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ORIGINAL RESEARCH

Human vs. robot service provider agents in service failures: comparing customer dissatisfaction and the mediating role of forgiveness and service recovery expectation

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Abstract
This study employs a 3 × 2 between-subject experimental design to investigate customer responses to hotel service failures attributed to different service provider agents (SPAs) [humans, humanoid robots, non-humanoid robots] in two types of service failure contexts [process and outcome]. It focuses on customers' initial psychological response [forgiveness], subsequent action-seeking behavior [service recovery expectation (SRE)], and overall outcome evaluation [dissatisfaction]. Hypotheses are grounded in Mind Perception Theory, Attribution Theory, and Expectancy Disconfirmation Theory. A two-way ANCOVA was used to compare mean scores across the dependent variables. The findings reveal that increased SPA humanness diminishes customers' forgiveness, elevates SRE, and intensifies dissatisfaction, with these differences occurring only in process failures and not in outcome failures. Subsequently, a serial mediation analysis for process failures indicated that forgiveness and SRE serially mediate the positive relationship between SPAs' humanness and customer dissatisfaction.

Keywords Service failures · Service robots · Humanness · Customer forgiveness · Service recovery expectation · Serial mediation model

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1 Introduction

Service failure has always been a major concern for businesses in the hospitality and service industries, as it directly impacts customer satisfaction, loyalty, reputation, and companies' financial performance (Komunda and Osarenkhoe 2012). Qualtrics XM Institute conducted a survey across 25 countries and found that organizations are at risk of losing $3.7 trillion annually due to poor customer experiences (Quaadgras and Temkin 2024). The study highlights that more than half of consumers (51%) tend to reduce or cease spending with a brand after just one negative experience, with the figure rising to over 60% for parcel delivery services and fast-food chains.

Advancements in AI and machine learning have revolutionized the hospitality industry, with service robots being employed to address labor shortages (Bowen and Morosan 2018). The deployment of humanoid robots in hospitality settings is increasingly prevalent, such as the Henn-na Hotel in Japan, Nam Heong restaurant in Malaysia, and Alibaba FlyZoo Hotel in China. Furthermore, COVID-19 has hastened the implementation of service robots in service settings to establish touchless systems and mitigate the transmission of viruses (Morosan 2021; Seo 2022).

Nowadays service robots are no longer rigid machines. They are designed to incorporate more human-like features such as appearance, emotions, and behaviors, and this process is known as robot anthropomorphism (Choi et al. 2021). According to the hierarchy of robot anthropomorphism, service robots classified as either humanoid or non-humanoid (Gong and Nass 2007). Non-humanoid service robots feature mechanical structures distinct from human anatomy, typically including wheeled or tracked vehicles, robotic arms, drones, and autonomous systems, such as the indoor delivery robot "SUCD" (Alpha Robotics 2024). In contrast, humanoid service robots are designed to assist humans with various tasks while resembling the human form in appearance and behavior, incorporating advanced technologies for communication, mobility, and perception (Abdi et al. 2022). Examples include "Pepper" (SoftBank Robotics 2024), "ASIMO" (Honda Global 2024), and "Sophia" (Hanson Robotics 2020).

Despite the intelligence of robots, occasional service delivery failures are inevitable due to various technical issues, including algorithmic flaws, software design challenges, and hardware malfunctions (Carlson and Murphy 2005). These failures can manifest in misinterpreting guest voice commands, failing to recognize objects like identification cards or room keys, and incorrect route planning during deliveries (Zhang et al. 2023b). For instance, McDonald's has removed AI-driven ordering systems from its drive-through restaurants in the U.S. after customers posted humorous incidents on TikTok, where voice bots mishandled their orders (Gerken 2024). Similarly, human employees are also not error-free.

Both humans and robots can act as service provider agents (SPAs). The greater the presence of human-like qualities in the SPAs, the more autonomous they are perceived to be (Lee et al. 2015). This autonomy refers to their ability to make decisions and perform tasks with intention and volition (Schein and Gray 2018).

As a result, they are regarded as more capable and need to bear greater responsibilities for failure (Bigman et al. 2019). Conversely, less humanness means more mechanization and less autonomy. Furthermore, trust has garnered substantial attention in Human–Robot Interaction (HRI) research, encompassing various dimensions such as reliability, competence, authenticity, and ethics (Malle et al. 2020). At its core, trust involves the expectation of service robots to possess these qualities. Hence, customers may have varying expectations, trust, and affective interaction towards different SPAs based on their levels of humanness, particularly during service failures. Consider the customer's reaction in the event of a coffee spill caused by a human SPA in a restaurant setting. How might this response differ if the spill were attributed to a humanoid robot or a non-humanoid robot? Would the customer's reactions exhibit significant variation across these three scenarios?

It is noteworthy that the type of service failure customers experience may also contribute to these differences. Customers' reactions vary depending on specific situations such as the severity and type of failure (Chan et al. 2007; Keiningham et al. 2014). In marketing literature, two distinct types of service failures are recognized: "process failure" and "outcome failure" (Li et al. 2016, 2021; Smith et al. 1999). Process failures are situations where customers' core needs appear to be fulfilled, but there are flaws or deficiencies in the process (e.g., inattentive service: receptionists being rude during check-in). In contrast, outcome failures point to instances where customers' fundamental requirements are not met (e.g., incorrect order or unavailable service: the actual room type does not match the reserved room type).

Previous studies have explored the impact of service failures in various hospitality settings, such as airlines (Xu et al. 2019), restaurants (Zhu et al. 2023), and hotels (Jeong and Lee 2017). However, there is a gap in research regarding the combined influence of considering the humanness of SPAs and the types of service failure simultaneously. It is impossible to offer precise advice to hoteliers without understanding how customers react to various types of failure. Some studies investigating robot service failures have overlooked the role of failure type in shaping customer responses (Arikan et al. 2023; Leo and Huh 2020; Zhang et al. 2023a). For instance, Leo and Huh (2020) suggested that robots are viewed as less accountable for service failures than humans, without considering the specific type of failure. Moreover, when analyzing the anthropomorphism of service robots, both humanoid and non-humanoid, it is crucial to add the perspective of real humans, which has been usually neglected, as they may have distinct perceptions and responses.

This study investigates disparities in customer response following a service failure, specifically focusing on customer forgiveness, service recovery expectation (SRE), and dissatisfaction. Forgiveness significantly influences customers' decisions to either complain or excuse the situation (Wolter et al. 2019). SRE reflects customers' desired corrective actions from service firms to restore satisfaction and trust, aiding hoteliers in understanding customer needs and recovery expectations. Moreover, assessing customer dissatisfaction provides direct feedback to hotels. Additionally, it is worthwhile to investigate whether the impact of SPAs' humanness on customer dissatisfaction is mediated by customer forgiveness and SRE, or if it exerts a direct effect on dissatisfaction. Previous studies have extensively explored

mediators in the relationship between robot anthropomorphism and the intention to use, identifying various factors such as robot-related mediators (e.g., consciousness, intelligence, and safety), functional mediators (e.g., ease of use and usefulness), and relational mediators (e.g., rapport and trust) (Blut et al. 2021). However, there is a lack of research on the mediating roles in the relationship between robot anthropomorphism and customer reactions during service failures. Failing to understand these mediating roles may result in ambiguity regarding the reasons behind customer dissatisfaction. Therefore, recognizing these mediating factors is crucial in service failure situations, as it can inform the development of effective service recovery strategies with significant practical implications.

This study seeks to tackle the following research questions:

1. Do customers exhibit significant differences in their levels of forgiveness, SRE, and dissatisfaction when faced with different kinds of service failures (process and outcome) involving SPAs that have varying degrees of humanness?
2. If such significant differences are found, is there a serial mediating effect of customer forgiveness and SRE on the relationship between SPAs' humanness and customer dissatisfaction?

