Computers in Human Behavior 138 (2023) 107415

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Tools or peers? Impacts of anthropomorphism level and social role on emotional attachment and disclosure tendency towards intelligent agents

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ARTICLE INFO

Keywords:
Anthropomorphic intelligent agents
Social role
Emotional attachment
Self-disclosure
Human–agent relationship

ABSTRACT

Owing to the development of anthropomorphic intelligent agent (IA) designs, users consider IAs as more than just inanimate tools. Previous studies have reported that anthropomorphic features can promote users' social feedback and aid in establishing intimate human–agent relationships. The present study examined the main and interaction effects of anthropomorphism level (a human-like IA vs. robot-like IA) and social role (servant vs. mentor) on emotional attachment, information disclosure tendency, and satisfaction in a smart home. The study participants were randomly assigned into four groups with balanced gender. The results indicate that high anthropomorphism and mentor role can positively predict users' emotional attachment. Additionally, users tend to disclose more personal information to the human-servant and robot-mentor IAs than the human-mentor and robot-servant IAs. Interestingly, social presence was determined to be a positive and significant mediator between anthropomorphic design and emotional attachment. The study findings highlight the importance of social role in anthropomorphic IA design and explain the mechanism of establishing effective human–agent relationships. Moreover, both theoretical and practical implications of these findings are analyzed.

1. Introduction

In the past decades, intelligent agents (IAs) have become crucial in people's daily lives, varying from customer-service agents on commerce websites to conversation agents on smartphones (e.g., Siri) and smart housekeepers. Typically, IAs accompanied by natural voice or virtual embodiment are more than just inanimate tools to users. According to the computer as social actors (CASA) theory, users unconsciously apply interpersonal social principles to human–IA interaction and expect humanness in IAs (Nass, Steuer, & Tauber, 1994, April; Schaumburg, 2001). Therefore, anthropomorphic design, including visual or linguistic cues presented by IA, can reshape the human–agent relationship further. The primary objective of the present study is to explore the influence of anthropomorphic design on human–agent relationships, which include the aspects of emotional attachment and information disclosure (Daher et al., 2017, August; Kontogiorgos et al., 2019; Tibert, Jaap, Frans, & Willemijn, 2014). On the one hand, anthropomorphic features can promote users' perceived social presence and human warmth, thereby inducing increased emotional attachment and social feedback (Daher et al., 2017, August; Kontogiorgos et al., 2019, July; Tibert, Jaap, Frans, & Willemijn, 2014). On the other hand, anthropomorphic visual cues can increase public self-awareness and privacy concerns, leading to less information exchange. This may hinder the establishment of intimate relationships (Pickard & Roster, 2020; Sah & Peng, 2015). Therefore, the impacts of anthropomorphism on users' emotional attachment and private information disclosure require further investigation.

In the current study, two aspects are considered when designing an anthropomorphic IA: "the degree to which the IA resembles a human being" and "the type of human role the IA should play." Existing studies primarily focus on the embodiment of IAs, involving verbal and nonverbal social behaviors. However, the social identity of the agent, which includes age, gender, race, and status, is also critical to the user–agent interaction (Edwards, Edwards, Stoll, Lin, & Massey, 2019; Reeves & Nass, 1996; Wang, Molina, & Sundar, 2020). For instance, users' attitudes towards computers with female voices differ from those towards male voices (Reeves & Nass, 1996). Additionally, users tend to trust IAs with an older voice more than those with a younger voice in the case of an agent with a teacher's identity. This is because they consider the former to be more knowledgeable than the latter (Edwards, Edwards, Stoll, Lin, & Massey, 2018).

The three major contributions of the current study can be summarized as follows. 1) The importance of social identity in the

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https://doi.org/10.1016/j.chb.2022.107415
Received 19 March 2022; Received in revised form 19 July 2022; Accepted 24 July 2022
Available online 23 August 2022

anthropomorphic design of IAs is highlighted. 2) Both the main and interaction effects of anthropomorphism level and social role on users' emotional attachment, disclosure tendency, and satisfaction are measured. 3) The mediating effects of social presence and privacy concern on emotional attachment and disclosure tendency are analyzed, and the mechanism of establishing intimate relationships between humans and IAs is explained.

1.1. Anthropomorphic design

Anthropomorphic design refers to applying the concept of human characteristics, particularly social-related properties, to inanimate computers. The easiest method of anthropomorphizing an IA is to use human images. Kang and Kim (2020) reported that a simple line drawing of a smiley face can evoke positive user feedback and deepen the user–agent relationship. Benlian, Klumpe, and Hinz (2020) also conducted research on IAs in smart homes and stated that adding a smiley face can reduce the harmful effects (e.g., stress) caused by technological intrusions. In addition to visual cues, linguistic cues are commonly used to shape the anthropomorphic embodiments of IAs. Previously, researchers compared voice interaction with chatting interaction (text) and suggested that IAs with human voices can reduce users' psychological resistance and receive warmer attitudes from the users (Hong, Cho, & Choi, 2017; Novielli, de Rosis, & Mazzotta, 2010). Moreover, non-humanoid robots without voice cues can exhibit humanness and social responsiveness via non-verbal social behaviors, such as moving robotic arms (Birnbaum, Mizrahi, Hoffman, Reis, & Sass, 2016; (Hoffman, Birnbaum, Vanunu, Sass, & Reis, 2014)).

