



Unpacking the psychological mechanisms of service robot adoption for lonely customers

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ARTICLE INFO

Keywords:

Service robots
Loneliness
Evolutionary theory of loneliness
Need for interaction
Information overload

ABSTRACT

This research attempts to bridge the fields of service robotics and loneliness studies, exploring the relationship between customers' psychological state and technology use. Drawing upon the Evolutionary Theory of Loneliness, we propose lonely customers have a strong service robot use intention, with need for interaction serving as a mediator and information overload as a moderator. A questionnaire survey of 354 UK-based respondents was conducted to test our hypotheses. Results indicate that loneliness positively affects service robot use intention, both directly and indirectly through a reduced need for interaction. Information overload weakens the negative relationship between need for interaction and service robot use intention. Findings offer insights for service providers in designing and implementing robotic services, suggesting a balanced approach that considers customers' psychological states and varying needs for interaction.

1. Introduction

Service robots, defined as autonomous systems that interact with, communicate with, and deliver service to customers (Wirtz et al., 2018). These robots offer the potential for novel experiences, increased efficiency, and 24/7 service availability (Tussyadiah et al., 2020). Service robots have become increasingly prevalent across various sectors, including hospitality, healthcare, retail, and beyond. The integration of service robots in various industries has fundamentally changed the nature of customer experiences and social dynamics (Nguyen, 2016), such as the potential loss of human touch and the overall impact on customer satisfaction (Rust and Huang, 2014).

Recent studies have explored the adoption of service robots across various sectors, examining their impact on customer experiences, satisfaction, and acceptance (Chiang et al., 2022; Ding et al., 2024). Functional benefits of service robot, customer perceived privacy and trust have been found as crucial factors in shaping adoption intentions (Roy et al., 2024; Lin and Mattila, 2021). Studies have also investigated the effects of robot anthropomorphism and acknowledgment on customer loyalty and emotional responses (Frank and Otterbring, 2023; Huang and Rust, 2018; Mende et al., 2019). The literature reveals paradoxical consumer responses, with

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Peer review under responsibility of Editorial Board of Journal of Digital Economy.

<https://doi.org/10.1016/j.jdec.2025.05.002>

Received 2 March 2025; Received in revised form 8 May 2025; Accepted 22 May 2025

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robots perceived as both “creepy” and “cool” (Kang et al., 2023; Zhu et al., 2023). Cognitive evaluations of robots, including perceived cuteness, utility, and autonomy, strongly influence consumer experience when interacting with robots (Huang et al., 2021). Overall, these studies reflect the ongoing challenges and opportunities in integrating service robots into everyday consumer experiences (Song et al., 2023; Wu and Huo, 2023; Yao et al., 2024). Yet, most studies have focused on the functional and emotional drivers of adopting service robots, while relatively few have examined the social-psychological mechanisms at play during customer–robot encountering in frontline services, particularly for customers of a specific psychological condition (e.g. feeling lonely).

Loneliness, a significant public health concern, is defined as the subjective feeling of social isolation (Cacioppo and Cacioppo, 2018). Loneliness is distinct from objective social isolation and can occur even in the presence of others (Cacioppo et al., 2014). It is considered a fundamental human motivation, rooted in the evolutionary need for social connection and belonging (Baumeister and Leary, 1995; Cacioppo and Cacioppo, 2018). When experiencing loneliness, people show a distinct psychological and behavioral profile that influences the way they interpret and interact with their social world (Cacioppo and Hawkey, 2009; Cacioppo and Patrick, 2008; Qualter et al., 2015).

While technologies offer new opportunities for connection, their impact on loneliness is paradoxical. Excessive technology use (e.g. social media) can exacerbate loneliness (Primack et al., 2017; Twenge et al., 2019). Shrum et al. (2023) note that while digital interactions may not match face-to-face quality, they can still satisfy certain social needs. Service robots, as a substitute of service agent, provide consistent, non-complex interactions, offering a less threatening social option for those sensitive to social rejection (Holthöwer and van Doorn, 2023).

