



Trust in Service Robot: the Role of Appearance Anthropomorphism

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ABSTRACT

An increasing number of hotels and restaurants are using service robots as front-line employees, yet the lack of customer trust in service robots affects the service experience. To enhance trust, companies have added anthropomorphic designs for service robots. The purpose of this paper is to investigate the potential mechanisms and boundary conditions for the effect of the appearance anthropomorphism of service robots on customer trust. Based on interpersonal attraction theory, this study conducted five laboratory experiments to explore the process by which an artificial intelligence's appearance anthropomorphic features affect trust. The results show that customers are more likely to trust service robots with a higher degree of appearance anthropomorphism. The anthropomorphic appearance of service robots affects three dimensions of interpersonal attraction, namely physical attraction, task attraction and social attraction, which in turn affects customer trust. In addition, customers' technology readiness moderates the effect of service robot anthropomorphism on interpersonal attraction. This paper enriches the theoretical explanation of the design and application of service robot anthropomorphism, develops research on customer trust in service robots, and provides guidance for marketing practices of service robots.

Keywords: Service robots; Anthropomorphic; Trust; Interpersonal attraction

1. Introduction

With the development of artificial intelligence (AI) and automation, the tourism and hospitality industries are increasingly introducing service robots to facilitate the service process (Tuomi et al., 2021). Service robots provide a human robot interaction (HRI) experience in a service delivery environment and benefit merchants by facilitating novel, fun and flexible interactions with customers (Choi, 2021; Kervenoael et al., 2020). In labor-intensive industries such as tourism and hospitality, service robots are expected to constitute the workforce of the future (Alexis, 2017). The International Foundation of Robotics predicts that the market for service robots will reach \$63.8 billion by 2025 (IFR, 2021).

The widespread use of service robots has changed the traditional service interaction model and improved efficiency, but it may also result in the value co-destruction of the interactive experience under the service-driven logic (Čaić et al., 2018). Research shows that AI affects consumers' perceived service quality, which in turn affects consumer satisfaction (Qin et al., 2022). A key factor of service robots affecting consumer experience is the lack of consumer trust (Everett et al., 2017). Trust is a strong determinant of willingness to use a service through enjoyment (Wu and Chang, 2005). Previous studies have shown that trust has a positive impact on customers' willingness to use AI technologies (Liu et al., 2022; Chi et al., 2023). If consumers do not like or intend to use service robots, cost savings and profits will remain unexploited (Allmendinger and Lombreglia, 2005; Bitner, 2001). Extant research provides little insight into the drivers of trust in service robots (Pinxteren et al., 2019), and how to increase consumer trust in service robots is a pressing issue for service companies to address today.

Previous research on the field of AI has found that anthropomorphism is one of the important features that influence users' trust in AI technologies (Lu et al., 2019). Research has shown that anthropomorphism has a positive effect on trust (Verberne et al., 2015; Kiesler et al., 2008; Luo et

al., 2006; Richards and Bransky, 2014; Waytz et al., 2014). This evidence has driven the development of humanoid robots with human-like facial expressions, voices, and names (Fink, 2012), but it is unclear which features most increase trust. Some studies have found that a product is more likely to stimulate anthropomorphic tendencies in users if it looks more similar to human appearance or has human facial features (Delbaere, 2011), and anthropomorphic appearance can increase consumer trust in robots (Leite et al., 2013, Yao Song, 2021). It has also been confirmed that industrial robot anthropomorphism not only did not show a positive effect on trust, but also distracted participants from the relevant task domain (Onnasch et al., 2021). The combined analysis revealed that the potential mechanisms by which anthropomorphism affects trust and the boundary conditions have not been explored. Furthermore, the positive impact of robot anthropomorphism on trust is limited to certain application domains, and the results need further validation in service industries where human interaction is intensive.

Therefore, this study explores in depth the potential mechanisms by which the anthropomorphic features of the service robot's appearance affect trust from the consumer's perspective. Based on the context of human-robot interaction, this paper introduces interpersonal attraction theory, which attributes the process by which the appearance anthropomorphic features of AI affect trust to three basic dimensions of human-robot attraction, namely, appearance attraction, task attraction, and social attraction. In addition, we analyze the boundary conditions of the impact of appearance anthropomorphic features of AI on trust from the perspective of technology readiness.

2. Theoretical background

2.1. Service robots and anthropomorphism

Service robots refer to interactive robots equipped with AI that are systematic, autonomous, and flexible, capable of interacting and communicating with businesses and customers and performing certain service tasks (Wirtz et al., 2018). Service robots offer various benefits to labor-intensive service industries, such as restaurants (Cristou et al., 2020). Restaurants can use robots to perform different tasks, including providing information, taking orders, serving food and drinks, cooking food, greeting and entertaining guests, moving items, and cleaning. The use of service robots during a pandemic can reduce the risk of food contamination and protect the health of FLEs from the spread of infection (Seyitoğlu and Ivanov, 2020). Service robots can be either physical or virtual. In the context of this study, we excluded virtual bots (e.g., online chatbots) and focused mainly on physical bots, which are service bots that provide services as front-line employees.

Service robots combine anthropomorphism with a higher level of automation and can perform more intelligent tasks than traditional ICT (Xiong et al., 2021). Anthropomorphism refers to the possession of human characteristics in non-human entities, which include psychological characteristics (emotions, personality, gestures, etc.) as well as non-psychological characteristics, such as the presence of physical similarities to the human body (e.g., head, eyes, arms, legs, etc.) (Keeley, 2004). Anthropomorphism helps to increase the acceptance of robots by human users, and the more human characteristics a robot exhibits, the more attractive it looks, and the more outgoing and cheerful it behaves, the more people will accept it (Goetz et al., 2003). In prior research on anthropomorphic traits, anthropomorphic traits depicted using visual or verbal language can evoke human consensus (Hood, 1995) and consequently influence human judgment and behavior. The anthropomorphism of service robots is mainly reflected in the morphology

(appearance) and behavior (e.g., movement and interaction) of the robot. Robotics uses such mechanisms to increase robot acceptance and facilitate human-robot interaction (Kim et al., 2019). Numerous studies have validated the positive impact of appearance anthropomorphism. For example, Leite et al. (2013) suggested that anthropomorphic appearance facilitates consumers' trust in robots, promotes long-term relationships with robots during human-robot interaction (Damiano and Dumouchel, 2018), and gives more praise and less criticism of robots, reducing vandalism and insulting behavior towards robots (Bartneck et al., 2006; Rehm and Krogsager, 2013). With the continuous development and evolution of technologies such as artificial intelligence, more and more restaurants are introducing service robots to serve their customers, and the appearance of the service robots used in restaurants varies. In the restaurant service context, how does the anthropomorphic appearance of service robots affect the judgment and behavior of customers?

