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Understanding the effect of anthropomorphic features of humanoid social robots on user satisfaction: a stimulus-organism-response approach

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Abstract

Purpose – Humanoid social robots (HSRs) are an innovative technology revitalizing various service sectors, such as the hospitality industry. However, limited research has explored how anthropomorphic features of HSRs influence user satisfaction with the services delivered by HSRs. To address this, a research model was proposed to evaluate how three distinct anthropomorphic features: appearance, voice and response, impact the perceived values (i.e. utilitarian, social and hedonic values) of HSRs, which, in turn, influence user satisfaction.

Design/methodology/approach – Data from an online survey of hotel customers was utilized to test the research model ($N = 509$).

Findings – The results indicated that appearance, voice, and response affect perceived utilitarian, hedonic and social values differently. The response feature of HSRs demonstrated the strongest impact on perceived utilitarian, social and hedonic values. In addition, voice affected all three perceived values, while appearance only affected perceived utilitarian and social values. Furthermore, perceived utilitarian, hedonic and social values showed positive impacts on user satisfaction, with hedonic value being the most influential factor.

Originality/value – This study contributes to the literature on HSRs and anthropomorphism by explaining how different anthropomorphic features affect users' value perceptions and user satisfaction with HSR services by utilizing the stimulus-organism-response (SOR) framework.

Keywords Anthropomorphic features, Humanoid social robots, Value perceptions, User satisfaction, Stimulus-organism-response framework

Paper type Research paper

1. Introduction

Physical and autonomous agents that are capable of operating based on assigned roles in socially appropriate ways during interactions within dynamic and complex social settings are

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typically introduced as humanoid social robots (HSRs) (Duffy, 2003). Distinguished by their advanced cognitive capabilities, HSRs function as social actors or companions across various service contexts, distinguishing them from traditional information systems (IS) (Song and Kim, 2022). As a result, HSRs have been increasingly deployed in diverse service industries, including education (Conti *et al.*, 2017; Sisman *et al.*, 2024), healthcare (Kwon *et al.*, 2018), retail (Chuah and Yu, 2021; Song and Kim, 2022), and hospitality (Liao and Huang, 2024; Murphy *et al.*, 2019; So *et al.*, 2024). Among these, the hospitality industry has been a highlight in implementing HSRs into their daily operations, aiming to reduce operating costs by using robots for repetitive or monotonous tasks and to enhance customer experiences through the provision of novel and personalized interactions with guests (De Kervenoael *et al.*, 2020). Notably, HSRs have been employed in various hotel services, such as butlers (e.g. Botlr), concierges (e.g. Connie), bellboys (e.g. Sacarino), and waitresses (e.g. Theresa) (Ozturk *et al.*, 2023). In addition, the necessity for contactless services and service delivery due to the outbreak of COVID-19 boosted HSRs' adoption in hospitality services (Song *et al.*, 2024).

Recent research has highlighted the importance of anthropomorphism in HSRs, emphasizing the need to consider these features when investigating user reactions to HSRs (Klüber and Onnasch, 2022; Li *et al.*, 2023). Previous studies have shown that anthropomorphic features influence user perceptions, attitudes, and behaviors concerning HSRs by either measuring a general perception of robot anthropomorphism (e.g. Moran *et al.*, 2015) or investigating a specific anthropomorphic feature of HSRs, such as appearance (Appel *et al.*, 2020; Prakash and Rogers, 2015), voice (Fan *et al.*, 2016; Konya-Baumbach *et al.*, 2023; Tamagawa *et al.*, 2011), or response (Diederich *et al.*, 2021; Okanda and Taniguchi, 2022). However, these studies have typically focused on a single anthropomorphic feature independently, leaving a gap in understanding how different anthropomorphic features might collectively or differentially impact user attitudes and behaviors. These effects could provide important guidelines for HSR design from the anthropomorphic design perspective. Thus, in-depth research is required to investigate the varying roles of different anthropomorphic features in triggering user perceptions, attitudes, and behaviors regarding HSRs.

Additionally, user satisfaction has been suggested to be a critical factor influencing various user behaviors related to technology-supported services, such as loyalty (Soliman *et al.*, 2024), purchase intention (Jia *et al.*, 2021), continuous usage intention (Lee *et al.*, 2021a), and the long-term success of information systems (IS) implementation (Vaezi *et al.*, 2019). Examining user satisfaction with HSR services could provide an understanding of users' various behaviors regarding HSRs as well as the long-term success of HSRs in different contexts. However, previous studies on social robots have mainly examined how anthropomorphic features affect users' continuous behavior intentions (Lee *et al.*, 2021a; Moussawi and Koufaris, 2019), while research on how anthropomorphic features affect user satisfaction with HSR services remains limited.

Furthermore, previous studies have highlighted the utilitarian, social, and hedonic values of IS as antecedents that affect user satisfaction with IS (Evelina *et al.*, 2020; Konya-Baumbach *et al.*, 2023). HSRs could be regarded as multi-purpose IS that provide utilitarian, hedonic, and social values for users. While interacting with HSRs, users could perceive different types of IS values. For instance, users may perceive HSRs' utilitarian value when the robots help them complete tasks and achieve certain goals. Users may also perceive social value when the robots interact with them while listening to and responding to inquiries. The humorous faces and charming voices of HSRs during communication can make users feel joyful, eliciting hedonic value. Further, users could perceive hedonic value when they feel enjoyment and happiness during their interactions with HSRs. However, limited research has attempted to uncover how HSRs' various anthropomorphic features affect the perceived IS values of these robots. Thus, it is unclear whether the appearance, voice, and response of HSRs have similar or different influences on user perceptions of the utilitarian, social, and hedonic values of HSRs, which could further affect user satisfaction with the robot-delivered services.

To address these research gaps, this study applies the stimulus-organism-response theory (SOR) (Mehrabian and Russell, 1974) to develop a research model that explores how the three anthropomorphic features of HSRs—appearance, voice, and response—influence user perceptions of the utilitarian, social, and hedonic values of HSRs, which in turn affect user satisfaction. This study employs a quantitative approach, utilizing survey data from 509 hotel customers who had prior interactions with HSRs during their stays in hotels. This targeted sample allows for a focused examination of the hospitality industry's use of HSRs.

By adopting the SOR theory, the current study addresses a critical gap in HSR and anthropomorphism literature through the exploration of the distinct effects of anthropomorphic features of HSRs, such as appearance, voice, and response on user satisfaction via perceived utilitarian, social, and hedonic values, which has been often overlooked by the existing research on social robots (Diederich *et al.*, 2021; Klüber and Onnasch, 2022; Seo, 2022). In doing so, this study broadens the scope of investigation in the field of social robotics and anthropomorphism, offering a comprehensive understanding of how different anthropomorphic features of HSRs influence user perceptions, with the response feature of HSRs emerging as the most impactful. In addition, this study deepens the understanding of value perceptions within the SOR framework by considering the perceived IS values as the organism, particularly in the context of HSRs, emphasizing the critical role of perceived hedonic value in driving user satisfaction. Further, in contrast to prior research that considered traditional technological features of IS as stimuli (Cheng *et al.*, 2022; Hlee *et al.*, 2023), the findings of the current study emphasize the importance of recognizing anthropomorphic features of HSRs as essential stimuli influencing users' attitudinal responses. This extends the application of the SOR framework to the context of HSRs, further reinforcing the theory's relevance in explaining human-robot interactions.

By uncovering the distinct roles of HSRs' appearance, voice, and response in shaping user perceptions of IS values and, subsequently, user satisfaction, this research offers valuable guidelines for the HSR designs targeting service settings, specifically focusing on the hospitality sector. Further, the study serves as a guide to HSR developers by emphasizing the importance of optimizing the response feature to enhance user satisfaction while also noting that voice articulation should be refined for better human-robot interactions (HRIs). For hotel managers, the findings highlight the need to align HSR features with their intended purpose and to ensure high-quality responses to meet customer expectations, thereby boosting satisfaction and service quality. Thus, the current study contributes to the broader discourse on humanlike technologies, providing empirical evidence that supports a deeper understanding of how anthropomorphism in technologies such as HSRs can drive user value perceptions and satisfaction.

2. Theoretical background

2.1 HSRs' anthropomorphic features

The anthropomorphism of robots is portrayed as the tendency of the "attribution of humanlike characteristics to nonhuman agents or objects," such as robots (Seeger *et al.*, 2021, p. 932). Researchers have investigated the anthropomorphism of various social robots, including chatbots (virtual and physical), voice assistants (Seeger *et al.*, 2021), personal intelligent agents, and HSRs (Moussawi *et al.*, 2022). Anthropomorphic or humanlike agents exhibit traits such as emotionality, desire, and warmth, which are conveyed through anthropomorphic design features (Fan *et al.*, 2016). Previous research has explored various anthropomorphic features of social robots, including their appearance (Appel *et al.*, 2020; Prakash and Rogers, 2015), voice (Fan *et al.*, 2016; Konya-Baumbach *et al.*, 2023; Tamagawa *et al.*, 2011), and response (Diederich *et al.*, 2021; Schuetzler *et al.*, 2020).

Social robots' diverse anthropomorphic features could lead to varying perceptions of their anthropomorphism and elicit conscious and unconscious responses from users (Kim and Sundar, 2012). Previous studies have categorized virtual robots' anthropomorphic features as

verbal or non-verbal, following the communication literature, and have included human identity as an additional feature of social robots (Seeger *et al.*, 2021). In addition, Feine *et al.* (2019) claimed that social robots' anthropomorphic features provide invisible, auditory, verbal, and visual social cues for virtual robots. Robots' verbal and non-verbal features could induce humanlike communication behavior between robots and humans (Seeger *et al.*, 2021). Their verbal features include spoken language, verbal styles, and social dialogues (Rossi *et al.*, 2018). Most HSRs can use speech recognition to understand and respond to users during HRIs, including language, voice, and responses. Non-verbal features include facial expressions, gaze, and body language (van Pinxteren *et al.*, 2019). These non-verbal cues, such as facial expressions and gaze, could also be related to HSRs' appearance (Li *et al.*, 2023).

Scholars have attempted to examine how robots' anthropomorphic features affect user perceptions, attitudes, and behaviors. Table 1 summarizes existing literature focusing on anthropomorphic features. Accordingly, in prior literature, significant attention has been given to the appearance, voice, and response features, and these features appear to substantially affect user perceptions and behaviors toward social robots. Prior studies have mainly focused on anthropomorphic features either generally (Kamide and Arai, 2017; Seeger *et al.*, 2021) or specifically, i.e. focusing on appearance (Liu *et al.*, 2022), voice (Fan *et al.*, 2016), or response (Schuetzler *et al.*, 2020). To date, only a few studies have endeavored to explore how various HSRs' anthropomorphic features influence user perceptions (Fan *et al.*, 2016; Liu *et al.*, 2022), and these studies have focused primarily on appearance and voice features, ignoring the other important features, such as responses, and the combined effects of these features on user perceptions and behaviors. In addition, previous studies on anthropomorphism have examined the direct influence of anthropomorphic features on attitudes or behaviors (Liu *et al.*, 2022; Moussawi *et al.*, 2022). However, the existing studies fail to describe the complex cognitive processes that link anthropomorphic features with user attitudes or behaviors in the context of HSRs. Therefore, the current study focuses on HSRs' appearance, voice, and response as anthropomorphic features to examine their diverse roles in affecting user satisfaction.

2.2 The stimulus-organism-response (SOR) framework

SOR theory assumes one's behaviors to be learning responses to external stimuli (Jacoby, 2002; Mehrabian and Russell, 1974). This theory implies that an individual's intrinsic condition is triggered when exposed to an external stimulus (Hsiao and Tang, 2021). A stimulus (S) is the external component that changes an individual's inner state, while an organism (O) is an individual's experience of affective cognition, which involves both cognitive and affective states. Specifically, the cognitive state is the thought process based on information processing, whereas the affective state is concerned with feelings or emotions (Benlian, 2015). A response (R) refers to an individual's ultimate natural reactions to a particular stimulus, including attitudinal and behavioral reactions (Hsiao and Tang, 2021; Xie *et al.*, 2023).