2 Literature review

2.1 The humanness of SPAs within the context of service failure

Humanness is defined as the level to which an individual possesses traits that are commonly associated with humans (Söderlund and Oikarinen 2021), and it can be observed in both non-human objects and humans themselves. Humanness is similar to anthropomorphism, with the distinction that anthropomorphism is predominantly employed to describe non-human objects. Features like appearance similarity, voice, gender and human behaviours such as proactivity are commonly perceived as indicators of human-like traits (Sproull et al. 1996). SPAs can be classified into humans, humanoid robots and non-humanoid robots according to the degree of humanness (Arikan et al. 2023). Prior research has emphasized the beneficial effects of robot anthropomorphism on customer satisfaction, trust, enjoyment, acceptance, engagement, and evaluation of service robots (Lu et al. 2019; Yam et al. 2021). However, it is crucial to investigate whether these beneficial effects continue to hold in situations involving service failure.

Service failure happens when the actual performance does not meet customer expectations (Hoffman and Bateson 1997), leading to customer discontent, reduced repatronage intention, and declining company profits (Sparks and Fredline 2007). Table 1 summarizes recent studies on service failures related to the anthropomorphism of service technologies, including service robots (e.g., Zhang et al. 2023a; Yam et al. 2021), self-service machines (e.g., Fan et al. 2020), and chatbots (e.g., Crolic et al. 2022). For instance, Barone et al. (2024) suggested that highly anthropomorphic robots receive more positive evaluations for service failures compared to less anthropomorphic machines. The cuteness of AI assistants can enhance

Table 1 Summary of literature on service failures related to the anthropomorphism of service technologies

Author(s) (year)	Focus/objective	Variables/factors	Key finding(s)	Theory(ies)
Barone et al. (2024)	How the portrayal of self-service technologies as anthropomorphic robots versus as automated machines affects consumer reactions during service failures	Anthropomorphic framing (automatic machines vs. robot); Perceived agency; Evaluation	Consumers evaluate service failures involving self-service technology presented as robots more positively than those depicted as automatic machines, influenced by a greater perception of agency, which are unconsciously held	Attribution theory
Arikan et al. (2023)	How consumers attribute service failure and recovery responsibilities and respond differently (to the company or to the agent) based on the type of service provider agent with different level of human-likeness	Type of service provider agent; Failure attribution; Recovery attribution; Forgiveness; Satisfaction	(1) Consumers hold the company more accountable for service failures when the agent is less human-like (2) They place a higher burden of recovery on human agents and a lower one on the company when the agents are human rather than robotic (3) Attributing failure to the company decreases consumer forgiveness and satisfaction, while attributing recovery to the company increases them	Anthropomorphism theory; Attribution theories; Social response theory
Becker et al. (2023)	How different types of robots (human-like versus machine-like) affect customer comfort in distinct ways	Human-likeness; Rapport; Social presence; Customer comfort	Compared to machine-like counterparts, human-like service robots help customers feel more at ease by fostering rapport. However, these positive effects wane in situations involving service failures	Comfort theory

Table 1 (continued)

Author(s) (year)	Focus/objective	Variables/factors	Key finding(s)	Theory(ies)
Cheng (2023)	How the anthropomorphism of service robots affects consumers' attributions in the context of service failures	Robots' anthropomorphism; Internal attribution; Forgiveness; Relationship norms	A negative relationship exists between the levels of anthropomorphism in service robots and customer forgiveness during service failures, mediated by internal attributions. Additionally, the relationship norms of consumers influence the impact of anthropomorphism on internal attributions and the subsequent forgiveness	Attribution theory
Zhang et al. (2023a)	How consumers respond to service failures with humanoid compared to non-humanoid robots, along with the varying effects on brand forgiveness and intentions to return, shaped by performance expectancy and gender differences	Type of service robots; Performance expectancy; Brand forgiveness; Revisit intention; Gender	Consumers hold higher performance expectations for non-humanoid robots. This expectation enhances brand forgiveness and intentions to return among male consumers, while it does not affect the forgiveness and return behaviors of female consumers	AI Device Use Acceptance (AIDUA) model; Appraisal theory; Gender self-socialization theory
Crolic et al. (2022)	How chatbots' anthropomorphism affects customer responses in service settings	Chatbot anthropomorphism; pre-interaction expectations; Customer anger; Customer satisfaction; Overall firm evaluation; Purchase intentions	When customers interact with a chatbot during a moment of anger, the anthropomorphism of the chatbot adversely affects their satisfaction, overall evaluation of the firm, and future purchase intentions. In contrast, this negative impact is not observed among customers who are not in an angry emotional state	Appraisal theory; Functionalist theory of emotion

Table 1 (continued)

Author(s) (year)	Focus/objective	Variables/factors	Key finding(s)	Theory(ies)
Choi et al. (2021)	How consumers' views on the warmth and competence of service robots affect their responses to service failures and recovery attempts	Robot anthropomorphism; Service failure type; Perceived warmth/competence; Apology; Explanation; Satisfaction; Behavioral intentions	(1) Consumers feel more dissatisfied following a process failure involving humanoid robots due to a perceived lack of warmth, compared to failures involving non-humanoid robots (2) Humanoid robots can effectively address a service failure on their own by offering a genuine apology and explanation, while non-humanoid robots are unable to do so (3) Human involvement can alleviate dissatisfaction after a non-humanoid robot's recovery attempts fall short	Mental accounting theory; Perceived warmth and competence; Social exchange theory
Lv et al. (2021)	How the cuteness of AI assistants impacts customer tolerance during service failures	Cuteness of AI assistant; Tenderness; Performance expectancy; Tolerance of service failure; Failure severity; Time-pressure	The cute design of AI assistants enhances customer tolerance for service failures by fostering feelings of tenderness and increasing performance expectations, with this effect being moderated by the severity of the failure and time pressure	Cognitive appraisal theory

Table 1 (continued)

Author(s) (year)	Focus/objective	Variables/factors	Key finding(s)	Theory(ies)
Yam et al., (2021)	How perceived agency and perceived experience boost the anthropomorphism of robots and reduce the adverse effects of service failures on customer satisfaction	Anthropomorphism; Perceived Agency; Perceived Experience; Service failure; Customer Satisfaction	Anthropomorphism generally enhances customer satisfaction, with perceived experience mediating this effect, while agency does not. Moreover, a greater perception of experience lessens the negative effects of service failures involving robots on customer satisfaction	Anthropomorphism theory; Mind perception theory
Fan et al. (2020)	How consumers' interdependent self-construal and their self-efficacy with technology collectively shape their reactions to service machines that exhibit human-like traits during instances of service failure	Technology anthropomorphism; Technology self-efficacy; Interdependent self-construal; Blame attribution; Consumer dissatisfaction	Consumers display different levels of dissatisfaction with a service failure resulting from an anthropomorphic self-service machine compared to a non-anthropomorphic one, with these reactions influenced by their interdependent self-construal and technology self-efficacy	Attribution theory; Customer participation theory; Social response theory
Leo and Huh (2020)	How do individuals assign responsibility for service failures to service robots as opposed to real humans providing the same failures, and to what extent does this differ?	Service provider type; Controllability of service provider; Blame attribution	People assign less responsibility to robots than to humans for service failures due to the perception of lower controllability. However, they assign more responsibility to the service company when a robot delivers a failed service compared to a human	Attribution theory

customers' tolerance for technological service failures (Lv et al. 2021). However, Arikan et al. (2023) found that customers regularly attribute greater responsibility to service provider agents that are more human-like. Hence, further exploration of the factors that impact the relationship between SPAs' humanness and customer reactions during service failures is necessary.