Users' attitudes towards anthropomorphic agents or robots can be explained by the CASA theory, which states that users respond socially to inanimate objects unconsciously, considering them as actual people (Nass et al., 1994; Schaumburg, 2001). This cannot be regarded as a cognitive error wherein users mistake inanimate computers for humans (Nass et al., 1994). By contrast, such social reactions to computers are commonplace. Previous studies have verified that users can perceive human warmth, different personalities (Lee, Peng, Jin, & Yan, 2006; Mennicken et al., 2016, September), or social identities (Reeves & Nass, 1996) from the agents' verbal or non-verbal cues. Lee et al. (2006) reported that users can recognize and perceive the diverse personalities of dog-shaped robots based on the frequencies of blinking eyes and wagging tails.

As more anthropomorphic features are likely to trigger more varied social behaviors from users, researchers have explored methods that can make computers similar to humans without triggering the uncanny valley effect (Gong, 2008; Kontogiorgos et al., 2019; Oh, Bailenson, Krmer, & Li, 2016). Another aspect considered was the type of human roles computers should resemble.

Social identity is a part of people's self-concept, which is derived from social groups (Tajfel & Turner, 1986). Studies on anthropomorphism computers have reported that users identify and assign social identities, such as gender (Lee, Nass, & Brave, 2000, April; Nass, Moon, & Green, 1997), age (Edwards et al., 2019), ethnicity (Nass et al., 1997), relative status (dominance or submissiveness) (Lei & Rau, 2021; Lin & Huang, 2018), and other elements to computers. Users prefer computers with similar personalities as they share the same social identity to a certain extent (Lee & Nass, 2003, April; Lee et al., 2006). This is congruent with the similarity attraction theory established in interpersonal communication (Byrne, Griffitt, & Stefaniak, 1967).

In addition to individual differences, usage scenarios affect users' expectations of the social characteristics of IAs. For instance, in the case of a smart home, most users prefer smart home agents that exhibit personalities with conscientiousness, kindness, and calmness, whereas others prefer energetic and creative designs (Mennicken et al., 2016, September). Dautenhahn (2007) reported three dimensions that identify users' requirements on social skills for robots in different usage scenarios: contact with humans (none, remote, long-term, and physical), robot functionalities (limited, clearly defined—open, adaptive, and shaped by learning), and roles (machines, tools—assistant, companions, and partners). Therefore, when an IA enters people's daily lives and integrates with the Internet of Things (IoT), it is no longer an inanimate tool but a social role that satisfies users' social needs via anthropomorphic designs.

1.2. Effects of anthropomorphic cues on user attitude and behavior

1.2.1. Emotional attachment

Both visual and linguistic andromorphic cues can elicit positive emotional responses from users (Chateau, Maffiolo, Pican, & Mersiol, 2005, October; Hong et al., 2017; Novielli et al., 2010). According to the first impression model in interpersonal communication, social behaviors—such as smiling and staring—facilitate the rapid formation of human–computer intimacy, willingness, and time of coexistence between people and agents (Cafaro, Vilhjálmsson, & Bickmore, 2016; Oh, Bailenson, Kramer, & Li, 2016). In the case of long-term interactions, Bickmore and Picard (2005) conducted a two-week follow-up survey of anthropomorphic IAs. They reported that IAs with social behaviors received higher scores of preference, trust, and willingness to use after a long-term interaction than those without social behaviors. In summary, anthropomorphic designs, including visual cues, linguistic cues, and non-verbal social behaviors, can positively influence users' attitudes and facilitate the establishment of user–agent relationships (Hong et al., 2017; Novielli et al., 2010).

In human–computer interactions, several researchers compare the human–computer relationship to the human–dog relationship, suggesting that users are dominant (Krueger, Mitchell, Deshpande, & Katz, 2021; Sinatra, Sims, Chin, & Lum, 2012). Warta, Kapalo, Best, and Fiore (2016) reported that users' perception of anthropomorphic robots gradually shifts from tools to teammate roles with increasingly complex and dynamic operational and social functions. However, some researchers have reported that computers can acquire leadership functions, guiding and commanding humans when their capabilities and knowledge surpass their human counterparts (Beton et al., 2017; Wesche & Sonderegger, 2019). Research on brand advertising has shown that the relative status of brand anthropomorphic roles and users affects users' attitudes towards the brand (Lin & Huang, 2018). Furthermore, consumers with interdependent self-construal prefer anthropomorphic brands playing superior "master" roles rather than subordinate "servant" roles (Lin & Huang, 2018).

Studies on virtual agents have reported that social presence is critical in shaping service encounters and users' attitude towards agents (Lee & Nass, 2003, April; Lee et al., 2006; Rourke, Anderson, Garrison, & Archer, 1999; Tibert, Jaap, Frans, & Willemijn, 2014). Social presence indicates the feeling of personal, sociable, and sensitive human contact in communication (Rourke et al., 1999). In agent-mediated communication, social presence can be enhanced by anthropomorphic cues, such as human-like images (Go & Sundar, 2019; Kontogiorgos et al., 2019), eye contact (Kontogiorgos et al., 2019, July 2019), and social identity (Go & Sundar, 2019). Tibert et al. (2014) confirmed that social presence plays a positive and significant mediating role between IA's anthropomorphic cues and satisfaction. Lee and Nass (2003, April) also studied non-embodied conversational agents and reported similar conclusions; specifically, that linguistic cues can shape agents' personalities and that their social presence is stronger when their personalities are consistent with those of the user.

