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ORIGINAL PAPER

Exploring the influence of perceived extroversion in embodied virtual agents on trust and likability

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Abstract

Embodied virtual agents (EVAs) are beginning to be researched to improve human—computer interaction. As EVAs become increasingly integrated into various aspects of daily life, understanding how to optimize their design to foster trust and likability among users is paramount. Leveraging insights from social psychology, particularly the concept of homophily, this study investigates the impact of perceived personality traits on user perceptions of EVAs. Specifically, we explore whether aligning the personality traits of EVAs with those of users increases engagement and fosters positive interactions. Drawing on a sample of 382 participants recruited through Amazon Mechanical Turk, we assessed participants' personality traits using the Big Five Inventory—2S, while the perceived extroversion of the agent was manipulated through facial expressions and body posture. Our findings suggest that participants were able to accurately identify the perceived extroversion of the agent ($p = .014$), and significant results indicate a homophily effect on trust, with participants exhibiting greater trust in agents perceived as having a similar level of extroversion ($p < .01$). However, no significant effect on likability was detected, suggesting a more nuanced relationship between perceived personality traits and user preferences. These findings highlight the potential of leveraging homophily in designing more engaging EVAs and underscore the importance of considering user–agent compatibility in human–computer interaction.

Keywords Embodied virtual agents (EVAs) · Extroversion · Homophily · Trust · Likability

1 Introduction

The use of digital agents is becoming increasingly common in everyday life. Digital agents are integral components of artificially intelligent software systems in fields such as business, education and healthcare (Dar & Bernardet 2020). In this context, digital agents need to be trusted and liked to reinforce engagement and persuade individuals. Thus, trust and likability are important dimensions of how people use technology, and their development or extinction plays essential roles in the ultimate adoption of embodied agents (Edwards & Sanoubari 2019).

Nonverbal channels are broadly supported by modalities such as visual and auditory modalities and are conducive to offering seamless, effortless and satisfactory communication (Kang et al. 2017). The visual modality offers a broad range of nonverbal cues through facial expressions and body postures that are able to communicate personality information. The most salient expressions that have been studied are smiling, frowning, eyebrow twitching, nostril flaring, head nods, gestures and postures. Moreover, all nonverbal cues are correlated with personality traits (Jensen 2016) and influence the way people perceive each other's personalities. Research has demonstrated that personality traits and congruence in personality profiles play a significant role in promoting individuals' inclinations to establish robust interpersonal engagement. Thus, personality may be an interesting variable to consider since it affects engagement (Ivaldi et al. 2017; Salam et al. 2017). Although several studies have examined human interaction with embodied agents, to the authors' knowledge, very few studies have assessed the personality factors that influence the trustworthiness and likability of these virtual agents among observers (Philip et al. 2020).

The relationship between the actual personality and how it is perceived needs significant clarification because the externalization and attribution of personality cues define various fundamental problems based on the Brunswik lens cognitive model (Pianesi 2012; Brunswik 1956). Vinciarelli and Mohammadi (2014) emphasized the importance of perceived personality not only in human interaction but also in human–agent interaction, particularly when the goal is to generate artificial personalities via embodied agents. While some studies have explored the connection between users' personalities and avatar personalities, they have mostly done so in an exploratory manner, allowing users to design avatars themselves (Vasalou & Joinson 2009; Fong and Raymond 2015; Gregoire 2015; Ratan & Sah 2015; Fokides 2020).

To our knowledge, there is a gap in the literature (Van Pinxteren et al. 2020) regarding the testing of predetermined specific face and body features to depict an agent's perceived personality and examine its alignment with users' personalities in the general population. Recognizing this gap, we conducted a study to address this specific issue, aiming to provide insights into how predetermined agent features relate to their perceived personalities, especially concerning users' personalities in the broader population.

In this paper, we focus on depicting one of the Big Five personality traits, extroversion, on embodied agents since it has been identified as the most important and critical dimension of the Big Five for interpersonal interaction (Reeves & Nass 1996). Our goal is to reveal which and how the personality traits of humans affect the intention to trust and like a virtual agent with different levels of perceived extroversion. First, we examine whether a trait's recognition cues are perceived as intended by observers and how this perceived agent extroversion level affects observers' intentions to trust and like agents. Second, we explore the interaction effect of perceived agent extroversion and the personality traits of observers in terms of trust and likability for revealing patterns of behaviour. This study can help better design embodied virtual agents (EVAs), which are based on the personality of the user, to promote trust and likability.