In IS domains, the SOR framework has been utilized to discuss individuals' attitudinal and behavioral responses to different IS in diverse contexts, such as social commerce (Fu *et al.*, 2018; Zhang *et al.*, 2014) and e-commerce (Cheng *et al.*, 2022). Table 2 summarizes existing IS studies that use the SOR framework. The table illustrates that the features and characteristics of IS have been widely used to capture stimuli factors, while cognitive reactions, such as various user perceptions, have commonly been used to represent organism factors. Prior literature shows that the SOR framework uncovers the intrinsic process of user responses and is more suitable for including various types of stimuli based on the studied context (Neves *et al.*, 2024). In addition, prior IS studies have considered the technological attributes or characteristics of IS as the stimuli that trigger individuals' perceptions or behaviors regarding IS (Cheng *et al.*, 2022; Hlee *et al.*, 2023; Ochmann *et al.*, 2024; Thapa *et al.*, 2024; Wang *et al.*, 2024). For example, Zhang *et al.* (2014) used the SOR framework to study individuals' intentions to engage in social commerce. They found that the technological

Table 1. Prior research on social robots' anthropomorphic features

Author(s)	Applied theory (or theories)	Method	Context	Robot type	Anthropomorphic features				Dependent variable(s)
					AP	VO	RE	GA	
Appel *et al.* (2020)	UVT	Experiment	Healthcare	Physical	x				Eeriness
Fan *et al.* (2016)	–	Experiment	Self-service	Physical and virtual		x		x	Customers' switching intentions
Kamide and Arai (2017)	–	Experiment	Culture	Virtual				x	Perceived comfortableness
Klüber and Onnasch (2022)	–	Survey	Healthcare	Physical	x	x			Robot preference
Konya-Baumbach *et al.* (2023)	Social presence	Experiment	E-commerce	Virtual		x			Customer responses (trust, purchase intention, WOM, satisfaction)
Kuchenbrandt *et al.* (2013)	MGP	Experiment	Education	Physical				x	Acceptance, willingness to interact
Liu *et al.* (2022)	–	Survey	Hospitality	Physical and virtual	x				Usage intention
Moussawi *et al.* (2022)	UMITC	Survey	Education	Virtual				x	Continued usage intention, perceived enjoyment
Pelau *et al.* (2021)	CASA	Survey	General service	Humanoid and virtual				x	Acceptance and trust
Prakash and Rogers (2015)	UVT	Experiment	Task context	Physical	x				Likability, anxiety, trust, and perceived usefulness
Schuetzler *et al.* (2020)	SPT	Experiment	General	Virtual			x		Perceived humanness, partner engagement
Seeger *et al.* (2021)	Anthropomorphism	Experiment	Healthcare	Virtual	x	x			Perceived anthropomorphism
Van Pinxteren *et al.* (2019)	Trust	Experiment	General	Physical	x				Usage intention, trust
Złotowski *et al.* (2018)	MET and DPM	Experiment	Education	Physical				x	Robot rating

Note(s): MGP = minimal group paradigm; UVT = uncanny valley theory; SPT = social presence theory; MET = media equation theory; DPM = dual-process model; CASA = computers as social actors theory; UMITC = unified model of IT continuance; AP = appearance; VO = voice; RE = response; GA = general anthropomorphism; WOM = word of mouth

Source(s): Authors' own creation

Table 2. Previous research on the SOR framework in the IS field

Reference	Context	Method	S	O	R
Animesh *et al.* (2011)	Social virtual world	Survey	• Interactivity • Sociability • Density • Stability	• Telepresence • Flow • Social presence	• Intention to purchase virtual goods
Chen *et al.* (2021b)	Charitable crowdfunding	Survey	• Perceived autonomy • Perceived competence • Perceived relatedness (social connection)	• Performance expectancy • Social influence • Altruism • Sense of self-worth	• Intention to donate
Chen *et al.* (2021a)	Online charities	Survey	• Central route • Informational peripheral route • Emotional peripheral route	• Trust • Empathic concern	• Donation intention • Forwarding intention
Cheng *et al.* (2022)	Chatbots	Survey	• Perceived warmth • Communication delay • Perceived competence	• Trust in chatbots	• Intention to switch
Cui *et al.* (2016)	Online auctions	Survey	• Effectiveness of bidding agent • Effectiveness of watch the item (WTI) • Network effect • Product diversity	• Perceived bidding utility • Perceived bidding enjoyment	• Bidder loyalty
Fei *et al.* (2021)	E-commerce live-streaming	Eye tracking experiment	• Herding message • Interaction text	• Endogenous attention • Exogenous attention	• Purchase intention
Gu *et al.* (2023)	Live-streaming shopping	Survey	• Information richness • Interactivity • Vividness • Social presence • Newness	• Perceived diagnosticity • Perceived enjoyment • Perceived social support • Memorable experience	• Continuance participation intention
Hlee *et al.* (2023)	Service robots	Survey	• Emotional HRIs • Functional HRIs	• Attitude	• Experiential outcomes • Performance outcomes
Hsiao and Tang (2021)	Pokémon Go	Survey	• Critical mass • Social interaction • Information timeliness • Content richness	• Attachment • Conformity	• Visiting intention • Continuance intention

(*continued*)

Table 2. Continued

Reference	Context	Method	S	O	R
Kim *et al.* (2020)	Virtual reality tourism	Survey	• Authentic experience	• Cognitive response • Affective response	• Attachment to VR • Visit intention
Lee *et al.* (2021b)	Crowdfunding campaign website	Experiment	• Motion of a progress bar • Color of a progress bar • Extra information of a progress bar	• Positive affect • Trust • Information diagnosticity	• Intention to back crowding projects
Ochmann *et al.* (2024)	Algorithmic recruiting	Experiment	• Transparency • Anthropomorphism	• Procedural justice • Distributive justice • Interpersonal justice • Informational justice	• Satisfaction • Recommendation
Wang *et al.* (2024)	Live e-commerce	Survey	• Attractiveness • Similarity • Expertise • Trustworthiness	• Affective response (parasocial interaction) • Cognitive response (perceived information quality) • Steamer-brand preference	• User stickiness
Xue *et al.* (2020)	Live social commerce	Survey	• Anchor-consumer interaction (personalization, responsiveness, entertainment) • Consumer-consumer interaction • Machine-consumer interaction (perceived control)	• Perceived usefulness • Perceived risk • Psychological distance	• Social commerce engagement
Zhang *et al.* (2015)	Social media	Survey	• Perceived task-relevant cues • Perceived affection-relevant cues	• Customer learning value • Social integrative value • Hedonic value	• Intention of future participation
Zheng *et al.* (2019)	Impulse buying in mobile commerce	Survey	• Interpersonal influence • Visual appeal • Portability	• Hedonic browsing • Utilitarian browsing	• Urge to buy impulsively
Zhu *et al.* (2020)	Cross-border electronic commerce	Survey	• Product description • Product display • Product content	• Curiosity • Concentration • Autotelic experience	• Impulse purchases

Source(s): Authors' own creation

elements of social commerce platforms, such as users' perception of their interactivity, personalization, and sociability, serve as stimuli to trigger their perceptions of virtual customer experiences in social commerce (an organism) concerning flow, social support, and social presence, which further drive their intentions to participate in social commerce (a response). Visual appeal, interpersonal influence, and portability of mobile commerce platforms were reported to serve as stimuli to trigger user perception of hedonic and utilitarian browsing (organism), which leads to their impulsive purchases (organism) (Zheng *et al.*, 2019). Furthermore, Cheng *et al.* (2022) used the SOR framework to study text-based chatbot usage among individuals and discovered that the perception of warmth, communication delay, and competence of a text-based chatbot served as stimuli to trigger users' trust in chatbots (an organism).

The widespread application of the SOR framework to explore users' attitudes and behavioral responses to different IS indicates that this framework could be an appropriate theoretical framework to study user satisfaction with robot services, particularly in relation to robots' anthropomorphic features. In addition, the uncanny valley theory posits that robots' anthropomorphic features can elicit spontaneous responses from users (Mori, 1970). This further supports the appropriateness of applying the SOR framework to study user satisfaction with robot services through the lens of anthropomorphic features. Unlike some studies that explore the direct relationships between anthropomorphism and user attitudes or behaviors (Seo, 2022), the SOR framework enables a deeper analysis of how anthropomorphic features influence user satisfaction by capturing the underlying cognitive mechanism through its organism component. This makes the SOR framework a well-suited theoretical stance to understand user satisfaction with HSR services.

Previous studies show that the SOR framework can effectively uncover the intrinsic process of user responses, allowing the inclusion of various types of stimuli tailored to the specific context being studied (Neves *et al.*, 2024). In IS research, the technological attributes or characteristics of IS have often been considered stimuli that trigger individuals' perceptions regarding IS (Cheng *et al.*, 2022; Hlee *et al.*, 2023; Ochmann *et al.*, 2024; Thapa *et al.*, 2024; Wang *et al.*, 2024). Recent research on robots has also applied the SOR framework and set anthropomorphic features of chatbots as stimuli to understand user trust, switching intentions, and user attitudes (Cheng *et al.*, 2022; Hlee *et al.*, 2023). These studies provide strong support for the current research, validating the consideration of anthropomorphic features of robots as stimuli, given that these features are technological attributes of humanlike robots. Additionally, cognitive processes have often been chosen and characterized as organisms in the SOR framework (Wang *et al.*, 2024; Zhu *et al.*, 2023). In the context of HSRs, user perception of IS values can represent the cognitive processes of users, making them suitable as the organism in accordance with the SOR framework. User satisfaction, which refers to users' attitudinal response to robot service, has also been categorized as a response in the SOR framework in previous research (Ochmann *et al.*, 2024), further supporting its inclusion in our study. Therefore, in alignment with the SOR framework, HSRs' anthropomorphic features as stimuli can trigger users' value perceptions (organism), which further affect user satisfaction (attitudinal response) toward HSRs.

2.3 User satisfaction

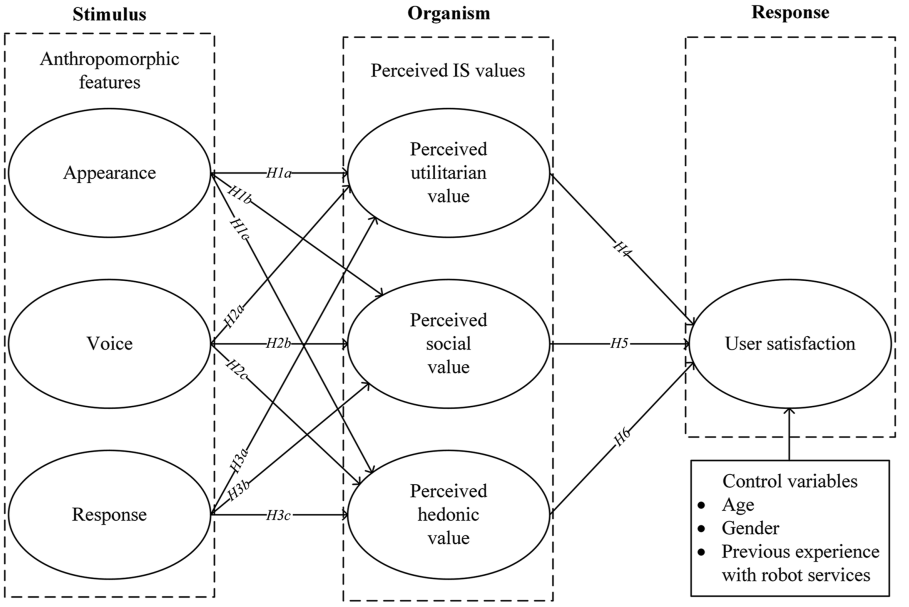
User satisfaction with an IS has been a dominant research topic in IS research since satisfaction has been identified as one of the most critical and widely used indicators to measure the success of an IS (Vaezi *et al.*, 2016, 2019). Some IS scholars have suggested that satisfaction constitutes the attitudes of users or the collection of feelings developed to assess the effectiveness or success of an IS (Petter *et al.*, 2013), highlighting that user satisfaction with an IS pertains to user attitudes and feelings stemming from perceived benefits that an individual anticipates during interactions with an IS (Kuo and Hsu, 2022).