1.2.2. Disclosure tendency

The anthropomorphic design may exhibit negative impacts on user experience. Previous studies have reported that human images significantly increase social anxiety and privacy concerns, leading to less information disclosure during human–agent communication (Pickard & Roster, 2020; Sah & Peng, 2015). Self-disclosure refers to the behavior of revealing personal information to others. In human–agent interactions,

users can obtain personalized services by disclosing their personal information. The privacy calculus theory explains the motivation of disclosure by stating that individuals disclose personal information based on a cost-benefit trade-off (Dinev, Xu, Smith, & Hart, 2013; Hallam & Zanella, 2017). Considering smartphones as an example, users may refuse requests from smartphones to obtain their personal information because of privacy concerns (Xu, Gupta, Rosson, & Carroll, 2012). By contrast, the perceived benefits of the disclosure, such as more personalized services, promote their acceptance of information sharing (Xu et al., 2012).

Researchers have not yet reached a consensus on disclosing information to anthropomorphic IAs. Although visual cues are known to negatively affect users' disclosure tendency, linguistic cues promote users' information disclosure on an anthropomorphic website (Pickard & Roster, 2020; Sah & Peng, 2015). According to the privacy calculus theory, social rewards, such as positive emotions obtained from social communication, may serve as intangible benefits and promote disclosure (Hallam & Zanella, 2017). In this context, anthropomorphic cues may influence users' privacy concerns and perceived benefits only in certain instances, resulting in inconsistent conclusions.

1.3. The present study

The present study employed anthropomorphism and social role as independent variables and investigated their effects on users' emotional attachment and disclosure tendency. The mediating effects of social presence and privacy concern of disclosure were also examined. Accordingly, the following hypotheses were postulated.

hypothesis 1a. Anthropomorphic cues positively affect users' emotional attachment towards IAs.

hypothesis 1b. Anthropomorphic cues positively affect users' satisfaction towards IAs.

hypothesis 2a. Relative status positively affects users' emotional attachment towards IAs.

hypothesis 2b. Relative status positively affects users' satisfaction towards IAs.

hypothesis 3c. The feelings of social presence elicited by anthropomorphic IAs positively affect emotional attachment towards IAs.

hypothesis 3b. The feelings of social presence elicited by anthropomorphic IAs positively affect satisfaction towards IAs.

hypothesis 4. Anthropomorphic cues negatively affect users' disclosure tendency towards IAs.

hypothesis 5. Relative status negatively affects users' disclosure tendency towards IAs.

hypothesis 6. Privacy concern elicited by anthropomorphic IAs negatively affects disclosure tendency towards IA.

2. Method

2.1. Participants

Sixty-four participants were enrolled in the experiment, wherein participants with no experience interacting with IAs were excluded. Table 1 lists their demographic information. Participants were compensated for their participation.

2.2. Experimental design and procedure

The experiment used a 2 (human-like or robot-like) × 2 (mentor or servant) between-subject design. Initially, images of a two-dimensional (2D) female cartoon and 2D robot cartoon with a neutral face (see Fig. 1) were used to provide visual cues of anthropomorphism level to the users in task 1 as social priming. 2D animation was used rather than three-dimensional animation to avoid the uncanny valley effect. Furthermore, the linguistic cues of IAs were manipulated considering the anthropomorphism level during the three tasks. The voice of human-like IA exhibited a natural and friendly tone, whereas that of robot-like IA was mechanical and high pitched. Subsequently, the present study manipulated the social identity using visual cues in social priming and verbal cues in communication content. For instance, the mentor IA stated, "I will be your mentor and provide your personalized suggestions," whereas the servant IA stated, "I will be your servant and provide your personalized service." Furthermore, servant IAs used words of respect, such as "Nin" in Chinese, whereas peer IA used common words, such as "Ni."

Table 1
Demographic information of participants.

Demographic information	Value/ specification	Frequency				
		HS	HM	RS	RM	Total
Age in years (M = 23.86, SD = 2.54)	20–22	5	3	8	6	22
	23–26	9	9	6	5	29
	27–30	2	4	2	5	13
Gender	Male	8	7	7	9	31
	Female	8	9	9	7	33
Familiarity with IA (M = 2.73, SD = 0.72)	1	0	0	0	0	0
	2	4	9	7	7	27
	3	9	6	7	5	27
	4	3	1	2	4	10

HS: Human-Servant; HM: Human-Mentor; RS: Robot-Servant; RM: Robot-Mentor.

The participants were instructed to perform tasks with the corresponding IA in a laboratory, simulating a smart home space with a controlled layout (see Fig. 2). The experimental space included a projector, sound-box, light-emitting diode strip, table lamp, humidifier, temperature and humidity sensor, human body sensor, and wireless button. All the smart devices were controlled remotely by a researcher sitting in the adjacent room via a smartphone. Additionally, the space was decorated to provide an immersive experience to the participants. A cloth-stand, side table (with various household goods), sofa, dog toy, and other items were also placed in the 4 m × 3 m space. The anthropomorphic IA was controlled remotely using a computer. The voices of the IAs were synthesized using text-to-speech software (XunJie Text-to-Voice software). The Wizard of Oz testing method facilitated the simulation of the interaction between the participants and IA without any failed cases resulting from imperfect natural speech recognition.

The duration of the experiment ranged from 25 to 35 min. Before the experiment, participants were required to read and sign an informed consent form that included the basic information of the experiment and the usage of their experimental data. Subsequently, a brief introduction to the experimental tasks was provided. The participants were guided into the smart home space and asked to sit on the sofa. They were informed that they could control smart devices by interacting with IA through voice in this environment.