Despite the growing body of research on service robots and loneliness separately, it is unclear whether loneliness serves as a determinant of service robot use intention (Appendix Table A). This study aims to address this gap via the Evolutionary Theory of Loneliness (ETL) lens, by proposing a research framework that examines the relationships between loneliness, need for interaction, information overload, and service robot use intention. ETL suggest that the experience of loneliness is influenced by both genes and social environment, and having meaningful social connections that match an individual's genetically biased predisposition is one of the humans' basic needs (Cacioppo and Patrick, 2008). Therefore, based on the ETL need for interaction underpins the underlying mechanism between lonely customers and their service robot use intention. We also argue that information overload, which is an unintended consequence of the fast-paced modern society (Shrum et al., 2023), acting as the environment factor that moderates the relationship between need for interaction and service robot use intention. To test our hypotheses, we conducted a questionnaire survey with 354 UK-based respondents recruited through Prolific, a leading online market research platform, to test the proposed hypotheses.

This study makes three key contributions to the field. First, it applies ETL to understand how customers' psychological states influence service robot adoption and how this relationship interacts with the cognitive and environmental factors from the lens of loneliness coping strategies. Second, by focusing on a specific customer segment's service encounter preference, namely the lonely customers, this study offers a new perspective by investigating the coping strategy (intention of human approach vs avoidance) mediated by people's need for social interaction. We argue lonely customers with a reduced need for interaction are more likely to use service robots due to a stronger tendency to avoid human contact. Lastly, the study enhances understanding of how an information-saturated environment affects the need for interaction and consequently, service robot adoption.

2. Theory and hypotheses

Loneliness is a complex psychological condition, which is defined as “an aversive state arising from the perception that one's belongingness needs are not being met” (Shrum et al., 2023, p1). The discrepancy between an individual's internal expectations and their perceived social relationships can exacerbate feelings of loneliness (De Jong-Gierveld and van Tilburg, 2006; Russell et al., 2012). To deal with the unpleasant sensation of loneliness, the ETL suggests that individuals often acknowledge and take proactive measures to rectify their current deficiency in social connections, either through active or passive coping strategies (Cacioppo et al., 2014; Vanhalst et al., 2014; Fumagalli, 2021). Active coping strategies directly confront issues and suggest that loneliness serves as a cue signaling a deficiency in social connectedness, prompting individuals to actively seek social connections to fulfil their innate need for social belonging (Cacioppo and Hawkey, 2009). By engaging with others, lonely individuals strengthen their social relationships for the purpose of interaction, positive feelings, self-conception, self-affirmation, and confirmation (Turner, 1988). Conversely, passive coping strategies involve avoidance, suggesting a self-protective approach for saving emotional energy, and avoiding social risks (Cacioppo et al., 2014).

In a service setting, studies have demonstrated that individuals experiencing loneliness find enjoyment in-store shopping experiences that involve personal interactions with salespersons (Smith et al., 2018), and that such positive consumer engagement and high-personalized service fulfil their social needs (Rippé et al., 2015; Song et al., 2018). On the other hand, individuals, seeking to conserve social energy or avoiding discomfort of in-person contact, may find the service substitute (i.e. service robot) particularly appealing as a passive coping strategy for human avoidance. However, the negative coping strategy is less explored.

Existing studies have also explored how technology has been adopted to tackle loneliness (Epley et al., 2008; Pieters, 2013). For instance, inanimate products, such as favored television programs, or intentionally designed sounds can fulfil an individual's need for belongingness through one-way parasocial relationships, acting as a form of social surrogacy (Derrick et al., 2009; Poupis et al., 2021). In frontline service, service robots are the non-human service encounter option, which offer an emotional release space for people to preserve their energy to combat loneliness and isolation (Appel et al., 2020). Therefore, lonely consumers might employ technologies as an escape from in-person social interaction, distancing themselves from human-human contact.