This paper makes a pivotal contribution to the field, as we examine whether the trustworthiness and likability of EVAs can be increased by endowing them with varying levels of extroversion through predetermined characteristics such as facial expressions and body postures. Specifically, we test two distinct versions of predetermined characteristics—one depicting an extroverted personality and the other depicting an introverted one. Notably, our participants accurately identified these predetermined characteristics, enabling us to discern their impact on user perceptions. Subsequently, we evaluate trust and likability based on perceived EVA extroversion and the extroversion level of the user. Through rigorous empirical investigation, our study elucidates the interplay among these variables, providing valuable insights into the mechanisms driving human–agent interactions. By clarifying the relationships between predetermined agent features and user extroversion, our findings contribute to theoretical understanding while also providing practical insights for refining the design and implementation of EVAs in diverse domains.

In the following sections, we present some background related to avatar appearance and user personality, homophily (Fu et al. (2012) and McPherson et al. (2001)) and the relationships between agents and users. In Sect. 3, we present the hypotheses to be examined and the implementation of the avatars. Section 4 presents the experiment conducted to investigate the effectiveness of our study and the results obtained. In Sect. 5, we discuss the importance of the study's implications and future work for optimizing the concept presented in this study. The paper concludes with Sect. 6 on the effectiveness of adapting the user interface of an EVA, shedding light on the potential for increased user engagement and interaction.

2 Background and related work

2.1 EVA appearance and user personality

Gregoire (2015) examined whether user-designed avatars' nonverbal cues can reveal a user's real-life personality traits based on the Big Five model. Participants were able to infer the extroversion, agreeableness and neuroticism levels of a student based on the design of their avatar but not their openness or conscientiousness levels. However, it was revealed that the way an avatar was designed reflected some of the owner's personality traits and may imply preferences for design based on these traits. Thus, it is possible to use these correlations between personality traits and nonverbal cues when designing avatars to extract patterns of preferences and increase the trustworthiness and likability of EVAs. Therefore, several studies have investigated the relationship between one's personal traits and those attached to one's avatars. Fong (2015) showed that people with specific personality traits tend to customize their avatars in different ways, which indicates a two-way path by which avatars' nonverbal cues can communicate information about one's personality.

One study on avatar appearance with respect to four personality traits (extroversion, agreeableness, conscientiousness and emotional stability) revealed four distinct profiles for avatars—idealized, actualized, alter ego and negative hero—which present correlations with the aforementioned user personality traits (Mancini & Sibilla 2017).

Furthermore, the more an avatar was perceived as similar to the user, the more the user liked it. Based on these findings, McCreery et al. (2012) and Mancini and Sibilla (2017) suggest the use of offline personality as a reference point for the customization of avatars to increase user identification with the avatar and lead to stronger engagement and more positive feelings.

In Schrader (2019), two different contexts were examined based on the design of the EVA. One was for learning purposes, and the other was for entertainment. The study showed that for learning purposes, the agent was more emotionally stable, warm and competent in relation to the agent designed for entertainment. In addition, the one designed for learning purposes revealed that the more similar the users perceived the agents to be to themselves, the more engaged they were with the agent. Thus, once again, the more similar the users perceived the agents to be to themselves, the more they liked the agents.

Additionally, Reeves and Nass (1996) claimed that extroversion and agreeableness are the most critical traits for adequately describing humans' personalities, with extroversion being the most important. This study focuses on the extroversion dimension and how it can be depicted by virtual agent appearance using nonverbal cues to examine the effect of homophily in terms of trust and likeability.

Regarding facial characteristics and body postures, there are certain features that are identified as owned by either extroverted or introverted people. These characteristics have not been tested for EVAs under this conceptualization. Thus, we suggest examining how these features are perceived when applied to an EVA regarding the level of extroversion. Reeves and Nass (1996), as well as later studies (Von der Puetten et al. 2010), assumed that the same social treatments arise in human–human and human–agent interactions; however, a more recent study suggests that there are important differences between how people perceive EVAs and how they perceive humans (Hoegen et al. 2015). Therefore, it is also relevant to study whether the impoverished digital version triggers the social process in ways similar to humans. The agent's appearance is based on facial features (Fong and Raymond 2015; Olivola et al. 2014; Wang et al. 2013) and body posture (Alameda-Pineda et al. 2015; Guimond & Massrieh 2012), which have been confirmed to denote humans' various levels of extroversion. According to previous studies, a large eye aperture, a smiley mouth and high eyebrows are perceived as extroverted facial characteristics, while a narrower eye aperture, a neutral mouth and low eyebrows are perceived as introverted facial characteristics. In terms of body posture, open arms and straight posture are perceived as characteristics of extroverts, while crossing hands in front of one's body is perceived as an introverted body posture.

