or mirror demonstrated greater attention towards the self compared to those who completed the task without those stimuli (Davis and Brock 1975). Additionally, studies have indicated that individuals tend to perceive greater similarities between their personalised avatars and their actual selves, and they were more likely to experience higher levels of self-awareness when embodying personalised avatars in digital spaces (e.g. Hooi and Cho 2013; Kang and Kim 2020; Vasalou, Joinson, and Pitt 2007). Taken together, arguments from OSA theory and relevant studies suggest that viewing and embodying personalised avatars can facilitate objective self-awareness.

Another key tenet of the OSA theory posits that humans tend to compare observed attributes of themselves to their expectations when experiencing objective self-awareness, which can trigger negative affect and self-evaluations (Duval and Wicklund 1972; Fejfar and Hoyle 2000; Ickes, Wicklund, and Ferris 1973). For example, individuals who viewed themselves through a mirror were more likely to experience negative affect than those who did not see themselves through a mirror (Fejfar and Hoyle 2000). Studies have also found that those who assumed personalised avatars in digital simulsations such as video games were more likely to experience stronger self-related thoughts than those who were assigned non-personalised avatars (e.g. Fischer, Kastenmüller, and Greitemeyer 2010; Kang and Kim 2020). Additionally, some studies have suggested that avatars mapped with photorealistic images of oneself tend to be perceived as less attractive than cartoon-like avatars (e.g. Ma and Pan 2022) and can trigger body dissatisfaction through increased actual-ideal self-discrepancies (e.g. Park 2018; Ridgway 2018). Based on arguments of the OSA theory and related literature, it is reasonable to believe that the embodiment of personalised avatars mapped with one's actual facial images can act as a means for objective self-awareness. This can facilitate negative self-evaluations by triggering individuals to think about the discrepancies between their actual and idealized appearances, particularly since avatars mapped with one's actual facial images are more likely to be perceived as less attractive and can trigger dissatisfaction. Therefore, it is hypothesized that:

> **H1:** Embodiment of a personalised avatar mapped with one's actual facial image will lead to a more negative change in state self-esteem than embodiment of a non-personalised avatar.

2.2. Computers are social actors

Next, the *Computers Are Social Actors* (CASA) paradigm can be drawn upon to understand how interactions with virtual agents may influence self-esteem. According to the CASA paradigm, humans tend to apply social heuristics used during interactions with other humans when interacting with computers (Nass, Steuer, and Tauber 1994). For instance, individuals tend to use polite phrases, such as 'thank you' and 'please', as well as pronouns such as 'you' more frequently when interacting with anthropomorphic figures on a digital system (Krämer 2008). Another study found that individuals were more likely to smile for a longer duration when the virtual character that they interacted with smiled at them (Krämer et al. 2013). These social reactions may be augmented by the physical attributes of virtual characters, including the emotions portrayed through facial expressions (e.g. happy, angry, or neutral), as well as directed eye contact and body orientation towards users in the virtual environment (Marschner et al. 2015). Based on these findings, it is reasonable to assume that interactions with virtual agents in a VR simulation may lead to changes in users' state self-esteem.

Additionally, it is crucial to take into account the valence of interactions when examining how interactions with virtual agents can influence self-esteem. Studies have found that exposure to negative life events is negatively associated with self-esteem (e.g. DeHart and Pelham 2007). In terms of interpersonal relationships, research has suggested that people's beliefs about themselves are shaped by their interactions with people of close relational ties (e.g. DeHart, Pelham, and Tennen 2006). Negative interactions with friends may have adverse implications on one's self-esteem and vice versa (Keefe and Berndt 1996). The deterioration in self-esteem resulting from negative interactions may stem from individuals' perceptions of their actions or behaviour as inappropriate. Negative social feedback can also exacerbate self-esteem issues during interactions with strangers or people of weak relational ties (Brown 2010). Conversely, positive social feedback has been shown to enhance self-esteem (e.g. Krause et al. 2021). Positive feedback in video games has also been found to enhance players' perceptions of their competence, while negative feedback diminishes feelings of competence (e.g. Burgers et al. 2015). In summary, insights from the CASA paradigm and related studies suggest that individuals tend to experience psychological states that are similar to interactions with other humans when interacting with virtual agents. Furthermore, the valence of interactions with virtual agents has the potential to influence one's self-esteem. Hence, it is postulated that:

> **H2:** Positive interactions with a virtual agent will lead to a more positive change in state self-esteem than negative interactions with a virtual agent.