2.1. Loneliness, need for interaction and service robot use intention

Drawing on ETL, this study investigates how lonely customers select service encounters within a service environment. Service robots, the non-human service encounter option, offer an emotional release space for people to preserve their energy to combat loneliness and isolation (Appel et al., 2020). Loneliness, often regarded as a temporary emotional condition, can influence how individuals perceive and interact with their environment (Cacioppo and Hawkey, 2009). Lonely individuals, who often experience reduced social self-efficacy (Tsai and Reis, 2009), may seek alternative forms of social interaction that feel safer or more controllable (Bandura, 1986). In service settings, human interactions are often functional but lack emotional depth, offering limited potential for meaningful connection or the alleviation of loneliness (Song et al., 2018). Comparatively, service robots are more appealing because of their predictable and non-judgmental nature. Robot interactions may present a more manageable and less emotionally taxing social scenario for those with low social self-efficacy (Bandura, 1997). As a result, lonely individuals may prefer to interact with service robot, reinforcing their isolation rather than risking further social disappointment. Thus, we posit:

H1. Loneliness is positively related to service robot use intention.

Humans are born with a sense of belonging and a need for interaction (Baumeister and Leary, 1995). The need for interaction drives humans to avoid feelings of deprivation when they are excluded from ongoing social activities. While some people have a strong need for belonging and social interaction, others prefer spending time alone and have a low desire to affiliate with others (Leary et al., 2003). Technological advancements make the avoidance of social interaction possible, further reducing people's need for physical interaction (Wang and Emurian, 2005).

Due to the rise of social media and other changes in modern life, such as new working patterns, the acceptance of sex toys, the normalization of divorce, the growing of singlehood and digital pornography, urbanization, and new designs of residencies, many social interactions are temporary, 'artificial' (Belk, 2022), and emotionally uninvolved. Situations like these may imply that one does not need to feel emotionally close to others, but only a part of the interactive flow in social interactions (Turner, 1988). Efforts for interaction are challenging because individuals often monitor situations to determine the conversational resources and the emotional energy required to extract emotional and cultural profit from social interaction (Turner, 1988). If such profits are predicted not to come, people's motivation to engage in interactions will decrease. Therefore, in modern society, particularly with easy access to technology (e.g. service robots), people have less need for social interaction even if they have a feeling of deprivation (loneliness) based on their calculation of cost versus reward (Shrum et al., 2023). Loneliness may lead to cognitive restructuring, altering one's perceived need for social interaction. Therefore, we hypothesize that:

H2. Loneliness is negatively related to need for interaction.

Technological advancements make the avoidance of interpersonal social interaction possible, further reducing the human need for physical interaction (Xiang, 2021). While some people have a strong need for belonging and social interaction, some prefer spending time alone and have a low desire to affiliate with others (Leary et al., 2003). For individuals with less need for interaction, using technology (i.e. service robots) is a preferable option, reflecting people's intrinsic motivation for spending time alone (Nguyen et al., 2018) as opposed to avoiding unpleasant social interactions.

H3. Need for interaction has a negative effect on service robot use intention.

Furthermore, through the calculation of the investment in emotional effort and cultural capital from the relationship initiator and the uncertainty caused by 'others' involved in the interaction, people may suppress their concerns based on utilitarianism and try their best to minimize the depletion (Turner, 1988). Within the service context, while individuals experiencing loneliness may have less motivation for interpersonal relationship development and prefer to avoid social interactions, a selection of non-human service providers poses fewer threats as it requires less emotional effort (Turner, 1988). Using service robots can thus avoid concerns about sequential and ongoing in-person interactions (Shrum et al., 2023). Therefore, we propose that lonely people's service robot use intention is mediated by their need for interaction.

H4. The need for interaction mediates the relationship between loneliness and service robot use intention.

