Disentangling the Effect of Anthropomorphic Features on Acceptance of Social Robots

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Short Paper

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Abstract

The anthropomorphic features of social robots are closely linked to user acceptance of social robots. Few studies have examined how anthropomorphic features affect user perceptions of the functions of social robots, a factor that can drive user acceptance of social robots. To answer this question, this study proposes a research model to investigate the effect of three key anthropomorphic features (appearance, voice, and response) of social robots on user perceptions of the robots' utilitarian, hedonic, and social functions, which motivate users' intention to accept social robots. The proposed research model will be validated with data collected via an online experiment in the hotel context. The research is expected to enrich the literature of social robot acceptance by linking anthropomorphic features and functions of social robots.

Keywords: Anthropomorphic features, social robots, acceptance, IS functions

Introduction

With the advancement of technology, social robots have been developed and increasingly applied in different services. Pepper, the social robot developed by SoftBank Robotics, has been used in healthcare, hospitality, and education contexts. A social robot can be defined as a physical "autonomous agent that can act in a socially appropriate manner based on its role in an interaction" (Welch et al. 2010, p. 392) embodied in a complex, dynamic, and social environment (Duffy 2003). Social robots are designed to understand and communicate with humans and behave as social actors. Social robots can sense and respond to environmental cues while understanding and following social rules (Sarrica et al. 2020). The cognitive capability of social robots separates them from other innovative information systems (IS) (Schuetz and Venkatesh 2020). Beyond accepting them as here technology, users can turn these robots into companions (Kuchenbrandt et al. 2013).

Prior studies related to social robots indicate that the human nature of robots is closely linked with the acceptance of these robots by users. More human likeness in social robots has shown positive engagement (Tondu 2012; Złotowski et al. 2015). In the context of robotics, the term anthropomorphism relates to the extent to which users perceive robots as human-like (Moran et al. 2015; Richert et al. 2018). Moran et al. (2015) highlighted the importance of embedding anthropomorphic features in robotic designs to form robotic personalities. Tondu (2012) discussed the anthropomorphic projections that affect human perceptions in interactions with robots. The acceptance of robots might deviate from the acceptance of other innovative IS (Klamer and Allouch 2010) because social robots have human-like cognitive capabilities and can respond to situated environments (Schuetz and Venkatesh 2020). There is a need to understand how the anthropomorphic features of social robots affect individual users' perceptions and acceptance of social robots.

Following the IS adoption literature, social robots can be categorized as a multipurpose system because social robots can be used for utilitarian, hedonic, and social purposes (Moussawi et al. 2021). For instance, social robots can respond to questions like a human can. The movement, voice, and appearance of robots can be appealing as cute kids, which might bring enjoyment to users and lead them to perceive robots as companions. Some prior research has argued that social robots, along with anthropomorphism, may influence user perceptions and acceptance of social robots (De Graaf and Allouch 2013; Klamer and Allouch 2010). Some research has also investigated how different anthropomorphic features affect the acceptance of social robots based on the uncanny valley theory (Nissen and Jahn 2021). However, there is a paucity of knowledge on how the different anthropomorphic features of social robots, which make social robots unique, can influence users' perceptions of the functions of social robots as an IS, such as the utilitarian, social, and hedonic functions of social robots, which have been found to motivate users' acceptance of an IS.

To the end, the current study aims to address the abovementioned research gap by investigating the effect of anthropomorphism of social robots on user acceptance intentions, here through utilitarian, social, and hedonic functions. Specifically, the current study explores how three anthropomorphic features (appearance, voice, and response) affect user perceptions of the utilitarian, social, and hedonic functions of social robots, which drive users' acceptance intention. An experiment will be conducted to collect the empirical data in the hotel context. The current study will help to explain how the three specific anthropomorphic features of social robots affect the acceptance of social robots by clarifying their roles in predicting the functions of social robots.