During the experiment, participants needed to complete three tasks by interacting with IA, see Fig. 3. In the first task, participants were asked to watch a video of IA's self-introduction as social priming. The video was projected on a white wall via the projector, providing both visual and linguistic anthropomorphic cues of the IA. The voice of the IA was maintained the same during all three tasks. The second task involved experiencing the basic functions of IA, including information consulting and remote control of smart devices. In the third task, participants experienced five rounds of personalized service. The IA asked the participants four questions regarding a topic (e.g., restaurant preference) and provided personalized suggestions based on the participants' answers. Table 2 summarizes the personalized service and question samples. After completing the tasks, the participants were

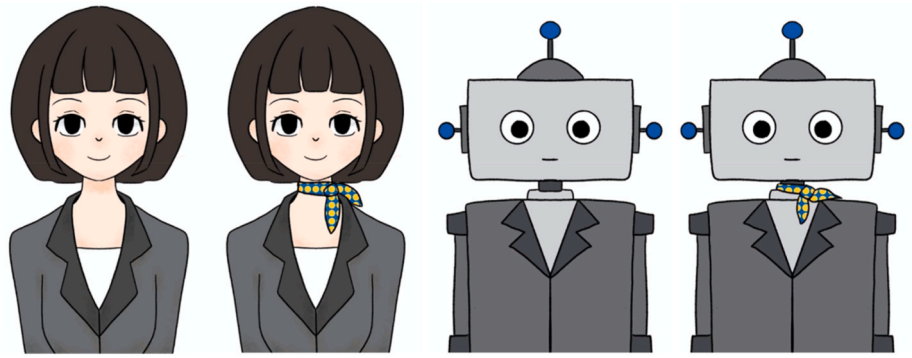

Fig. 1. Animated human-mentor, human-servant, robot-mentor, and robot-servant.

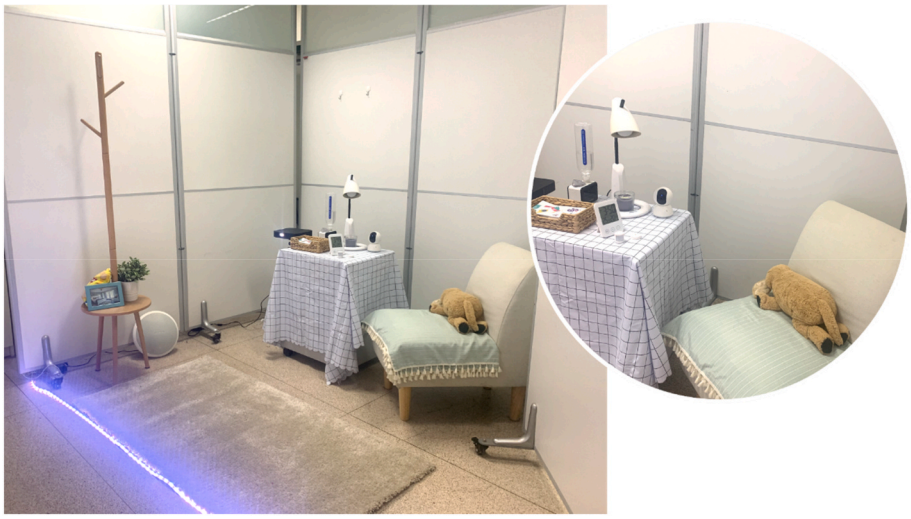

Fig. 2. Laboratory setting.

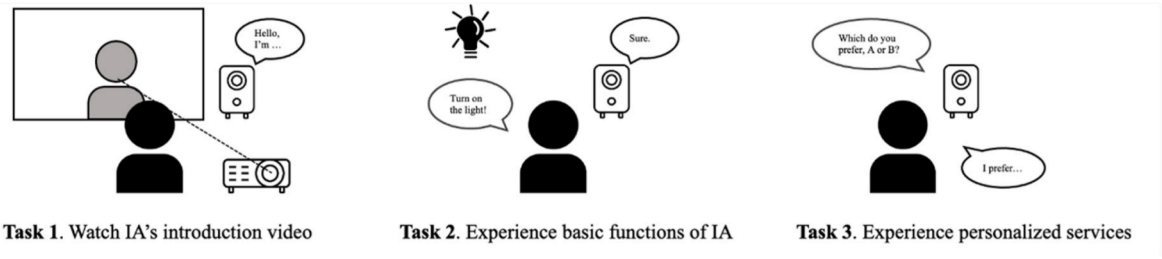

Fig. 3. Three experimental tasks.

Table 2
Question samples of task 3.

Personalized service	Required information type	Question samples
Restaurant recommendation	Interests	Which do you prefer, Chinese food or Western food?
Finance consulting	Money	How much is your monthly expenditure on food, above 3000 or below 3000 RMB?
Emotional ease	Personality	Do you feel stressed when talking in public?
Dietary recommendations	Body	What are your height and weight?
Study/Work tips	Work/study	How long do you spend studying/working each week?

asked to answer post-task questionnaires and attend a brief interview.

2.3. Measurements

Anthropomorphism. The perceived anthropomorphism level of IAs was measured to test humanness cues. The study adopted the scale reported in a previous study on human-like robots, which includes three items (Bartneck, Kulić, Croft, & Zoghbi, 2009). The scale was validated and determined to be reliable (Bartneck et al., 2009), and exhibited adequate consistency in our sample.

Relative status. To test the manipulation of two social roles (servant and mentor), the perceived relative status of IAs was measured. The questions were generated from a study on anthropomorphic brand design (Lin & Huang, 2018). The adapted scale included three items and exhibited suitable consistency in our sample.

Emotional attachment. The present study adopted a one-dimensional scale (Jiménez & Voss, 2014), which included four items to determine the emotional attachment. The scale exhibited adequate convergent validity and reliability in the prior study as well as our sample.