2.2. Trust

Trust is an important component of interpersonal interactions that influences people's decisions about the behavior of others in personal and organizational settings, and trusting others also implies taking the risk of suffering harm from the other person's behavior (Schroeder et al.,2018). In the age of intelligence, trust also plays an important role in the interaction between humans and intelligent machines (Liu et al., 2022). Trust in technology is defined as an attitude or belief that the technology (e.g., service bots, recommendation agents, automated online chatbots, and websites) can help users achieve their desired goals (Tussyadiah et al., 2020).

Previous research has shown that trust has a positive effect on users' attitudes and willingness to adopt a new technology product (Kaushik et al., 2015; Tussyadiah et al., 2020; park, 2020). With the innovation and development of technology, machine services will become more and more accepted by the general public, thus enhancing customers' trust in service robots is key to this process. In the field of human-computer interaction, anthropomorphism is considered a strong determinant not only of user preference but also of perceived trust (Duffy, 2003, Brave et al., 2005; Kiesler et al., 2008; Luo et al., 2006; Richards and Bransky, 2014; Waytz et al., 2014). It was found that anthropomorphic driverless cars are given more trust and tolerance than non-anthropomorphic driverless cars (Waytz et al., 2014); similarly, robots with anthropomorphic features are trusted more (Leit et al., 2013). These findings all indicate the effective role of anthropomorphism in enhancing trust in the AI domain. However, Onnasch et al. (2021) found in their study of industrial human-robot interaction that anthropomorphism did not have a beneficial effect and even had a negative impact on the perceived reliability of the robot. In fault-free interactions, trust behavior was not significantly affected by the anthropomorphic robot design, but there was a relatively large decrease in trust behavior after participants experienced a malfunction of the robot. This shows that no consistent conclusions have been reached in the research on the effects of robot anthropomorphism on customer trust. Does service robot appearance anthropomorphism affect customer trust during service encounters? In summary, this paper explores the mechanism and boundary conditions of the influence of the degree of service robot appearance anthropomorphism on customer trust, using restaurant service as a context.

2.3. Interpersonal attraction theory

Interpersonal attraction refers to the tendency or propensity of individuals to evaluate others or symbols of others in a positive (or negative) way (Berscheid & Hatfield, 1978). Individuals are more inclined to communicate with another individual who is perceived to be more attractive, and this communication promotes the formation of intimate relationships (Rubin & Mchugh, 1987). Interpersonal attraction is a determining factor in the development and continuation of relationships in the social environment of human interaction (Çolak & Kobak, 2011). Interpersonal attraction has different dimensions and can be divided into three components, namely task attraction, social attraction, and appearance attraction (McCroskey and McCain, 1974). Task attraction indicates how easy it is to handle something, social attraction is based on socially or personally preferred attributes, and physical attraction is attributed to perceived appearance (Han & Yang, 2018).

Interpersonal attraction applies not only to human interaction contexts, but also to the domain of human-robot interaction. In the field of consumer behavior and artificial intelligence, there are very few results linking anthropomorphism and interpersonal attraction. In a study on intelligent speech, Edwards et al. (2019) explored the positive impact of age identity on its task attraction and social attraction. In a study on virtualization, owak & Rauh (2005) found that anthropomorphic features of vision positively influenced interpersonal attraction and trust. Hellen and Sääksjärvi (2013) noted that people's cognitive attitudes, behaviors, and reactions change when they interact with robots with different appearance images, and as the anthropomorphism of the robot's appearance increases, people perceive the robot to be more intelligent and smart. It can be seen that the anthropomorphic appearance of service robots affects customers' perceptions of interpersonal attraction and, consequently, their perceptions of trust. Therefore, this study explores the potential mechanisms by which service robot appearance anthropomorphism affects customer trust in terms of three basic dimensions of interpersonal attraction, namely: physical attraction, task attraction, and social attraction.

3. Research Model and Hypothesis

3.1. Appearance anthropomorphism and trust

The theory of social information processing (TIP) suggests that customers will self-process the signals sent by the actor and then use them to guide the corresponding behavior (Tybout, 1981). Under different task situations, individuals will actively identify the specific cues that are most important to them to satisfy their social needs. When communicating with others or objects, customers will evaluate and judge the cues and information presented by the interactive objects according to their own social experience, and make behavioral feedback that is consistent with that judgment (Low, 2001). The anthropomorphism of service robot, as a human-like social information cue, can affect the behavior of customers. Individuals will make anthropomorphic reasoning on service robots because of the humanoid characteristics observed, so as to treat service robots as humans for attribution and response (Waytz, 2014). It has been shown that objects with human facial features and overall appearance tend to be more likely to stimulate anthropomorphic perception in individuals (Wang & Xie, 2014), which in turn influences people's judgment and behavior (Yu & Xu, 2020). Leite et al. (2013) suggested that anthropomorphic appearance is beneficial to increase consumers' trust in robots. Hancock et al. (2011) argued that appearance features associated with the robot itself are important for building trust with users. The

study by You et al. (2018) further shows that the more similar a robot's appearance is to human appearance, the easier it is to gain trust, that is, the appearance similarity between a robot and a human promotes trust in robots. Based on this, this study proposes:

H1: Compared with low degree of anthropomorphism, customers have higher degree of trust in high degree of anthropomorphism service robots

3.2. The mediating role of physical attraction

Physical attraction is based on “dress and physical features” (McCroskey and McCain, 1974). In this paper, physical attraction refers to the user's perception of the service robot's appearance and physical characteristics. The factors that influence interpersonal attraction are the static attributes and features that exist in others first (appearance, personality, socioeconomic status), and then the dynamic processes that arise when we interact with others (familiarity, reward, proximity). Not only do people prefer physically attractive people more, but they also tend to perceive a sense of familiarity with physically attractive people (Monin, 2003). Many studies have shown that the visual attraction of a product is an important factor in users' emotional affinity with a product. Yang et al. (2016) and Cyr et al. (2006) showed that visual attraction has a positive effect on perceived enjoyment. Nanda et al. (2008) reported the positive effect of visual elements of smartphones on users' emotional reactions and preferences for specific products. If the appearance of a product is more similar to human appearance or has human facial features, it is more likely to stimulate the anthropomorphic tendency of users (Delbaere et al., 2011). Nowak & Rauh's (2005) research on virtualization shows that the anthropomorphic features of vision have a positive impact on interpersonal attraction and trust. Therefore, this paper argues that appearance anthropomorphism enhances the appearance attraction of service robots, which in turn enhances customers' perception of trust in service robots.

H2: Physical attraction mediates the relationship between the degree of service robot anthropomorphism and customer trust. Compared with the low degree of anthropomorphism, customers perceive the physical attraction of high degree of anthropomorphism service robots to be higher.