2.2.1. Moderating effect of virtual agent interaction valence

While embodying a personalised avatar is hypothesised to have adverse effects on state self-esteem, the valence of interactions with a virtual agent in the VR simulation may moderate this effect. For instance, one study found that individuals exposed to a stimulus designed to induce self-focused attention and received positive feedback about a fictitious personality trait reported higher levels of self-esteem than those who received negative feedback (Ickes, Wicklund, and Ferris 1973). Another study showed that individuals were more likely to attribute the causality of events to themselves when primed with a self-focused attention stimulus (Duval and Wicklund 1973). These findings suggest that positive interactions with a virtual agent may prompt individuals to attribute those positive interactions to their actual selves and feel more positive about themselves, particularly when the embodied avatar is personalised and mapped with their facial image. On the other hand, negative interactions with a virtual agent while embodying a personalised avatar may have the opposite effect. Therefore, it is hypothesized that:

> **H3:** Individuals who embody a personalised avatar mapped with their actual facial image will experience a more positive change in state self-esteem when there are positive interactions with a virtual agent, compared to negative interactions with a virtual agent while embodying a personalised avatar.

3. Method

A virtual environment was used to test the study hypotheses. The following sections will cover the design of the virtual environment, avatar personalisation manipulation, design of the virtual agent, as well as the manipulation of virtual agent interactions.

3.1. Materials

3.1.1. Virtual simulation

The virtual environment was designed and implemented using *Unity* (Unity Technologies, n.d.). The simulation was situated in a restaurant setting. Participants took on the role of a service staff who had to interact with a customer represented by a virtual agent. At the start of the simulation, participants were given approximately one and a half minute to familiarize with their avatar appearance and the controls. They were instructed to look at themselves in the mirror, move their arms and body, and move the objects placed in front of the mirror. Thereafter, participants proceeded to the restaurant for the main simulation. During the simulation, they had to fulfil various requests from the virtual agent, including taking food orders and serving the meal. Interactions with the virtual agent were facilitated through various pre-scripted dialogues, and participants had the choice between two response options for each scenario. For instance, participants could select a prosocial response, such as 'I'm glad to hear that', or an antisocial response, such as 'Oh, it's not that great', in response to the virtual agent's comment on the food's smell. Other interactions involved handing a towel to the virtual agent when they accidentally spilled water on themselves towards the end of the simulation, the virtual agent provided feedback about participants' service and left the restaurant. Participants completed the virtual simulation while standing, and their head movements were tracked by the *Oculus Quest 2* headset (Meta n.d.). Body movements of the avatar were controlled by the controller.

3.1.2. Avatar personalisation

The 3D avatar was modelled using *Maya* (Autodesk n.d.-a) and *3DS Max* (Autodesk n.d.-b). In both personalised and non-personalised conditions, participants embodied the avatars from a first-person perspective. In the personalised avatar condition, photos which contained participants' faces were imported into the VR program that was configured on the *Oculus Quest 2* headset and mapped onto the avatar (see Figure 1). In the non-personalised avatar condition, participants were assigned a default avatar without their actual faces (see Figure 2). The face of the default avatar was mapped using photorealistic facial images generated by Artificial Intelligence (AI; Generated Photos n.d.). The non-personalised avatar's gender and skin tone were adjusted to match participants' gender and race. Prior to interactions with the virtual agent, participants were instructed to observe the appearance of their avatar through a mirror. A mirror was also positioned next to the service counter where participants interacted with the customer to draw their attention towards the avatar's facial features during the simulation.

Figure 1. Personalised avatar mapped with a user's facial image.

3.1.3. Avatar attractiveness

A pre-test was conducted to examine if there were any differences in perceived attractiveness between the personalised and non-personalised avatars ($N = 79$; 35 males, 44 females). Attractiveness was measured using one statement, 'The appearance of the character is attractive', rated on a five-point Likert scale (1: strongly disagree; 5: strongly agree). Findings from the paired-samples t-test indicated that the attractiveness of the personalised avatars ($M = 2.54$, $SD = 1.12$) were not significantly higher than the attractiveness of the non-personalised avatars ($M = 2.51$, $SD = 0.95$), $t(78) = 0.29$, $p = .77$, $d = 1.15$.

3.1.4. Virtual agent design and interactions

The virtual agent that participants interacted with, as well as the background customers were modelled using *Maya 2020* (Autodesk n.d.-a) and *3DS Max 2021* (Autodesk n.d.-b). The virtual agents had photo-realistic facial features which were mapped using AI-

Figure 2. Non-personalised avatar mapped with an AI-generated facial image.

Figure 3. Virtual agent with a thumbs up gesture in the positive interaction condition.

generated faces. Various head movements, hand gestures, eye contact, and body orientation were implemented to simulate human-like movements (Marschner et al. 2015). The gender of the interactant virtual agent matched participants' gender in the simulations. The skin tone of the virtual agent was kept constant across the experimental conditions.

Interactions with the virtual agent involved both text dialogues and non-verbal cues. In the positive interaction condition, dialogues from the virtual agent were scripted with positive words and feedback. An example of a dialogue in the positive interaction condition is, 'Thank you for the great meal! The bill was just right as well. This definitely isn't the last time I'll be here'. The positive interactions were accompanied with affirmative non-verbal cues, including the nodding of head and a thumbs up gesture (see Figure 3).