Previous studies have examined the factors determining user satisfaction with IS from different perspectives. For example, Cao *et al*. (2018) considered trust to be an antecedent in satisfaction, and continuance intention to be an outcome of satisfaction from a trust transfer perspective. Bhattacherjee (2001) posited that the perceived usefulness of an IS and users' extent of confirmation are associated with user satisfaction with IS use, and their satisfaction could lead to users' continuance intention to use such IS. Later, this model was widely applied to examine user satisfaction and continuance intention in IS research. Some scholars have examined user satisfaction with IS from the IS attribution view. For example, DeLone and McLean (2003) stated that attributes such as information quality, system quality, and service quality of an IS are associated with user satisfaction and have also been extensively utilized in the IS domain to investigate user satisfaction and IS success. Meanwhile, previous research has suggested other attributes such as timeliness, perceived ease of use, user attitude, convenience, perceived usefulness, and accuracy to serve as antecedents of user satisfaction based on their research contexts (Vaezi *et al*., 2016).

The critical role of user satisfaction in measuring the success of an IS has also drawn scholars' attention to user satisfaction with HSRs. For example, Song and Kim (2022) categorized user satisfaction as an emotion and experimented on user satisfaction together with irritation, anger, and happiness in HSR use. Similarly, Kwon *et al.* (2018) found that a lower difference in empathy between a user and HSR yields higher user satisfaction with service robots in the healthcare context. Additionally, Xie *et al.* (2023) described how anthropomorphic cues are related to interaction satisfaction by arguing that satisfaction is a reaction attitude toward smart home assistants. Though anthropomorphic features of HSRs have been argued to be important in understanding user perception, attitude, behavior regarding HSRs, and the success of HSR implementation, only a few studies have attempted to elaborate on how the anthropomorphic features of HSRs influence value perceptions associated with using HSRs and how these perceived values further affect user satisfaction with HSR services.

3. Research model and hypotheses

Drawing on the SOR framework, we developed a research model (see Figure 1) to examine the varied effects of different anthropomorphic features on perceived utilitarian, hedonic, and social values, which, in turn, determine user satisfaction with HSR services. In the context of social robots, prior studies have highlighted appearance (Appel *et al*., 2020; Prakash and Rogers, 2015), voice (Fan *et al*., 2016; Konya-Baumbach *et al*., 2023; Tamagawa *et al*., 2011), and response (Diederich *et al*., 2021; Okanda and Taniguchi, 2022) features as prominent anthropomorphic features. HSRs' appearance refers to how HSRs look and mimic humanlike physical appearance, including the face, body, legs, and dynamic characteristics such as facial expressions (Appel *et al*., 2020; Klüber and Onnasch, 2022; Liu *et al*., 2022; Prakash and Rogers, 2015), and personality features such as gender (Seo, 2022). These elements elicit non-verbal cues during HRIs. Further, robots' appearance has been reported to impact user perceptions regarding robots (Castro-González *et al*., 2016). HSR's voice is also a key design element in communication, providing verbal cues during HRIs. Additionally, the capability to communicate through voice is a key determinant when assessing user preferences for robots, and a robot's voice has been found to be a critical factor in user engagement (Klüber and Onnasch, 2022). Moreover, responses of HSRs can be either verbal or non-verbal in nature based on their interaction style, environment, or robot type (Złotowski *et al*., 2015). HSRs could possess affective and cognitive capabilities and combine emotional and rational thinking, thereby understanding users' requirements (Čaić *et al*., 2019). When HSRs' responses to users resemble the responses that occur during human–human interactions, users may not discriminate between HSRs and humans (Okanda and Taniguchi, 2022), and these interactions produce positive perceptions regarding HSRs. However, HSRs' failure in



Source(s): Authors' own creation

Figure 1. Research model

responses could lower users' expectations concerning HSRs' human likeness, leading to uncertainties concerning HSRs use and user dissatisfaction with robot services (Diederich *et al.*, 2021; Fan *et al.*, 2016). Accordingly, appearance, voice, and response features of HSRs are selected in this study.

Previous studies have considered perceived utilitarian, social, and hedonic values of IS as dominant motivators for IS use (Evelina *et al.*, 2020; Stock *et al.*, 2015). Therefore, the current study conceptualizes these three types of perceived IS values for HSRs as the organism in the SOR framework, which are triggered by HSRs' three anthropomorphic features and subsequently influence user satisfaction. Specifically, HSRs' appearance, voice, and response are characterized as external stimuli (S) that trigger users' perceived utilitarian, social, and hedonic values (O). These perceived values, in turn, affect users' attitudinal response (R), such as user satisfaction with HSR services (Ochmann *et al.*, 2024). Prior research has suggested that users' age, gender, and previous robot use experience affect their perceptions of using IS, such as social robots (Kang *et al.*, 2023). Thus, we set users' age, gender, and previous experience with robot services as control variables.

Humanlike designs have been found to transfer human characteristics to HSRs and influence user perceptions (Duffy, 2003). When users see the humanlike appearance of HSRs, such as physical appeal and facial expressions, they might perceive HSRs as similar to humans and assume HSRs to be capable of performing tasks like human employees. Therefore, users are likely to infer humanlike service quality from HSRs when HSRs have humanlike congruence, thus influencing their perceptions of the utilitarian value of HSRs. Similarly, when HSRs look like humans, users tend to interact with HSRs in a manner similar to how they interact with humans and carry out social interactions like human-human interactions. HSRs with humanlike faces can be perceived to be sociable (Broadbent *et al.*, 2013). Facial expressions and maintaining eye contact are elements of human-human communication. The facial expressions of HSRs and eye contact with humans during HRIs can increase user

engagement with HSRs, similar to human-human interactions. Therefore, the humanlike appearance of HSRs could strengthen user perceptions of the social value of HSRs. Furthermore, the humanlike appearance of HSRs has been found to increase users' positive emotions, such as making users feel enjoyment and pleasure in the frontline service context (Belanche *et al.*, 2020). HSRs with a humanlike appearance could evoke users' curiosity and enjoyment while performing their dedicated tasks (Chi *et al.*, 2023; De Graaf and Ben Allouch, 2013; Liu *et al.*, 2022). Users' interest and curiosity during interactions with HSRs can further make users feel a sense of joy. Thus, the humanlike appearance of HSRs could trigger user perceptions of the hedonic value of HSRs. Overall, HSRs' humanlike appearance can be reasonably assumed to trigger users' cognitive responses, including their perception of the IS values related to HSRs, and it is plausible to assume the following hypotheses:

H1a. HSRs' appearance is positively linked to user perceptions of robots' utilitarian value.

H1b. HSRs' appearance is positively linked to user perceptions of robots' social value.

H1c. HSRs' appearance is positively linked to user perceptions of robots' hedonic value.

HSRs can communicate with users through voice-based speech. As an expressive communication medium, voice can reflect speakers' features, such as age, gender, emotion, and personality (Li *et al.*, 2023). Compared to a mechanical or technical voice, an HSR's humanlike voice can convey richer implicit information (e.g. emotion and personality), facilitating social expression and interactions between users and robots (Moran *et al.*, 2015). For instance, the humanlike voices of HSRs, which are soft, faintly accented, and lively, could make human-robot communication more similar to human-human communication than machinelike voices, thereby making users perceive such HSRs as having stronger humanlike cognitive capability to communicate with humans and perform tasks following their requests. Thus, the humanlike voice of an HSR could enhance user perceptions of the utilitarian value. In addition, the humanlike voice of an HSR can make users feel that they are talking with a human, perceiving the social interactions with HSRs as similar to human-human interactions and fulfilling social experiences during HRIs (Conti *et al.*, 2017). When an HSR possesses a lively voice without monotonous articulation, users are likely to feel connected and develop trust and rapport during HRIs (Li *et al.*, 2023). The openness and sense of comfort in communication with a robot with a soft and lively voice could even make users perceive an HSR as a social companion, unlike a machine. Therefore, the humanlike voice of HSRs may improve user perception of the social value. Additionally, a humanlike voice is deemed more pleasurable than a synthesized voice (Kühne *et al.*, 2020; Schreibelmayr and Mara, 2022). Also, Li *et al.* (2023) argued that the soft and lively voices of robots during HRIs can make users feel more engaged and enjoyable. Based on the above grounds, the HSRs' voice can be assumed to improve the perceived utilitarian, hedonic, and social values. The more humanlike the voice of an HSR, the stronger the perception of the IS values related to HSRs. Therefore, the following hypotheses are proposed:

H2a. HSRs' voice is positively linked to user perceptions of robots' utilitarian value.

H2b. HSRs' voice is positively linked to user perceptions of robots' social value.

H2c. HSRs' voice is positively linked to user perceptions of robots' hedonic value.

The response feature is another key anthropomorphic feature of an HSR. HSRs usually interact with users via verbal or non-verbal responses (Złotowski *et al.*, 2015). Effective and timely responses are required when performing specific tasks assigned to HSRs, and users might not perceive such HSRs to be useful or to have good utilitarian value if the robots fail to provide meaningful, prompt responses to users or engage with users in interactive dialogues (Fan *et al.*, 2016). Prior research has indicated that robot responses can affect user perceptions regarding

robots (Belanche *et al.*, 2020; Birnbaum *et al.*, 2016). Specifically, a more responsive robot is perceived as more competent and sociable than a less responsive robot (Birnbaum *et al.*, 2016). Chatbots with higher-level response skills, such as offering tailored and varied responses, have been reported to be more anthropomorphic and socially present than chatbots with less-skilled response features (Schuetzler *et al.*, 2020). In the context of HSRs, the appropriate responses delivered promptly by HSRs can enable smooth engagement between the robots and users and mimic human-human interactions, which further develop the users' belief that HSRs are competent in completing tasks and sociable enough to interact with, enhancing user perceptions of the utilitarian and social values (Song and Kim, 2022). Similarly, meaningful and real-time interactive dialogues are likely to make users feel that HSRs are vivid and realistic, making their experience more pleasant (Okanda and Taniguchi, 2022). HSRs' responses to users, such as gestures and physical movements carried out according to users' requests, could trigger users' perceived enjoyment and happiness, similar to the enjoyment of playing games. Therefore, it is reasonable to assume that HSRs' responses to users during HRIs would affect users' perceived utilitarian, social, and hedonic values; thus, the more prompt, appropriate, and real-time responses HSRs provide, the stronger the perception of the HSRs' IS values. Therefore, it is reasonable to suggest the following hypotheses:

H3a. HSRs' response is positively linked to user perceptions of robots' utilitarian value.

H3b. HSRs' response is positively linked to user perceptions of robots' social value.

H3c. HSRs' response is positively linked to user perceptions of robots' hedonic value.

HSRs' utilitarian value, such as their adaptability and usefulness, influences user satisfaction with robots (Bhattacherjee, 2001; Moussawi *et al.*, 2022). Users tend to be satisfied if their expectations are fulfilled during technology use (De Graaf *et al.*, 2015). When users perceive HSRs to have high utilitarian value, i.e. the robots are effective in fulfilling their intended functions and tasks, users could perceive the robots to be useful in service delivery, leading to satisfaction. Additionally, better task performance of HSRs can meet users' expectations for using HSRs, affecting user satisfaction with the service delivered by HSRs. HSRs with higher utilitarian capabilities can perform tasks with high levels of competency and reliability, such as efficiently handling queries, which are more likely to fulfill users' expectations and make them more satisfied with the service delivered by HSRs (Chen and Girish, 2023). Therefore, we argue that the higher the perception of the utilitarian value of HSRs, the higher the satisfaction among users, and propose the following hypothesis:

H4. User perception of the utilitarian value of HSRs positively affects their satisfaction with HSR services.