3.3. The mediating role of task attraction

Task attraction is generally considered the degree to which it is easy or valuable to work with someone (Bekiaris et al., 2016). In this study, task attraction refers to the customer's perception of the service robot's ability to complete a given task and its reliability as a working partner. Studies have shown that anthropomorphic design of machines can produce certain expected effects (Hur et al., 2015; Kim et al., 2016). With the increase of anthropomorphic appearance of robots, people's perceived intelligence level of robots also increases (Hellen et al., 2013). Trust is a multidimensional concept that reflects the perceived competence, integrity, and benevolence of another entity (Mayer et al., 1995). When humans attribute human capabilities, such as rational thought and emotion to a robot, the perception of the robot's ability to perform the intended function is enhanced (Duffy, 2003). For example, Gong (2008) showed that avatars with a more human-like appearance were perceived to be more capable of making decisions and more

trustworthy. Haring et al. (2016) found that, compared with non-anthropomorphic robots, consumers tend to think that robots with anthropomorphic characteristics have a higher level of perceptual intelligence. Although this level of perceived intelligence decreases after interaction with the robot, it is still higher than that of the non-anthropomorphic robot. Therefore, this study concludes that appearance anthropomorphism increases the customer's perception of the service robot's ability to complete tasks, which in turn increases the customer's perception of trust in the service robot.

H3: Task attraction mediates between the degree of service robot anthropomorphism and customer trust. Compared with the low degree of anthropomorphism, customers perceive the task attraction of high degree of anthropomorphism service robots to be higher.

3.4. The mediating role of social attraction

Social attraction is the degree to which an individual is liked by society or individuals (Bekiaris et al., 2016). In this article, social attraction refers to the willingness of the user to communicate or become friends with the service robot. Previous studies have found that in terms of appearance design, doll faces, small body size, feminine or toddler designs enhance the degree of cuteness of a product (Gorn et al., 2008; McVeigh 2000). The more humanized the robot is, the more attractive it is in appearance, and the more extroverted it is in behavior, the more people will accept the robot (Goetz et al., 2003). In a study of the social robot pet AIBO, Lee et al. (2006) found that anthropomorphic features increased participants' assessments of intelligence and social attraction. Therefore, this study concluded that appearance anthropomorphism enhanced the social attraction of the service robot, which in turn enhanced customers' perceptions of trust in the service robot.

H4: Social attraction mediates between the degree of service robot anthropomorphism and customer trust. Compared with the low degree of anthropomorphism, customers perceive the social attraction of high degree of anthropomorphism service robots to be higher.

3.5. The moderating Role of technology readiness

Technology readiness is defined as the propensity of individuals to accept, adopt and use new technologies in order to achieve their goals in any aspects of family life and work (Parasuraman and Colby, 2015). Technology readiness can be viewed as an overall psychological state that results from a gestalt of psychological enablers and inhibitors that together determine a person's propensity to use a new technology. Different perceptions of the same new technology can exist due to differences in people's knowledge of and reactions to the technology (Mick and Fournier, 1998), and such perceptions can trigger both positive and negative emotions.

Currently, the specific applications of robotics and artificial intelligence technologies are relatively new and advanced technology applications. However, both robotics and artificial intelligence technology have been developed for decades. People have been more or less familiar with robots through various science materials and television. As ordinary consumers, some people know more about robotics and AI technology, have more relevant knowledge reserves, and pay less attention to the appearance and behavior of robots; while some consumers have less knowledge reserves related to robotics and AI technology, and will pay attention to the external characteristics of robots in the first place when receiving robot services. Differences in consumers'

technology readiness can make a difference in the degree of interpersonal attraction that consumers perceive in service robots.

H5: Technology readiness moderates the effect of service robot appearance anthropomorphism on customers' interpersonal attraction perception. Specifically, for consumers with low technology readiness, the impact of high anthropomorphism on customer interpersonal attraction perception is significantly higher than that of low anthropomorphism. For consumers with high technology readiness, there is no significant difference between high anthropomorphism and low anthropomorphism on customer interpersonal attraction perception.

In summary, the theoretical framework model shown in Figure 1 is constructed in this paper.

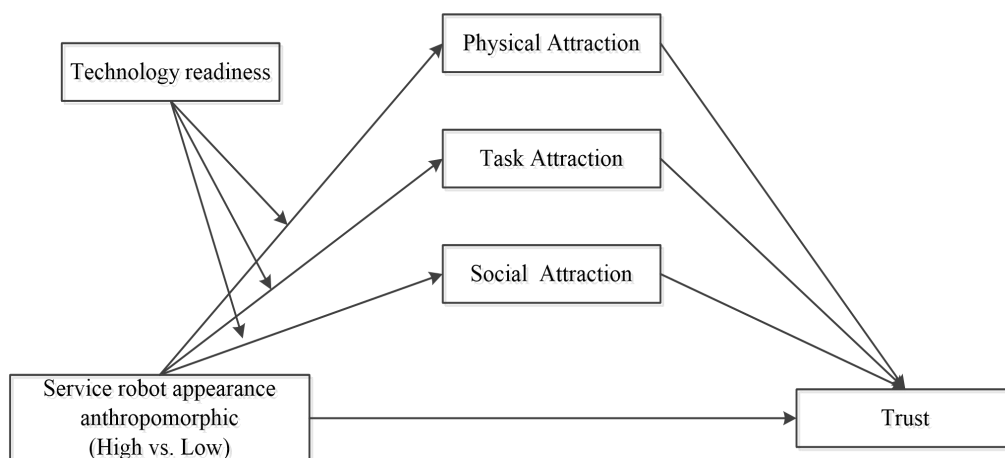


Figure 1. Theoretical model.

4. Research Method

In this paper, a laboratory experimental method was used to collect data and thus to test our research hypothesis. Based on the appearance design perspective, this study analyzes the relationship between the degree of anthropomorphism of service robots and customer trust and its underlying mechanism through a pretest and three experiments in the restaurant service industry.

4.1. Pretest

The purpose of the pretest was to demonstrate that the anthropomorphic manipulation was effective. Before the formal experiment, 50 students (56% female; Mage = 20.5 years) were recruited to rate the anthropomorphic appearance of two different service robots. Participants were shown pictures of two service robots in Figure 2 and Figure 3, which are the most commonly used restaurant service robots. After viewing the images, the participants rated the degree of anthropomorphism of the two robots on a 7-point scale. The results of the analysis showed that the appearance anthropomorphism score of the service robot in Figure 2 was significantly lower than the anthropomorphism score of the service robot in Figure 3 ($M_{low} = 2.04$ vs. $M_{high} = 5.48$; $F(1, 98) = 200.78$, $p < 0.001$), indicating that participants were able to identify service robots with different degrees of appearance anthropomorphism and that the anthropomorphism manipulation was effective.



Figure 2 service robots1



Figure 3 service robots2

4.2. Study 1

Method

Study 1 used a one-factor (service robot appearance anthropomorphism: high vs. low) between-subjects experimental design, and the service scenes of service robots with different degrees of anthropomorphism were presented through picture and text scenario simulation method. We continued to use the appearance of the two service robots from the pretest in Figure 4 and Figure 5, but the experimental situation was determined to be a familiar restaurant dining situation so that the subjects could quickly immerse themselves in the situation. Participants were asked to imagine the following scenario based on the illustration: You and your friend come to a restaurant to eat, and the service robot in this restaurant will guide you to the appropriate seat and provide you with the order and recommendation service.