Satisfaction. The users' service encounter satisfaction was measured based on four self-generated statements regarding IA's performance. The satisfaction scale of self-disclosure exhibited sufficient convergent validity and reliability in our sample.

Social presence. The present study evaluated the user-perceived social presence of the IoT value-added services (VAs) using a short questionnaire that was adapted from a previously proposed social presence scale (Yoo & Alavi, 2001). The short version of the questionnaire has been validated and determined to be reliable in prior studies (Tibert et al., 2014; Yoo & Alavi, 2001); the same was observed in our sample.

Self-disclosure. A new self-disclosure questionnaire was generated, which included the self-disclosure tendency of five types of information, namely interests, work, money, personality, and body. The self-generated scale of self-disclosure exhibited suitable convergent validity and reliability in our sample.

Privacy concern. The present study adopted the scale reported in a previous study on online privacy trade-off, which includes three items (Dinev et al., 2013). The website items were replaced with IA items, and the scale was factorially unidimensional and internally consistent in our sample.

Validity and reliability analyses of the questionnaires used the package semTools in the computing environment R version 4.0.3 to compute Cronbach's alpha, composite reliability, average variance extracted (AVE), and factor loadings (Table 3). Cronbach's alphas and composite reliabilities were higher than the suggested cut-off value of 0.70, indicating that the measurements were reliable. Convergent validity was investigated by analyzing the AVE values and factor loadings. Ideally, the AVE values should be greater than 50%, whereas factor loadings should exceed 0.5 to be considered practically significant. Both these criteria were satisfied, verifying that the convergent validity was ensured.

2.4. 2.4 data analysis

All statistical analyses were performed using the computing environment R version 4.0.3. Two-way ANOVAs were conducted using the package "stats" (Chambers, Freeny, & Heiberger, 1992). As satisfaction and disclosure data do not follow the normal distribution, the function "bcpower" in package "car" was used to perform the box-cox transform to modify them to normal distribution (Yeo and Johnson, 2000). The correlation and mediation analyses were performed using the packages "stats" and "mediation" in R (Tingley, Yamamoto, Hirose, Keele, & Imai, 2014).

To assessed common method bias (CMB), Harman's single-factor test using the un-rotated principal component analysis was employed (MacKenzie & Podsakoff, 2012; P. M. Podsakoff, MacKenzie, Lee, & Podsakoff, 2003; Philip M. Podsakoff & Organ, 1986). The results indicated that first five eigenvalues were greater than 1.40. The five-factor accounted for 75% of the total variance, and one single-factor accounted for 39% of the variance, which is lower than the suggested 50% threshold (P. M. Podsakoff et al., 2003). In addition, the results of common latent factor test showed that the common factor variance is 14%, which is also lower than the suggested 50% threshold(P. M. Podsakoff et al., 2003). Therefore, these results suggest that CMV does not pose a serious threat to the study validity.

3. Results

3.1. Manipulation testing

The present study performed a 2 × 2 between-group experiment, considering anthropomorphism level (human or robot) and relative status (mentor or servant). A *t*-test on perceived anthropomorphic robots yielded the expected effect, wherein IA in the human condition received higher scores in anthropomorphism than in the robot condition; $t(57.67) = 3.67$, $p < 0.001$. Moreover, IA in the mentor condition received higher scores than the servant condition in the social-role ranking, $t(46.79) = 4.41$, $p < 0.001$.

Table 3
Convergent validity and reliability statistics considering 64 participants.

Construct	Items	α	CR	AVE
Anthropomorphism (Bartneck et al., 2009)	ANT-1: machine-like (1)/ human-like (7) ANT-2: unconscious (1)/ conscious (7) ANT-3: artificial (1)/life-like (7)	0.90	0.90	0.75
Relative status	RS-1: subordinate (1)/peer (7) RS-2: servant (1)/mentor (7) RS-3: obey me (1)/help me (7)	0.94	0.95	0.86
Emotional attachment (Jiménez & Voss, 2014)	EA-1: no emotional bond (1)/ Strong emotional bond (7) EA-2: not emotionally connected (1)/Emotionally connected (7) EA-3: not linked by feelings (1)/Linked by feelings (7) EA-4: no feelings of attachment (1)/Strong feelings of attachment (7)	0.92	0.92	0.76
Satisfaction	SAT-1: I am satisfied with the service SAT-2: I think the communication with IA is pleasant. SAT-3: I will recommend it to others. SAT-4: I will use it again.	0.90	0.91	0.71
Privacy concern (Dinev et al., 2013)	PC-1: I do not feel comfortable with the type of information the IA requests from me. PC-2: I felt that these websites gather highly personal information about me. PC-3: the information I provide to the IA is extremely sensitive.	0.81	0.82	0.60
Disclosure	DSC-1: I am willing to disclose my daily route. DSC-3: I am willing to disclose my tastes in music. DSC-4: I am willing to disclose my monthly revenue and expenditure. DSC-8: I am willing to disclose information related to my health. DSC-10: I am willing to disclose my negative emotions, such as anxiety	0.91	0.92	0.55
Social Presence (Tibert et al., 2014)	SP-1: I felt a sense of human contact with the IA. SP-2: I felt a sense of personalness with the IA. SP-3: I felt a sense of sociability with the IA. SP-4: I felt a sense of human warmth with the IA. SP-5: I felt a sense of human sensitivity with the IA.	0.89	0.89	0.62

Note: All variables were measured on a 7-point Likert scale.

3.2. Hypotheses testing

Table 4 summarizes the mean values and standard deviations of

Table 4
Mean values and standard deviations of dependent variables in four groups.