The present paper proceeds as follows: First, a theoretical background composed of anthropomorphism, IS functions, and acceptance of social robots is presented to provide the theoretical support. Second, the proposed research model and research hypotheses are discussed. Then, the planned research method is explained. Finally, the paper concludes with the expected contributions and limitations study.

Theoretical Background

Research on Anthropomorphism

The literature provides a discussion on the concept of anthropomorphism in robot research. Different scholars have identified the term anthropomorphism in similar ways. Table 1 lists several definitions in the literature.

Author	Definition
Fan et al. (2016)	Inclusion of human-like traits, motivations, intentions, emotions, and behaviors to nonhuman agents.
Złotowski et al. (2018)	Attribution of human-like characteristics to nonhuman entities.
Airenti (2015)	An extension of the forms of interactions typical of human communication to nonhumans.
Duffy (2003)	Possibility of attributing human characteristics to inanimate objects, animals, and others.
Ruijten et al. (2019)	Attribution of human-like characteristics that people ascribe to a robot.

Table 1. Definitions of anthropomorphism

Anthropomorphism has been observed in different senses in the natural sciences, human-computer interaction, and psychology. The word is formed from the addition of Greek words Anthropos (man) and morphe (structure or form). The rationalization of an entity's behavior in a certain social environment is expected by applying cognitive or emotional states in anthropomorphism (Duffy 2003). The human-like traits or characteristics include emotionality, desire, warmth, and openness. Despite objects possessing such traits, nonhuman agents with such characteristics are commonly classified as anthropomorphic or human-like (Fan et al. 2016).

Some scholars have explained the anthropomorphic attributes of social robots from different perspectives. Złotowski et al. (2018) argued that the anthropomorphic design of robots is achieved through factors such as movement, gestures, embodiment, verbal communication, and emotions; these factors affect user perceptions of robots and human behavior during human-robot interactions. Doering et al. (2015) highlighted the key anthropomorphic attributes such as embodiment, voice output, social behavior, and movement and mobility, arguing that an adequate amount of embodiment is essential for a robot to interact with a human. However, following the uncanny valley theory, real human features might disturb the robotic experience if a robot looks overly human-like (Tondu 2012). As Kuchenbrandt et al. (2013) explained, socially acting robots should embrace human nature as much as possible and behave according to social norms. For example, personal spaces need to be preserved when approaching customers (Doering et al. 2015). Moran et al. (2015) argued that anthropomorphic attributes include intelligence, autonomy, and adaptability. The potential level of intelligence that a robot has is mainly influenced by the level of AI integrated into it. Fully autonomous robots can understand commands and respond without human control or intervention. In addition, robot adaptability refers to the capability of adapting and responding to different situations for social robots and is a key anthropomorphic attribute binding the robot to the environment. According to Kamide and Arai (2017), there are both positive and negative anthropomorphic features when it comes to social robots. Friendliness, sociability, curiousness, politeness, organizational skills, and humbleness are positive anthropomorphic features, while rudeness, impatience, distractedness, hard-heartedness, and aggressiveness are classified as negative anthropomorphic features.

Prior literature has also applied different theories to explain perceived anthropomorphism. For example, based on the three-factor theory, Epley et al. (2007) suggested elicited agent knowledge, efficiency motivation, and social motivation as the three main psychological determinants of anthropomorphism. From the lens of efficiency and social contact, Fan et al. (2016) investigated customers' intentions to switch to social robots. According to Fan et al. (2016), efficiency motivation has helped in understanding the role of anthropomorphism in strengthening consumers' sense of control and confidence, whereas social contact reflects the sense of social connectedness and comfort between anthropomorphic robots and consumers. Złotowski et al. (2018) explained anthropomorphism from the view of media equation theory; they argued that the anthropomorphic features are determined by dual processes: the fast and intuitive implicit process to identify an object as human-like and an explicit reflective process modifying the initial judgment involving work memory and cognitive decoupling. They emphasized that social treatment and the identification of a robot, which is explained by media equation theory, corresponds to implicit anthropomorphism. However, as described by Złotowski et al. (2015), anthropomorphism is not solely presented or observed from the robot's characteristics; the observer's characteristics, such as motivation, social background, gender, and age, also influence their perceptions of anthropomorphism.