Nevertheless, it is crucial to consider that the type of failure may have a potential influence on these relationships. Researchers have distinguished between two categories of failure: process failure and outcome failure (Li et al. 2016, 2021; Smith et al. 1999). Process failure pertains to shortcomings in service delivery, such as rude staff or delays in service (Li et al. 2021). Outcome failure occurs when essential products or services are not provided, such as overbooking or items being out of stock after purchasing (Li et al. 2016). Process failure relates to the peripheral component of service (e.g., staff attitude), while outcome failure pertains to the core service component (e.g., flight cancellation) (Li et al. 2021). Process failures undermine social resources like status and esteem, while outcome failures result from capability-related issues, leading to the depletion of economic resources like money and time (Chan et al. 2007; Smith et al. 1999). Therefore, understanding the impact of failure type is crucial when studying service failures attributed to different SPAs.

2.2 Mind perception theory

To further understand the nuances in customer reactions to service failures by SPAs, it is essential to consider the theoretical underpinnings. Mind perception theory suggests that both human and non-human entities are evaluated along two dimensions: perceived agency (the capacity to think, plan, and take action) and perceived experience (the capacity to feel emotions and physical sensations like hunger, pain, and pleasure) (Gray et al. 2007). Human adults are generally perceived to possess both high levels of agency and experience, whereas robots are usually regarded as having low experience and moderate agency (Gray et al. 2007; Gray and Wegner 2012). Consequently, the greater the humanness of the SPA, the stronger the customer's perception of its agency and experience.

The dimensions of mind perception are highly similar to the warmth and competence perceptions (Fiske et al. 2007). Perceptions of warmth are associated with qualities such as trustworthiness, friendliness, and helpfulness, while perceptions of competence relate to attributes like competency, intelligence, and skillfulness. As a result, social cognition elements of the warmth and competence elements are well mapped onto perceived experience and perceived agency (Waytz et al. 2010). Similarly, the service robot acceptance framework states that consumers' perceived experience (warmth) is influenced by social-emotional and affective factors (e.g., ability to display empathy and understanding), while perceived agency (competence) is influenced by functional factors (e.g., technical capabilities and task performance) (Wirtz et al. 2018).

When SPAs are perceived to have high levels of agency (competence) and experience (warmth), they are considered autonomous and trusted, namely, they are capable enough to make decisions and act intentionally and volitionally

(Yam et al. 2021). Meanwhile, they are more likely to take more responsibility and blame when services fail (Schein and Gray 2018). Moreover, conscious misbehaviour is more psychologically damaging than the same unconscious misbehaviour (Gray and Wegner 2008). In other words, distracted or retaliatory behavior by SPAs is more likely to cause higher dissatisfaction compared to unintentional service failures. In addition, expressing anger and filing complaints against low-humanness SPAs is futile and pointless, as these emotional reactions may not be acknowledged or received by them.

2.3 Attribution theory

Attribution theory posits that individuals seek to determine the reasons behind events in order to comprehend why they happen (Weiner 1986). Responsibility is typically evaluated through three dimensions: locus of causality, controllability, and stability (Folkes 1984; Weiner 1985). Locus of causality refers to whether the cause is perceived as internal (related to personal actions or characteristics) or external (associated with outside factors). Controllability captures consumers' beliefs about whether the SPA could have prevented a failure. Stability concerns the perceived likelihood of the failure happening again, distinguishing between transient and enduring issues (Weiner 1985).

Service robots, which operate on computer algorithms, are generally seen as having less control over outcomes, leading to external attribution (Hong and Williams 2019). In contrast, SPAs that exhibit more human-like traits are often perceived as having greater control, resulting in internal attribution of responsibility. For example, Leo and Huh (2020) contend that robots are viewed as having less control than humans in service scenarios, which leads to lower responsibility assigned to robotic service providers for failures. Consequently, customers tend to assign greater responsibility, including blame, which can diminish forgiveness and increase recovery expectations, to SPAs with higher autonomy and greater humanness than to those with lower humanness that function more obediently during service failures.

However, since process failures do not directly compromise the consequence, customers may be more tolerant of them compared to outcome failures. Conversely, the occurrence of an outcome failure signifies that customers' fundamental needs have not been met, resulting in a significant disparity between the received outcome and the price paid. This perceived imbalance can evoke feelings of injustice or inequity (Adams 1965), leading to similar levels of grievance and dissatisfaction, regardless of the type of SPAs involved. As a result, customer perceptions may vary primarily in response to process failures.

2.4 Forgiveness, SRE, and dissatisfaction

Forgiveness is an individual's willingness to forgo retaliation against the offender, to reduce anger, and to show compassion and generosity (Bies et al. 2016). It involves

a transformative process where an individual's attitude towards past offenders undergoes a shift towards increased positivity and decreased negativity, encompassing positive reconstruction, perspective-taking, and tolerance (Yagil and Luria 2016; Zaki and Al-Romeedy 2024). Grasping the extent of customer forgiveness is crucial in the context of service failures. For instance, customer forgiveness can significantly enhance their satisfaction in a positive manner when they encounter a service failure (Muhammad 2020). Harrison-Walker (2019) reveals that forgiveness serves as a mediator in the connection between recovery strategies and favorable outcomes (e.g., reconciliation and re-patronage intention). Customer forgiveness facilitates trust restoration, loyalty-building, and refining customer relationships, ultimately influencing customer retention (Yagil and Luria 2016).

H1a. In the event of process failures, there is a significant difference in customer forgiveness across different SPAs, such that failures caused by SPAs with higher levels of humanness result in lower customer forgiveness.

H1b. In the event of outcome failures, there is no significant difference in customer forgiveness across different SPAs.

Service recovery expectation (SRE) refers to the belief held by individuals about how a service failure ought to be addressed (Harris et al. 2006). SRE is vital for service firms as it provides valuable insights into customer demands, facilitating effective and targeted recovery efforts. Bagherzadeh et al. (2020) proposed that SRE has an inverse relationship with satisfaction after a service failure. Furthermore, different customers with various characteristics may have different levels of SRE. Lin (2010) found that new customers have higher SRE than old ones, females have higher SRE than males, and introverted guests usually have higher SRE than extroverted guests. However, there is a scarcity of studies examining whether customers' experiences of service failure delivered by different types of SPA result in varying levels of SRE.

H2a. In the event of process failures, there is a significant difference in customer SRE across different SPAs, such that failures caused by SPAs with higher levels of humanness result in higher SRE.

H2b. In the event of outcome failures, there is no significant difference in customer SRE across different SPAs.

The expectancy disconfirmation theory (Oliver 1980) is commonly applied in marketing literature to understand customer behavior and satisfaction. It centers on customers' pre-purchase expectations and their post-purchase evaluations of actual performance or outcomes, assessing their experiences before and after acquiring goods or services (Oh et al. 2022; Pizam and Milman 1993). The theory emphasizes the concept of disconfirmation, which reflects the gap between anticipated expectations and actual performance. Positive disconfirmation (outcomes meet or exceed expectations) leads to satisfaction, while negative disconfirmation (outcomes fall short of expectations) results in dissatisfaction (Pizam and Milman 1993). Service failures generate negative disconfirmation, making dissatisfaction a key indicator for understanding customer reactions. Leo and Huh (2020) discovered that customers tend to assign less blame to robots than humans because they perceive robots as having less control. Additionally, Cheng (2023) observed that low-anthropomorphism robots receive more tolerance for service failures as they are perceived primarily as

software with predefined functions and hardware settings. Consequently, customers may exhibit higher dissatisfaction towards SPAs with a higher level of humanness, given the contrasting attributions of blame and tolerance.

H3a. In the event of process failures, there is a significant difference in customer dissatisfaction across different SPAs, such that failures caused by SPAs with higher levels of humanness lead to higher dissatisfaction.