Figure 4 Low appearance anthropomorphic scenes



Figure 5 High appearance anthropomorphic scenes

A total of 76 full-time students from a Chinese university were invited to participate in the experiment, including 36 males and 40 females, with an average age of 20 years. Participants were randomly assigned to two experimental groups (service robot appearance anthropomorphism: high vs. low). After reading the picture and text messages, participants answered questions to measure their trust in the service robot. The measurement of customer trust is based on the research of Nunamaker et al. (2011). There are four items in total, and the measurement items are “I trust this service robot” “I will follow the advice given by the service robot” “I believe that the service robot can perform its duties well” “I believe that the service robot will understand me better after constant communication and interaction” . Likert 7-point measurement method was adopted for all

measurements (1 represents strongly disagree, 7 represents strongly agree). Finally, participants were asked to fill in statistical information such as gender and age.

Results

We first used SPSS22.0 software to analyze and process the data, and Cronbach's alpha coefficient was used to test the reliability of the customer trust perception scale. The results showed that the Cronbach's α of the customer trust scale was 0.852, indicating that the scale had a good level of reliability. One-factor ANOVA was then used to examine the difference in customer trust between high and low levels of service robot appearance anthropomorphism. The results of the data analysis showed that there was a significant difference in customer trust between service robot appearance anthropomorphism ($M_{high} = 5.37$, $M_{low} = 4.73$, $F(1, 74) = 11.90$, $p < 0.05$). Gender ($p = 0.12$) and age ($p = 0.289$) had no significant effect on customer trust perceptions. This indicates that customer trust were higher in the high anthropomorphism experimental group compared to the low anthropomorphism experimental group, that is, anthropomorphism effectively promoted customer trust perceptions, and H1 was supported by validation. Study 1 examines the main effects of anthropomorphism and customer trust. In order to further explore the possible intermediary mechanism, study 2, 3 are conducted on the basis of study 1.

4.3. Study 2

Method

The purpose of this study was to explore the mediating role of physical attraction in the effect of service robots appearance anthropomorphism (high vs. low) on trust. The method of study 2 is similar to study 1, but the text description of experiment material is different. Participants were asked to imagine the following scenario based on the illustration: You and your friend come to a restaurant for dinner, and the service robot in this restaurant guide you to the appropriate seat and provide you with the order and recommendation service. More than ten minutes after you order through the service robot, the service robot brings your food and asks you to touch his head after you get the food.

A total of 80 full-time students from a Chinese university were invited to participate in the experiment, including 36 males and 48 females, with an average age of 20.6 years. The measure of Interpersonal attraction was borrowed from Han and Yang's (2018) study, with a total of three dimensions. The measure of physic attraction include three questions, namely "I think this service robot is beautiful" "I find this service robot visually attractive" and "This service robot is well-dressed". The measure of task attraction include three questions, namely "This service robot can help me with my tasks" "I will use the service robot as a partner" "I can get my work done with the service robot". The measure of task attraction include three questions, namely "This service robot can communicate with me in a friendly way" "I consider the service robot as a friend" "I get along well with the service robot". Finally, participants were asked to fill in statistical information such as gender and age. We collected the results of the experiment and ended it by thanking the participants.

Results

The Cronbach's α for the study 2 physical attraction scale was 0.951, task attraction scale was 0.835, social attraction scale was 0.832, and the Cronbach's α for the customer trust Scale Cronbach's α was 0.852, indicating that the scales had a good level of reliability. According to the results of the one-way ANOVA test, physical attraction was significantly different in the two

experimental groups ($M_{high} = 4.96$, $M_{low} = 3.74$, $F(1, 78) = 22.76$, $p < 0.001$), indicating that anthropomorphism initiated customers' perception of the robot's physical attraction. Similarly, task attraction ($M_{high} = 5.49$, $M_{low} = 4.72$, $F(1, 78) = 11.63$, $p < 0.01$) and social attraction ($M_{high} = 5.44$, $M_{low} = 4.53$, $F(1, 80) = 22.71$, $p < 0.001$) were significantly different in the two experimental groups. Consistent with the results of Experiment 1, customer trust perceptions were significantly different in the two experimental groups ($M_{high} = 5.27$, $M_{low} = 4.56$, $F(1, 78) = 17.22$, $p = 0.000 < 0.001$).

To test the mediating role of hypotheses H2, H3 and H4, we first did a regression analysis of service robot appearance anthropomorphism on each of the three mediating variables, and the results showed that service robot appearance anthropomorphism had a positive effect on physical attraction ($\beta = 1.251$, $t = 8.563$, $p < 0.01$), task attraction ($\beta = 0.132$, $t = 3.398$, $p < 0.01$), and social attraction ($\beta = 0.921$, $t = 4.752$, $p < 0.001$).

Next, we further examined the mediating effects of physical attractions, task attraction, and social attraction. Low anthropomorphism was coded as 0 and high anthropomorphism was coded as 1. The PROCESS program of SPSS was used to select model 4 (mediated model test) and set the number of bootstrapping times to 5000. Results showed (Table 1) that the direct effect of service robot appearance anthropomorphism to trust reached a significant level ($\beta = 0.502$, $LLCI = 0.252$, $ULCI = 0.752$, interval not including 0). Confidence interval results for the mediated paths of physical attraction ($\beta = 0.341$, $LLCI = 0.135$, $ULCI = 0.600$), task attraction ($\beta = 0.529$, $LLCI = 0.197$, $ULCI = 0.890$) and social attraction ($\beta = 0.599$, $LLCI = 0.327$, $ULCI = 0.871$) all reached a significant level without 0. Service robot appearance anthropomorphism can influence customer trust through the mediating effects of physical attraction, task attraction, and social attraction. H2, H3, and H4 are supported.

Table1. Outputs of Bootstrap test of mediating effects

	Mediator	Effect	SE	t value	P value	BootLLCI	BootULCI
Direct effect	-	0.502	0.182	3.998	0.0001	0.252	0.752
	physical attraction	0.341	0.118	-	-	0.135	0.600
Indirect effect	task attraction	0.529	0.177	-	-	0.197	0.890
	social attraction	0.599	0.139	-	-	0.327	0.871

4.6. Study 3

Method

Study 3 was designed using a 2(service robot appearance anthropomorphism: low vs. high) \times 2(technology readiness: high vs. low) design, where the anthropomorphism level was a between-group design and the technology readiness level was a within-group design. The manipulation and experimental scenario of service robot anthropomorphism was consistent with study 1. A total of 84 full-time students from a Chinese university were invited to participate in the experiment, including 40 males and 44 females, with an average age of 20.3 years. Participants were randomly assigned to two experimental groups (service robot appearance anthropomorphism: high vs. low). Then answer the technology readiness measurement questions. Technology readiness was measured with reference to Parasuraman and Colby's (2015) study, representative

questions include “New technology helps me achieve a higher quality of life” “Technology gives me more freedom to choose my space” “Technology makes my life more productive”, etc.