	HM		HS		RM		RS	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ant rowhead	3.75	1.33	4.79	1.5	4.97	1.06	3.9	1.65
RS rowhead	5.05	1.34	5.03	1.31	5.85	0.59	4.72	1.59
EA rowhead	3.26	1.3	4.08	1.6	4.29	1.19	3.5	1.39
SAT rowhead	5.12	1.01	5.45	1.42	5.85	0.64	4.84	1.17
SP rowhead	3.91	1.11	4.2	1.37	4.69	0.84	3.51	1.6
DSC rowhead	5.67	0.95	5.59	1.16	6.07	0.75	5.48	0.94
PC rowhead	3.88	1.06	3.81	1.32	3.54	1.4	4.02	1.12

dependent variables calculated in four groups. Two-way ANOVAs was employed to test the main effects and interaction effects of anthropomorphism level and social role on emotional attachment, satisfaction, and self-disclosure (Table 5). The main effects of anthropomorphism level on emotional attachment were significant ($F(1,60) = 4.89$, $p = 0.031$, $\eta 2 = 0.08$), whereas the effect of social role on emotional attachment was not significant ($F(1,60) = 3.39$, $p = 0.070$, $\eta 2 = 0.05$). Participants reported higher emotional attachment towards human-like IA, validating hypothesis 1a. The anthropomorphism level in terms of social role interaction was not significant; $F(1, 60) = 0.14$, $p = 0.714$, $\eta 2 < 0.01$.

A bootstrapping procedure using 5000 bootstrap samples was performed to test the mediating effects of social presence (Table 6). The results indicate that social presence mediated the effects of anthropomorphism level and social role on emotional attachment and satisfaction, validating hypothesis 3. No significant correlation was observed between privacy concern and emotional attachment; $t(62) = -0.28$, $p = 0.745$. However, a significant and negative correlation existed between privacy concern and satisfaction; $t(62) = -2.87$, $p = 0.006$.

As the distributions of satisfaction and self-disclosure did not follow the normal distributions, the original data need to be initially transformed to normal distributions before performing ANOVAs. The main effects of anthropomorphism level on satisfaction were significant ($F(1,60) = 6.82$, $p = 0.011$, $\eta 2 = 0.10$), and participants reported higher satisfaction towards human-like and mentor IAs, validating hypothesis 1b and hypothesis 2b. Similarly, the main effect of social role on satisfaction was also significant; $F(1,60) = 5.34$, $p = 0.024$, $\eta 2 = 0.08$. The interaction effect between anthropomorphism level and social role interaction on satisfaction was significant as well; $F(1,60) = 4.72$, $p = 0.034$, $\eta 2 = 0.07$. The impact of social role on satisfaction was more significant in the low-anthropomorphic group than the high-anthropomorphic group. In other words, the participants reported higher satisfaction towards the robot-mentor IA than the robot-servant IA.

hypothesis 4 and *hypothesis 5* predicate the negative effects of anthropomorphism and mentor role on users' disclosure tendency. The obtained results indicate that the main effects of anthropomorphism level and social role on self-disclosure were not significant, invalidating *hypothesis 4* and *hypothesis 5*. However, interaction effects on self-disclosure were significant; $F(1,60) = 12.33$, $p < 0.001$, $\eta^2 = 0.17$. In other words, participants reported a higher disclosure tendency to a servant IA than a mentor IA in the high-anthropomorphic group, whereas the disclosure tendency towards mentor IA was higher than that towards servant IA in the low-anthropomorphic group. Fig. 4 illustrates the interaction plots. The results of the mediation analysis did not identify the significant mediating effect of privacy concerns on the disclosure. As the current study did not determine the main effects of anthropomorphism level and social role on privacy concerns, any mediating effect on dependent variables was not identified. Therefore, hypothesis H6 was not verified. Interestingly, there is a significant negative relationship between privacy concern and disclosure; $t(62) = -3.58$, $p < 0.001$. Additionally, a significant positive relationship was identified between social presence and disclosure; $t(62) = 2.01$, $p = 0.049$.

Table 6
Mediating effect of social presence and immersion on emotional attachment.

Mediation path	ACME	95% Confidence intervals		P value
		LL	UL	
Anthropomorphism level→ SP→EA	0.62	0.07	1.17	0.028
Social role→ SP→EA	0.99	0.44	1.58	<0.001
Anthropomorphism level→ SP→SAT	0.46	0.08	0.88	0.024
Social role→ SP→SAT	0.71	0.29	1.17	<0.001
Anthropomorphism level → PC→DSC	0.06	−0.10	0.22	0.46
Social role→ PC→DSC	0.04	−0.06	0.24	0.54

4. Discussion

A 2 × 2 laboratory experiment was conducted to explore the influence of anthropomorphic design of IAs on user–agent communication, including emotional attachment, satisfaction, and information disclosure. This section analyzes these dependent variables individually.

4.1. Emotional attachment and satisfaction

hypothesis 1a states that participants perceive higher emotional attachment towards IA in the experiment in the high-anthropomorphism condition than the low-anthropomorphism condition; the results supported this hypothesis. This result is consistent with those reported in previous studies on anthropomorphic robots. For instance, a study on intimate home appliances reported that users establish an intimate relationship with home cleaners and experience fun by adding cartoon features to them (Sung, Guo, Grinter, & Christensen, 2007, September). As both machine-like and human-like cues were used to manipulate different anthropomorphism levels in our experiment, the result can be interpreted as follows: participants are more likely to establish emotional attachment with agents sharing human identity rather than those with robot identity. Moreover, previous studies have reported that people are more likely to establish intimate relationships with agents exhibiting identities similar to their own (Hornsey, 2008; Worchel, Rothgerber, Day, Hart, & Butemeyer, 1998). Thus, the results obtained in the current study are consistent with those reported in previous studies.