HSRs are identified diversely, for instance, as social actors, social companions, or social partners, depending on the environments in which they operate and the nature of social interactions they perform during HRIs. The social value of HSRs entices users to perceive robots as sufficiently humanlike (Pelau *et al.*, 2021). When users perceive that HSRs can engage in communication that closely mimics human-to-human interaction—through language, understanding, and responsive behavior—they are more likely to feel a sense of connection and relational bonding with the robots, similar to their connections with other humans (Fan *et al.*, 2016). In addition, when users perceive an enhanced social value, they could feel that the HSRs can fulfill their expectations for social interaction, replicating human-human interactions and making them highly satisfied with robot services. Further, prior literature has shown that when users perceive a higher social value of a technology, they are more likely to be satisfied with their usage (Evelina *et al.*, 2020; Huang *et al.*, 2021). Accordingly, it can be inferred that increased user perceptions of the social value of HSRs could improve user satisfaction with the service delivered by the robots; thus, the following hypothesis is suggested:

H5. User perception of the social value of HSRs positively affects user satisfaction with HSR services.

The unique anthropomorphic features of HSRs could make users experience enjoyable interactions with HSRs (Kang *et al.*, 2023; Kim and Sundar, 2012). Prior research has found that users are more satisfied with robots when they perceive fun and joy during their use and engage in interactions with robots (Huang *et al.*, 2021). For instance, in healthcare settings, users perceive the high social value of social robots since social robots offer entertainment and emotional support to patients, thereby enhancing their overall experience and making them satisfied with robot usage. Studies in the hospitality industry have also shown that users' emotional experiences, including fun and surprise, generated when using robots in hotels can increase their satisfaction with robotic services (Luo *et al.*, 2021). Therefore, it is reasonable to assume that when users perceive a higher hedonic value of HSRs, they are likely to have higher satisfaction with the service delivered by HSRs. Thus, the following hypothesis is proposed:

H6. User perception of the hedonic value of HSRs positively affects user satisfaction with HSR services.

4. Research methodology

4.1 Construct measurements

Items that had been validated by prior studies were adapted to assess all constructs included in this study (the measurement items are presented in the Appendix). Slight modifications were applied to the measurement items of each construct to fit the context of HSR usage. The items for appearance, response, perceived utilitarian value, and perceived social value were evaluated using a seven-point Likert scale, which ranged from 1 = strongly disagree to 7 = strongly agree, while the items for voice, perceived hedonic value, and user satisfaction were assessed using a similar seven-point semantic differential scale. Appearance was measured with items adapted from the work of Liu *et al.* (2022), voice with items adapted from the work of Stern *et al.* (2002), and response with items adapted from the work of Lankton *et al.* (2015). Measurement items from the work of Im and Workman (2004) were adapted to assess perceived utilitarian value. A combination of items gathered and modified from Pelau *et al.* (2021) and Zhang *et al.* (2021) was used to measure perceived social value, while items adapted from van der Heijden (2004) were utilized to measure perceived hedonic value. User satisfaction was evaluated in accordance with the items proposed by Bhattacherjee (2001).

4.2 Data collection

An online survey, developed in English, was conducted to gather data from hotel customers since the hotel industry has pioneered the deployment of HSRs to serve customers (Chi *et al.*, 2023). Prior to the main study, a pilot study was carried out with 12 respondents to collect feedback on the research instruments. The measurements were modified to improve their clarity and accuracy based on the pilot study's feedback. The survey was designed using Qualtrics and launched for data collection on Amazon Mechanical Turk (AMT) from 6–15th September 2022. AMT, a crowdsourcing platform, has been extensively used in research areas such as business management and psychology to enlist participants for research. It is recognized as an appropriate source of research data since the AMT user population is reflective of the general public and responds to experimental conditions in a manner comparable to traditional participant groups (Schuetzler *et al.*, 2020; Steelman *et al.*, 2014).

To ensure the quality of the responses, a filtering question: "*Have you ever used humanoid social robots in hotels?*" was included at the beginning of the survey, aiming to exclude participants who had not experienced HSRs. Then, the respondents were inquired about the types of HSRs they had experienced in hotels to confirm their previous use. Finally, questions regarding respondents' demographic background, usage experience, and perceptions

regarding HSRs were presented. Overall, the survey included three attention checks. Each research participant who completed the survey was provided with monetary compensation ($1.50) upon completion, which took about 10 min.

In total, we received 567 responses. Afterward, 58 responses with similar answers to all questions were excluded. In accordance with Armstrong and Overton (1977), an analysis was performed to compare the initial 25% and last 25% of survey participants in terms of their age and gender to evaluate nonresponse bias. The results revealed no significant differences, indicating that nonresponse bias was not a concern in this study. Finally, 509 responses were used as the study's valid data sample. Gender, age, travel frequency, and frequency of robot use among the survey respondents are presented in Table 3. Accordingly, the majority of respondents were between 30 and 39 years old (38.5%), and respondents were almost equally distributed by gender. Additionally, most respondents had traveled 1–2 times per year (52.7%) and experienced robots 2–3 times (59.7%) during their stays.

4.3 Validity and reliability

We tested for common method bias (CMB) by employing Harman's single-factor test, as proposed by Podsakoff *et al.* (2003). The highest variance was 37.974%, which accounted for less than 50% of the total variance, indicating that CMB was not a critical issue in the current study. In addition, the marker variable (MV) approach was used to test for the presence of CMB (Podsakoff *et al.*, 2003). Symbolic patriotism (Parker, 2010) was selected as the MV because the variable is unrelated to the variables under investigation and the context of this study. The bootstrapping process did not reveal any alterations in the path coefficients in the presence of the MV, and the R^2 values showed minor variations: ΔR^2 (perceived utilitarian value) = +0.064, ΔR^2 (perceived social value) = +0.076, ΔR^2 (perceived hedonic value) = +0.050, and ΔR^2 (user satisfaction) = +0.002, verifying that the constructs were unaffected by CMB (Tehseen *et al.*, 2017). The variance inflation factor (VIF) values were also tested to examine multicollinearity. The VIF values ranged from 1.311 to 1.642, falling below the threshold of 3.300 (Kock and Lynn, 2012), indicating the absence of multicollinearity issues.

Smart PLS 4.0 was used to assess the measurement model. The convergent validity of the model is established when the standard threshold values of factor loadings are greater than 0.700, the composite reliability (CR) of constructs exceeds 0.700, and the average variance

Table 3. Demographic information of the survey respondents and their HSR use experiences

Measurement	Item	Count	Percentage (%)
Gender	Male	261	51.3
	Female	248	48.7
Age (years)	18–29	172	33.8
	30–39	196	38.5
	40–49	95	18.7
	50–59	33	6.5
	≥60	13	2.5
Travel frequency (per year)	Less than once	30	5.9
	1–2	268	52.7
	3–4	189	37.1
	≥5	22	4.3
Frequency of robot use (per visit)	Once	35	6.9
	2–3	304	59.7
	4–5	139	27.3
	>5	31	6.1

Source(s): Authors' own creation

extracted (AVE) surpasses 0.500 (Hulland, 1999). Some items were removed from the constructs due to issues with construct validity and factor loadings. Subsequently, the factor loadings of the measurement items surpassed the threshold of 0.700, while the CR and AVE values were also above 0.700 and 0.500, respectively (see Table 4), confirming the convergent validity of the current study. Further, Cronbach's alpha values above 0.7 (Henseler *et al.*, 2016) indicated that the constructs exhibit a satisfactory level of internal consistency reliability.

Both the Fornell–Larcker criterion (Fornell and Larcker, 1981) and the heterotrait–monotrait ratio of correlation (HTMT) (Henseler *et al.*, 2015) were applied to test discriminant validity. As presented in Table 5, the AVE square root of each construct exceeded the correlation values of any other constructs. The cross-loadings (see Table 6) indicate that each construct item had a stronger loading on its parent construct than on other constructs (marked in *italic*). All HTMT values for the constructs were below 0.900 (see Table 7), which is the threshold for the HTMT ratio suggested by Henseler *et al.* (2015). Accordingly, the discriminant validity of the research data was established.

4.4 Results

The structural model was tested using the PLS bootstrapping process. As postulated, appearance had a significant and positive relationship with perceived utilitarian value ($\beta = 0.251$, $p < 0.001$) and perceived social value ($\beta = 0.265$, $p < 0.001$). However, the relationship between appearance and perceived hedonic value was insignificant. The voice also showed significant positive correlations with perceived utilitarian value ($\beta = 0.171$, $p < 0.001$), perceived social value ($\beta = 0.190$, $p < 0.001$), and perceived hedonic value ($\beta = 0.308$, $p < 0.001$). Similarly, response was significantly and positively related to perceived utilitarian value ($\beta = 0.452$, $p < 0.001$), perceived social value ($\beta = 0.368$, $p < 0.001$), and perceived hedonic value ($\beta = 0.372$, $p < 0.001$). In addition, perceived utilitarian value ($\beta = 0.217$, $p < 0.001$), perceived social value ($\beta = 0.121$, $p < 0.05$), and perceived hedonic value ($\beta = 0.514$, $p < 0.001$) displayed significant positive correlations with user satisfaction. Therefore, as depicted in Figure 2, all other proposed hypotheses were supported, except H1c. The model explained 50.1% of the variance in perceived utilitarian value, 43.2% of the variance in perceived social value, 40.1% of the variance in perceived

Table 4. Results from the confirmatory factor analysis

Construct	Item	Factor loading	Cronbach's alpha	CR	AVE
Appearance (AP)	AP1	0.898	0.745	0.897	0.797
	AP2	0.887			
Voice (VO)	VO1	0.809	0.705	0.835	0.627
	VO2	0.789			
	VO3	0.778			
Response (RE)	RE1	0.889	0.724	0.879	0.784
	RE2	0.882			
Perceived utilitarian value (PUV)	PUV1	0.792	0.713	0.839	0.635
	PUV2	0.796			
	PUV3	0.802			
Perceived social value (PSV)	PSV1	0.815	0.755	0.859	0.671
	PSV2	0.798			
	PSV3	0.844			
Perceived hedonic value (PHV)	PHV1	0.898	0.769	0.897	0.813
	PHV2	0.905			
User satisfaction (US)	US1	0.871	0.710	0.873	0.775
	US2	0.890			

Source(s): Authors' own creation

Table 5. Values of correlation and square roots of AVE (shown in italic along the diagonal)

	AP	VO	RE	PUV	PSV	PHV	US
AP	*0.893*						
VO	0.403	*0.792*					
RE	0.446	0.443	*0.885*				
PUV	0.522	0.473	0.640	*0.797*			
PSV	0.506	0.460	0.571	0.634	*0.819*		
PHV	0.388	0.512	0.552	0.525	0.432	*0.901*	
US	0.388	0.484	0.499	0.563	0.480	0.680	*0.680*

Source(s): Authors' own creation

Table 6. Cross-loadings

	AP	VO	RE	PUV	PSV	PHV	US
AP1	*0.898*	0.418	0.468	0.438	0.450	0.423	0.381
AP2	*0.887*	0.299	0.326	0.495	0.454	0.267	0.311
VO1	0.321	*0.809*	0.409	0.359	0.401	0.531	0.407
VO2	0.365	*0.789*	0.325	0.373	0.351	0.342	0.356
VO3	0.271	*0.778*	0.307	0.396	0.332	0.316	0.382
RE1	0.441	0.437	*0.889*	0.562	0.511	0.514	0.409
RE2	0.348	0.346	*0.882*	0.572	0.499	0.463	0.476
PUV1	0.440	0.384	0.461	*0.792*	0.456	0.405	0.460
PUV2	0.406	0.355	0.541	*0.796*	0.530	0.434	0.441
PUV3	0.402	0.392	0.528	*0.802*	0.529	0.417	0.446
PSV1	0.388	0.374	0.449	0.508	*0.815*	0.346	0.357
PSV2	0.423	0.384	0.464	0.519	*0.798*	0.345	0.397
PSV3	0.431	0.372	0.488	0.530	*0.844*	0.369	0.423
PHV1	0.356	0.489	0.493	0.435	0.377	*0.898*	0.585
PHV2	0.344	0.435	0.502	0.511	0.401	*0.905*	0.640
US1	0.341	0.400	0.451	0.467	0.388	0.584	*0.871*
US2	0.343	0.450	0.429	0.523	0.455	0.612	*0.890*