Results

The Cronbach’s α for the physical attraction scale of experiment 5 was 0.944, the Cronbach’s α for the task attraction scale was 0.792, the Cronbach’s α for the social attraction scale was 0.864, the Cronbach’s α for the trust scale was 0.765, and the Cronbach’s α for the technology readiness scale was 0.765, indicating that the scale has a high level of reliability. The PROCESS Macro, developed by Hayes, was used in SPSS to test the mediated model with moderation. The results of the analysis are shown in Table 2, where the product term of service robot appearance anthropomorphism and customer technology readiness had a significant effect on the perceived attraction of customer appearance ($t=-2.781, p<0.01$). The effect of the product of service robot appearance anthropomorphism and customer technology readiness on customer perception of task attraction was significant ($t=-2.063, p<0.05$). The effect of the product of service robot appearance anthropomorphism and customer technology readiness on the perceived social attraction of customers was significant ($t=-2.129, p<0.05$). Hypothesis 5: Customer technology readiness moderates the effect of appearance anthropomorphism on interpersonal attraction was supported.

Table 2 Moderating effect of customers’ technology readiness

	Physical attraction			Task attraction			Social attraction		
	coeff	se	t	coeff	se	t	coeff	se	t
constant	2.289	1.110	2.062*	5.035	0.857	5.878***	4.950	0.817	6.061***
appearance anthropomorphism	0.936	0.286	3.278***	0.467	0.220	2.118*	0.636	0.210	3.027**
technology readiness	0.222	0.202	1.098	0.249	0.156	1.601	0.224	0.148	1.507
appearance anthropomorphism* technology readiness	-1.131	0.407	-2.781**	-0.647	0.314	-2.063*	-0.637	0.299	-2.129*
R-Square		0.215			0.111			0.152	
F		4.271			1.956			2.802	

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

To further explore the specific role of moderating variables, simple slope analysis was used. As shown in Figure 6a, the effect of appearance anthropomorphism on the perceived physical attraction of customer is stronger when technology readiness is low compared to the case of high technology readiness, which is shown in the graph with a larger slope for high technology readiness. Similarly, as shown in Figures 6b and 6c, the relationship between the effect of service robot appearance anthropomorphism on the perception of task attraction and social attraction is stronger in the low technology readiness condition.

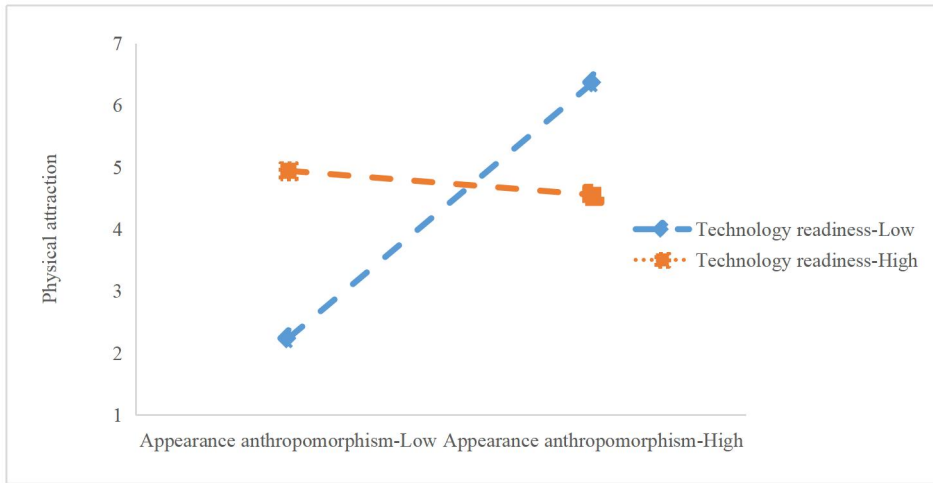


Figure 6a. Moderating role of technology readiness between appearance anthropomorphism and physical attraction

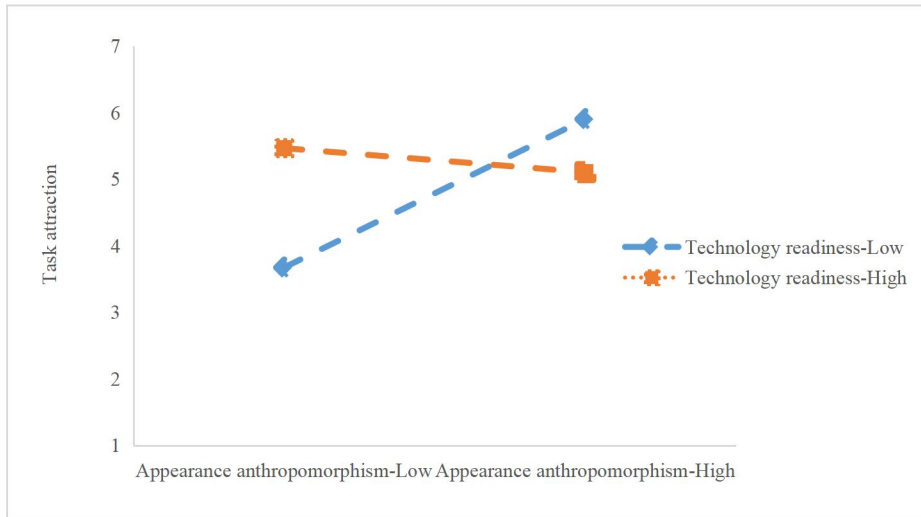


Figure 6b. Moderating role of technology readiness between appearance anthropomorphism and task attraction

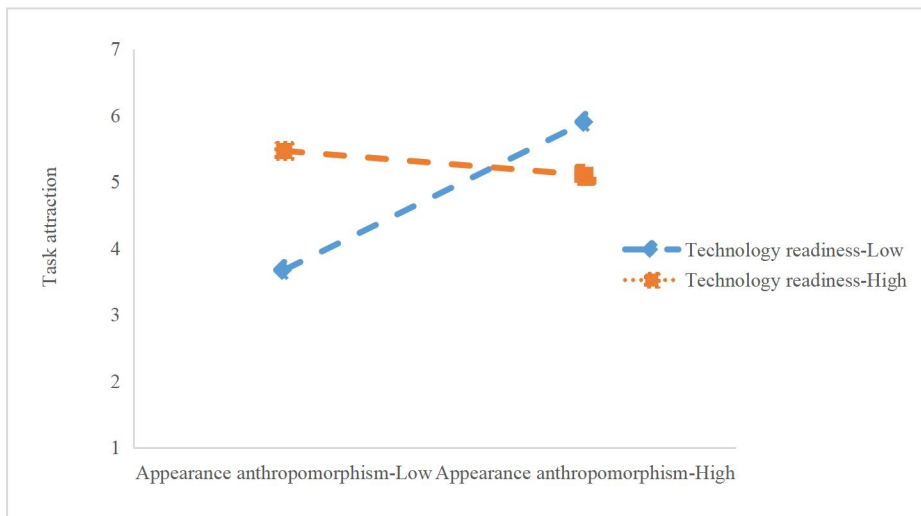


Figure 6c. Moderating role of technology readiness between appearance anthropomorphism and social attraction