Although participants reported higher average emotional attachment towards mentor IA than servant IA, the difference was not sufficiently significant to support *hypothesis 2a*. However, the interpretation can be made as follows: although different social roles were set to

Table 5
Results of the two-way ANOVA on emotional attachment, satisfaction, and disclosure.

Effect	EA			SAT			DSC		
	F	P	η^2	F	P	η2	F	P	η^2
Anthropomorphism level	4.89	0.031	0.08	6.82	0.011	0.10	0.12	0.729	<0.01
Social role	3.39	0.070	0.05	5.34	0.024	0.08	2.08	0.155	0.03
Anthropomorphism level × Social role	0.14	0.714	<0.01	4.72	0.034	0.07	12.33	<0.001	0.17

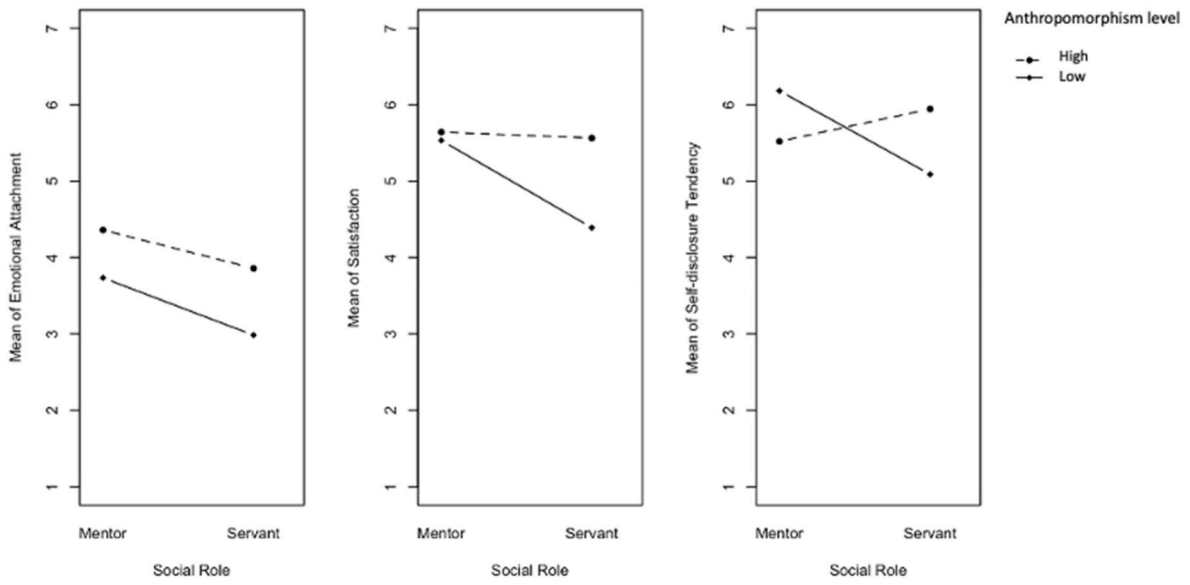

Fig. 4. Interaction impacts of anthropomorphism and relative status on a) emotional attachment, b) satisfaction, and c) self-disclosure.

correspond to the relative status, users remain in a relatively dominant position in the smart home scenario.

Furthermore, social presence is a positive and significant mediator between anthropomorphic design and emotional attachment, validating *hypothesis 3a*. This is consistent with the results reported by a study on virtual agents that social presence is crucial in shaping agent-mediated services (Tibert et al., 2014).

In addition to emotional attachment, service satisfaction was included in our study. *hypothesis 1b* and *hypothesis 2b* were both validated as participants reported higher scores in satisfaction considering human and mentor agents. Interestingly, the interaction effect on satisfaction between anthropomorphism level and social role is significant. Participants preferred mentor identity when interacting with a robot-like agent, whereas the difference between human-mentor and human-servant was insignificant. This can be attributed to the robot-servant agent serving more as a tool than a peer, leading to users preferring a peer rather than an inanimate tool in agent-mediated communication. This explanation was verified because social presence played a positive and significant mediating role between anthropomorphic design and emotional attachment.

4.2. Disclosure tendency

Information disclosure is essential in personalized service and intimate relationship establishment. *hypothesis 4* states that anthropomorphic features can prevent participants from disclosing information, whereas *hypothesis 5* states that participants tend to disclose more to a servant than a mentor. However, an interaction effect between anthropomorphism level and social role indicated that participants tend to disclose more to a human agent than a robot agent in the servant condition, which contradicts our hypothesis. This can be attributed to multiple reasons. For instance, previous studies reported that users tend to apply stereotypes of social identities, such as age and gender, to computer actors (Nass et al., 1994; 1997). This is because linguistic cues serve as identity cues to induce users' trust and perceived social presence (Edwards et al., 2019). Moreover, a study reported that agents can induce higher social presence when the synthesized voice is matched with the textual content (Lee & Nass, 2003, April). As users may maintain stereotypes, such as "inanimate" or "emotionless" about the mechanical voice in the robot-servant condition, the combination of robot voice and words of respect may sound unusual to participants. Therefore, participants reported the lowest social presence among the four groups in the robot-servant condition. According to a previous study, participants prefer communicating with agents of higher social presence than inanimate tools (Widener & Lim, 2020). Therefore, the disclosure tendency towards the robot-servant IA was the lowest. Another reason can be that the robot-servant agent aroused the highest privacy concern, which was negatively correlated to users' disclosure tendency. Therefore, the disclosure tendency was lower in the robot-servant condition than that in the robot-mentor condition.