H3b. In the event of outcome failures, there is no significant difference in customer dissatisfaction across different SPAs.

2.5 The mediating effect of forgiveness and SRE in process failures

The expectancy disconfirmation theory also helps explain the relationship between forgiveness/SRE and dissatisfaction in process failures. While negative disconfirmation arises after a service failure, high levels of forgiveness can mitigate negative emotions like anger and resentment, promoting positive feelings such as relief, peace, empathy, and happiness (Yagil and Luria 2016). This emotional shift may reduce the emphasis on responsibility attribution and the impact of negative disconfirmation, ultimately decreasing dissatisfaction. Furthermore, customers who are more forgiving tend to have lower SRE, as they have emotionally reconciled the failure to some degree and may not require as extensive a recovery effort to achieve satisfaction.

In the consumption context, elevated expectations are more likely to lead to negative disconfirmation, whereas lower expectations typically result in positive disconfirmation (Qazi et al. 2017). Hien et al. (2024) found that when customers have high expectations for a service, they are less likely to confirm positive disconfirmation. Bagherzadeh et al. (2020) suggested that SRE are negatively related to satisfaction after a service failure, indicating that higher SRE correlates with lower satisfaction. In situations of service failure, customers with elevated SRE often have specific and demanding requirements for SPAs to adequately address the issue. Meeting these heightened expectations requires significant effort and resources from the SPA, increasing the likelihood of unsuccessful recovery attempts compared to scenarios with lower SRE, where customers may have more lenient criteria. Conversely, customers with lower SRE are likely to experience reduced dissatisfaction because they do not expect extensive recovery efforts and are thus less prone to feeling let down by any recovery actions taken (Hess et al. 2003). As a result, the SPA is more likely to effectively address the failure, leading to a decrease in customer dissatisfaction.

The Stimulus-Organism-Response (SOR) theory (Mehrabian and Russell 1974) serves as an effective framework for understanding why the impact of SPAs' humanness on customer dissatisfaction through the mediating roles of forgiveness and SRE. This theory is widely applied to explore how external stimuli influence an individual's internal processes (the organism) and subsequently lead to behavioral responses in the context of the services industry (e.g., Kim et al. 2020; Tan 2023). In this study, customers' levels of dissatisfaction (response) following a service failure (stimulus) are mediated by their internal interpretations—specifically, their

experiences of forgiveness and SRE. These interpretations are shaped by their perceptions, emotions, thoughts, and attitudes related to the service failure.

H4. SPAs' humanness is positively related to customer dissatisfaction during process failures.

H5. Customer forgiveness and SRE serially mediates the relationship between SPAs' humanness and customer dissatisfaction during process failures.

3 Methods

3.1 Design and stimulus selection

A 3×2 between-subjects scenario-based experimental design was adopted in this study, incorporating three different types of SPAs: humans, humanoid robots, and non-humanoid robots, along with two categories of service failures: process failure and outcome failure. This hypothetical scenario-based approach not only provides a strong level of internal validity (Kim and Jang 2014), but also circumvents costs and ethical issues in the actual setting.

The scenario setting is in a hotel check-in context because it is a typical and realistic scenario that customers encounter frequently (see Appendix). Additionally, consumers view the robot check-in process as more critical than simpler tasks, such as delivery robots in room service or restaurants, which leads to greater attention on the anthropomorphized nature of robots due to the deeper interactions involved (Tussyadiah and Park 2018). Three images were selected to represent humans, humanoid robots, and non-humanoid robots based on their adherence to the definition of humanness. All of them are female with feminine features and/or voices, as Seo (2022) discovered that female service robots elicited greater pleasure compared to their male counterparts. There are two types of service failure scenarios, which are process failure (inattentive service: long queue time and the passionless receptionist addressing the guest by the wrong gender, i.e., Mr. as Ms. or Ms. as Mr.) and outcome failure (unavailable service: the actual room available at check in is not the type of room that the guest preferred and reserved). These scenarios were adopted from Smith et al. (1999).

3.2 Questionnaire

All the measurements were adapted from developed scales from previous research (see Table 4). The questionnaire includes four items measuring forgiveness (Xie and Peng 2009), five items measuring service recovery expectation (Lin 2010), and two items measuring customer dissatisfaction (Sarofim et al. 2022). All items were measured on a 7-point Likert scale anchored from "strongly disagree (1)" to "strongly agree (7)". Additionally, respondents' demographic information (gender, age, and highest level of education) and behavioral information (frequency of hotel stays in the past two years and frequency of interactions with service robots) were

also collected. The questionnaire was translated into Chinese using the "back-translation" method (Brislin 1986) since the participants are mainly Chinese.

3.3 Participants and procedures

The target population for this study includes individuals aged 18 and older who have stayed in a hotel in the last two years. Data were collected by recruiting participants with monetary compensation (9 CNY per respondent, 1.27 USD equivalently) at wjx.cn online platform in May 2023, with participants are primarily Chinese. China's growing service industry and adoption of service robots in the hospitality sector made it an ideal location for the study (Chen et al. 2022). A total of six scenarios (3 SPA types × 2 failure types) were included in the study (see Appendix). Eligible respondents were randomly assigned scenarios to read and then completed survey questions, followed by providing demographic information.

3.4 Manipulation check

Prior to the main data collection, a manipulation check was performed to verify that the manipulation of the humanness of SPAs and the type of failure were clearly distinguishable from each other. Six manipulations (3 SPA type × 2 failure type) were randomly distributed to 120 respondents at the online platform wjx.cn. Respondents evaluated these two categorical factors with the following statements: "I think the service provider agent in the picture looks like a real human" and "I think this service failure is an inattentive service rather than an unavailable service".

The one-way ANOVA revealed that humans ($M = 6.28$, $SD = 0.960$) were significantly different from humanoid robots ($M = 4.70$, $SD = 1.067$) and non-humanoid robots ($M = 1.93$, $SD = 0.694$, $F(2,117) = 228.955$, $p < 0.01$). The independent-sample t-test indicated that process failures ($M = 4.78$, $SD = 1.303$) significantly differed from outcome failures ($M = 2.27$, $SD = 1.351$, $t(118) = 10.384$, $p < 0.01$). Thus, the manipulation created for this research were successful.

3.5 Control variables

Demographic differences play a critical role in technology adoption research (Hong et al. 2017). Extensive studies have shown that age significantly influences technology acceptance, with younger generations generally demonstrating greater adaptability to new technologies than older individuals (McAndrew and Jeong 2012). Younger users tend to prioritize extrinsic benefits, such as the perceived usefulness of innovations (Liébana-Cabanillas et al. 2014). Furthermore, research indicates that technology usage and acceptance vary by gender, with men often displaying task-oriented behavior and a more instrumental approach compared to women, who tend to focus on maintaining interpersonal connections (Ferenczi et al. 2017; Thelwall and Vis 2017). Additionally, education level and past experience contribute to users' knowledge and skills, which in turn influence their behavioral beliefs about technology acceptance. Moreover, Tarhini et al. (2016) indicated that both educational

attainment and familiarity with technology moderate several relationships within the Technology Acceptance Model (TAM), affecting variables such as self-efficacy, perceived usefulness, and revisit intention. To mitigate these potential effects, this study includes respondents' gender, age, education level, frequency of hotel stays, and frequency of robot interactions as control variables in the data analysis.

4 Results

4.1 Sample description

A total of 396 usable samples were collected, which well surpasses the recommended guideline of having a minimum of 10–15 respondents per measurement item, as recommended by Hair et al. (2006). With 11 measurement items included in this study, a minimal sample size of 110 (10 * 11) would be required. It also exceeds the suggested minimum of 30 cases for each scenario being tested (Wu et al. 2015). This ensures a robust sample size for valid and reliable results in our study. Table 2 displays the usable sample sizes for each experiment.