To test for H5, the Bootstrap method was used to test for moderated mediation, and the SPSS PROCESS model7 was selected, setting the number of Bootstrapping to 5000. The results of examining the mediated moderating effects of customers' technology readiness are shown in Table 3. From the analysis results, the BootLLCI and BootULCI values in the analysis of moderating effects mediated by appearance attraction, task attraction and social attraction do not include 0, indicating the presence of moderating effects with mediation. When customers' technology readiness is low, the results of the analysis of BootLLCI and BootULCI values for all three mediating variables do not include 0, indicating a significant mediating effect. In contrast, when customers' technology readiness is high, the analytical results for the three mediating variables, BootLLCI and BootULCI values both include 0, indicating that the mediating effect is not significant at this time. These results are consistent with the H5.

Table 3 Moderating effects with mediators

	Index	Effect	BootSE	BootLLCI	BootULCI
Mediating effects of physical attractiveness	Moderating effect of technology readiness	-0.243	0.120	-0.529	-0.061
	effect1(M-1SD)	0.382	0.155	0.141	0.738
	effect2(M+1SD)	0.021	0.084	-0.149	0.192
Mediating effects of task attractiveness	Moderating effect of technology readiness	-0.170	0.090	-0.360	-0.012
	effect1(M-1SD)	0.249	0.116	0.049	0.507
	effect2(M+1SD)	-0.004	0.0757	-0.166	0.141
Mediating effects of social attractiveness	Moderating effect of technology readiness	-0.142	0.097	-0.371	-0.0003
	effect1(M-1SD)	0.248	0.1378	0.0298	0.556
	effect2(M+1SD)	0.037	0.061	-0.086	0.170

5. Discussion and Implications

5.1. Conclusions

In recent years, service robots have been increasingly implemented in the tourism and hospitality industries to facilitate service processes (Tuomi et al., 2021), and trust plays an important role in the interaction between humans and service robots(Liu et al., 2022). However, few scholars have explored the mechanism of the effect of service robot appearance anthropomorphism on trust. Based on the restaurant service context, this paper examines the effect of service robot appearance anthropomorphism on consumer trust through experimental study.

First, there is a positive effect of the service robot anthropomorphic appearance on customer trust. Study 1 verified hypothesis 1 that compared with low degree of anthropomorphism, customers have higher degree of trust in high degree of anthropomorphism service robots.

Second, interpersonal attraction mediates the effect of service robot appearance anthropomorphism on customer trust. Study 2 tested hypothesis 2, 3, and 4, respectively, that the three dimensions of interpersonal attraction (physical attraction, task attraction, and social attraction) mediated the effect of service robot appearance anthropomorphism on customer trust.

Third, technology readiness have a moderating effect in the process of online service robot appearance anthropomorphism on Interpersonal attraction. Study3 verified hypothesis 5 that for consumers with low technology readiness, the impact of high anthropomorphism on customer interpersonal attraction perception is significantly higher than that of low anthropomorphism. For

consumers with high technology readiness, there is no significant difference between high anthropomorphism and low anthropomorphism on customer interpersonal attraction perception.

5.2. Theoretical Contributions

This study makes some contributions to existing research on both anthropomorphism and human-machine trust.

First, this study examines the impact of service robot anthropomorphic features on consumer trust from the consumer's perspective. Although previous studies have verified the positive impact of anthropomorphism on trust (Tussyadiah et al., 2021; Van Pinxteren et al., 2019), they have not been specific to the feature of appearance. This paper examines the effect of anthropomorphism on consumer trust through an experimental study based on a restaurant service context with a service robot, which supports the results of previous studies in other application contexts of branding and artificial intelligence. It not only enriches anthropomorphism-related research, but also lays the foundation for the study of consumer attitudes and behaviors under the AI service trend.

Second, from the perspective of human-machine interaction, this paper treats service robots as "human-like" actors and introduces interpersonal attraction theory to reveal the impact of service robot appearance anthropomorphism on customer trust. Consistent with the results of previous studies, the anthropomorphization of service robots has a positive effect on customer trust (Tussyadiah et al., 2020). The level of anthropomorphism is particularly important for building trust (Hancock et al., 2011). To further investigate the mechanisms underlying the influence of service robot appearance anthropomorphism on customer trust, this paper attributes the process of service robot appearance anthropomorphism on consumer trust to three basic dimensions of interpersonal attraction, namely, appearance attractiveness, task attractiveness, and social attractiveness, which influence consumer trust in service robots. This study broadens the research on interpersonal attraction in the field of artificial intelligence and consumer behavior.

Finally, this paper introduces consumers' personal factors into the research framework and explores the boundary conditions of the relationship between technology readiness for service robot appearance anthropomorphism and consumers' perceived interpersonal attraction in terms of consumers' technology readiness. By introducing the moderating variable of technological readiness, it is demonstrated that customers' trust in service robots differs among different groups of characteristics, which reveals the influence of individual characteristics on human-robot interaction to a certain extent. In addition, this paper links customers' technological readiness with their trust in the service robot, which broadens the scope and application of technological readiness.

5.3. Managerial Implications

This paper has important reference value for the practical application of service robots in marketing.

First, in the context of artificial intelligence era, the introduction of robots in the service industry to provide services for consumers has become an inevitable trend. According to the conclusion of this paper, in the restaurant service interaction scene, enterprises should focus on improving consumers' perception of service subjects through anthropomorphic design. Specifically, enterprises can add anthropomorphic elements to the design of the robot's

appearance, such as eyes, mouth, smiley face, tie, and love, so that customers can feel the friendliness and enthusiasm similar to the communication with real service personnel, and thus improve customers' trust in the service robot.

Second, when selecting service robots, companies should not only focus on professional service capabilities, but also ensure the face value of service robots to provide customers with tangible evidence of wisdom service quality assurance, thereby improving customers' positive sensory evaluation of the robots. Companies can control the three dimensions of service robots: appearance attraction, task attraction and social attraction, so as to eliminate the stereotype of robots as "cold, stiff, clumsy and incompetent" and thus enhance consumer trust.

Finally, companies should clarify the boundary factors of the impact of service robot form anthropomorphism on consumers' perception of interpersonal attraction, i.e., pay attention to consumers' technology readiness. It is recommended that companies make appropriate observations during the process of human-machine interaction, such as replacing customers with real waiters in a timely manner if they are found to have skeptical and negative attitudes toward the service robot's services during the ordering and delivery process. In addition, service companies can improve consumers' understanding of artificial intelligence and robotics through customer education and voice explanations to eliminate customers' doubts in the process of using service robots and promote customers' trust in them.