Functions of Social Robots as an IS

According to the IS literature, an IS can be multi-purposed, such as utilitarian-, hedonic- and social-oriented, depending on the system design and users' motivation (Brown and Venkatesh 2005; Gan and Li, 2018; Heijden 2004). The utilitarian, hedonic and social functions of IS have been employed to explain IS acceptance in a different context. Moussawi et al. (2021) argued that social robots are multipurpose IS since social robots can be used for utilitarian, hedonic, and social purposes.

The utilitarian function of an IS is task-oriented and provides users with instrumental value. Social robots are capable of serving in households, elderly care, and schools (Fong et al., 2003). Users can use social robots to fulfill their needs or solve problems. In addition, social robots provide functional value to users through their utilitarian functions if users accomplish their objectives and goals with social robots. Thus, social robots are utilitarian systems (Klamer and Allouch 2010). Social robots provide utilitarian functions to their users across different domains. Prior research has applied some utilitarian variables, such as usefulness and ease of use, to explain users' intention to use social robots (De Graaf and Allouch 2013). Following the prior IS literature, when social robots are perceived as useful, that is, when the utilitarian function is served, users tend to accept social robots.

The hedonic function of an IS refers to the enjoyment and fun in using an IS (Brown and Venkatesh 2005; Heijden 2004). Emotions such as enjoyment, playfulness, and escapism impel the emotions of users through hedonic function (Feijóo et al. 2009; Gorini et al. 2009). As stated by De Graaf and Allouch (2013), users can experience enjoyment, sociability, and companionship in using social robots, which reflect the hedonic functions of social robots. Some scholars have also argued that the enjoyment and attractiveness associated with using social robots can determine the hedonic function of social robots. Lee et al. (2003) argued that the positive judgment of a robot's physical appearance can lead to user perceptions of the hedonic function. The verbal design and other human-like movements and gestures can also make users feel the fun and enjoyment of using social robots. Klamer and Allouch (2010) identified playfulness as a critical element in understanding the usage and acceptance of social robots.

Social function is composed of the capability of an IS to make social interactions with users (Chau and Xu 2012; Gan and Li 2018). Social robots can understand human emotions and behaviors in social environments. Embedded social intelligence and social skills in social robots drive the interaction capabilities of social robots (Breazeal et al., 2008). When social robots are designed as utilitarian-oriented systems, in many instances, they cater as platforms for interactions (Klamer and Allouch 2010). This allows users to build long-term relationships, that is, friendships. The relationships can either be local, bound to the operating environment, or—if the robot is used widely—form a network, such as in elderly healthcare systems (Alaiad and Zhou 2014). Moreover, in childcare hospitals with autistic children, social robots can be used as a mediator with shared attention (Robins et al. 2004), where children can freely express their thoughts and experiences to one another and to the robot. In addition, the humanoid features are emphasized by Klamer and Allouch (2010) as major social factors affecting the social function of social robots.

Acceptance of Social Robots

Prior literature has investigated individuals' acceptance of social robots from different views (Premathilake et al. 2021). Klamer and Allouch (2010) argued that some concepts in traditional technology acceptance theories can still explain user acceptance of social robots, such as technology artifacts, user trust, entertainment, and social interactions. Heerink et al. (2008) investigated the acceptance of a cat-shaped zoomorphic robot among elderly users, finding that perceived playfulness, enjoyment, social presence, and the nature of interactions lead to elderly users' intention to accept the social robots. De Ruyter et al. (2005) investigated the social intelligence of social robots in the home context via experiments, showing that social intelligence is vital in determining users' acceptance of social robots. De Graaf and Allouch (2013) found that usefulness, enjoyment, companionship, sociability, adaptability, and perceived behavioral control are associated with user acceptance of social robots. Wirtz et al. (2018) extended the technology acceptance model to investigate social robot acceptance by investigating their functional, social-emotional, and relational elements.