Table 3 displays the demographic characteristics of the respondents.

4.2 Reliability and validity

Confirmatory factor analysis (CFA) was performed using AMOS to evaluate the reliability and validity of the measurement model. The results revealed that the measurement model had an acceptable fit (*CMIN/DF = 2.789, RMSEA = 0.067, CFI = 0.962, TLI = 0.949, IFI = 0.962*). As exhibited in Table 4, Cronbach's alpha and composite reliability (CR) of all variables were greater than 0.7, demonstrating acceptable internal consistency reliability. Moreover, the average variance extracted (AVE) for all variables exceeded 0.5, further demonstrating convergent validity. Furthermore, Table 5 demonstrates that the Heterotrait-Monotrait (HTMT) ratio between the three variables is below the recommended threshold of 0.9, as suggested by Henseler et al. (2015). This indicates that discriminant validity has been achieved.

Table 2 Usable sample size for each experiment

Experiment	Human	Humanoid robots	Non-humanoid robots
Process failure	67	63	66
Outcome failure	66	66	68

Table 3 Demographic and behavioural profile of the respondents ($N=396$)

Variable	Frequency (N)	Percent (%)
Gender		
Male	171	43.2
Female	225	56.8
Age		
18–24	30	7.6
25–29	119	30.1
30–39	204	51.5
40–49	37	9.3
50–59	3	0.8
60–64	3	0.8
Level of Education		
Secondary (middle school/high school)	13	3.3
Tertiary (college/university)	344	86.9
Postgraduate	39	9.8
Frequency of hotel stay (past 2 years)		
1–5 times	119	30.1
6–10 times	163	41.2
11–20 times	85	21.5
More than 20 times	29	7.3
Frequency of robot interaction		
More than 5 times	46	11.6
3–5 times	155	39.1
1–2 times	108	27.3
Not yet, but interested	84	21.2
Not yet, and not interested	3	0.8

4.3 Hypotheses testing

4.3.1 Differences in forgiveness, SRE, and dissatisfaction

Two-way ANCOVA was performed to test H1a, H1b, H2a, H2b and H3a, H3b, controlling respondents' gender, age, education level, frequency of hotel stays, and frequency of robot interactions. The assumption testing, including outliers and homogeneity of variances ($p=0.462$ *for forgiveness;* $p=0.436$ *for SRE,* $p=0.158$), were confirmed through boxplot inspection and Levene's test, respectively.

Forgiveness: A statistically significant interaction effect was observed between the SPA type and the failure type ($F(2,385)=4.726$, $p=0.009$, *partial* $\eta 2=0.024$). Subsequently, the result of the simple main effects for the SPA type indicated a statistically significant difference in forgiveness scores when the process failure is encountered across three different types of SPA ($F(2,385)=7.087$, $p<0.001$, *partial* $\eta 2=0.036$). However, the SPA type did not have a statistically significant effect on

Table 4 Confirmatory factors analysis

Constructs	Measurement items	Loadings	Composite reliability	AVE	Cronbach's alpha
Forgiveness	1. I would think favorably of this receptionist	0.766	0.8316	0.5533	0.832
	2. Based on the failure caused by the receptionist, I would forgive her	0.719			
	3. Based on the failure caused by the receptionist, I would condemn* her	0.692			
	4. I would disapprove* of this receptionist	0.794			
SRE	1. I have high expectations of service recovery	0.721	0.8378	0.5084	0.834
	2. I expect the receptionist to provide me with explanations	0.742			
	3. I expect to receive practical compensations and claims	0.704			
	4. I do not hope to see the receptionist simply pass the buck to somethings that are beyond her control	0.668			
	5. I expect that the receptionist makes sincere efforts to apologize	0.728			
Dissatisfaction	1. The service provided by the receptionist was not good enough	0.772	0.7693	0.6252	0.767
	2. The service provided by the receptionist was not acceptable	0.809			

Note: *Indicates the reverse code

Table 5 Discriminant validity: Heterotrait-Monotrait (HTMT) ratio

	Forgiveness	SRE	Dissatisfaction
Forgiveness			
SRE	0.498		
Dissatisfaction	0.896	0.653	

forgiveness when the outcome failure is encountered ($F(2,385)=0.323$, $p=0.724$, *partial* $\eta 2=0.002$). The result of the pairwise comparisons indicated that the significant difference only lies between humans and non-humanoid robots ($p<0.001$). Specifically, Non-humanoid robots had the highest level of forgiveness, followed by humanoid robots and last humans with significant differences in the event of process failure ($M_{Non\text{-}humanoid\text{-}robots}=4.070$ *vs.* $M_{Humanoid\text{-}robots}=3.742$ *vs.* $M_{Humans}=3.346$), whereas there was no significant difference in their level of forgiveness in the event of outcome failure (see Fig. 1). Thus, the findings provided support for H1a and H1b.

SRE: The interaction effect between the SPA type and the failure type on SRE was statistically significant ($F(2,385)=3.069$, $p=0.048$, *partial* $\eta 2=0.016$). Subsequently, the result of the simple main effects for the SPA type revealed a statistically significant difference in SRE scores when the process failure is encountered across three types of SPA ($F(2,385)=8.998$, $p<0.001$, *partial* $\eta 2=0.045$). However, the SPA type did not have a statistically significant effect on SRE when the outcome failure is encountered ($F(2,385)=1.718$, $p=1.181$, *partial* $\eta 2=0.009$). Pairwise comparisons indicated that the significant difference lies between humans and non-humanoid robots ($p<0.001$) and humanoid robots and non-humanoid robot ($p=0.004$). Specifically, human had the highest level of SRE ($M=5.620$), followed by humanoid robots ($M=5.521$) and last non-humanoid robots ($M=5.034$), whereas

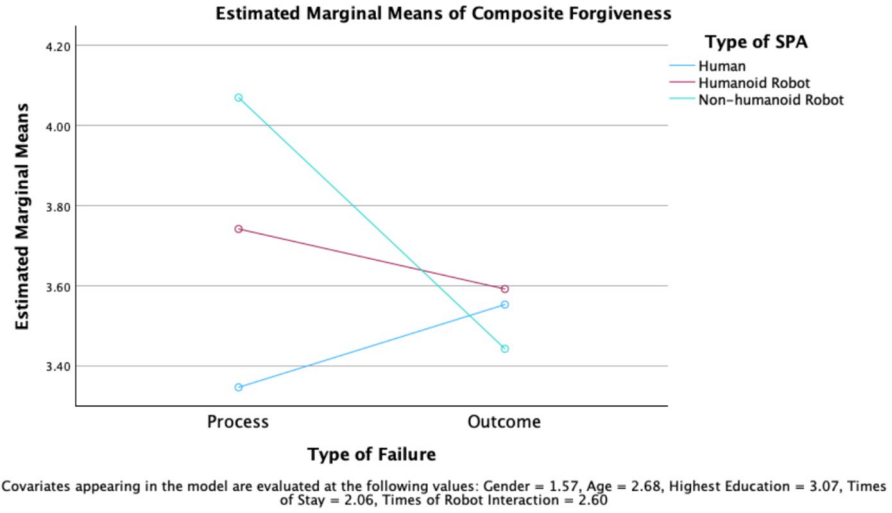


Fig. 1 Mean differences in forgiveness

there was no significant difference in their level of SRE in the event of outcome failure (see Fig. 2). Thus, the findings provided support for H2a and H2b.