Source(s): Authors' own creation

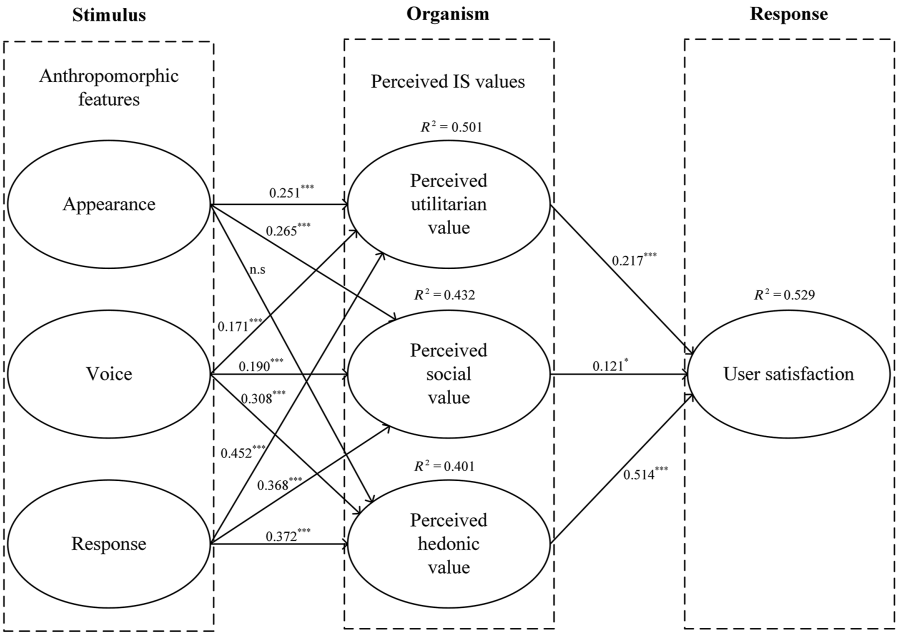
Table 7. Correlations' Heterotrait–Monotrait ratios

	AP	VO	RE	PUV	PSV	PHV	US
AP							
VO	0.553						
RE	0.604	0.611					
PUV	0.718	0.669	0.791				
PSV	0.674	0.625	0.771	0.764			
PHV	0.510	0.679	0.739	0.708	0.566		
US	0.533	0.679	0.698	0.791	0.653	0.819	

Source(s): Authors' own creation

hedonic value, and 52.9% of the variance in user satisfaction. Age, gender, and previous experience with robot services, included as control variables, showed no significant effects on user satisfaction.

Stone–Geisser's Q^2 in SmartPLS 4.0 was used to assess the predictive relevance of the model (Geisser, 1974; Stone, 1974). The Q^2 values for perceived utilitarian value, perceived



Note(s): *$p < 0.05$; ***$p < 0.001$; n.s not significant
Source(s): Authors' own creation

Figure 2. Research model with results

social value, perceived hedonic value, and user satisfaction were 0.483, 0.413, 0.386, and 0.334, respectively, indicating strong predictive relevance. Moreover, the model fit was calculated by utilizing the standardized root mean square residual (SRMR) (Henseler *et al.*, 2016). A better model fit was indicated through the SRMR value, which was 0.067, falling below the recommended threshold of 0.080 (Hu and Bentler, 1999).

5. Discussion

The current study investigated the varied effects of HSRs' different anthropomorphic features on perceived utilitarian, social, and hedonic values, which subsequently influenced user satisfaction with robot services. The results revealed that HSRs' three anthropomorphic features: appearance, voice, and response, as stimuli in the SOR framework, play distinct roles in triggering users' perceptions of the utilitarian, social, and hedonic values of HSRs. Specifically, the responses of HSRs showed the strongest influence on all perceived values. Apart from an insignificant influence of appearance on perceived hedonic value, all other relationships between anthropomorphic features and perceived values were significant. Additionally, all perceived IS values as organism in the SOR framework, contributed to user satisfaction (attitudinal response), with perceived hedonic value exerting the strongest effect.

The findings of this study raised several intriguing insights. First, the findings revealed that the three anthropomorphic features as stimuli affect the perception of the utilitarian value of HSRs differently. The responses influenced user perceptions of utilitarian value most strongly ($\beta = 0.452$, $p < 0.001$), followed by appearance ($\beta = 0.251$, $p < 0.001$), with voice having the weakest influence ($\beta = 0.171$, $p < 0.001$). This finding aligns with Birnbaum *et al.* (2016), who claimed that robots' responses primarily trigger user perceptions concerning the robots' competency in performing different tasks. HSRs' physical appearance and voice may induce

user perceptions of the robots' humanlikeness and the degree to which user–HSR interactions could resemble traditional human–human service encounters at hotels. However, the responses from HSRs could elevate personalized interactions more than appearance and voice, as these features are mostly static in nature. The appearance and voice of an HSR may initially attract the attention of users due to curiosity. Nevertheless, the responses from HSRs could result in positive and lasting user experiences that provide utilitarian value, making them the critical factor affecting the perceived utilitarian value more than HSRs' appearance and voice.

Second, the study found that appearance, voice, and responses, as stimuli, influence the perceived social value of HSRs differently. The response feature demonstrated the strongest link with user perceptions of social value ($\beta = 0.368$, $p < 0.001$), followed by appearance ($\beta = 0.265$, $p < 0.001$), with voice exerting the least influence ($\beta = 0.190$, $p < 0.001$). As Birnbaum *et al.* (2016) state, responsive robots are perceived as more sociable than unresponsive robots. Meanwhile, robots' responses, when understood meaningfully by users, foster friendships and lead to psychological bonds between users and robots during HRIs (MacDorman *et al.*, 2009). In hotels, HSRs, such as receptionist robots, are expected to interact with users by mimicking human social behaviors (Belanche *et al.*, 2020). Users expect personalized, context-specific, and timely responses when they engage with hotel service robots. Robots that provide relevant and personalized responses are perceived as more socially engaging, elevating their social value (Vishwakarma *et al.*, 2024). This aligns with the idea that the responsive behavior of HSRs mimics human social interactions, enhancing the perceived social value of HSRs. Appearance, which is important for the initial impression of users, plays a secondary role as it does not engage with users during ongoing interactions. However, appearance can still influence the perception of social value by conveying a level of human likeness and making users more open to interactions (Broadbent *et al.*, 2013). The weaker impact of voice on perceived social value may be attributed to its function primarily as a medium for communication rather than a driver of dynamic social interactions. This observation aligns with the findings of Li *et al.* (2023), which suggest that while a robot's humanlike voice may capture users' initial attention, it does not, however, independently contribute to deeper or sustained social engagement. Thus, HSRs' responses more strongly trigger users to perceive robots' social value than their voice and appearance.

Third, from the three anthropomorphic features, only response and voice, as stimuli, were found to trigger user perception of HSRs' hedonic value. The response had a stronger influence on user perceptions of the hedonic value ($\beta = 0.372$, $p < 0.001$) than voice ($\beta = 0.308$, $p < 0.001$), while appearance exhibited no effect. The study by Birnbaum *et al.* (2016) on social robots showed that effective responses from social robots positively affect their appealing traits and the tendency of users to approach them while realizing their utility or function. Similarly, according to the findings of this study, HSRs' responses are the main stimuli for the perception of hedonic value. While HSRs' responses could arouse joy and fun among hotel customers, they also rely on robots' voices to perceive the hedonic value during their use. Previous studies have found that realistic-sounding voices could evoke a high level of enjoyment among users when interacting with voice assistants (Schreibelmayr and Mara, 2022). However, the role of HSRs' appearance as visual stimuli is mostly static during the HRIs in hotel services, and therefore, it may not contribute to the perception of hedonic value for users at the level of HSRs' response or voice.

Finally, as hypothesized, user perception of the utilitarian, hedonic, and social values of HSRs positively impacted user satisfaction (attitudinal response) with robotic services. The perceived hedonic value ($\beta = 0.514$, $p < 0.001$) had the strongest impact on user satisfaction, followed by the utilitarian value ($\beta = 0.217$, $p < 0.001$) and the social value ($\beta = 0.121$, $p < 0.05$). These results align with prior findings of De Graaf and Ben Allouch (2013), who noted that a stronger perception of the IS values involving adaptability, usefulness, enjoyment, companionship, and sociability leads to greater satisfaction levels with robotic services.

Accordingly, HSRs can substitute for human employees by evoking joy and positive emotions during interactions, which eventually enhances overall user satisfaction. In addition, the findings of this study are consistent with the findings of Odekerken-Schröder *et al.* (2022), which revealed that both utilitarian and hedonic values of HSRs influence customer repatronage intentions, mirroring user satisfaction. Although the perceptions of utilitarian, hedonic, and social values affect user satisfaction, the perceived hedonic value exerts the strongest influence due to its emotional aspect, fostering positive memories and emotional connections within overall user experiences. Further, the perception of enjoyment or pleasure influences users' intrinsic motivation to use robots (Said *et al.*, 2024). As a result, in contexts such as hotels where users often seek enjoyment, the hedonic perception of HSRs could surpass the perception of utilitarian value or social value.

6. Conclusion

6.1 Theoretical contributions

This paper makes several theoretical contributions to the existing literature. First, this study is one of the first studies to investigate the effects of different anthropomorphic features such as appearance, voice, and response of HSRs on user satisfaction through the organism of users' value perceptions (utilitarian, social, and hedonic values). Unlike prior research, which has predominantly concentrated on a single anthropomorphic feature when disentangling the role of anthropomorphic features of HSRs on user perceptions and behaviors (Diederich *et al.*, 2021; Klüber and Onnasch, 2022; Seo, 2022), the current study broadens the scope by examining three distinct features: appearance, voice, and response. This approach not only extends the existing framework of anthropomorphic features of HSRs but also offers a comprehensive understanding of how various anthropomorphic features of HSRs shape user perceptions and behaviors differently. Specifically, by unveiling the distinct effects of the three different anthropomorphic features on user satisfaction through the mechanism of user perceptions of the utilitarian, social, and hedonic values of HSRs, our findings reveal that response, as a stimulus, strongly influences all three perceived IS values compared to voice and appearance, with appearance particularly lacking influence on the perception of hedonic value. These insights highlight the complexity of the cognitive process acting as the organism, providing a detailed explanation of how various anthropomorphic features of HSRs shape users' attitudinal responses.

Second, the current study deepens the understanding of the role of IS value perceptions as an organism within the SOR framework, particularly in investigating the impact of different anthropomorphic features on user satisfaction with HSR services. While HSRs are generally designed to offer utilitarian, social, and hedonic values, especially within the hotel context where they are primarily intended for utilitarian purposes (Ozturk *et al.*, 2023), our findings emphasize the critical importance of hedonic value perception in determining user satisfaction. The study reveals that perceived hedonic value exerts the most substantial impact on user satisfaction, surpassing the effects of both perceived utilitarian and perceived social values.

Finally, this study provides novel insights into the HSR literature by confirming that the anthropomorphic features of HSRs can effectively function as stimuli within the SOR framework to trigger users' intrinsic cognition and attitudinal responses, such as user satisfaction. While previous studies have predominantly applied traditional technological features of IS as stimuli in the SOR framework (Cheng *et al.*, 2022; Hlee *et al.*, 2023), our findings demonstrate that the anthropomorphic features of HSRs—distinctive and innovative aspects of humanlike technologies—should be recognized as vital stimuli. This recognition advances the understanding of how users cognitively and behaviorally interact with humanlike technologies, thereby influencing their attitudinal responses. This contribution not only extends the applicability of the SOR framework but also enriches the broader discourse on HRIs and the design of socially interactive technologies.

6.2 Practical contributions

The findings of this study deliver actionable insights for robot developers and hotel management, offering practical guidance on optimizing design and deployment of HSRs to enhance user satisfaction.

For HSR developers, the study highlights the critical importance of the response feature in shaping user perceptions of utilitarian, social, and hedonic values. Since responses were found to be the most influential factor across all perceived values, and with perceived hedonic value emerging as the most impactful factor on user satisfaction, developers should prioritize improving the quality and humanlikeness of HSRs' responses, focusing on their hedonic capabilities. Enhancements to the response of HSRs could include optimizing response times, enabling more personalized, natural, and adaptive interactions similar to human-human interactions, and ensuring that responses effectively address user needs in real-time. Such improvements can elevate the utility of HSRs, simultaneously enhancing the overall user experience through more engaging and enjoyable interactions, which may eventually result in higher user satisfaction with HSR services.