2.2. The moderating role of information overload

In digital era, individuals immerse themselves in huge amounts of information. The capacity of the human brain to process this influx of information does not keep pace, resulting in *information overload*. Overwhelmed information leads to a state of *multiphrenia* - a conflict in people's identities, roles, and themselves (Gergen, 1991) and a perceived loss of control and social fatigue (Ravindran et al., 2014), reinforcing the unwillingness to interact with human.

Information overload represents an environmental condition that can influence cognitive processes and behavioral choices (Eppler and Mengis, 2004). Social cognitive theory (SCT) recognizes the crucial role of environmental factors in shaping behavior (Bandura, 1986). High information overload may increase cognitive load, making simpler robot interactions more appealing even for those with high interaction needs. This aligns with SCT's recognition of how people adapt their behavior to environmental conditions (Bandura, 1997). Under high information overload, individuals may become more open to robot interactions as a way to manage their cognitive resources (Bandura, 2001). We then hypothesize that:

H5. Information overload moderates the relationship between the need for interaction and service robot use intention. Under low

information overload conditions, the negative relationship between need for interaction and service robot use intention would be stronger. As information overload increases, the relationship becomes weaker (less negative). Fig. 1 presents the conceptual framework.

3. Method

Participants were recruited through Prolific, a professional research data collection platform known for providing high-quality data (Palan and Schitter, 2018). To ensure data quality, several screening criteria were applied: participants must be UK residents, have English as their first language, and have a Prolific approval rate above 95 %. From an initial distribution to 450 participants, we received 401 responses. After removing incomplete responses ($n = 32$) and responses that failed attention checks ($n = 15$), 354 valid responses remained, yielding a response rate of 78.7 %. Early and late respondents were compared to assess non-response bias, with no significant differences found.

The final sample comprised 62 % males and 37 % females. Age distribution included 11 % aged 18–24 years, 35 % aged 25–34 years, 25 % aged 35–44 years, 16 % aged 45–54 years, and 12 % aged 55 years and above. A majority of participants (58 %) were employed in full-time positions, and 60 % had obtained a bachelor's degree or higher education qualification. The sample demographics were representative of the UK online population (Office for National Statistics, 2023). To ensure the quality of responses, we included attention check questions and monitored completion times. Responses completed in less than 5 minutes (the minimum time determined in pilot testing) were excluded from the analysis.

The measurement scales for loneliness were adapted from Russell et al. (2012), need for interaction from Dabholkar (1996), information overload from Karr-Wisniewski and Lu (2010), and service robot use intention from Ivanov and Webster (2019). To ensure participant understanding, we provided a brief explanation: “Service robots have been introduced in many public service settings such as shopping malls, restaurants, and hotels. They can greet customers, offer directions, and provide services much like human employees.” All items were measured using a 7-point Likert scale.

4. Results

PLS-SEM was applied to assess the model. As this research had an overall sample size of 272 and five constructs with several indicators, PLS-SEM is appropriate due to its suitability for exploratory models and its effectiveness in handling complex path relationships with moderate sample sizes (Hair et al., 2019). The use of PLS-SEM avoids the constraints of LISREL and AMOS, and is a better alternative for this study than covariance-based SEM (Hair et al., 2019). As presented in Table 1, indicator loading results showed high reliability, with all loading greater than the critical value of .707. All AVE values exceeded .5, establishing a satisfactory convergent validity. In addition, internal consistency reliability was satisfactory with both Cronbach's alpha and CR values higher than .7. Furthermore, the HTMT results (Table 1) show that constructs were below the conservative threshold value of .85 (Hair et al., 2019). Thus, discriminant validity was also established.