Thus, the first hypothesis to examine is split into four subhypotheses as follows:

H1a *Wider eye apertures and smiley faces with high eyebrows are perceived as characteristics of extroverted virtual agents.*

H1b *Open arms and straight postures are perceived as characteristics of extroverted virtual agents.*

H1c *Narrower eye apertures, neutral mouths and low eyebrows are perceived as characteristics of introverted virtual agents.*

H1d *The crossing of hands in front of one's body is perceived as a characteristic of introverted virtual agents.*

The subhypotheses pertain to whether a serious appearance leads agents to be perceived as introverted and whether smiley and open body language leads agents to be perceived as extroverted. If so, homophily principles could be applied to elicit or predict positive feelings in human–agent interactions.

2.2 Homophily effects

Empirical studies have shown that regardless of personality, people are more likely to trust and engage with similar people than with dissimilar people (Tajfel 1982; Wilson & Sherrell 1993; Dunn &Rosanna 2012) since they tend to like people who have characteristics similar to their more than those who do not (Cialdini 1993). The homophily concept has been studied for many years, and it has been claimed that perceived homophily is one of the most significant features of interpersonal relationships. Furthermore, the level of trust and likability increases when people receive advice from similar others (Cialdini & Trost 1998). In addition, this fundamental principle claims that when a person perceives an interlocutor as having a personality similar to their own, they are more likely to engage and be influenced by the advice offered. Therefore, we investigate whether agents with high perceived personality homophily are more likely to be liked and trusted by people than those perceived to have a dissimilar personality.

This principle applies to not only human-to-human interactions but also human-to-agent interactions (Tapus et al. 2007, 2008; Tay et al. 2014; Aly & Tapus 2016; Salam et al. 2017; Ivaldi et al. 2017; Kang et al. 2017;). This is justifiable since a study has shown that social responses to computers are fundamentally social (Nass et al. 1994). However, in humans, this happens naturally, while in the case of virtual agents, it must be managed in a way that appears natural. Hence, an experimental investigation was undertaken to explore the potential application of the homophily principle to human–agent interactions concerning perceived extroversion. Two dependent variables, namely trust and likeability (Zhou et al. 2019), were examined for an eHealth application that uses avatars to embody virtual agents. This study, devoid of a priori assumptions regarding participants' accurate perceptions of the intended extroversion level, was designed to investigate the applicability of the homophily principle in relation to participants' extroversion traits and the extent to which they perceive extroversion in EVAs. This led us to formulate the following hypotheses:

H2a *Extroverted individuals trust EVAs they perceive as extroverted more than those they perceive as introverted, and introverted individuals trust EVAs they perceive as introverted more than those they perceive as introverted.*

H2b *Extroverted individuals like EVAs they perceive as extroverted more than those they perceive to be introverted, and introverted individuals like EVAs they perceive as introverted more than those they perceive as extroverted.*

3 User study and agent design

3.1 Experimental design

In this study, we explore whether EVAs can be perceived as being extroverted or introverted and whether this perception affects people's feelings of trust and affinity based on the homophily principle of human interactions. This study uses the Big Five Factor Model dimensions to measure personality traits, and the focus is given to the extroversion dimension (high extraversion and low extraversion) expressed in virtual agents' facial expressions and body postures as an initial step (Sacco & Brown 2018; Küster et al. 2019).

The first treatment aims to portray an introvert agent through subtle facial expressions and a closed body posture. The facial expression features a narrower eye aperture, a neutral mouth and low eyebrows, conveying a sense of introspection and reservation. The body posture is characterized by crossing the hands in front of the body, symbolizing a guarded and inwards-focussed demeanour. In contrast, the second treatment seeks to portray an extrovert avatar through more pronounced facial expressions and open body language. The facial features include wide eye aperture and a smiling face with raised eyebrows, exuding warmth and sociability. The body posture is characterized by open arms and a straight stance, reflecting an outgoing and confident demeanour. These distinct cues aim to effectively convey the various personality traits associated with introversion and extroversion.

Our investigation had two primary objectives: first, to ascertain the accuracy with which participants in the experiment perceive varying degrees of extroversion in agents; and second, to establish whether the perceived level of agent extroversion is correlated with participants' own extroversion, specifically in relation to trust in and likability towards the agent.

3.2 Participants and procedure

Three hundred eighty-two participants were recruited from Amazon Mechanical Turk (55.55% female, MAge = 38.30, SDAge = 12.23). Informed consent was obtained from all individual participants included in the study. Participants were selected to have an approval rating higher than 95% and were paid $0.3 each.

Participants were told that they would be asked to give their opinion on an EVA that would be used in a health app to provide users with information and advice regarding their daily well-being. Afterwards, each participant received pictures (Nowak et al. (2009)) of one of the four versions of the virtual agent: introverted body posture, introverted face, extroverted body posture and extroverted face. Men received a male version of the virtual agent's picture, while women received a female version (Ratan et al. 2019). After stimulus presentation, participants completed items measuring the personality of the virtual agent, trust, likeability, personality and control.