Prior research has also investigated user acceptance of social robots from the anthropomorphism view. Some research has found that increasing the anthropomorphic features of social robots can lead to user acceptance. However, drawing on anthropomorphism theory, person–technology fit model, and self-regulation theory, Benlian et al. (2020) found the negative impacts of the anthropomorphic features of social robots on the use of social robots at home. Drawing on the uncanny valley theory and dual-process theory, and data collected via experiments, Nissen and Jahn (2021) found the uncanny valley effect of anthropomorphic features of social robots on perceived intuitive and deliberate trustworthiness. When the level of anthropomorphism is at a medium level, users' use intention will decrease and be mediated by reduced perceived intuitive and deliberate trustworthiness, whereas when the anthropomorphism level is high, perceived intuitive trust will increase and further affect use intention positively.

Utilitarian, hedonic and social functions of an IS have been found to be the dominant motivation for users' acceptance of an IS. However, the importance of anthropomorphic features of social robots in predicting their utilitarian, hedonic, and social functions have not been particularly studied in the context of social robots.

Proposed Research Model and Hypotheses

The theoretical model was developed by linking user perceptions of different anthropomorphic features to IS functions. Appearance, voice, and response are postulated as reflecting the anthropomorphic features of social robots. The three anthropomorphic features are supposed to affect user perceptions of the utilitarian, social, and hedonic functions of social robots, which motivate users' intention to accept social robots. The proposed research model is presented in Figure 1.

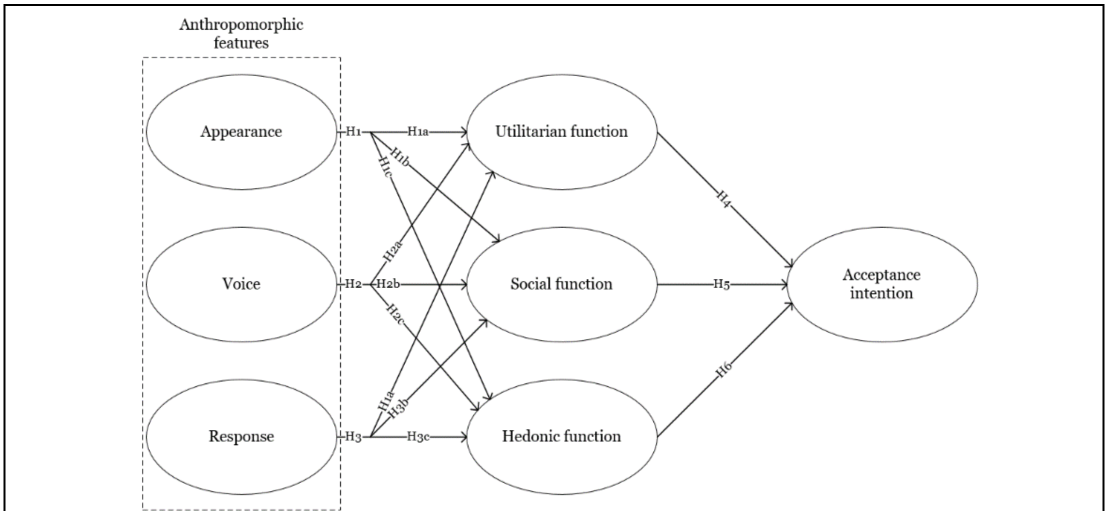

Figure 1. Research model

The appearance of a robot is designed for the interaction style and making the actions, cognition, and perceptions of robots visible through physical features (Choi and Kim 2009). Embodiment is a key feature of social robots that determines their appearance. As described by Fong et al. (2003) and Tung and Law (2017), the morphology of robots is linked to an embodiment, where robots can be seen in different forms, for example, in the form of humans (anthropomorphic). Humanoid designs can mimic human features, such as appearance and interactions. Further, they can perform actions like humans, talk to humans and each other, and meet the needs of users (Ruijten et al. 2019). With this in mind, we assume that the appearance of social robots will affect user perceptions of the instrumental function, the social interaction function of social robots, and their enjoyment in using social robots. The more human-like appearance of social robots, the higher perceptions of their utilitarian, hedonic, and social functions. Thus, the following hypotheses are postulated:

H1a. The appearance of social robots positively affects user perceptions of the utilitarian function of social robots.
H1b. The appearance of social robots positively affects user perceptions of the social function of social robots.
H1c. The appearance of social robots positively affects user perceptions of the hedonic function of social robots.