To evaluate the structural model, common method bias, coefficient of determination (R^2), Q^2 , effect size (f^2), model fit, identical t values and beta value were examined. Variance inflation factors (VIFs) are below 3.3 (between 1.086 and 1.340), indicating no common method bias issue (Kock, 2015). R^2 reflects the value of the variance explained, and the R^2 value of .438 for the dependent variables (intention to use service robot) is considered moderate in-sample predictive power (Chin, 1998). Effect sizes were also assessed to determine the extent to which exogenous latent variables influence the R^2 value of an endogenous latent variable. Following the guidelines of Cohen (1988), namely .02 for a small effect, .15 for a medium effect, and .35 for a large effect, our results show a medium effect on the path of LL -> NFI ($f^2 = .021$), and LL -> SRUI ($f^2 = .023$) and a large effect for NFI -> SRUI ($f^2 = .713$). Furthermore, Stone-Geisser's blindfolding test was applied to evaluate the predictive relevance (Q^2) (Tenenhaus et al., 2005). Results show that the Q^2 values are greater than zero implying the proposed conceptual model has high predictive validity. Additionally, the model fit was assessed, with the results showing a standardized root mean square residual (SRMR) value of .070, which is less than the model fit criterion of .08, indicating an adequate fit (Henseler et al., 2016).

A bootstrapping procedure with 5000 iterations was then performed to evaluate the statistical significance and relevance of the path coefficients. The results reflect that all the hypotheses are supported (Table 2). The results also show that the negative impacts of LL on NFI and the impact of NFI on SRUI are all significant, supporting H3 ($\beta = -.159$, $p < .05$) and H4 ($\beta = -.634$, $p < .001$). The mediating effect of NFI between LL and SRUI was then examined by applying the bootstrapping approach. Table 2 shows that a

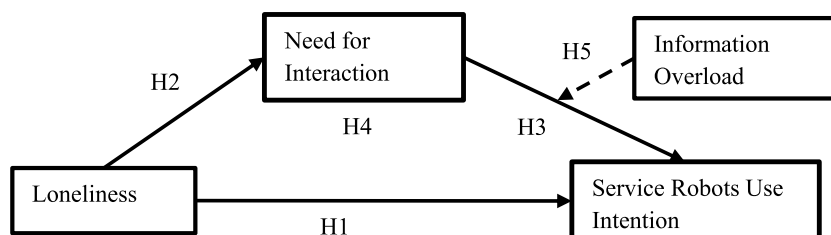


Fig. 1. Conceptual framework.

Table 1
Validity and reliability for constructs.

Number of items		Factor loading	C _α	CR	AVE	HTMT			
						1	2	3	4
LL	LL 1 I feel lonely	.853	.941	.951	.707				
	LL 2 I feel left out	.850							
	LL3 There are no people I feel close to	.873							
	LL 4 I feel there are no people I can seek help	.859							
	LL 5 My social relationships are superficial	.780							
	LL 6 I feel no one really knows me well	.837							
	LL 7 I feel my interests and ideas are not shared by those around me	.844							
	LL 8 I feel people are around me but not with me	.906							
NFI	NFI 1 Human contact in providing services makes the process enjoyable for me	.893	.837	.891	.675	.167			
	NFI 2 I like interacting with the person who provides the service	.898							
	NFI 3 Personal attention by the service employee is very important to me	.720							
	NFI 4 It bothers me to use a machine when I could talk with a person instead.	.759							
IO	IO 1 I often have the feeling that I get too much information on social media to make a good decision.	.701	.882	.885	.724	.285	.107		
	IO 2 I find that I am overwhelmed by the amount of information I have to process on social media on a daily basis.	.840							
	IO 3 I am often distracted by the excessive amount of information available to me on social media.	.987							
SRUI	SRUI 1 I intend to use service robots (whenever and wherever I can)	.884	.933	.952	.833	.215	.724	.058	
	SRUI 2 Even if there is human service, I prefer to use service robots/technology if they are available.	.931							
	SRUI 3 I try to avoid human service providers if there are service robots.	.896							
	SRUI 4I always use service robots if they are available.	.923							

Notes: LL: Loneliness; IO: Information Overload; SRUI: Service Robot Use Intention; NFI: Need for Interaction.