To measure the perceived EVA extroversion, we used two items from the ten-item Big Five scale (Gosling et al. 2003). In this test, participants were asked to indicate the extent to which they agreed with two statements regarding the personality of the

Fig. 1 Male and female agent versions based on the level of extroversion—facial expression

digital agent: I see the agent as extroverted and enthusiastic, and I see the agent as reserved and quiet (1 = not at all—9 = very much so).

To measure trust, we used one item from previous studies (Heerink et al. 2010; Tay et al. 2014) adapted to fit the purpose of our study: I would trust the agent if she or he gave me advice (1 = not at all—9 = very much so). To measure appreciation, we included one item: How much do you like the agent? (1 not at all—9 very much so).

To measure participants' personality, we used the short version of the Big Five Inventory-2 (Soto and John 2017). In this test, participants were asked to indicate the extent to which they agreed with 30 statements regarding their personality, such as I am somebody who tends to be quiet, I am someone who worries a lot and I am somebody who is full of energy (1 = disagree strongly—5 = agree strongly). We use the five items of this version to examine their effects on participants' trust and affinity in terms of perceived EVA extroversion.

Figures 1 and 2 present the agents used for the experiments. There are male and female versions for both levels of extraversion and are depicted according to the description in 3. A detailed description of the 3D modelling process that was used to create these models can be found in Appendix.

4 Results

The agents were categorized manually based on a variable representing their intended portrayal as either extroverted or introverted, and subsequently, the users' extroversion levels were employed in the analytical process. The data collected were normally distributed, and the analysis of the perceived agent personality was performed with the use of an independent samples t test, similar to the analysis of how this perception affects the trust and likeability experienced by participants. Regarding the feelings—dependent variables—elicited by each EVA, correlation matrices revealed

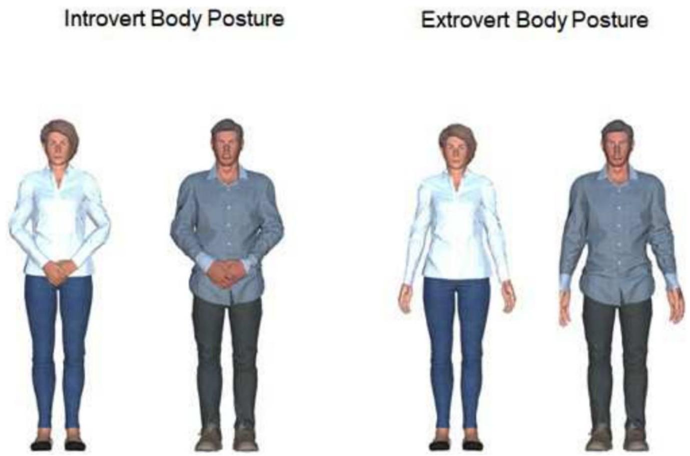

Fig. 2 Male and female agent versions based on the level of extroversion—body posture

significant predictors for both trust and likeability. The analysis of the data was performed by SPSS version 26, 64-bit edition for Windows 10.

4.1 Perceived agent extroversion

An independent samples *t* test was conducted to compare the perceived agent extroversion level in the smiley/open arms and serious/closed arms conditions. For the t tests, our preliminary assumption checks yielded positive results. The Shapiro–Wilk test confirmed that the data in each group had a normal distribution ($p > 0.05$). Furthermore, Levene's test for equality of variances indicated no significant difference in variance between the groups ($p > 0.05$). These findings validate the assumptions necessary for conducting t tests and increase the reliability of our inferential analysis.

Afterwards, we ran the t tests, and there was a significant difference in the scores for the smiley/open *arms* ($M = 4.82$, $SD = 1.07$) and serious/closed arms ($M = 4.474$, $SD = 1.26$) agents; $t(380) = -2.888$, $p = 0.004$, $d = 0.29$.

These results suggest that facial expressions and body posture truly affect the perceived extroversion levels of EVAs. Specifically, when agents are designed with smiley faces and open arms, they are perceived as more extroverted than those designed with serious faces and closed arms. For the remainder of the paper, "smiley agent" refers to the agent with open arms and a slight smile, while "serious agent" to the agent with closed arms and neutral facial expression.

Therefore, H1a, b, c and d are accepted.

Since the EVAs received significantly different ratings regarding perceived extroversion, we used the median value to split them into two groups and examine the differences in trust and likability levels.

In the following regression analyses, our preliminary assumption checks yielded favourable results. The examination of the residual histograms revealed a relatively symmetrical distribution, indicating normality. Statistical tests, including the Shapiro–Wilk test for normality ($p > 0.05$) and the Breusch–Pagan test for homoscedasticity ($p > 0.05$), further supported these findings. Overall, these successful preliminary checks allowed the execution of the following two regression analyses to examine the relationships among the variables.