Dissatisfaction: The interaction effect between the SPA type and the failure type on dissatisfaction was found to be statistically significant ($F(2,385)=4.687$, $p=0.010$, partial $\eta 2=0.024$). Subsequently, conducting simple main effects analysis for the SPA type revealed a statistically significant difference in dissatisfaction scores when encountering process failure across the three SPA types ($F(2, 385)=10.130$, $p<0.001$, partial $\eta 2=0.050$). However, the SPA type did not have a statistically significant effect on dissatisfaction when encountering outcome failure ($F(2, 385)=0.501$, $p=0.606$, partial $\eta 2=0.003$). Pairwise comparisons indicated significant differences between humans and non-humanoid robots ($p<0.001$). Specifically, humans exhibited the highest level of dissatisfaction with a mean score of 5.274, followed by humanoid robots ($M=5.023$), and lastly, non-humanoid robots ($M=4.357$) in the event of process failure. Conversely, there was no significant difference in their levels of dissatisfaction in the event of outcome failure (see Fig. 3). Thus, the findings provided support for H3a and H3b.

4.3.2 Exploring relationships with a serial mediation model

The PROCESS Macro Model 6 was employed in this study for its robust capability to analyze both the total effect of SPAs' humanness on customer dissatisfaction and the potential mediating roles of forgiveness and SRE in this relationship, while controlling for respondents' gender, age, education, frequency of hotel stays, and frequency of robot interactions. As H1b, H2b, and H3b revealed that there are no statistical differences in customer forgiveness, SRE, and dissatisfaction across the three types of SPAs in the event of outcome failures, the mediation analysis focuses solely on process failures, involving 196 cases. The total effect model clarifies the

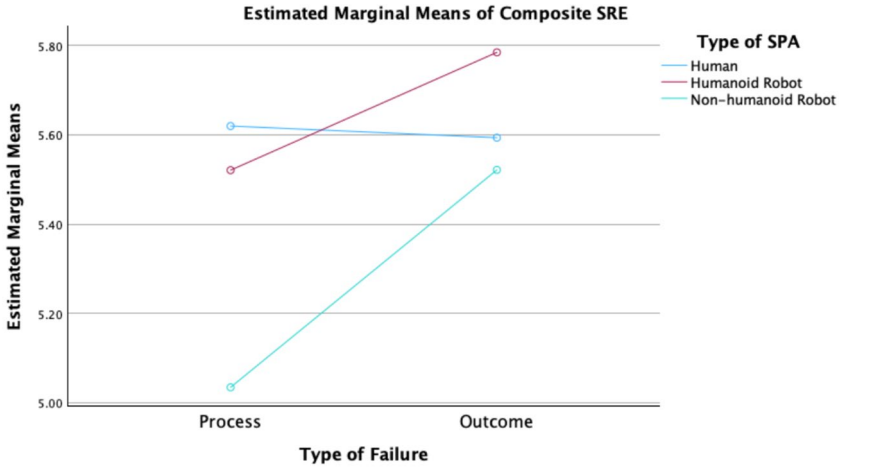


Fig. 2 Mean differences in SRE

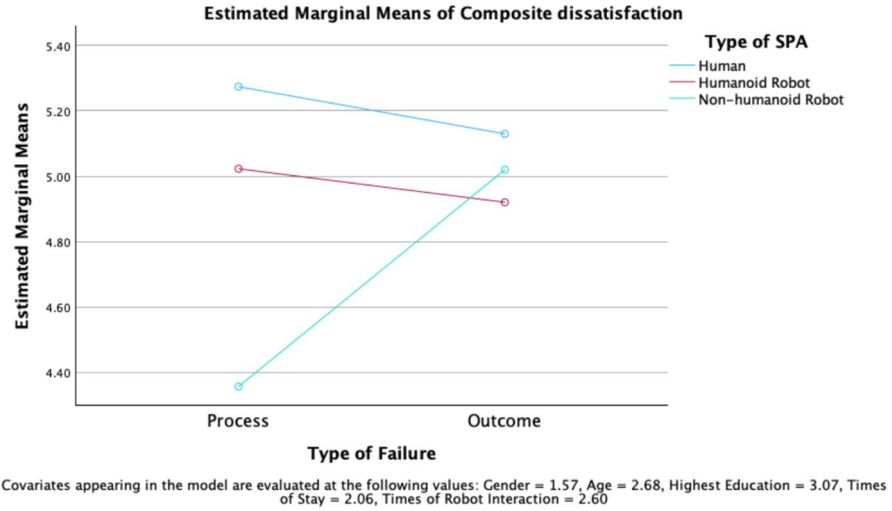


Fig. 3 Mean differences in dissatisfaction

overall impact of SPAs' humanness on customer dissatisfaction during process failures, without accounting for mediators. Additionally, the model allows for an examination of the mediating effects of forgiveness and SRE by isolating the direct and indirect effects, consistent with recent research methodologies (Bhutto et al. 2021; Marshall et al. 2020). This macro model was chosen for its effectiveness in correcting measurement errors and for overcoming the Sobel test's limitations (Hayes 2017; Huertas-Valdivia et al. 2018).

Table 6 presents the serial mediation model, with all path coefficients calculated using PROCESS v4.2, Model 6, employing 5000 bootstrap samples and a 95% bias-corrected confidence interval (CI) to assess the significance of the model (Hayes 2017). Figure 4 visualizes all path relationships. Analysis of H4 tested the total effect of SPAs' humanness on customer dissatisfaction (c). The regression analysis results indicated that SPAs' humanness is positively related to customer dissatisfaction ($\beta = 0.469$, $SE = 0.096$, $p < 0.001$), supporting H4.

H5 posits that customer forgiveness and SRE serially mediate the relationship between SPAs' humanness and customer dissatisfaction. The analysis revealed a significant indirect effect of SPAs' humanness on customer dissatisfaction through customer forgiveness and SRE, indicated by a 95% CI that did not contain zero ($\beta = 0.048$, $SE = 0.019$, $CI\ [0.017, 0.093]$). Specifically, SPAs' humanness significantly negatively predicted forgiveness (a_1: $\beta = -0.377$, $SE = 0.093$, $p < 0.001$), and forgiveness significantly negatively predicted SRE (d_{21}: $\beta = -0.307$, $SE = 0.052$, $p < 0.001$). In turn, SRE significantly positively predicted dissatisfaction (b_2: $\beta = 0.414$, $SE = 0.072$, $p < 0.001$). Furthermore, there was no direct effect of SPAs'

Table 6 Results of serial mediation analysis in the event of process failures

		Forgiveness (M1)			SRE (M2)			Dissatisfaction (Y)			95% CI	
		Coeff	SE	P	Coeff	SE	P	Coeff	SE	P	LLCI	ULCI
Model 1	Humanness (X)	−0.377	0.093	< 0.001	–	–	–	–	–	–	−0.560	−0.193
		$R^2 = 0.120$, F(6, 189) = 4.283, p = < 0.010										
Model 2	Humanness (X)	–	–	–	0.187	0.070	< 0.010	–	–	–	0.049	0.324
	Forgiveness (M1)	–	–	–	−0.307	0.052	< 0.001	–	–	–	−0.410	−0.203
					$R^2 = 0.239$, F(7, 188) = 8.443, p = < 0.001							
Model 3	Humanness (X)	–	–	–	–	–	–	0.129	0.070	0.068	−0.009	0.267
	Forgiveness (M1)	–	–	–	–	–	–	−0.570	0.056	< 0.001	−0.680	−0.459
	SRE (M2)	–	–	–	–	–	–	0.414	0.072	< 0.001	0.273	0.557
								$R^2 = 0.598$, F(8, 187) = 34.734, p = < 0.001				
Model 4 (Total, direct and indirect effects)	Humanness → Dissatisfaction (Total effect)							0.469	0.096	< 0.001	0.279	0.658
	Humanness → Dissatisfaction (Direct effect)							0.129	0.070	0.068	−0.009	0.267
	Humanness → Forgiveness → Dissatisfaction (Indirect effect)							0.214	0.058	< 0.05	0.110	0.337
	Humanness → SRE → Dissatisfaction (Indirect effect)							0.078	0.037	< 0.05	0.011	0.156
	Humanness → Forgiveness → SRE → Dissatisfaction (Indirect effect)							0.048	0.019	< 0.05	0.017	0.093