Table 2
Hypotheses test.

	Hypotheses	Support?	Coefficient	SE	T values	P value	95 % CI	
							Lower	Upper
Direct effect	H1 LL - > SRUI	Yes	.115	.045	2.574	.010	.032	.206
	H2 LL - > NFI	Yes	-.142	.053	2.666	.008	-.252	-.044
	H3 NFI - > SRUI	Yes	-.638	.033	19.613	.000	-.700	-.570
Mediating effect	H4: LL - > NFI - > SRUI	Yes	.091	.034	2.65	.008	.028	.161

Notes: LL: Loneliness; SRUI: Service Robot Use Intention; NFI: Need for Interaction.

significant mediating effect (H5, $\beta = .101$, $p = .01$); therefore, H5 is supported. Furthermore, the VAF values were assessed to determine the magnitude of the mediation effect, with the values (46.3 %) between 20 % and 80 %, indicating a partial mediating effect (Hair et al., 2019).

We then used the process model in SmartPLS to test the second stage moderated mediation effect, specifically, whether IO moderates the effect of NFI on SRUI. “Moderated mediation occurs when the strength of an indirect effect depends on the level of some variable, or in other words when mediation relations are contingent on the level of a moderator” (Preacher et al., 2007, p. 193). As the mediation result was demonstrated, we now focus on evaluating the moderation effect. The result reveals that the interaction between information overload and NFI is significant for SRUI ($\beta = .092$, $p < .005$). One of the paths in a mediation model is sufficient to claim the moderation of mediation (Hayes, 2017); thus, the result supports the conclusion that the indirect effect of LL on SRUI through NFI is reduced by IO.

A simple main effects analysis was then performed to examine the path of LL - > NFI - > SRUI at 1 SD above and below the mean of

Table 3
Moderated Mediation test results.

Path	Coefficient	SE	T values	P values	CI	
					2.50 %	97.50 %
H5: IO x NFI - > SRUI	.092	.029	3.132	.002	.037	.152
Conditional direct effects						
LL - > NFI - > SRUI conditional on IO at +1 SD	.069	.069	.030	2.257	.024	.009
LL - > NFI - > SRUI conditional on IO at -1 SD	.100	.101	.044	2.267	.023	.013
LL - > NFI - > SRUI conditional on IO at Mean	.084	.085	.037	2.291	.022	.011

Notes: LL: Loneliness; IO: Information Overload; SRUI: Service Robot Use Intention; NFI: Need for Interaction.

the IO. Results show that at all levels, high (mean +1SD), media (mean), and low (mean - 1SD) for IO, the main effect from LL via NFI on SRUI was significant (see Table 3). Compared with the high level of IO from Fig. 2, the low level resulted in a steeper slope. The results show that a significant moderating effect is supported, suggesting that when IO increased, the mediating effect of NFI on SRUI decreased.

5. Discussion and conclusion

This study aimed to address important research questions concerning the relationship between loneliness and the intention to use service robots, as well as the roles of need for interaction and information overload in this relationship. Our findings provide significant insights into these questions and offer strong support for our hypotheses, which can be effectively explained through the lens of ETL.

Our results identify loneliness as a potential driver of service robot use. This finding aligns with the development of ETL with dual coping strategies: active and passive (Shrum et al., 2023). Loneliness can reduce an individual's confidence in social interactions and the predictable and non-judgmental nature of robot interactions are more appealing (Holthöwer and van Doorn, 2023).

The study also found that loneliness negatively impacts the need for interaction, which in turn reduces the intention to use service robots. This mediation effect can be understood through ETL's explanation of cognitive restructuring in response to chronic loneliness (Cacioppo and Hawkley, 2009). The reduced need for interaction may represent an adaptive response where lonely individuals adjust their social expectations and behaviors.