4.2 Examining the relationships among willingness to trust, perceived extroversion of an embodied agent and the extroversion participant profile

A stepwise multiple regression analysis was performed with trust as the dependent variable and participant extroversion, perceived agent extroversion and the interaction effect of participant extroversion and perceived agent extroversion as the independent variables. There were no main effects, but there was a positive interaction effect on the level of trust in agents ($t = 5.611$, $p = 0.000$), *with* $R^2 = 7.7\%$, Table 1.

Therefore, to understand the nature of the effect, we use a regression equation of slopes (Aiken & West 1991) in which we compare the regression slopes for low (− 1SD) and high (+ 1SD) levels of participant extroversion. We created two participant extroversion levels.

In Table 2 and Table 3, we present the results of regressing participant extroversion and perceived agent extroversion against trust. We examined the impact of perceived

Table 1 Multiple regression analysis regarding trust

	B (Standard error)	Beta (t value)
Interaction effect of participant extroversion and perceived avatar extroversion	.562*** (.155)	.294 (5.611)
Constant	1.156	
Adjusted R^2	.077	
$N = 382$		

*p < .05; **p < .01; ***p < .001

Table 2 Low-extroversion (introversion) participants—trust

	B (Standard error)	Beta (t value)
Interaction effect of participant extroversion and perceived avatar extroversion	− .111 (.148)	− .080 (− 745)
Constant	4.019	
Adjusted R^2	.050	
$N = 89$		

*p < .05; **p < .01; ***p < .001

Table 3 High-extroversion participants—trust

	B (Standard error)	Beta (t value)
Interaction effect of participant extroversion and perceived avatar extroversion	.352** (.127)	.160 (2.769)
Constant	5.115	
Adjusted R^2	.022	
$N = 293$		

*$p < .05$; **$p < .01$; ***$p < .001$

avatar extroversion on trust within two distinct regression groups: one comprising high-extroversion participants and the other comprising low-extroversion participants. This analysis revealed that among participants with low extroversion, the perceived level of avatar extroversion did not significantly affect their trust in the avatar ($b = -0.111$, $SE = 0.148$, $p > 0.05$). Among participants with a high level of extroversion, the more extroverted they perceived the avatar to be, the more willing they were to trust it, with this effect having great strength ($b = 0.352$, $SE = 0.127$, $p < 0.01$). In Fig. 3, we present a graphical representation of the outcomes derived from the regression analysis to examine the relationships among participant extroversion, perceived agent extroversion and trust levels.

The homophily effect was verified in the case of trust for extroverted but not introverted participants; H2a is partially accepted.

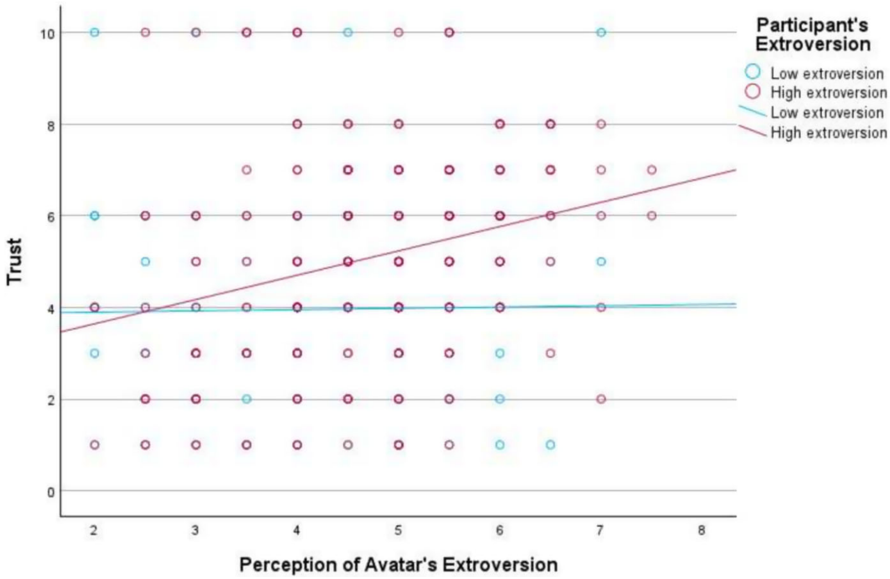

Fig. 3 Interaction effect of participant extroversion and perceived agent extroversion on trust

4.3 Analysing the relationships among likability, perceived extroversion of an embodied agent and the extroversion participant profile

Similarly, we assumed that perceived agent extroversion would moderate the likability of the agent. In this case, stepwise multiple regression analysis was performed with likability as the dependent variable and participant extroversion, perceived agent extroversion and the interaction effect of participant extroversion and perceived agent extroversion as the independent variables. In this case, Table 4, there was a main effect of perceived extroversion ($t = 8.932$, $p = 0.000$) on the level of likability, along with an interaction effect on likability ($t = 3.814$, $p = 0.000$), with $R^2 = 22\%$.