Conversely, dialogues were scripted with negative words and content in the negative interaction condition. An example dialogue is, 'No thanks for the mediocre meal. The bill was too costly as well. This definitely is the last time I'll be here'. The virtual agent also demonstrated apathetic and condescending non-verbal cues, such as the shaking of head and crossing of arms (see Figure 4).

3.2. Study design

A 2 (avatar personalisation: personalised avatar vs. non-personalised avatar) x 2 (virtual agent interaction valence: positive vs. negative) between-subjects experiment was conducted to examine the effect of the experimental manipulations on state self-esteem change. The study was approved by the *Institutional Review Board*. In the avatar personalisation condition, participants embodied either a personalised avatar mapped with their facial image or a non-personalised avatar mapped with a default AI-generated facial image. In the virtual agent interaction valence condition, interactions with the virtual agent were manipulated to either be positive or negative.

3.3. Procedure

The study comprised three components. Participants first completed a pre-study questionnaire three to seven days prior to the experiment. After which, they were randomly assigned to the experimental conditions. During the experiment, all participants had their photos taken in the laboratory before the VR simulation. The photos were used to create the avatars for those assigned to the personalised avatar condition. Thereafter, participants completed the VR simulation that lasted for approximately 10–15 min. After the simulation, participants proceeded to a private room to complete a post-study questionnaire. Participants were de-briefed and compensated with approximately USD 7 gift vouchers at the end of study.

Figure 4. Virtual agent with a crossed arm gesture in the negative interaction condition.

3.4. Participants

A total of 179 people participated in the study. The final sample size was 171, after removal of participants who failed the attention check questions or encountered technical issues during the simulation. The mean age of participants was 22.30 years ($SD = 3.11$ years). There were 64 males (37.4%), 97 females (56.7%), and 10 who identified with other gender categories (5.9%). Among the participants, 163 were undergraduates (95.3%). Across conditions, 85 were assigned a personalised avatar (49.7%), 86 were assigned a non-personalised avatar (50.3%), 88 were assigned to the positive interaction condition (51.5%), while 83 were assigned to the negative interaction condition (48.5%).

3.4. Measures

The following measures were included in the questionnaire administered to participants.

3.4.1. State self-esteem

State self-esteem was measured in both pre- and post-study questionnaire. A total of 10 statements were adapted from the *Rosenberg Self-Esteem Scale* (Rosenberg 1965), rated on a five-point Likert scale (1: strongly disagree; 5: strongly agree). Sample statements include, 'I feel that I have a number of good qualities' and 'I wish I could have more respect for myself' (reverse-coded). The measure had high reliability scores across both pre – ($\alpha = .89$) and post-study questionnaire (Cronbach's $\alpha = .92$).

3.4.2. User-avatar similarity

Perceived similarity between participants and their embodied avatar was measured in the post-study questionnaire. The measure was used as a manipulation check to ensure that participants who embodied the personalised avatar experienced higher user-avatar similarity than those who embodied a non-personalised avatar. The five-item measure was adapted from the *Similarity Identification Scale* (Van Looy et al. 2012), rated on a five-point Likert scale (1: strongly disagree; 5: strongly agree). An example statement is, 'My character's face resembles mine'. The measure had a high reliability score (Cronbach's $\alpha = .90$).

3.4.3. Virtual agent interaction valence

Perceived valence of interactions with the virtual agent was measured in the post-study questionnaire. The purpose of the measure was to examine the differences in perceived interaction valence between both positive and negative interaction conditions as a manipulation check. The three-item measure was rated on a seven-point semantic differential scale (1: very negative; 7: very positive). An example item is, 'How would you rate your experience with serving the customer?' The measure had a high reliability score ($\alpha = .97$).

3.4.4. Presence

Perceived presence during the virtual simulation was measured in the post-study questionnaire. The 10-item measure was adapted from the *Multimodal Presence Scale for Virtual Reality Environments* (Makransky, Lilleholt, and Aaby 2017), rated on a five-point Likert scale (1: strongly disagree; 5: strongly agree). An example statement is 'I had a sense of acting in the virtual environment, rather than operating something from outside'. The measure had a satisfactory reliability score (Cronbach's $\alpha = .87$).

3.4.5. Immersion

Perceived immersion during the virtual simulation was measured in the post-study questionnaire. The 12-item measure was adapted from the *Augmented Reality Immersion* questionnaire (Georgiou and Kyza 2017), rated on a seven-point Likert scale (1: strongly disagree; 7: strongly agree). An example statement is 'I was more focused on the activity rather than on any external distraction'. The measure had a satisfactory reliability score (Cronbach's $\alpha = .80$).

4. Results

Statistical analyses were conducted using the software *SPSS Statistics* (Version 27; IBM n.d.). Descriptive statistics of the key variables of interest across the experimental conditions are presented in Table 1.