The analysis of interaction effects indicated that users maintain different expectations from agents with different levels of anthropomorphism. This conclusion was consistent with Dautenhahn's theory on socially intelligent robots, which explains that users' evaluation of robots' social abilities is influenced by robot roles (Dautenhahn, 2007). Therefore, users tended to disclose more personal information to agents who exhibited matched anthropomorphic traits with social roles during communication.

4.3. Implications and limitations

The development of artificial intelligence has deeply integrated IAs into people's daily lives. Anthropomorphic IA designs can aid users in understanding the mental model of human–agent interaction and reduce the intrusiveness of new technology. According to the CASA theory, users substitute the social manners of human beings to the interaction with anthropomorphic IAs.

Previous studies on anthropomorphic IAs focus on the embodiment and social manners of IAs; however, their social identity is not sufficiently investigated. The social identity of the agent, such as age, gender, race, and relative status, is also critical to the user–agent interaction in anthropomorphic IAs. Therefore, the present study included the social role of agents in research variables and identified diverse impacts of social roles on subjective evaluations. Additionally, the findings highlight the importance of matching traits with roles in anthropomorphic designs. The current study also discussed the importance of social presence and privacy concerns between anthropomorphic design and subjective evaluation. The mediating analysis explains the theoretical foundation of anthropomorphic design and describes the operation of CASA theory in agent-mediated service.

Certain limitations of the present study can be summarized as follows. First, it adopted both visual and linguistic cues in anthropomorphism manipulation, which exhibited diverse impacts on social perception and disclosure. Therefore, further investigations are

necessary to explore the different impacts of visual and linguistic anthropomorphic cues on disclosure in agent-mediated communication. Second, the individual differences, such as self-construal and acceptance of technology, were not considered in the current study. Future research is required to explore the potential individual traits that influence user perceptions of anthropomorphic agents.

5. Conclusions

Anthropomorphic IAs, ranging from non-embodied conversational agents to physical robots, are playing an increasingly important role in people's daily lives. According to the CASA theory, users will unconsciously regard anthropomorphic IAs as humans and develop further intimate relationships with them. Additionally, anthropomorphic IAs can play various social roles, including peers, subordinates, and superiors. Previous studies have extensively discussed the benefits and drawbacks of anthropomorphic agents. However, they placed more emphasis on the consistency of tangible cues, such as visual and linguistic cues. The current study aimed to investigate further the social role in anthropomorphism design, an abstract concept concealed in the tangible cues.

Based on existing studies on anthropomorphic agents, the present study summarized two dimensions of anthropomorphism design: anthropomorphism level and social role. Furthermore, it proposed six main hypotheses and measured both the direct and interaction effects of anthropomorphism level and the social role in terms of emotional attachment, satisfaction, and self-disclosure. *Hypotheses 1* and *2* were supported by the results of an ANOVA test indicating that human features and equal status (i.e., mentor role) can increase the emotional attachment and satisfaction towards anthropomorphic IAs. In addition, the results of the mediation effect supported *hypothesis 3a*, that designers can promote users' emotional attachment to IAs by enhancing the social presence of IAs. This finding provides new guidance for the design of IAs for emotional support. In addition to a high level of anthropomorphism, appropriate social roles, such as an equal status relationship between friends, also enhance the social presence of intelligent agents, which in turn promotes interpersonal intimacy.

Regarding information disclosure, the experimental results did not provide solid evidence to support hypotheses 4, 5, and 6. Although the main effects of anthropomorphism level and social roles were not significant, anthropomorphism level in terms of the social role was identified as a critical factor in eliciting user disclosure tendency in personalized services. In addition, reported privacy concerns significantly inhibited information disclosure, while the social presence of IAs significantly promoted it. Therefore, designers should focus more on how to improve social presence and lessen users' privacy worries while designing IAs that aim to provide personalized services. Designers must consider not only the synchronization of tangible cues (such as visual or linguistic anthropomorphic cues) but also their coordination with abstract concepts (e.g., social roles). Users would be less willing to reveal personal information in inappropriate pairings, such as the mechanical design with low-status social identification used in the experiment. Further studies on the synchronization of diverse dimensions in anthropomorphic design are needed.

The development of virtual imaging technology and artificial intelligence technology suggests a near future in which IAs will occupy social roles from servants to mentors or even superiors to users. Therefore, matching anthropomorphism cues and the social role is critical to achieving a specific purpose, like establishing an intimate human–agent relationship. The present study established clear benefits of proper anthropomorphism design in the human–agent relationship.

Additionally, the study discussed the theoretical complexity of individuals' psychological, attitudinal, and behavioral responses to the agent. The results indicate that designers can promote the user–agent relationship by improving the social presence of agents during human–agent communication. The current study provides important groundwork for continued research on the human–agent relationship. Furthermore, it developed an experimental setting where participants could establish an intimate relationship with IAs by disclosing personal information. It is suggested that anthropomorphic IAs have the potential to achieve emotional feedback and become social companions.

Declaration of competing interest

The author(s) has/have declared that there are no competing interests.

Funding

This work was supported by the National Key R&D Program of China under Grant [2018AAA0101702].

Credit author statement

Andong Zhang Conceptualization, Methodology, Software, Investigation, Writing -Original draft preparation, Writing – review & editing. **Pei-Luen Patrick Rau**Conceptualization, Resources, Supervision, Project administration, Funding acquisition

Data availability

Data will be made available on request.

Acknowledgments

None.

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