The main effect explains that the more extroverted the agent was perceived to be, the more participant liked it. However, it was crucial to examine the interaction effect again and determine its strength. Thus, as for trust, we created two categories based on participant extroversion level and examined the two regression groups; their results are shown in Tables 5 and 6.

The observed interaction effect between groups of participants based on their extroversion levels suggests that the impact of perceived avatar extroversion on likability varies with the individual's extroversion/introversion level. Specifically, for

Table 4 Multiple regression analysis regarding likability

	B (Standard error)	Beta (t value)
Interaction effect of participant extroversion and perceived avatar extroversion	.513*** (.134)	.177 (3.814)
Perceived avatar extroversion	.807*** (.090)	.411 (8.932)
Constant	− .330	
Adjusted R^2	.214	
$N = 382$		

*p < .05; **p < .01; ***p < .001

Table 5 Low-extroversion (introversion) participants—likability

	B (Standard error)	Beta (t value)
Interaction effect of participant extroversion and perceived avatar extroversion	− .219 (.117)	− .197 (− 1.871)
Constant	3.745	
Adjusted R^2	.028	
$N = 89$		

*p < .05; **p < .01; ***p < .001

Table 6 High-extroversion participants—likability

	B (standard error)	Beta (t value)
Interaction effect of participant extroversion and perceived avatar extroversion	.492*** (.134)	.210 (3.673)
Constant	5.385	
Adjusted R^2	.041	
$N = 89$		

*$p < .05$; **$p < .01$; ***$p < .001$

participants who perceived the agent as highly extroverted, a statistically significant relationship emerged between their own extroversion levels and likability; conversely, for participants who perceived the agent as low in extroversion, a positive relationship between their extroversion and likability was noted, but statistical significance was not attained.

In Fig. 4, we present a graphical representation of the outcomes derived from the regression analysis conducted to examine the relationships among participant extroversion, perceived agent extroversion and likability levels.

Thus, the homophily effect was verified in the case of likability for extroverted but not introverted participants; H2b is partially accepted.

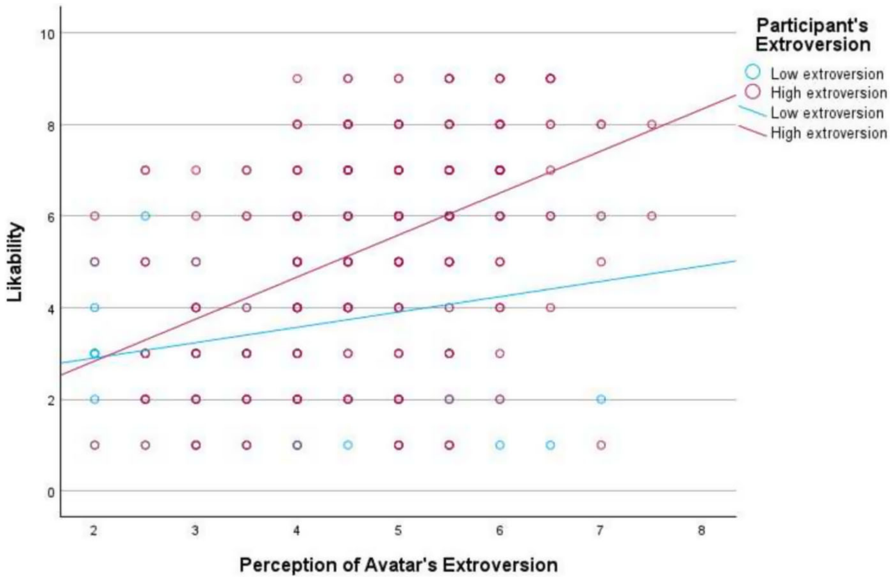

Fig. 4 Interaction effect of participant extroversion on trust regressed by perceived agent extroversion

5 Discussion and limitations

In this study, we tested two groups of static agent design features inspired by human characteristics that define extroverted and introverted individuals. The aims were to examine both whether perceived agent extroversion is achieved and whether and how this perception affects trust and likeability based on the homophily concept. According to ter Stal et al. (2020), trust and likeability are affected by depicted age, gender and the role of agents; thus, we expanded this idea by examining the effects of user-perceived agent extroversion.