4.1. Manipulation check

Independent-samples *t*-tests were conducted to examine if the intended experimental manipulations were successful.

4.1.1. Personalised avatar manipulation

Participants in the personalised avatar condition reported significantly higher levels of user-avatar similarity ($M = 3.23$, $SD = 1.03$) than those in the non-personalised avatar condition ($M = 2.69$, $SD = 1.00$), $t(169) = 3.48$, $p = .001$, $d = 1.02$.

Table 1. Descriptive statistics of key variables across conditions.

	Personalised Avatar		Non-personalised Avatar	
	Positive interactions ($n = 44$)	Negative interactions ($n = 41$)	Positive interactions ($n = 44$)	Negative interactions ($n = 42$)
	M (*SD*)			
State self-esteem (pre-study)	3.14 (0.82)	3.20 (0.76)	3.28 (0.74)	3.29 (0.76)
State self-esteem (post-study)	3.32 (0.85)	3.31 (0.68)	3.38 (0.81)	3.35 (0.79)
State self-esteem change (post-minus pre-)	0.18 (0.32)	0.10 (0.32)	0.10 (0.40)	0.06 (0.28)
User-avatar similarity	6.12 (1.23)	2.57 (1.36)	6.23 (1.02)	1.95 (0.76)
Virtual agent interaction valence	3.13 (0.68)	3.08 (0.80)	3.21 (0.77)	3.24 (0.78)
Presence	5.48 (0.65)	5.40 (0.82)	5.52 (0.73)	5.51 (0.77)
Immersion	3.14 (0.82)	3.20 (0.76)	3.28 (0.74)	3.29 (0.76)

4.1.2. Virtual agent interaction valence manipulation

Participants in the positive interaction condition reported significantly more positive evaluations towards the interactions with the virtual agent ($M = 6.18$, $SD = 1.12$) than those in the negative interaction condition ($M = 2.26$, $SD = 1.14$), $t(169) = 22.68$, $p < .001$, $d = 1.13$.

4.2. Effect of avatar personalisation and virtual agent interaction valence on state self-esteem

Prior to hypothesis testing, a two-way ANOVA was conducted to examine the equivalence of baseline state self-esteem across the experimental conditions. This analysis method enables testing of any significant differences in state self-esteem across the experimental groups to ensure equivalence in baseline state self-esteem.

The results showed that there was no significant difference in pre-study state self-esteem between those who embodied a personalised avatar and those who embodied a non-personalised avatar, $F(1, 167) = 0.89$, $p = .35$, $\eta_p^2 = 0.53$. Similarly, there was no significant difference in pre-study state self-esteem between those who had positive interactions and those who had negative interactions with the virtual agent, $F(1, 167) = 0.10$, $p = .76$, $\eta_p^2 = 0.06$. There was also no significant difference in pre-study state self-esteem across the two experimental manipulations altogether, $F(1, 167) = 0.04$, $p = .85$, $\eta_p^2 = 0.02$. Therefore, it can be assumed that there is equivalence in baseline state self-esteem across the experimental conditions. Both pre- and post-study self-esteem scores were also normally distributed across the experimental conditions, as assessed by the Shapiro-Wilk's test ($p > .05$).

Next, a three-way mixed ANOVA was conducted to examine the effect of avatar personalisation and virtual agent interaction valence on state self-esteem change from pre- to post-study (Figure 5). This approach allowed testing for the main effect of the avatar personalisation and virtual agent interaction valence manipulations (between-subject factors), while accounting for effect of time in which the state self-esteem measure was administered (pre- or post-study; within-subject factor). It also accounts for the interaction effect across the key study manipulations and time on state self-esteem. Age, gender, perceived user-avatar similarity, perceived virtual agent interaction valence, presence, and immersion were entered into the analysis as covariates. Pairwise comparisons were conducted with 95% confidence intervals and *p*-values are Bonferroni-adjusted.

The main effect of the covariates (i.e. age, gender, perceived user-avatar similarity, perceived virtual agent interaction valence, presence, and immersion) on state self-esteem change from pre- to post-study were also examined. There was no main effect of age on state self-esteem change, $F(1, 161) = 0.97$, $p = .33$, $\eta_p^2 = 0.05$. Gender had no main effect on state self-esteem change, $F(1, 161) = 2.04$, $p = .16$, $\eta_p^2 = 0.01$. Perceived user-avatar similarity had no main effect on state self-esteem change, $F(1, 161) = 1.95$, $p = .17$, $\eta_p^2 = 0.11$. Perceived virtual agent interaction valence had no main effect on state self-esteem change, $F(1, 161) = 0.23$, $p = .63$, $\eta_p^2 = 0.01$. Presence had no main effect on state self-esteem change, $F(1, 161) = 0.11$, $p = .74$, $\eta_p^2 = 0.01$. Finally, immersion had no main effect on state self-esteem change, $F(1, 161) = 0.23$, $p = .64$, $\eta_p^2 = 0.01$.