Limitations and Future Research

There are several shortcomings in this paper, which need to be improved in subsequent studies.

First, the picture-text initiation method may affect the authenticity of the experimental effect and there may be some potential risks of bias. In the future, if the research conditions allow, the field experiment can be used to select real tourism service scenarios and directly invite customers to participate in the field behavior experiment.

Second, the anthropomorphism of service robots in this paper is mainly based on the appearance of service robots already in use in the market, without considering the uncanny valley, namely robots that are too human-like may bring potential fear, anxiety and mistrust.

Third, this study only explored the impact of anthropomorphism on consumer trust, including the anthropomorphic features of voice and movement. Future classes further explore the interaction effects of anthropomorphism in various aspects of service robots such as appearance, language, and movement.

References

- Alexis, P. (2017). R-Tourism: Introducing the Potential Impact of Robotics and Service Automation in Tourism. *Ovidius University Annals, Series Economic Sciences*, 17(1), 211-216.
- Allmendinger, G., & Lombreglia, R. (2005). Four strategies for the age of smart services. *Harvard business review*, 83(10), 131.
- Bartneck, C., Reichenbach, J., & Carpenter, J. (2006, September). Use of praise and punishment in human-robot collaborative teams. In ROMAN 2006-The 15th IEEE International Symposium on Robot and Human Interactive Communication (pp. 177-182). IEEE.

- Bekiari, A., & Spyropoulou, S. (2016). Exploration of verbal aggressiveness and interpersonal attraction through social network analysis: Using university physical education class as an illustration. *Open Journal of Social Sciences*, 4(06), 145.
- Berscheid, E. & Hatfield, E. 1978. *Interpersonal Attraction*, Addison-Wesley Reading, Ma.
- Bitner, M. J. (2001). Self-service technologies: what do customers expect?. *Marketing Management*, 10(1), 10-11.
- Brave, S., Nass, C., & Hutchinson, K. (2005). Computers that care: investigating the effects of orientation of emotion exhibited by an embodied computer agent. *International journal of human-computer studies*, 62(2), 161-178.
- Chi, O. H., Chi, C. G., Gursoy, D., & Nunkoo, R. (2023). Customers' acceptance of artificially intelligent service robots: The influence of trust and culture. *International Journal of Information Management*, 70, 102623
- Choi, Y., Oh, M., Choi, M., & Kim, S. (2021). Exploring the influence of culture on tourist experiences with robots in service delivery environment. *Current Issues in Tourism*, 24(5), 717-733.
- Christou, P., Simillidou, A., & Stylianou, M. C. (2020). Tourists' perceptions regarding the use of anthropomorphic robots in tourism and hospitality. *International Journal of Contemporary Hospitality Management*, 32(11), 3665-3683.
- Čaić, M., Odekerken-Schröder, G., & Mahr, D. (2018). Service robots: value co-creation and co-destruction in elderly care networks. *Journal of Service Management*, 29(2), 178-205.
- Çolak, F. U., & Kobak, K. (2011). Determining interpersonal attraction in educational environment and the relation with motivation. *International Journal on New Trends in Education and Their Implications*, 2(1), 47-56.
- Cyr, D., Head, M., & Ivanov, A. (2006). Design aesthetics leading to m-loyalty in mobile commerce. *Information & management*, 43(8), 950-963.
- De Kervenoael R., Hasan R., Schwob A., Goh E. (2020). Leveraging human-robot interaction in hospitality services: incorporating the role of perceived value, empathy, and information sharing into visitors' intentions to use social robots. *Tour. Manag.* 78:104042.
- De Kervenoael, R., Hasan, R., Schwob, A., & Goh, E. (2020). Leveraging human-robot interaction in hospitality services: Incorporating the role of perceived value, empathy, and information sharing into visitors' intentions to use social robots. *Tourism Management*, 78, 104042.
- Delbaere, M., McQuarrie, E. F., & Phillips, B. J. (2011). Personification in advertising. *Journal of Advertising*, 40(1), 121-130.
- Duffy, B. R. (2003). Anthropomorphism and the social robot. *Robotics and autonomous systems*, 42(3-4), 177-190.
- Edwards, C., Edwards, A., Stoll, B., Lin, X., & Massey, N. (2019). Evaluations of an artificial intelligence instructor's voice: Social Identity Theory in human-robot interactions. *Computers in Human Behavior*, 90, 357-362.
- Everett, J., Pizarro, D., & Crockett, M. (2017). Why are we reluctant to trust robots?. *The Guardian*, 24.
- Fink, J. (2012, October). Anthropomorphism and human likeness in the design of robots and human-robot interaction. In International conference on social robotics (pp. 199-208). Springer, Berlin, Heidelberg.

- Goetz, J., Kiesler, S., & Powers, A. (2003, November). Matching robot appearance and behavior to tasks to improve human-robot cooperation. In *The 12th IEEE International Workshop on Robot and Human Interactive Communication, 2003. Proceedings. ROMAN 2003.* (pp. 55-60). Ieee.
- Go, H., Kang, M., & Suh, S. C. (2020). Machine learning of robots in tourism and hospitality: interactive technology acceptance model (iTAM)—cutting edge. *Tourism review*, 75, 625–636.
- Gong, L. (2008). How social is social responses to computers? The function of the degree of anthropomorphism in computer representations. *Computers in Human Behavior*, 24(4), 1494-1509.
- Gorn, G. J., Jiang, Y., & Johar, G. V. (2008). Babyfaces, trait inferences, and company evaluations in a public relations crisis. *Journal of Consumer Research*, 35(1), 36-49.
- Han, S., & Yang, H. (2018). Understanding adoption of intelligent personal assistants: A parasocial relationship perspective. *Industrial Management & Data Systems*, 118(3), 618-636.
- Hancock, P. A., Billings, D. R., & Schaefer, K. E. (2011). Can you trust your robot?. *Ergonomics in Design*, 19(3), 24-29.
- Haring, K. S., Silvera-Tawil, D., Takahashi, T., Watanabe, K., & Velonaki, M. (2016, February). How people perceive different robot types: A direct comparison of an android, humanoid, and non-biomimetic robot. In *2016 8th international conference on knowledge and smart technology (kst)* (pp. 265-270). IEEE.
- Hellen, K., & Sääksjärvi, M. (2013). Development of a scale measuring childlike anthropomorphism in products. *Journal of Marketing Management*, 29(1-2), 141-157.
- Hood, D. D., Eisenach, J. C., & Tuttle, R. (1995). Phase I safety assessment of intrathecal neostigmine methylsulfate in humans. *The Journal of the American Society of Anesthesiologists*, 82(2), 331-343.
- Hur, J. D., Koo, M., & Hofmann, W. (2015). When temptations come alive: How anthropomorphism undermines self-control. *Journal of Consumer Research*, 42(2), 340-358.
- IFR, I. (2020). Executive summary world robotics 2020 industrial robots.
- Kaushik, A. K., Agrawal, A. K., & Rahman, Z. (2015). Tourist behaviour towards self-service hotel technology adoption: Trust and subjective norm as key antecedents. *Tourism Management Perspectives*, 16, 278–289.
- Keeley, B. L. (2004). Anthropomorphism, primatomorphism, mammalomorphism: understanding cross-species comparisons. *Biology and Philosophy*, 19, 521-540.
- Kiesler, S., Powers, A., Fussell, S. R., & Torrey, C. (2008). Anthropomorphic interactions with a robot and robot-like agent. *Social Cognition*, 26(2), 169-181.
- Kim, S., Chen, R. P., & Zhang, K. (2016). Anthropomorphized helpers undermine autonomy and enjoyment in computer games. *Journal of Consumer Research*, 43(2), 282-302.
- Kim, S. Y., Schmitt, B. H., & Thalmann, N. M. (2019). Eliza in the uncanny valley: Anthropomorphizing consumer robots increases their perceived warmth but decreases liking. *Marketing letters*, 30(1), 1-12.
- Lee, K. M., Peng, W., Jin, S. A., & Yan, C. (2006). Can robots manifest personality?: An empirical test of personality recognition, social responses, and social presence in human-robot interaction. *Journal of communication*, 56(4), 754-772.
- Leite, I., Martinho, C., & Paiva, A. (2013). Social robots for long-term interaction: a survey. *International Journal of Social Robotics*, 5(2), 291-308.