Although our study did not find evidence suggesting that gender influenced the outcomes of preference effects in our specific study population, it is essential to recognize that gender may play a significant role in other research contexts. Gender differences in preferences, behaviours and responses to interventions have been documented in various fields, including healthcare, psychology and consumer behaviour. Additionally, considering gender alongside other demographic variables in study design and analysis can provide valuable insights into potential disparities and inform more tailored interventions and policies. Therefore, future research should continue to explore the interaction between gender and preference effects to better understand how these factors intersect and influence outcomes.

For this study, we focussed on the effect of user-perceived agent extroversion and how it influences feelings of trust and likeability when homophily conditions are met. More specifically, we used facial features and body postures that convey extroverted and introverted characteristics and applied them to tailor EVAs. We then examined how participants in the study perceived these agent features along with the effects of perceived agent extroversion regarding willingness to trust and like the agent. Finally, we explored some significant main effects of participant personality traits in terms of trust and likability, regardless of the level of extroversion perceived in the agent.

The results verified the first hypothesis since the EVAs were perceived as either introverts or extroverts using facial and body features as predicted and intended. This result was significant; however, it had a small effect size, meaning that not all participants perceived the serious agent as introverted or the smiley agent as extroverted. In essence, if we consider the agent design as representative of an "inherent" personality based on how humans classify nonverbal cues and contrast this with the responses obtained, it becomes apparent that a pronounced alignment between the "inherent" and perceived extroversion was not observed. This result is consistent with those obtained in studies on human–human interactions that strongly support the dichotomy between actual and perceived personality traits (Evans et al. 2008; Steele et al. 2009). These studies posit that actual personality attributes frequently diverge from their perceived counterparts, with the latter often assuming greater significance in the context of interpersonal communication and interaction. Since agents are assigned human-like features, concepts that appeal to humans, such as the differences that each agent may provoke in users, are expected to be verified. This occurs because observers process nonverbal cues to produce a personalized perception (Colman 2009; Vinciarelli & Mohammadi 2014).

Concerning the second hypothesis, the detected interaction effect between participant extroversion level and perceived agent extroversion was significant for both trust and likability. This finding partially confirms the presence of a homophily effect, thereby leading to partial acceptance of the hypothesis, particularly among extroverted participants. Experiments with robots (Tapus et al. 2007, 2008) have revealed that people listen and enjoy interacting with agents who exhibit behaviours similar to their own or adapt their behaviours to the user's personality. In our context, we found that in terms of trust, participants with high levels of introversion rated the agents they perceived to have low extroversion as more trustworthy, whereas the participants with high levels of extraversion rated the agents they perceived to have high extroversion as more trustworthy. These results are consistent with those of the aforementioned studies. In terms of likeability, the agent perceived as highly extroverted was liked more by both groups of participants, which is not surprising since it seems friendlier. This finding supports the essential role of extroversion in likeability, expanding on previous findings (Richmond et al. 2008; Cafaro et al. 2012).

Overall, the perceived extroversion level can affect the willingness to trust and like EVAs and the desire to continue interacting with them. The results can help tailor the artificial personalities of EVAs by adapting their user interfaces according to the perceived extroversion level that is appropriate for increasing trust and affinity from users. This concept can be extended to a study that categorizes visual features (or other feature) into clear characteristic categories to predict trust and likeability based on observers' personality traits (Astrid et al. 2010).

One notable limitation of our study lies in the reliance on self-reporting tools and single-item measures to gauge the trustworthiness and likability of the agent. To address this limitation in future investigations, we intend to employ mixed-methods approaches that encompass a broader spectrum of measurement tools, allowing for more comprehensive assessments of participants' interactions, trust levels and perceptions of likability towards EVAs. Moreover, our study's omission of gender analysis precludes us from drawing conclusions regarding potential gender disparities in preference effects. Moving forwards, studies should use more inclusive methodologies, encompassing larger and more diverse study populations while explicitly examining the role of gender in shaping preference effects.

Furthermore, this study mainly aimed to provide an understanding of the relationships among the variables, so the low R-squared value does not negate the importance of any significant variables. Even with a low R2, statistically significant P values indicate that the relationships and coefficients have the same interpretation. However, while our study provides valuable insights into the relationships among the variables, it is important to acknowledge the limitations associated with the small R2 values obtained in our analysis. The small R2 values indicate a low amount of variance in the data explained by the independent variables. This could be considered a limitation, particularly in experimental studies where the number of independent variables is limited. Despite efforts to control for various factors, the complexity of human behaviour and the multitude of influencing factors may have contributed to the small R2 values observed. Therefore, it is crucial to interpret the findings with caution and recognize that additional unmeasured variables may also play a role in the outcomes observed. Addressing these limitations and expanding the scope of investigation can lead to a more comprehensive understanding of the factors influencing the willingness to trust and likability in the context of EVAs and participant personality profiles.