H1 predicted that virtual embodiment of a personalised avatar will lead to a more negative change in state self-esteem than embodiment of a non-personalised avatar. There was no main effect of embodying a personalised avatar on state self-esteem from pre- to post-study, $F(1, 161) = 0.78$, $p = .38$, $\eta_p^2 = 0.04$. Therefore, H1 is not supported. However, the pairwise comparison which was used to detect differences in state self-esteem across time in each experimental group revealed that those who embodied a personalised avatar experienced a positive change in state self-esteem from pre- to post-study (0.13 (95% CI, 0.06–0.21), $p < .001$). Similarly, there was a significant change in state self-esteem from pre- to post-study (0.09 (95% CI, 0.01–0.16), $p = .02$) among those who embodied a non-personalised avatar.

Next, H2 predicted that positive interactions with a virtual agent will lead to a more positive change in state self-esteem than negative interactions with a virtual agent. There was no main effect of virtual agent interaction valence on state self-esteem from pre- to post-study, $F(1, 161) = 0.02$, $p = .89$, $\eta_p^2 = 0.00$. Hence, H2 is not supported. However, the pairwise comparison

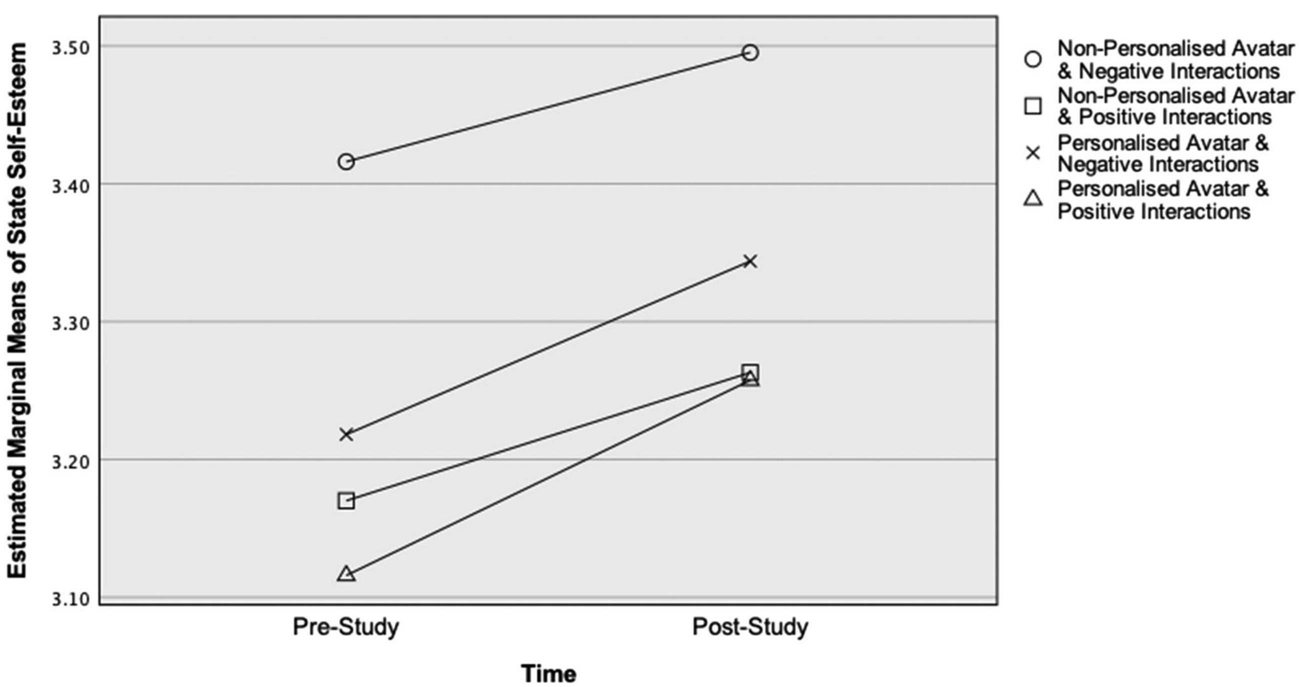

Figure 5. Effect of avatar personalisation and virtual agent interaction valence on state self-esteem.

indicated that those who had positive interactions with the virtual agent experienced a positive change in state self-esteem from pre- to post-study (0.12 (95% CI, 0.00–0.23), $p = .04$). Those who had negative interactions with the virtual agent did not experience a significant change in state self-esteem from pre- to post-study (0.10, (95% CI, −0.02 to 0.22), $p = .09$).