Note: *Control variables:* Gender, Age, Education, Frequency of hotel stay, Frequency of robot interaction

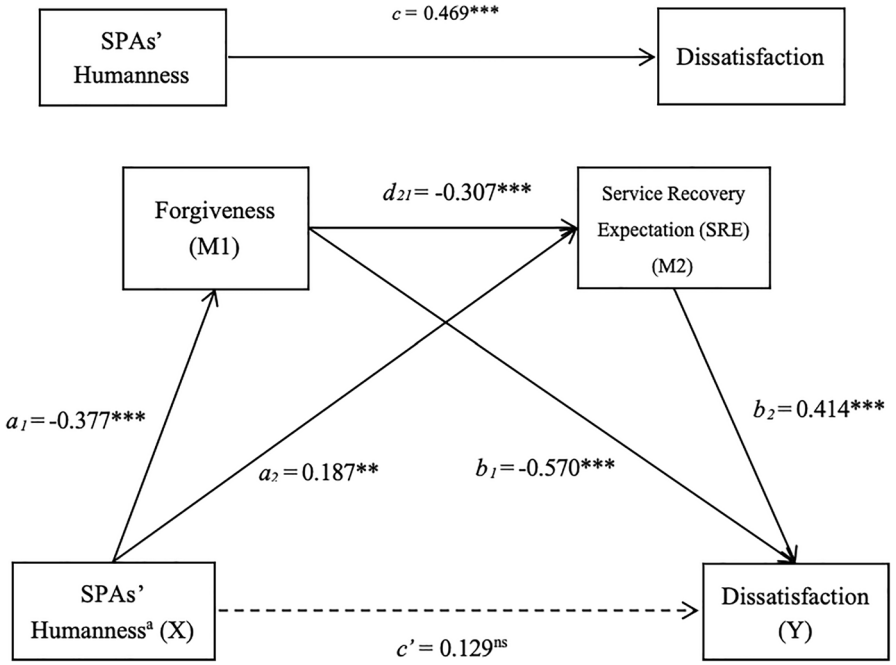


Fig. 4 The serial mediation model in the event of process failures. (Notes: [a]1 = Non-humanoid robots, 2 = Humanoid robots, 3 = Humans; N = 196; [ns]p > 0.05, *p < 0.05, **p < 0.01, ***p < 0.001)

humanness on customer dissatisfaction (*C': β = 0.129, SE = 0.070, p = 0.068*). These results suggested that the positive effect of SPAs' humanness on customer dissatisfaction is mediated by forgiveness and SRE rather than occurring directly. Therefore, H5 was supported, confirming full mediation. Additionally, the independent mediation effects of forgiveness (*β = 0.214, SE = 0.058, CI [0.110, 0.337]*) and SRE (*β = 0.078, SE = 0.037, CI [0.011, 0.156]*) on the association of SPAs' humanness and dissatisfaction were also supported, as the 95% CI for the independent indirect effects did not include zero.

5 Discussion

5.1 Discussion of findings

The findings of the study suggest that, in the context of service failure, customers' levels of forgiveness, SRE, and dissatisfaction vary based on their perception of the SPA's "humanness." Specifically, as the humanness of the SPA increases, forgiveness decreases, SRE rises, and dissatisfaction intensifies. However, these significant

variations are primarily observed in cases of process failures that involve minor flaws or deficiencies. In contrast, during outcome failures, where there are substantial imbalances or injustices in meeting customers' core needs, customers tend to react similarly and show no significant differences. This finding aligns with previous studies that indicate that factors such as failure severity, criticality, and magnitude can influence customer satisfaction during service failures (e.g., Chang et al. 2015; Cho et al. 2017). For example, Chang et al. (2015) observed that the severity of a failure influences the attribution of locus, with more significant attribution occurring in severe failure scenarios compared to those involving minor failures. Similarly, Cho et al. (2017) found that when customers experience low levels of regret and disappointment, the severity of service failures has an amplifying effect on their dissatisfaction.

While pairwise comparisons indicated that significant differences in process failures exist only in certain comparisons, for example, significant differences in forgiveness mean were found solely between human SPAs and non-humanoid robots. Nevertheless, the mean scores consistently demonstrated a discernible trend: higher humanness of the SPA corresponded to lower level of customer forgiveness, elevated SRE, and increased dissatisfaction. Prior studies on this topic blended both consistency and conflicts. The findings align with the assertion that SPAs with more humanness exhibit higher intelligence, competence, and warmth, thereby leading to higher customer expectations and less tolerance for service failures (Blut et al. 2021). For example, Cheng (2023) noted that high-anthropomorphism robots receive less tolerance for service failures compared to low-anthropomorphism robots. Leo and Huh (2020) found that customers assign less blame to robots than humans for failures due to their perception of robots having lower control. Additionally, Crolic et al. (2022) found that when customers are in an angry emotional state, chatbot anthropomorphism adversely impacts customer satisfaction, evaluations of the firm, and future purchase intentions. However, opposing views existed among other scholars, believing that SPAs with less humanness are regarded as more predictable and controllable, having higher expectations from customers (Zhang et al. 2023a). Arikan et al. (2023) suggested that consumers generally hold a more favorable perception of humanoid robots than non-humanoid ones during service failures as they believe humanoid robots can learn from mistakes and provide improved service in the future, while non-humanoid robots are presumed to have higher stability perceptions and are assumed to repeat their mistakes the next time. Lv et al. (2021) indicated that the cute design of AI assistants positively influences customer tolerance for service failures, with this effect mediated by feelings of tenderness and performance expectancy. Additionally, according to Mori's (1970) "uncanny valley theory," robots or virtual entities that closely resemble humans but do not achieve complete perfection can evoke feelings of unease or strangeness in observers.

Notably, the positive relationship between SPAs' humanness and customer dissatisfaction in process failures is serially mediated by forgiveness and SRE, with no

direct effect observed. This indicates that customers' feelings about the service failure (forgiveness) and their expectations for recovery (SRE) significantly influence their overall dissatisfaction, rather than the humanness of the SPA directly causing dissatisfaction. This aligns with previous studies suggesting that customers' emotional responses and expectations play a crucial role in determining their overall satisfaction (Liljander and Strandvik 1997). Furthermore, higher humanness of SPAs raises customers' expectations for effective recovery, which, if unmet, can lead to increased dissatisfaction (Bagherzadeh et al. 2020). Thus, it is the interplay of forgiveness and SRE that ultimately shapes customer dissatisfaction, rather than the humanness of the SPA acting as a direct cause of negative evaluations.

5.2 Theoretical implications

This study theoretically contributes to the literature on service failure, human–robot interaction (HRI), and robot anthropomorphism. First, a new theoretical foundation was applied in the research areas of service failure and robot anthropomorphism. This study pioneers the use of Mind Perception Theory (Gray et al. 2007) to explain how individuals evaluate SPAs with varying levels of humanness during service failures. When SPAs are perceived to possess high agency (e.g., capability, autonomy) and experience (e.g., empathy), they are seen as more competent in decision-making, resulting in increased responsibility and blame during failures. Attribution Theory (Weiner 1986) helps elucidate customers' causal attributions regarding service failures, distinguishing between internal and external attributions based on perceived control. Service robots, relying on computer algorithms, are seen as having less control, resulting in external attribution and lower responsibility in service failures, whereas SPAs with more human-like traits are viewed as having greater control, leading to internal attribution and increased responsibility. Expectancy Disconfirmation Theory (Oliver 1980) further supports the rationale behind the relationships among forgiveness, SRE, and dissatisfaction.