The voice feature, although not as critical as the response feature, still significantly impacts all perceived values. Developers are advised to optimize the voice quality of HSRs by refining elements such as softness, tone, loudness, and accent and by developing the voice to be more humanlike. A well-modulated voice can potentially enhance user engagement with HSRs (Li *et al.*, 2023), contributing to a more pleasant and engaging experience, ultimately leading to improved user satisfaction with HSR services.

The findings also suggest that HSR developers could deprioritize extensive customization of appearance, given its insignificant impact on hedonic value. Instead, resources could be better utilized to enhance interactive capabilities, such as the ability to engage in responsive, meaningful, socially engaging, emotionally resonant conversations as well as practical functionalities, ensuring that HSRs are more effective in fulfilling their roles in hotel settings. For example, designs could focus on optimizing HSRs' ability to assist with assigned tasks (e.g. check-ins and navigational assistance), thereby improving the overall guest experience through the functions of HSRs rather than focusing on features such as appearance.

For hotel managers, the study's findings underscore the importance of enhancing the perceived utilitarian, hedonic, and social values of HSRs to boost user satisfaction. Managers should carefully consider the primary purpose of the HSRs they deploy—whether it is to serve utilitarian tasks, provide entertainment, foster social interactions, or serve a combination of tasks. Depending on the intended purpose, robots with different features should be deployed. For instance, if the goal is to improve customer service, HSRs should be equipped with highly responsive features to ensure they can meet customer needs effectively. If the goal is to entertain hotel guests, an HSR with a pleasant, humanlike voice combined with effective responses is recommended, as it can significantly enhance guests' enjoyment and satisfaction. However, despite the intended purpose, the hotel managers needs to ensure the quality of HSRs' responses through the evaluation of feedback from hotel customers. By promoting the functionality and unique experiences that HSRs offer, managers can divert guest attention away from appearance and toward the robot's contributions to service quality. This approach enhances user satisfaction with HSR services while aligning with the practical realities of resource allocation in HSR design and deployment.

6.3 Limitations and avenues for future research

The current study encountered a few limitations. First, it mainly included three anthropomorphic features of HSRs: appearance, voice, and response. Other factors, such as social robots' level of autonomy, could be considered in future research to explain how anthropomorphic features influence user behaviors involving HSRs. Second, the study's data were gathered from hotel customers who had experienced robots during their stay. In the future, researchers could consider duplicating this study across different contexts to enhance

its generalizability. Third, this study examined user satisfaction with HSR services using the SOR framework. Further research could consider investigating the impact of anthropomorphic features on perceived humanness, perceived hospitality, or emotions by applying alternative theories such as social cognitive theory, social presence theory, or trust. Finally, future research could also investigate the effects of anthropomorphic features on users' affective states, such as their positive and negative feelings or emotions, deviating from the current study's focus on how these features impact user perception of IS values in terms of utilitarian, social, and hedonic values.

References

Animesh, A., Pinsonneault, P., Yang, S.B. and Oh, W. (2011), "An odyssey into virtual worlds: exploring the impacts of technological and spatial environments on intention to purchase virtual products", *MIS Quarterly*, Vol. 35 No. 3, p. 789, doi: 10.2307/23042809.

Appel, M., Izydorczyk, D., Weber, S., Mara, M. and Lischetzke, T. (2020), "The uncanny of mind in a machine: humanoid robots as tools, agents, and experiencers", *Computers in Human Behavior*, Vol. 102, pp. 274-286, July 2019, doi: 10.1016/j.chb.2019.07.031.

Armstrong, J.S. and Overton, T.S. (1977), "Estimating nonresponse bias in mail surveys", *Journal of Marketing Research*, Vol. 14 No. 3, pp. 396-402, doi: 10.1177/002224377701400320.

Belanche, D., Casaló, L.V., Flavián, C. and Schepers, J. (2020), "Robots or frontline employees? Exploring customers' attributions of responsibility and stability after service failure or success", *Journal of Service Management*, Vol. 31 No. 2, pp. 267-289, doi: 10.1108/JOSM-05-2019-0156.

Benlian, A. (2015), "IT feature use over time and its impact on individual task performance", *Journal of the Association for Information Systems*, Vol. 16 No. 3, pp. 144-173, doi: 10.17705/1jais.00391.

Bhattacherjee, A. (2001), "Understanding information systems continuance: an expectation-confirmation model", *MIS Quarterly*, Vol. 25 No. 3, p. 351, doi: 10.2307/3250921.

Birnbaum, G.E., Mizrahi, M., Hoffman, G., Reis, H.T., Finkel, E.J. and Sass, O. (2016), "What robots can teach us about intimacy: the reassuring effects of robot responsiveness to human disclosure", *Computers in Human Behavior*, Vol. 63, pp. 416-423, doi: 10.1016/j.chb.2016.05.064.

Broadbent, E., Kumar, V., Li, X., Sollers, J., Stafford, R.Q., MacDonald, B.A. and Wegner, D.M. (2013), "Robots with display screens: a robot with a more humanlike face display is perceived to have more mind and a better personality", in Slater, M. (Ed.), *PLoS One*, Vol. 8 No. 8, e72589, doi: 10.1371/journal.pone.0072589.

Čaić, M., Mahr, D. and Oderkerken-Schröder, G. (2019), "Value of social robots in services: social cognition perspective", *Journal of Services Marketing*, Vol. 33 No. 4, pp. 463-478, doi: 10.1108/JSM-02-2018-0080.

Cao, X., Yu, L., Liu, Z., Gong, M. and Adeel, L. (2018), "Understanding mobile payment users' continuance intention: a trust transfer perspective", *Internet Research*, Vol. 28 No. 2, pp. 456-476, doi: 10.1108/intr-11-2016-0359.

Castro-González, Á., Admoni, H. and Scassellati, B. (2016), "Effects of form and motion on judgments of social robots' animacy, likability, trustworthiness and unpleasantness", *International Journal of Human-Computer Studies*, Vol. 90, pp. 27-38, doi: 10.1016/j.ijhcs.2016.02.004.

Chen, C.-F. and Girish, V.G. (2023), "Investigating the use experience of restaurant service robots: the cognitive–affective–behavioral framework", *International Journal of Hospitality Management*, Vol. 111 No. 2023, 103482, doi: 10.1016/j.ijhm.2023.103482.

Chen, H., Li, W., Lyu, T. and Zheng, X. (2021a), "Understanding people's participation in online charities: a dual-process approach of trust and empathic concern", *Industrial Management and Data Systems*, Vol. 121 No. 7, pp. 1642-1663, doi: 10.1108/IMDS-09-2020-0513.

Chen, Y., Dai, R., Wang, L., Yang, S., Li, Y. and Wei, J. (2021b), "Exploring donor's intention in charitable crowdfunding: intrinsic and extrinsic motivations", *Industrial Management and Data Systems*, Vol. 121 No. 7, pp. 1664-1683, doi: 10.1108/IMDS-11-2020-0631.

Cheng, X., Zhang, X., Cohen, J. and Mou, J. (2022), "Human vs AI: understanding the impact of anthropomorphism on consumer response to chatbots from the perspective of trust and relationship norms", *Information Processing and Management*, Vol. 59 No. 3, 102940, doi: 10.1016/j.ipm.2022.102940.

Chi, O.H., Chi, C.G., Gursoy, D. and Nunkoo, R. (2023), "Customers' acceptance of artificially intelligent service robots: the influence of trust and culture", *International Journal of Information Management*, Vol. 70, 102623, December 2022, doi: 10.1016/j.ijinfomgt.2023.102623.

Chuah, S.H.-W. and Yu, J. (2021), "The future of service: the power of emotion in human-robot interaction", *Journal of Retailing and Consumer Services*, Vol. 61, 102551, January, doi: 10.1016/j.jretconser.2021.102551.

Conti, D., Di Nuovo, S., Buono, S. and Di Nuovo, A. (2017), "Robots in education and care of children with developmental disabilities: a study on acceptance by experienced and future professionals", *International Journal of Social Robotics*, Vol. 9 No. 1, pp. 51-62, doi: 10.1007/s12369-016-0359-6.

Cui, X., Lai, V.S. and Lowry, P.B. (2016), "How do bidders' organism reactions mediate auction stimuli and bidder loyalty in online auctions? The case of Taobao in China", *Information and Management*, Vol. 53 No. 5, pp. 609-624, doi: 10.1016/j.im.2016.01.005.

De Graaf, M.M.A. and Ben Allouch, S. (2013), "Exploring influencing variables for the acceptance of social robots", *Robotics and Autonomous Systems*, Vol. 61 No. 12, pp. 1476-1486, doi: 10.1016/j.robot.2013.07.007.

De Graaf, M.M.A., Allouch, S.B. and Klamer, T. (2015), "Sharing a life with Harvey: exploring the acceptance of and relationship-building with a social robot", *Computers in Human Behavior*, Vol. 43, pp. 1-14, doi: 10.1016/j.chb.2014.10.030.

De Kervenoael, R., Hasan, R., Schwob, A. and 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*, Vol. 78, pp. 1-15, doi: 10.1016/j.tourman.2019.104042.

DeLone, W.H. and McLean, E.R. (2003), "The DeLone and McLean model of information systems success: a ten-year update", *Journal of Management Information Systems*, Vol. 19 No. 4, pp. 9-30, doi: 10.1080/07421222.2003.11045748.

Diederich, S., Lembcke, T.-B., Brendel, A.B. and Kolbe, L.M. (2021), "Understanding the impact that response failure has on how users perceive anthropomorphic conversational service agents: insights from an online experiment", *AIS Transactions on Human-Computer Interaction*, Vol. 13 No. 1, pp. 82-103, doi: 10.17705/1thci.00143.

Duffy, B.R. (2003), "Anthropomorphism and the social robot", *Robotics and Autonomous Systems*, Vol. 42 Nos 3-4, pp. 177-190, doi: 10.1016/S0921-8890(02)00374-3.

Evelina, T.Y., Kusumawati, A., Nimran, U. and Sunarti (2020), "The influence of utilitarian value, hedonic value, social value, and perceived risk on customer satisfaction: survey of e-commerce customers in Indonesia", *Business: Theory and Practice*, Vol. 21 No. 2, pp. 613-622, doi: 10.3846/btp.2020.12143.

Fan, A., Wu, L.(L.) and Mattila, A.S. (2016), "Does anthropomorphism influence customers' switching intentions in the self-service technology failure context?", *Journal of Services Marketing*, Vol. 30 No. 7, pp. 713-723, doi: 10.1108/JSM-07-2015-0225.

Fei, M., Tan, H., Peng, X., Wang, Q. and Wang, L. (2021), "Promoting or attenuating? An eye-tracking study on the role of social cues in e-commerce livestreaming", *Decision Support Systems*, Vol. 142, 113466, doi: 10.1016/j.dss.2020.113466.

Feine, J., Gnewuch, U., Morana, S. and Maedche, A. (2019), "A taxonomy of social cues for conversational agents", *International Journal of Human-Computer Studies*, Vol. 132, pp. 138-161, doi: 10.1016/j.ijhcs.2019.07.009.

Fornell, C. and Larcker, D.F. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 1, p. 39, doi: 10.2307/3151312.

Fu, S., Yan, Q. and Feng, G.C. (2018), "Who will attract you? Similarity effect among users on online purchase intention of movie tickets in the social shopping context", *International Journal of Information Management*, Vol. 40, pp. 88-102, doi: 10.1016/j.ijinfomgt.2018.01.013.

Geisser, S. (1974), "A predictive approach to the random effect model", *Biometrika*, Vol. 61 No. 1, pp. 101-107, doi: 10.2307/2334290.

Gu, Y., Cheng, X. and Shen, J. (2023), "Design shopping as an experience: exploring the effect of the live-streaming shopping characteristics on consumers' participation intention and memorable experience", *Information and Management*, Vol. 60 No. 5, 103810, doi: 10.1016/j.im.2023.103810.