Finally, H3 predicted that in personalised avatar condition, there will be a more positive change in state self-esteem when there are positive interactions, compared to negative interactions with the virtual agent. There was no interaction effect between embodying a personalised avatar and virtual agent interaction valence on state self-esteem from pre- to post-study, $F(1,\ 161) = 0.00$, $p = .98$, $\eta^2_p = 0.00$. Therefore, H3 is not supported. However, the pairwise comparison showed that those who embodied a personalised avatar and had positive interactions with the virtual agent experienced a positive change in state self-esteem from pre- to post-study (0.14 (95% CI, 0.01–0.28), $p = .04$). Those who embodied a personalised avatar and had negative interactions with the virtual agent did not experience a significant change in state self-esteem from pre- to post-study (0.13, (95% CI, −0.01 to 0.26), $p = .06$). Those who embodied a non-personalised avatar and had positive interactions with the virtual agent did not experience a significant change in state self-esteem from pre- to post-study (0.09 (95% CI, −0.04 to 0.23), $p = .18$). Finally, those who embodied a non-personalised avatar and had negative interactions with the virtual agent did not experience a significant change in state self-esteem from pre- to post-study (0.08, (95% CI, −0.07 to 0.23), $p = .30$).

5. Discussion

5.1. Avatar personalisation

Contrary to the study predictions, findings from this study showed that embodiment of a personalised avatar mapped with participants' facial image did not result in a more negative change in state self-esteem than embodiment of a non-personalised avatar. Instead, results from the pairwise comparisons showed that participants experienced an increase in state self-esteem, regardless of whether they embodied a personalised or non-personalised avatar.

One possible explanation may be attributed to the reduction in self-awareness during virtual embodiment. While studies that drew upon the OSA theory suggest that self-awareness induced by viewing oneself through mirrors is associated with negative affect and worsened self-esteem (e.g. Fejfar and Hoyle 2000; Ickes, Wicklund, and Ferris 1973), some studies have found that embodying an avatar in immersive platforms such as VR can have a negative effect on body awareness (e.g. Döllinger et al. 2023a). That is, individuals may have experienced lower awareness towards their internal body signals when completing various tasks while embodying an avatar, relative to completing those tasks using their physical bodies in real life. Additionally, some studies suggest that individuals may seek to reduce discrepancies experienced through objective self-awareness by directing their attention towards other aspects external from the self (e.g. Duval and Wicklund 1973; Silvia and Duval 2001). While presence and immersion did not predict state self-esteem change in this study, it is plausible that simply embodying an avatar during the virtual simulation may have reduced participants' tendencies to deliberate upon their physical appearances, thereby shifting their attention towards other aspects of the virtual experience.

Next, the experience of being able to accomplish the tasks from the simulation in this study may have led to improvements in state self-esteem among participants, regardless of whether they embodied a personalised or non-personalised avatar. This assumption is based on the conceptualisation of self-esteem, which encompases various sub-dimensions, such as appearance, performance, and social perceptions from others (Heatherton and Polivy 1991; Heatherton and Wyland 2003). In this context, the ability to complete the required tasks in the virtual simulation may have triggered positive perceptions towards one's performance, therefore, resulting in a positive shift in state self-esteem in both avatar personalisation conditions, as observed from the pairwise comparison results. Future studies should seek to delineate the specific mechanisms that led to the observed findings in this study.

5.2. Virtual agent interaction valence

Similarly, there was no main effect of virtual agent interaction valence on state self-esteem change. However, findings from the pairwise comparisons indicated that there was a significant improvement in state self-esteem from pre- to post-study among those who encountered positive interactions with the virtual agent.

Although the CASA paradigm and related studies suggest that humans tend to respond to computers in ways that are similar to how they react during human-human interactions (Krämer 2008; Krämer et al. 2013; Nass, Steuer, and Tauber 1994), this assumption may not be universally applicable. Some scholars have argued that simulated social interactions with virtual characters may not necessarily yield effects that are similar to human-human interactions due to certain technological factors, including image fidelity and believability of the virtual agents (Kothgassner and Felnhofer 2020). It is possible that the valence of the virtual interaction may not be perceived as strongly as expected due to the avatar's visual fidelity. Additionally, some studies have also found that negative feedback given by a virtual agent elicited the least negative affect, relative to negative feedback from an avatar controlled by a human (e.g. Horstmann, Gratch, and Krämer 2021). Similarly, in this study, participants may have dismissed experiences from the negative interactions, given that the interactions were facilitated by a virtual agent, which may have been perceived to be fictional. Nevertheless, the positive change in state self-esteem among those who encountered positive interactions presents an interesting finding for future studies, which suggests that individuals may attribute the virtual experience to their self-evaluations, if interactions with the virtual agent are positive.

5.3. Avatar personalisation and virtual agent interaction valence

Finally, while there was no interaction effect between avatar personalisation and virtual agent interaction valence on state self-esteem, results from the pairwise comparisons indicated that those who embodied a personalised avatar and had positive interactions with the virtual agent experienced some improvements in state self-esteem. However, there were no significant changes in state self-esteem across the other experimental conditions.