- Liu, X. S., Yi, X. S., & Wan, L. C. (2022). Friendly or competent? The effects of perception of robot appearance and service context on usage intention. *Annals of Tourism Research*, 92, 103324.
- Low, G. S., & Mohr, J. J. (2001). Factors affecting the use of information in the evaluation of marketing communications productivity. *Journal of the Academy of Marketing Science*, 29, 70-88.
- Lu, L., Cai, R., & Gursoy, D. (2019). Developing and validating a service robot integration willingness scale. *International Journal of Hospitality Management*, 80, 36-51.
- Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of management review*, 20(3), 709-734.
- McVeigh, B. J. (2000). How Hello Kitty Commodifies the Cute, Cool and Camp: 'Consumutopia' versus 'Control' in Japan. *Journal of Material Culture*, 5(2), 225-245.
- Mick, D. G., & Fournier, S. (1998). Paradoxes of technology: Consumer cognizance, emotions, and coping strategies. *Journal of Consumer research*, 25(2), 123-143.
- Monin, B. (2003). The warm glow heuristic: when liking leads to familiarity. *Journal of personality and social psychology*, 85(6), 1035.
- Onnasch, L., & Hildebrandt, C. L. (2021). Impact of anthropomorphic robot design on trust and attention in industrial human-robot interaction. *ACM Transactions on Human-Robot Interaction (THRI)*, 11(1), 1-24.
- Nanda, P., Bos, J., Kramer, K. L., Hay, C., & Ignacz, J. (2008). Effect of smartphone aesthetic design on users' emotional reaction: An empirical study. *The TQM Journal*, 20(4), 348-355.
- Nowak, K. L., & Rauh, C. (2005). The influence of the avatar on online perceptions of anthropomorphism, androgyny, credibility, homophily, and attraction. *Journal of Computer-Mediated Communication*, 11(1), 153-178.
- Parasuraman, A., & Colby, C. L. (2015). An updated and streamlined technology readiness index: TRI 2.0. *Journal of service research*, 18(1), 59-74.
- Park, S. (2020). Multifaceted trust in tourism service robots. *Annals of Tourism Research*, 81, 102888.
- Qin, M., Zhu, W., Zhao, S., & Zhao, Y. (2022). Is artificial intelligence better than manpower? The effects of different types of online customer services on customer purchase intentions. *Sustainability*, 14(7), 3974.
- Rehm, M., & Krogsgager, A. (2013, August). Negative affect in human robot interaction—impoliteness in unexpected encounters with robots. In *2013 IEEE RO-MAN* (pp. 45-50). IEEE.
- Richards, D., & Bransky, K. (2014). Forget Me Not: What and how users expect intelligent virtual agents to recall and forget personal conversational content. *International Journal of Human-Computer Studies*, 72(5), 460-476.
- Rubin, R. B. & Mchugh, M. P. 1987. Development of parasocial interaction relationships. *Journal of Broadcasting & Electronic Media*, 31, 279-292
- Seyitoğlu, F., & Ivanov, S. (2020). A conceptual framework of the service delivery system design for hospitality firms in the (post-) viral world: The role of service robots. *International Journal of Hospitality Management*, 91, 102661.
- Song, Y., & Luximon, Y. (2021). The face of trust: The effect of robot face ratio on consumer preference. *Computers in Human Behavior*, 116, 106620.

- Tuomi, A., Tussyadiah, I. P., & Stienmetz, J. (2021). Applications and implications of service robots in hospitality. *Cornell Hospitality Quarterly*, 62(2), 232-247.
- Tussyadiah, I. P., Zach, F. J., & Wang, J. (2020). Do travelers trust intelligent service robots?. *Annals of Tourism Research*, 81, 102886.
- Tybout, A. M., Calder, B. J., & Sternthal, B. (1981). Using information processing theory to design marketing strategies. *Journal of Marketing Research*, 18(1), 73-79.
- Xiong, X., Wong, I. A., & Yang, F. X. (2021). Are we behaviorally immune to COVID-19 through robots?. *Annals of tourism research*, 91, 103312.
- Xu, L., Yu, F., Wu, J., Han, T., & Zhao, L. (2017). Anthropomorphism: Antecedents and consequences. *Advances in Psychological Science*, 25(11), 1942-1954.
- Yang, H., Yu, J., Zo, H., & Choi, M. (2016). User acceptance of wearable devices: An extended perspective of perceived value. *Telematics and Informatics*, 33(2), 256-269.
- Verberne, F. M., Ham, J., & Midden, C. J. (2015). Trusting a virtual driver that looks, acts, and thinks like you. *Human factors*, 57(5), 895-909.
- Wang, T., Xie Z. A review of the literature of personification marketing[J]. *Foreign Economics & Management*, 2014, 36(1): 38-45.
- Waytz, A., Heafner, J., & Epley, N. (2014). The mind in the machine: Anthropomorphism increases trust in an autonomous vehicle. *Journal of experimental social psychology*, 52, 113-117.
- Wirtz, J., Patterson, P. G., Kunz, W. H., Gruber, T., Lu, V. N., Paluch, S., & Martins, A. (2018). Brave new world: service robots in the frontline. *Journal of Service Management*, 29(5), 907-931.
- Wu, J. J., & Chang, Y. S. (2005). Towards understanding members' interactivity, trust, and flow in online travel community. *Industrial Management & Data Systems*, 105(7), 937-954.
- Van Pinxteren, M. M., Wetzels, R. W., R ger, J., Pluymaekers, M., & Wetzels, M. (2019). Trust in humanoid robots: implications for services marketing. *Journal of Services Marketing*, 33(4), 507-518.