Henseler, J., Ringle, C.M. and Sarstedt, M. (2015), "A new criterion for assessing discriminant validity in variance-based structural equation modeling", *Journal of the Academy of Marketing Science*, Vol. 43 No. 1, pp. 115-135, doi: 10.1007/s11747-014-0403-8.

Henseler, J., Hubona, G. and Ray, P.A. (2016), "Using PLS path modeling in new technology research: updated guidelines", *Industrial Management and Data Systems*, Vol. 116 No. 1, pp. 2-20, doi: 10.1108/IMDS-09-2015-0382.

Hlee, S., Park, J., Park, H., Koo, C. and Chang, Y. (2023), "Understanding customer's meaningful engagement with AI-powered service robots", *Information Technology and People*, Vol. 36 No. 3, pp. 1020-1047, doi: 10.1108/ITP-10-2020-0740.

Hsiao, C.-H. and Tang, K.-Y. (2021), "Who captures whom – Pokémon or tourists? A perspective of the Stimulus-Organism-Response model", *International Journal of Information Management*, Vol. 61, 102312, doi: 10.1016/j.ijinfomgt.2021.102312.

Hu, L. and Bentler, P.M. (1999), "Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives", *Structural Equation Modeling: A Multidisciplinary Journal*, Vol. 6 No. 1, pp. 1-55, doi: 10.1080/10705519909540118.

Huang, D., Chen, Q., Huang, J., Kong, S. and Li, Z. (2021), "Customer-robot interactions: understanding customer experience with service robots", *International Journal of Hospitality Management*, Vol. 99, 103078, October, doi: 10.1016/j.ijhm.2021.103078.

Hulland, J. (1999), "Use of partial least squares (PLS) in strategic management research: a review of four recent studies", *Strategic Management Journal*, Vol. 20 No. 2, pp. 195-204, doi: 10.1002/(SICI)1097-0266(199902)20:2<195::AID-SMJ13>3.0.CO;2-7.

Im, S. and Workman, J.P. (2004), "Market orientation, creativity, and new product performance in high-technology firms", *Journal of Marketing*, Vol. 68 No. 2, pp. 114-132, doi: 10.1509/jmkg.68.2.114.27788.

Jacoby, J. (2002), "Stimulus-organism-response reconsidered: an evolutionary step in modeling (consumer) behavior", *Journal of Consumer Psychology*, Vol. 12 No. 1, pp. 51-57, doi: 10.1207/153276602753338081.

Jia, J.W., Chung, N. and Hwang, J. (2021), "Assessing the hotel service robot interaction on tourists' behaviour: the role of anthropomorphism", *Industrial Management and Data Systems*, Vol. 121 No. 6, pp. 1457-1478, doi: 10.1108/IMDS-11-2020-0664.

Kamide, H. and Arai, T. (2017), "Perceived comfortableness of anthropomorphized robots in US and Japan", *International Journal of Social Robotics*, Vol. 9 No. 4, pp. 537-543, doi: 10.1007/s12369-017-0409-8.

Kang, S.-E., Koo, C. and Chung, N. (2023), "Creepy vs cool: switching from human staff to service robots in the hospitality industry", *International Journal of Hospitality Management*, Vol. 111, 103479, April, doi: 10.1016/j.ijhm.2023.103479.

Kim, Y. and Sundar, S.S. (2012), "Anthropomorphism of computers: is it mindful or mindless?", *Computers in Human Behavior*, Vol. 28 No. 1, pp. 241-250, doi: 10.1016/j.chb.2011.09.006.

Kim, M.J., Lee, C.-K. and Jung, T. (2020), "Exploring consumer behavior in virtual reality tourism using an extended stimulus-organism-response model", *Journal of Travel Research*, Vol. 59 No. 1, pp. 69-89, doi: 10.1177/0047287518818915.

Klüber, K. and Onnasch, L. (2022), "Appearance is not everything - preferred feature combinations for care robots", *Computers in Human Behavior*, Vol. 128, 107128, December 2021, doi: 10.1016/j.chb.2021.107128.

Kock, N. and Lynn, G. (2012), "Lateral collinearity and misleading results in variance-based SEM: an illustration and recommendations", *Journal of the Association for Information Systems*, Vol. 13 No. 7, pp. 546-580, doi: 10.17705/1jais.00302.

Konya-Baumbach, E., Biller, M. and von Janda, S. (2023), "Someone out there? A study on the social presence of anthropomorphized chatbots", *Computers in Human Behavior*, Vol. 139, pp. 1-18, June 2022, doi: 10.1016/j.chb.2022.107513.

Kuchenbrandt, D., Eyssel, F., Bobinger, S. and Neufeld, M. (2013), "When a robot's group membership matters", *International Journal of Social Robotics*, Vol. 5 No. 3, pp. 409-417, doi: 10.1007/s12369-013-0197-8.

Kühne, K., Fischer, M.H. and Zhou, Y. (2020), "The human takes it all: humanlike synthesized voices are perceived as less eerie and more likable. Evidence from a subjective ratings study", *Frontiers in Neurorobotics*, Vol. 14, pp. 1-15, December, doi: 10.3389/fnbot.2020.593732.

Kuo, C.-S. and Hsu, C.-C. (2022), "Continuance intention to use and perceived net benefits as perceived by streaming platform users: an application of the updated IS success model", *Behavioral Sciences*, Vol. 12 No. 5, 124, doi: 10.3390/bs12050124.

Kwon, O., Kim, J., Jin, Y. and Lee, N. (2018), "Impact of human-robot interaction on user satisfaction with humanoid-based healthcare", *International Journal of Engineering and Technology(UAE)*, Vol. 7 No. 2, pp. 68-75, doi: 10.14419/ijet.v7i2.12.11038.

Lankton, N., McKnight, D.H. and Tripp, J. (2015), "Technology, humanness, and trust: rethinking trust in technology", *Journal of the Association for Information Systems*, Vol. 16 No. 10, pp. 880-918, doi: 10.17705/1jais.00411.

Lee, K.Y., Sheehan, L., Lee, K. and Chang, Y. (2021a), "The continuation and recommendation intention of artificial intelligence-based voice assistant systems (AIVAS): the influence of personal traits", *Internet Research*, Vol. 31 No. 5, pp. 1899-1939, doi: 10.1108/INTR-06-2020-0327.

Lee, Y., Coyle, J.R. and Chen, A.N.K. (2021b), "Improving intention to back projects with effective designs of progress presentation in crowdfunding campaign sites", *Decision Support Systems*, Vol. 147, 113573, doi: 10.1016/j.dss.2021.113573.

Li, M., Guo, F., Wang, X., Chen, J. and Ham, J. (2023), "Effects of robot gaze and voice human-likeness on users' subjective perception, visual attention, and cerebral activity in voice conversations", *Computers in Human Behavior*, Vol. 141 No. 195, 107645, doi: 10.1016/j.chb.2022.107645.

Liao, J. and Huang, J. (2024), "Think like a robot: how interactions with humanoid service robots affect consumers' decision strategies", *Journal of Retailing and Consumer Services*, Vol. 76, 103575, June 2023, doi: 10.1016/j.jretconser.2023.103575.

Liu, X., Yi, X. and Wan, L.C. (2022), "Friendly or competent? The effects of perception of robot appearance and service context on usage intention", *Annals of Tourism Research*, Vol. 92, 103324, January 2022, doi: 10.1016/j.annals.2021.103324.

Luo, J.M., Vu, H.Q., Li, G. and Law, R. (2021), "Understanding service attributes of robot hotels: a sentiment analysis of customer online reviews", *International Journal of Hospitality Management*, Vol. 98, 103032, April 2020, doi: 10.1016/j.ijhm.2021.103032.

MacDorman, K.F., Green, R.D., Ho, C.-C. and Koch, C.T. (2009), "Too real for comfort? Uncanny responses to computer generated faces", *Computers in Human Behavior*, Vol. 25 No. 3, pp. 695-710, doi: 10.1016/j.chb.2008.12.026.

Mehrabian, A. and Russell, J.A. (1974), *An Approach to Environmental Psychology*, The MIT Press, Cambridge, MA.

Moran, S., Bachour, K. and Nishida, T. (2015), "User perceptions of anthropomorphic robots as monitoring devices", *AI and Society*, Vol. 30 No. 1, pp. 1-21, doi: 10.1007/s00146-013-0515-6.

Mori, M. (1970), "Bukimi No Tani [The uncanny valley]", *Energy*, Vol. 7 No. 4, pp. 33-35.

Moussawi, S. and Koufaris, M. (2019), "Perceived intelligence and perceived anthropomorphism of personal intelligent agents: scale development and validation", *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2019-January, pp. 115-124, doi: 10.24251/HICSS.2019.015.

Moussawi, S., Koufaris, M. and Benbunan-Fich, R. (2022), "The role of user perceptions of intelligence, anthropomorphism, and self-extension on continuance of use of personal intelligent agents", *European Journal of Information Systems*, Vol. 32 No. 3, pp. 1-22, doi: 10.1080/0960085X.2021.2018365.

Murphy, J., Gretzel, U. and Pesonen, J. (2019), "Marketing robot services in hospitality and tourism: the role of anthropomorphism", *Journal of Travel and Tourism Marketing*, Vol. 36 No. 7, pp. 784-795, doi: 10.1080/10548408.2019.1571983.

Neves, C., Oliveira, T. and Sarker, S. (2024), "Citizens' participation in local energy communities: the role of technology as a stimulus", *European Journal of Information Systems*, pp. 1-24, doi: 10.1080/0960085X.2024.2302426.

Ochmann, J., Michels, L., Tiefenbeck, V., Maier, C. and Laumer, S. (2024), "Perceived algorithmic fairness: an empirical study of transparency and anthropomorphism in algorithmic recruiting", *Information Systems Journal*, Vol. 34 No. 2, pp. 384-414, doi: 10.1111/isj.12482.

Odekerken-Schröder, G., Mennens, K., Steins, M. and Mahr, D. (2022), "The service triad: an empirical study of service robots, customers and frontline employees", *Journal of Service Management*, Vol. 33 No. 2, pp. 246-292, doi: 10.1108/JOSM-10-2020-0372.

Okanda, M. and Taniguchi, K. (2022), "How do children answer questions from a physically present humanoid robot?", *Infant and Child Development*, Vol. 31 No. 3, p. 10, doi: 10.1002/icd.2300.

Ozturk, A.B., Pizam, A., Hacikara, A., An, Q., Chaulagain, S., Balderas-Cejudo, A., Buhalis, D., Fuchs, G., Hara, T., Vieira de Souza Meira, J., García Revilla, R., Sethi, D., Shen, Y. and State, O. (2023), "Hotel customers' behavioral intentions toward service robots: the role of utilitarian and hedonic values", *Journal of Hospitality and Tourism Technology*, Vol. 14 No. 5, pp. 780-801, doi: 10.1108/JHTT-07-2022-0223.

Parker, C.S. (2010), "Symbolic versus blind patriotism: distinction without difference?", *Political Research Quarterly*, Vol. 63 No. 1, pp. 97-114, doi: 10.1177/1065912908327228.

Pelau, C., Dabija, D.-C. and Ene, I. (2021), "What makes an AI device humanlike? The role of interaction quality, empathy and perceived psychological anthropomorphic characteristics in the acceptance of artificial intelligence in the service industry", *Computers in Human Behavior*, Vol. 122, 106855, doi: 10.1016/j.chb.2021.106855.

Petter, S., Delone, W. and McLean, E.R. (2013), "Information systems success: the quest for the independent variables", *Journal of Management Information Systems*, Vol. 29 No. 4, pp. 7-62, doi: 10.2753/MIS0742-1222290401.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y. and Podsakoff, N.P. (2003), "Common method biases in behavioral research: a critical review of the literature and recommended remedies", *Journal of Applied Psychology*, Vol. 88 No. 5, pp. 879-903, doi: 10.1037/0021-9010.88.5.879.