As discussed earlier, while it is possible that simplying embodying an avatar and completing the assigned tasks in the VR simulation may have enhanced state self-esteem, the effect of the virtual experience on self-esteem may be more pronounced when individuals are able to embody a personalised avatar and experience positive interactions. In one study, participants who embodied a personalised avatar that was mapped with their actual facial features in VR experienced a greater sense of embodiment, compared to those who were assigned to embody avatars with pre-determined facial features (Döllinger et al. 2023a). Studies have also suggested that people are more likely to accept positive feedback when they are primed with an objective self-awareness stimulus (e.g. Cohen et al. 1985; Ickes, Wicklund, and Ferris 1973). Integrating these findings, it is reasonable to infer that participants who embodied a personalised avatar in this study may have been more likely to internalize the positive interactions with the virtual agent, given that they may have experienced a greater sense of embodiment towards the avatar, compared to those who embodied a non-personalised avatar.

It is also worth noting that negative interactions with virtual agents may not necessarily worsen self-esteem when individuals embody a personalised avatar. Participants may have dismissed those negative experiences by shifting their attention towards the fictional nature of the virtual agent (Horstmann, Gratch, and Krämer 2021). Furthermore, studies have found that people tend to avoid self-focused attention after being presented with negative feedback (e.g. Davis and Brock 1975) or attribute those negative feedback to external factors, particularly when they were primed with an objective self-awareness stimulus (e.g. Cohen et al. 1985). Another study also found that priming individuals to experience objective self-awareness helped them to buffer against negative feedback (Xu et al. 2021). Based on the extant literature and findings from this study, it is plausible that individuals who embodied the personalised avatar may have discounted negative feedback from the virtual agent by shifting their focus to the tasks in the virtual simulation or perceived the virtual agent as a fictional entity.

5.4. Limitations and future research

5.4.1. Measures

One limitation of this study is the measure of state self-esteem. This study employed the *Rosenberg Self-Esteem Scale* (Rosenberg 1965), which is often used to measure global self-esteem. Past studies have employed the *Rosenberg Self-Esteem Scale* to measure state self-esteem by asking participants how they felt at a particular point in time (e.g. Vrabel, Zeigler-Hill, and Southard 2018). Similarly, participants in this study were asked to indicate their responses towards the self-esteem measures based on how they felt about themselves at that particular point in time when they were completing the questionnaire. However, the effect of the experimental manipulations on self-esteem in this study may not have been large enough to attain significance, given that the measure may be less sensitive in detecting fluctuations in self-esteem (Heatherton and Polivy 1991). This is despite adapting the scale to ensure that participants reported feelings about themselves at the given point in time when completing the questionnaire. Next, participants may have experienced some levels of cognitive load from the virtual simulation and the other post-study questionnaire measures. Hence, this scale was also chosen to minimize fatigue among participants, since it had fewer items relative to other state self-esteem measures (e.g, Heatherton and Polivy 1991). Future studies should utilize other state self-esteem scales to measure the effect of avatar personalisation and virtual agent interactions on changes in state self-esteem.

Another limitation is the lack of explicit measure towards participants' self-awareness in this study. Past studies that have drawn upon the OSA theory took on the assumption that exposing individuals to self-related stimulus, such as listening to one's own tape-recorded voice, viewing oneself through a mirror (e.g. Diener and Wallbom 1976; Ickes, Wicklund, and Ferris 1973) primes self-awareness, without explicitly measuring participants' self-awareness. Additionally, past studies have found that those who perceived greater similarities between themselves and their digital avatars experienced higher levels of self-awareness (Hooi and Cho 2013; Vasalou, Joinson, and Pitt 2007). Therefore, it is assumed that a personalised avatar in this study will induce higher levels of perceived similarities between participants and their avatars (as observed from the manipulation check) and induce higher levels of self-awareness among participants. Nevertheless, future studies should examine if perceived self-awareness mediates the effect of avatar personalisation on state self-esteem.

Next, virtual embodiment was operationalized as an objective affordance in this study where participants assumed the body of the avatar and controlled the movements of the avatar in the virtual simulation (Bailey, Bailenson, and Casasanto 2016) across the experimental conditions, rather than being examined as a perception and experimental manipulation. Drawing upon existing studies (e.g. Döllinger et al. 2023b; Döllinger et al. 2023a), it is plausible that virtual embodiment, as well as avatar personalisation may reduce users' tendencies to think about their actual appearances and personal attributes, given the heightened sense of embodiment and lowered body awareness during the embodiment process. As a result, embodying a personalised avatar may not have triggered participants to deliberate on their physical attributes, thereby leading to the absence of main effect for the avatar personalisation manipulation. Although similar measures such as immersion and presence were administered in this study, future studies should account for the extent to which users experience a sense of embodiment towards their avatar, as well as body awareness during the virtual embodiment process, and how those perceptions may influence the effect of avatar personalisation and virtual agent interactions on state self-esteem.