Second, this study develops and empirically tests a new framework that predicts customer perceptions in process failures, while the findings indicate that customers do not display significant differences in reactions to outcome failures. The serial mediation model established in this study revealed that customers' negative reactions to process failures are mediated first by their initial psychological response (forgiveness) and then by their action-seeking behavior (SRE), ultimately leading to their final evaluation of dissatisfaction. The model aligns with the SOR theory (Mehrabian and Russell 1974), demonstrating how customers' evaluations (response) of service failures caused by different SPAs (stimulus) are shaped by their internal processes of forgiveness and SRE (organism).

Third, the novel findings contribute to the existing body of knowledge. By examining the interaction between SPA type and failure type, it expands upon previous frameworks that either overlooked the consideration of failure types when exploring

differences in SPAs or neglected the inclusion of SPA types when investigating failure types (Arikan et al. 2023; Leo and Huh 2020; Smith et al. 1999; Zhang et al. 2023a). The results reveal a fascinating dichotomy surrounding the "humanness" of SPAs, portraying it as a double-edged sword. On one side, increased humanness is associated with enhanced autonomy, trust, and customer expectations. However, it also brings forth greater responsibility and reduced tolerance when service failures occur. This contrasts with the majority of previous studies that predominantly emphasized the positive aspects of robot anthropomorphism, such as promoting trust, intention of use, enjoyment, and customer satisfaction (Song et al. 2024; Van Pinxteren et al. 2019; Yam et al. 2021).

5.3 Managerial implications

This study also offers valuable insights for managerial practice. First of all, managers should recognize that the humanness of SPAs plays a significant role in customer forgiveness, SRE, and dissatisfaction, especially in situations involving process failures. These insights can guide managers in making informed decisions regarding the design and implementation of SPAs, taking into account the likelihood of service failures. For instance, in roles such as luggage handler, in-room dining and housekeeping deliverer, restaurant busser or runner, or public area cleaner and disinfector, which involve repetitive and straightforward tasks, the occurrence of service failures is relatively low. In such cases, the design of robots with higher levels of humanness, incorporating features that are perceived as cute or anthropomorphic, can enhance customer engagement and increase intention to use, as suggested by previous research (Barone et al. 2024; Lv et al. 2021).

When it comes to roles or tasks with a higher likelihood of service failure, the findings of the study highlight that customer responses may vary in the context of process failures. However, when core requirements are not met, customers tend to exhibit similar levels of response. Managers can reasonably anticipate customers' reactions based on the types of failure customers encounter or the type of SPAs involved in service delivery. This knowledge can aid managers in effectively allocating their resources and tailoring their service recovery efforts. For example, when a process failure is caused by SPAs with high levels of humanness, managers should allocate the highest level of remedies to rectify the failure as customers tend to exhibit highest SRE and lowest forgiveness in such cases. Failing to meet these heightened expectations may result in customer dissatisfaction. Conversely, in the event of outcome failures, managers can be informed that customers' reactions tend to be similar, regardless of the type of SPAs involved in delivering the service.

Additionally, when SPAs with lower levels of intelligence and humanness are engaged in service delivery, managers should ensure transparent communication regarding the limitations of these SPAs. Transparently communicating its boundaries (e.g., OpenAI's ChatGPT includes a statement on its platform "ChatGPT can

make mistakes. Check important info.") can help manage customer expectations and enhance forgiveness. For example, the robot SPAs can be trained to clearly communicate their capabilities and limitations at the start of their conversations with the customers. This transparency helps the customers understand what to expect, reducing potential frustration and increasing the likelihood of forgiveness.

5.4 Limitations and future directions

This study has its limitations. First, a fictitious hotel check-in scenario was utilized in the research design, and respondents were presented with a picture of the SPA to visualize the different SPAs instead of experiencing the real scenario, which may constrain the validity of the findings. Consequently, it is strongly recommended that future research can be carried out in authentic field settings such as service venues using different types of SPAs. Second, the study was conducted with respondents based in China, the results may not be generalizable to respondents with different ethnicity, cultures and levels of technology acceptance and adoption. Different cultures may have varying levels of forgiveness and expectations towards service recovery. Therefore, future studies should include a more diverse range of participants from various nationalities to better understand cultural differences and enhance the applicability of the findings. Third, beyond the hotel context, the scope of this study can be broadened to include areas such as restaurants, airlines, and tourist attractions. The latter two, in particular, have seen less exploration compared to hotels and restaurants. Furthermore, the study design may have inherent limitations as it does not account for factors such as the hotel's star rating, technology readiness, and the purpose of stay, which previous research has shown can have an impact (Ariffin and Maghzi 2012; Knutson et al. 1993; Wang et al. 2017). Future researchers are encouraged to incorporate these factors into their research design for a more comprehensive understanding. Finally, future studies should explore the specific extent to which the uncanny valley is encountered and compare customer reactions to validate this theory. This understanding is crucial for mitigating the uncanny valley effect in the adoption and design processes of humanoid service robots, ultimately enhancing user acceptance and satisfaction.

Appendix

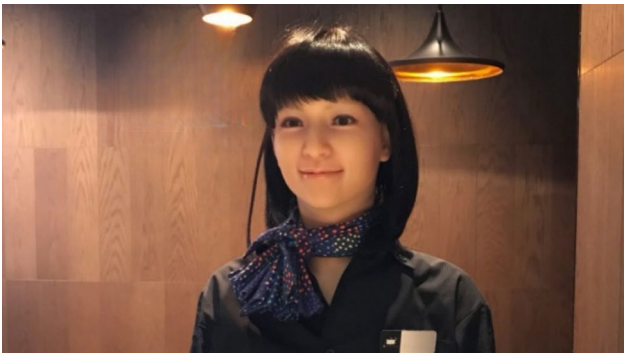
Study scenario

[Type of SPA]

Participants encountered one of the following service provider agents:

Human: You are being served by this human receptionist, as you can see in the picture below. She is experienced in delivering customer service at the front desk.

Humanoid robot: You are being served by this robot receptionist, as you can see in the picture below. She has a highly similar appearance to humans and is competent to deliver customer service at the front desk.



Non-humanoid robot: You are being served by this robot receptionist with a female voice, as you can see in the picture below. The robot receptionist can provide the same functions as humans when it comes to delivering customer service at the front desk.

[Scenario description]

Imagine you are traveling on an important business trip. After a busy day, you arrived at Hotel X at 9 pm to check in and prepare for a good rest to get rid of the day's fatigue.

The following are two scenarios of service failure.

Process failure: You waited in line for 10 min and there was only one staff on duty at the front desk. When you got to the desk, the receptionist answered several telephone calls when you were trying to check-in. When the receptionist handed you your room key card, she addressed you by the wrong gender, i.e., Mr. as Ms. or Ms. as Mr. You were very tired and not happy about the check-in experience. You told the receptionist that the check-in service was unacceptable.

Outcome failure: You waited in line for 2 min. You have reserved a non-smoking room with a king-sized bed before you arrived and received confirmation from the hotel. However, the receptionist looked up your prepaid reservation and informed you that the type of room that you had reserved was not available. If you still want to stay at this hotel, the receptionist can only arrange a smoking room with a twin-sized bed for you. You were very tired and not happy about the check-in experience. You told the receptionist that the check-in service was unacceptable.

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Data availability Data supporting the findings of this study can be accessed upon a reasonable request by contacting bobby-zuwen.huang@connect.polyu.hk.

Declarations

Conflict of interest The authors declare no competing interests.

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