Robot social expression is defined as the capability within a robot to disclose itself socially by communication and emotion. Voice is a key feature that caters to social expression and interactions between robots and users. The voice and the robot's personality are closely bound to each other (Moran et al. 2015). Because voice helps in interactions with robots, users may feel comfortable with a human-like voice. For example, a female voice suits reception robots better than a male voice (Gockley et al. 2005), and in elderly care, robots may mimic the tasks and functions of nurses and, therefore, have a female voice (Tuisku et al. 2019). Kuchenbrandt et al. (2013) provided evidence that a human-like voice elicits more anthropomorphic inferences compared with a synthetic voice. Moreover, Duffy (2003) outlined that judgment on the intelligence of a robot is influenced by voice. This situation can arise during interactions, such as playing games and serving customers in a hotel. Therefore, based on the above reasoning, we assume that voice will affect user perceptions of the utilitarian, hedonic, and social functions of social robots. The following hypotheses are suggested:

H2a. The voice of social robots positively affects user perceptions of the utilitarian function of social robots.
H2b. The voice of social robots positively affects user perceptions of the social function of social robots.
H2c. The voice of social robots positively affects user perceptions of the hedonic function of social robots.

The response feature of a social robot serves as the main function in its interactions. There can be verbal or nonverbal responses according to the robot, situation, or user (Złotowski et al. 2015). Serving specific tasks assigned to robots requires effective communication. The interactive voice or signs of social robots act as supportive features when providing services to dedicated users. Failure to do so might even trigger customer-switching intentions (Fan et al. 2016). According to Kuchenbrandt et al. (2013), social robots elicit social responses that are similar to human-human reactions. Additionally, robots providing social responses show evidence that they are being anthropomorphized. If the responses are mindless and automatic, robots would not be considered good social actors (Złotowski et al. 2018), even adversely affecting the hedonic function because unintentional and irrelevant responses jeopardize the enjoyment of users (Choi and Kim 2009). Based on the above discussion, the following hypotheses related to the response feature are put forward:

H3a. The response of social robots positively affects user perceptions of the utilitarian function of social robots.
H3b. The response of social robots positively affects user perceptions of the social function of social robots.
H3c. The response of social robots positively affects user perceptions of the hedonic function of social robots.

Utilitarian factors are related to practicality and usability. In the field of human-robot interaction, the proper functional capabilities of robots enable positive interactions with users. Further, the acceptance of social robots is influenced by utilitarian factors, such as usefulness and adaptability (De Graaf and Allouch 2013). When users are satisfied with the service or task that robots aim to fulfill, they naturally tend to build acceptance intentions by considering future benefits and values. Therefore, the following hypothesis is assumed:

H4. The perceived utilitarian function of social robots positively affects users' intentions to accept social robots.

The social function of social robots even makes users name them as social companions, social actors, or partners (Zhu and Chang 2020; Złotowski et al. 2018). Generally, powerless individuals tend to value connectedness rather than control in social interactions. These individuals are frequently observed in hospitals and childcare, where social robots are engaged the most (Fan et al. 2016). The provision of social interactions could generate acceptance intentions and is even regarded as a major factor affecting acceptance intentions (Alaiad and Zhou 2014). Therefore, the following hypothesis is proposed:

H5. The perceived social function of social robots positively affects users' intentions to accept social robots.