6 Conclusion and future work

This study has elucidated the pivotal role of perceived extroversion in interactions between users and EVAs. The research focussed on the impact of nonverbal cues—specifically facial expressions and body posture—on the trust in and likeability of EVAs.

Notably, the findings revealed a fascinating link between perceived EVA extroversion and user' trust. Participants demonstrated the ability to accurately discern agent extroversion based on nonverbal cues. Moreover, there was a clear indication of a "homophily effect" concerning trust: Users tended to place greater trust in EVAs they perceived as having a similar level of extroversion to themselves. However, this effect did not significantly influence the likeability of the agents. Participants generally preferred extroverted agents, irrespective of their own extroversion level.

Our future research endeavours will address the limitations of this study's scope, aiming to explore additional factors that influence the outcomes of interest. These factors may encompass a broad array of variables, ranging from other personality traits and contextual factors to individual differences. Furthermore, our focus will shift towards enhancing the communication capabilities of agents by adapting multiple channels tailored to users' personality traits, building upon our initial exploration of extroversion. We envision conducting studies that integrate personality traits with the visual agent modalities, aiming to predict observers' perceptions of these agents more comprehensively. To this end, real-life studies will be conducted, incorporating not only self-report questionnaires but also physiological and behavioural measures to provide a more holistic evaluation of user–agent interactions. Ultimately, our overarching goal remains to empower human–agent interaction by identifying sets of predefined features that are perceived favourably by users, thereby fostering stronger trust in and engagement with EVAs.

Moreover, future research should try to increase the *generalizability* of our results by testing them in a real app. We foresee the application of this methodology to robots in future work, expanding the experimental setting beyond virtual agents to include physical embodiments. The experimental setup developed in our study can serve as a robust framework for experiments involving androids and other nonhuman agents, particularly in sectors where social agents are imperative for inspiring trust and likability. By adapting our methodology to real-world scenarios involving physical agents, we aim to contribute to the development of socially adept robots capable of effectively interacting with humans in diverse settings, ultimately enhancing user experiences and fostering meaningful human–agent relationships.

Appendix

EVA design: 3D modelling

The 3D computer graphics software Autodesk Maya and the open-source Blender were used to create two EVA versions. The basic stages of development had two main steps: 3D modelling and rigging. Texturing, including UV mapping, retopology and sculpting, is the most important 3D modelling method in our study. Texturing determines how the agent's surface looks, including its resolution and colour. Rigging, on the other hand, is the step in which a skeleton is added to a 3D model consisting of a bone hierarchy. Each bone is usually parented to the previous bone, with every model maintaining a main bone, which is usually placed on the hips and defines the basic skeleton through the spine, legs and hands. This skeleton is responsible for the movement of the agent and allows it to be animated in a realistic and human-like way, and in our case, it supports various body postures.

Furthermore, another significant part of this development is the ability to create facial expressions through facial animations for increased human realism. The standard technique for facial animation is the muscle blending technique, which is a keyframe animation, also known as BlendShapes. This is a bone transformation-controlled animation in which a motion capture system is paired with a machine learning system or system for procedurally generated animations. For the purposes of this study, the BlendShapes technique is appropriate since it affects the muscles directly by providing a tagged timeline of positional and rotational changes.

Fuse CC, along with Mixamo, provides the appropriate functionalities for implementing the aforementioned stages of development. For the first step, the agents are designed with high-quality textures, including all the desired characteristics that are to be adapted later on appropriately (face, age, gender, etc.). After the modelling step is completed, the agent moves to step two, the rigging where the bone structure defines the body posture as described above. The rigged agent, along with a predefined BlendShape system, can be exported in an .fbx type of file, which serves as input in Unity3D. Unity can exploit blendshapes to achieve the desired facial expressions.

All the blendshapes have a measurement system from 0 to 100, where 0 means the blendshape is disabled and 100 the blendshape depicts the maximum of the predefined movement of the muscle. For example, 0 for the feature "mouth" means that the mouth is completely closed, and 100 means that the mouth opens as much as possible, which is considered the modelling stage. Any size larger than 100 will indicate abnormal poses in the face.

To achieve the facial expressions of the agent, regarding extroversion, a combination of blendshapes is enabled with specific values. All the facial expressions are stored with a corresponding group of blendshape metrics that are applied to the agent on demand. The two versions of the agent have the same blend shapes in the beginning, and afterwards, each of them, based on the requirements of the facial expressions and body posture, stores a different set of values labelled after the level of extroversion depicted. When the configuration is completed, the application creates a table with the metrics that correspond to the different levels of extroversion.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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