5.4.2. Context of virtual simulation

Another notable point regarding the absence of main effect across both avatar personalisation and virtual agent interaction valence manipulations may be attributed to the context of virtual simulation. Specifically, participants took on the role as a service staff in a restaurant setting in this study, which may be a different experience from one's typical everyday life experiences. Related literature suggests that fabricated experiences and private self-presentation may inhibit identity shifts (e.g. Carr et al. 2021; Kelly and Rodriguez 2006). In this context, the lack of relevance of the virtual simulation to participants' everyday life experiences, as well as the absence of other human users in the virtual environment may have diminished self-related thoughts and prompted them to dissociate the virtual experience from their actual selves. Future studies should examine the effect of avatar personalisation on state self-esteem in other contexts that may be more relevant to users' everyday life, such as a virtual simulation situated in a workplace context or interactions with other users in the virtual world.

It is worth noting that the virtual simulation used in this study has adequate ecological validity. Specifically, the virtual simulation used in this study was designed in a restaurant setting and users were tasked to take on the role as a service staff in the restaurant, similar to video games and virtual simulations used in existing studies. For instance, studies have found that the use of personalised avatars in video games and VR can trigger stronger psychological and behavioural reactions than those who used non-personalised avatars (e.g. Bailey, Wise, and Bolls 2009; Hollingdale and Greitemeyer 2013; Radiah et al. 2023), despite the fictional nature of those simulations. Similarly, the extant literature also suggested that humans tend to respond to computers in ways that are similar to interactions with another human, when digital characters possess human-like features (e.g. Krämer 2008; Krämer et al. 2013; Marschner et al. 2015). Therefore, it is reasonable to believe that the virtual simulation used in this study has adequate ecological validity, given that it was designed to be similar to video games and virtual simulations that have been tested in existing research studies, as well as content that are available in the market.

5.4.3. Avatar and virtual agent appearance

In this study, avatar personalisation was manipulated by mapping users' actual facial image onto the avatar. However, there are other physical attributes of an avatar, such as hairstyle, height, and body size that may influence users' perceptions towards the avatar, and the way they think and feel towards themselves (e.g. Kocur et al. 2020; Yee and Bailenson 2007; Yee, Bailenson, and Ducheneaut 2009). This may have limited the effect of avatar personalisation in this study, which should be accounted for in future studies. It is also worth noting that while user-avatar similarity differed significantly between those who embodied a personalised and non-personalised avatar in this study, future research could examine how embodying an extremely dissimilar avatar may influence state self-esteem, given that users may mindlessly tend to assume the attributes of their embodied avatar, even when the avatar does not contain any personalised features (e.g. Yee and Bailenson 2007; Yee, Bailenson, and Ducheneaut 2009).

Finally, although various characteristics such as body posture, hand gestures, eye contact, and body orientation (Bogdanovych, Trescak, and Simoff 2016; Marschner et al. 2015) were incorporated into the design of the virtual agent, there were likely certain visual features that require further refinement. For instance, various studies have proposed that eye motions, such as blinks and appropriate eyelid movements may enhance the believability of virtual characters (Ruhland et al. 2015). In this VR simulation, the virtual agent's facial features were pre-dominantly static and that may have lowered the visual realism of the character. Visual realism has been found to be a positive predictor of the magnitude of emotional responses, such as fear induced among VR users (Hvass et al. 2017). Hence, it is possible that the limitations posed by the design of the virtual agent in this simulation may have diminished participants' perceived significance towards the interactions that they had towards the virtual character. Future work and virtual simulations should account for other visual elements that may enhance the realism of the characters to potentially elicit stronger psychological responses among users. Future related studies should also examine participants' perceptions towards the realism of the interactant virtual agent to understand how perceived realism may influence the effect of those virtual interactions on self-esteem.

6. Conclusion

Altogether, literature on the OSA theory suggest that embodying a personalised avatar may have negative implications on one's state self-esteem. However, positive interactions with virtual characters may help to moderate the effect of embodying a personalised avatar and enhance state self-esteem. Although those hypotheses were not supported, this study provided some preliminary indications that embodying a personalised avatar and having positive interactions with virtual agents in VR may improve state self-esteem. Additionally, findings from this study suggest that negative interactions with virtual agents may not necessarily lead to worsened state self-esteem. While presence and immersion were not predictors of state self-esteem change in this study, further research is needed to delineate the underlying factors that may influence the effect of avatar personalisation and interactions with virtual agents. This includes examining whether successfully completing assigned tasks in virtual simulations can enhance state self-esteem, how perceived embodiment of the avatar and realism of the interactant virtual agent may influence state self-esteem change, as well as administering other state self-esteem scales to measure changes in self-esteem from pre- to post-study.

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