The level of likability or enjoyment that users perceive depends on their mode of interaction. Interactions can be either enjoyable or uncomfortable based on the user experience. And likability and enjoyment have proven to influence acceptance of social robots (Heerink et al. 2008; Moran et al. 2015). For example, in elderly care, social robots are engaged in entertainment, and users are more likely to use social robots when they perceive more enjoyment in using the social robots (Heerink et al., 2008). Hence, the hedonic function is directly linked with acceptance intentions regarding social robots. Based on this discussion, the following hypothesis is proposed:

H6. The perceived hedonic function of social robots positively affects users' intentions to accept social robots.

In addition, the age, gender, and innovativeness of users are set as control variables in the proposed research model.

Planned Research Method

The constructs included in the research model will be measured using multiple-item scales measured with the five-point Likert scale. The construct items will be developed based on the literature, and some modifications will be made to make them fit the social robot context. The measurement items of appearance, voice, and response are adapted from the research of Bührke et al. (2021). The items of construct utilitarian and hedonic functions are taken from the research of Zhou et al. (2015) and Heijden (2004). The construct of social function is measured with the items from the work of Gan and Li (2018). The items of acceptance intention will be taken from Davis (1989). Some demographic background information and the research participants' innovativeness will also be collected.

The planned research method is an experiment and will be conducted in the context of the hotel industry. We selected the hotel industry for the following reasons: First, the hotel industry has been the pioneer in applying social robots in service. Second, social robot implementation might be even more popular in the hotel sector in the post-COVID-19 era. We plan to collect empirical data in collaboration with a hotel that is planning to implement robots to serve its customers.

An online survey will be developed and delivered to the partner hotel for data collection. The partner hotel will send an email invitation to their customers and invite them to participate in the experiment. The research objectives of the study will be introduced to the research participants, and a consent form will be signed electronically before the research participants proceed to answer the online survey. At the beginning of the survey, a video (approximately a five-minute video) showing how a social robot serves customers in a hotel will be presented to the participants. The social robots presented in the video will be similar to the robot Pepper developed by Softbank Robotics, which has a human-like appearance and kids-like voice and provides different services to hotel customers, such as reception desk service, room delivery, social communication, etc. After the video show, the respondents will first be asked to report what service the social robots have provided, as shown in the video, to confirm whether the participants have paid attention to the content (e.g., service provided by social robots); the participants will then report their perceptions on the anthropomorphic features of the social robots and the functions of social robots as well as their intention to accept social robots in hotel service. We plan to collect about 400 responses to empirically test the proposed research model. Economic incentives will be provided to the respondents who have completed the online questionnaire. The collected data will be analyzed using structural equation modeling via statistical software SmartPLS.

Expected Contributions

The expected contribution of this study is twofold. A contribution to IS literature will come from providing whether different anthropomorphic features, such as appearance, voice, and responses, affect user perceptions of the utilitarian, social, and hedonic functions of social robots in the hotel context. Also, a verification of the three different IS functions in predicting the acceptance of social robots will be conducted to provide an understanding of social robot acceptance, and this can provide insights into how anthropomorphic features affect user acceptance of social robots directly via user perceptions of the functions of social robots.

In addition, the research results of the current study will serve as guidance to robot developers on the anthropomorphic design from a user perspective. Specifically, developers will be able to understand what and how anthropomorphic features are valued and recognized by users, along with how anthropomorphic features should be designed to trigger users' perceptions of the utilitarian, social, and hedonic functions of social robots, which might lead to user acceptance of social robots. Furthermore, this study might provide hotel operators some practical suggestions on the anthropomorphic feature development of social robots in hotel service to realize the utilitarian, social, and hedonic functions of the social robots and make social robots to be accepted by hotel customers.

There are certain limitations in the current study. In the current study mainly, user acceptance of social robots based on the major IS functions will be investigated. Future research can also examine user acceptance of social robots from other theoretical views, such as task–technology fit, technology affordance, and so forth. In addition, a key focus will be given to the effects of the anthropomorphic features of social robots on their functions as an IS; other factors should be considered, such as the empathy of social robots and other emotions.

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