Prakash, A. and Rogers, W.A. (2015), "Why some humanoid faces are perceived more positively than others: effects of human-likeness and task", *International Journal of Social Robotics*, Vol. 7 No. 2, pp. 309-331, doi: 10.1007/s12369-014-0269-4.

Rossi, S., Staffa, M. and Tamburro, A. (2018), "Socially assistive robot for providing recommendations: comparing a humanoid robot with a mobile application", *International Journal of Social Robotics*, Vol. 10 No. 2, pp. 265-278, doi: 10.1007/s12369-018-0469-4.

Said, N., Ben Mansour, K., Bahri-Ammari, N., Yousaf, A. and Mishra, A. (2024), "Customer acceptance of humanoid service robots in hotels: moderating effects of service voluntariness and culture", *International Journal of Contemporary Hospitality Management*, Vol. 36 No. 6, pp. 1844-1867, doi: 10.1108/IJCHM-12-2022-1523.

Schreibelmayr, S. and Mara, M. (2022), "Robot voices in daily life: vocal human-likeness and application context as determinants of user acceptance", *Frontiers in Psychology*, Vol. 13, pp. 1-17, May, doi: 10.3389/fpsyg.2022.787499.

Schuetzler, R.M., Grimes, G.M. and Scott Giboney, J. (2020), "The impact of chatbot conversational skill on engagement and perceived humanness", *Journal of Management Information Systems*, Vol. 37 No. 3, pp. 875-900, doi: 10.1080/07421222.2020.1790204.

Seeger, A.-M., Pfeiffer, J. and Heinzl, A. (2021), "Texting with humanlike conversational agents: designing for anthropomorphism", *Journal of the Association for Information Systems*, Vol. 22 No. 4, pp. 931-967, doi: 10.17705/1jais.00685.

Seo, S. (2022), "When female (male) robot is talking to me: effect of service robots' gender and anthropomorphism on customer satisfaction", *International Journal of Hospitality Management*, Vol. 102, 103166, October 2021, doi: 10.1016/j.ijhm.2022.103166.

Sisman, B., Steinrücke, J. and de Jong, T. (2024), "Does giving students feedback on their concept maps through an on-screen avatar or a humanoid robot make a difference?", *International Journal of Social Robotics*, Vol. 16 No. 8, pp. 1783-1796, doi: 10.1007/s12369-024-01144-y.

So, K.K.F., Kim, H., Liu, S.Q., Fang, X. and Wirtz, J. (2024), "Service robots: the dynamic effects of anthropomorphism and functional perceptions on consumers' responses", *European Journal of Marketing*, Vol. 58 No. 1, pp. 1-32, doi: 10.1108/EJM-03-2022-0176.

Soliman, M., Gulvady, S., Elbaz, A.M., Mosbah, M. and Wahba, M.S. (2024), "Robot-delivered tourism and hospitality services: how to evaluate the impact of health and safety considerations on visitors' satisfaction and loyalty?", *Tourism and Hospitality Research*, Vol. 24 No. 3, pp. 393-409, doi: 10.1177/14673584231153367.

Song, C.S. and Kim, Y.-K. (2022), "The role of the human-robot interaction in consumers' acceptance of humanoid retail service robots", *Journal of Business Research*, Vol. 146, pp. 489-503, February 2021, doi: 10.1016/j.jbusres.2022.03.087.

Song, X., Li, Y., Leung, X.Y. and Mei, D. (2024), "Service robots and hotel guests' perceptions: anthropomorphism and stereotypes", *Tourism Review*, Vol. 79 No. 2, pp. 505-522, doi: 10.1108/TR-04-2023-0265.

Steelman, Z.R., Hammer, B.I. and Liman, M. (2014), "Data collection in the digital age: innovative alternatives to student samples", *MIS Quarterly*, Vol. 38 No. 2, pp. 355-378, doi: 10.25300/misq/2014/38.2.02.

Stern, S.E., Mullennix, J.W. and Wilson, S.J. (2002), "Effects of perceived disability on persuasiveness of computer-synthesized speech", *Journal of Applied Psychology*, Vol. 87 No. 2, pp. 411-417, doi: 10.1037//0021-9010.87.2.411.

Stock, R.M., Oliveira, P. and von Hippel, E. (2015), "Impacts of hedonic and utilitarian user motives on the innovativeness of user-developed solutions", *Journal of Product Innovation Management*, Vol. 32 No. 3, pp. 389-403, doi: 10.1111/jpim.12201.

Stone, M. (1974), "Cross-validatory choice and assessment of statistical predictions", *Journal of the Royal Statistical Society: Series B (Methodological)*, Vol. 36 No. 2, pp. 111-133, doi: 10.1111/j.2517-6161.1974.tb00994.x.

Tamagawa, R., Watson, C.I., Kuo, I.H., MacDonald, B.A. and Broadbent, E. (2011), "The effects of synthesized voice accents on user perceptions of robots", *International Journal of Social Robotics*, Vol. 3 No. 3, pp. 253-262, doi: 10.1007/s12369-011-0100-4.

Tehseen, S., Ramayah, T. and Sajilan, S. (2017), "Testing and controlling for common method variance: a review of available methods", *Journal of Management Sciences*, Vol. 4 No. 2, pp. 142-168, doi: 10.20547/jms.2014.1704202.

Thapa, S., Panda, S., Ghimire, A. and Kim, D.J. (2024), "From engagement to retention: unveiling factors driving user engagement and continued usage of mobile trading apps", *Decision Support Systems*, Vol. 183, 114265, doi: 10.1016/j.dss.2024.114265.

Vaezi, R., Mills, A., Chin, W. and Zafar, H. (2016), "User satisfaction research in information systems: historical roots and approaches", *Communications of the Association for Information Systems*, Vol. 38 No. 1, pp. 501-532, doi: 10.17705/1CAIS.03827.

Vaezi, R., Mills, A. and Chin, W. (2019), "User satisfaction with information systems: a comprehensive model of attribute-level satisfaction", *Communications of the Association for Information Systems*, Vol. 45 No. 1, pp. 165-206, doi: 10.17705/1CAIS.04513.

van der Heijden (2004), "User acceptance of hedonic information systems", *MIS Quarterly*, Vol. 28 No. 4, p. 695, doi: 10.2307/25148660.

van Pinxteren, M.M.E., Wetzels, R.W.H., Rüger, J., Pluymaekers, M. and Wetzels, M. (2019), "Trust in humanoid robots: implications for services marketing", *Journal of Services Marketing*, Vol. 33 No. 4, pp. 507-518, doi: 10.1108/JSM-01-2018-0045.

Vishwakarma, L.P., Singh, R.K., Mishra, R., Demirkol, D. and Daim, T. (2024), "The adoption of social robots in service operations: a comprehensive review", *Technology in Society*, Vol. 76, 102441, August 2023, doi: 10.1016/j.techsoc.2023.102441.

Wang, L., Zhu, H., Li, X. and Zhao, Y. (2024), "Formation mechanism of user stickiness in live e-commerce: the hybrid PLS-SEM and ANN approach", *Industrial Management and Data Systems*, Vol. 124 No. 3, pp. 1234-1262, doi: 10.1108/IMDS-04-2023-0231.

Xie, Y., Zhu, K., Zhou, P. and Liang, C. (2023), "How does anthropomorphism improve human-AI interaction satisfaction: a dual-path model", *Computers in Human Behavior*, Vol. 148, 107878, January, doi: 10.1016/j.chb.2023.107878.

Xue, J., Liang, X., Xie, T. and Wang, H. (2020), "See now, act now: how to interact with customers to enhance social commerce engagement?", *Information and Management*, Vol. 57 No. 6, 103324, doi: 10.1016/j.im.2020.103324.

Zhang, H., Lu, Y., Gupta, S. and Zhao, L. (2014), "What motivates customers to participate in social commerce? The impact of technological environments and virtual customer experiences", *Information and Management*, Vol. 51 No. 8, pp. 1017-1030, doi: 10.1016/j.im.2014.07.005.

Zhang, H., Lu, Y., Wang, B. and Wu, S. (2015), "The impacts of technological environments and co-creation experiences on customer participation", *Information and Management*, Vol. 52 No. 4, pp. 468-482, doi: 10.1016/j.im.2015.01.008.

Zhang, S., Meng, Z., Chen, B., Yang, X. and Zhao, X. (2021), "Motivation, social emotion, and the acceptance of artificial intelligence virtual assistants—trust-based mediating effects", *Frontiers in Psychology*, Vol. 12, pp. 1-10, doi: 10.3389/fpsyg.2021.728495.

Zheng, X., Men, J., Yang, F. and Gong, X. (2019), "Understanding impulse buying in mobile commerce: an investigation into hedonic and utilitarian browsing", *International Journal of Information Management*, Vol. 48, pp. 151-160, doi: 10.1016/j.ijinfomgt.2019.02.010.

Zhu, W., Yan, R. and Ding, Z. (2020), "Analysing impulse purchasing in cross-border electronic commerce", *Industrial Management and Data Systems*, Vol. 120 No. 10, pp. 1959-1974, doi: 10.1108/IMDS-01-2020-0046.

Zhu, P., Liu, Z., Li, X., Jiang, X. and Zhu, M.X. (2023), "The influences of livestreaming on online purchase intention: examining platform characteristics and consumer psychology", *Industrial Management and Data Systems*, Vol. 123 No. 3, pp. 862-885, doi: 10.1108/IMDS-07-2022-0430.

Złotowski, J., Proudfoot, D., Yogeeswaran, K. and Bartneck, C. (2015), "Anthropomorphism: opportunities and challenges in human–robot interaction", *International Journal of Social Robotics*, Vol. 7 No. 3, pp. 347-360, doi: 10.1007/s12369-014-0267-6.

Złotowski, J., Sumioka, H., Eyssel, F., Nishio, S., Bartneck, C. and Ishiguro, H. (2018), "Model of dual anthropomorphism: the relationship between the media equation effect and implicit anthropomorphism", *International Journal of Social Robotics*, Vol. 10 No. 5, pp. 701-714, doi: 10.1007/s12369-018-0476-5.

Appendix

Table A1. Details of the measurement items

Construct	Measurement items	Reference
Appearance	The appearance of the HSR in the hotel was humanlike The HSR in the hotel resembled a person The appearance of the humanoid social robot called to mind the world of human beings* The appearance of the humanoid social robot reminded me of an instrument. (Reverse-coded)* The appearance of the humanoid social robot called to mind the world of machines. (Reverse-coded)* The appearance of the humanoid social robot was machinelike. (Reverse-coded)*	Liu *et al.* (2022)
Voice	The voice of the HSR in the hotel was Loud-voiced–soft-voiced Deep-voiced–squeaky-voiced Fast-speaking–slow-speaking* Heavily accented–faintly accented Too slow–too fast* Heavily nasal–faintly nasal* Monotonous–lively*	Stern *et al.* (2002)
Response	The HSR in the hotel was responsive to all needs The HSR provided timely answers to customers' questions* I was able to obtain advice and feedback from the HSR in the hotel without delay	Lankton *et al.* (2015)
Perceived utilitarian value	The inclusion of the HSR in the hotel was relevant to my needs and expectations when I was in the hotel (or the needs and expectations of relatives or friends)* The inclusion of the HSR in the hotel was considered suitable for my desires The inclusion of the HSR in the hotel was appropriate to my needs and expectations (or the needs and expectations of relatives or friends) The inclusion of the HSR in the hotel was useful	Im and Workman (2004)
Perceived social value	The HSR could facilitate bi-directional communication* The HSR could listen to my needs The HSR was easy to get along with The HSR could understand me	Pelau *et al.* (2021) and Zhang *et al.* (2021)
Perceived hedonic value	When I used an HSR in a hotel, I perceived the robot as Disgusting–enjoyable Dull–exciting* Unpleasant–pleasant Boring–interesting*	van der Heijden (2004)
User satisfaction	Robot services in the hotel made me Dissatisfied–Satisfied* Displeased–Pleased* Frustrated–Contented Terrible–Delighted	Bhattacherjee (2001)
Symbolic patriotism**	When I see my country's flag flying, I feel extremely good My love for my country is extremely strong	Parker (2010)

Note(s): * = excluded from this study, * * = marker variable
Source(s): Authors' own creation

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