Furthermore, our findings indicate that high levels of information overload weaken the mediating effect of the need for interaction on the relationship between loneliness and service robot use intention. This moderation effect aligns with SCT's emphasis on environmental influences (Bandura, 1986). Under conditions of high information overload, individuals may prefer the simpler, more controlled interactions offered by service robots, demonstrating an adaptive response to complex environmental conditions as described in SCT (Bandura, 2001).

5.1. Theoretical contributions

This study makes several important contributions to the existing literature. First, our research advances loneliness literature within the service and technological contexts. The application of ETL offers a new lens for understanding the complex interplay between personal psychological state (loneliness), cognitive perceptions (need for interaction), environmental influences (information overload), and behavioral intentions (service robot use). Our elucidation of how these various elements interact and influence each other

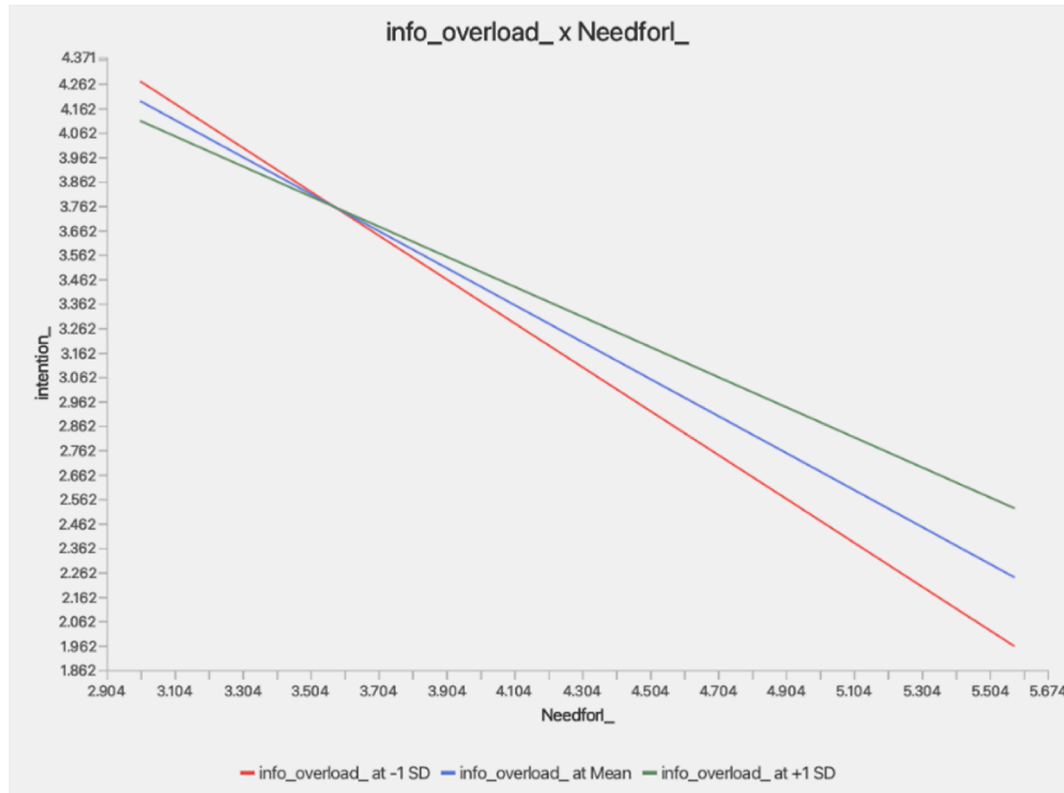


Fig. 2. Moderation analysis plot.

provides a more nuanced understanding of the psychological processes underlying service robot adoption, extending the theoretical foundations of human-robot interaction studies (Huang and Rust, 2018).

While previous studies have examined the impact of human service on loneliness (Rippé et al., 2018), our work made the pioneering investigation on how loneliness influences customers' intention to use non-human service, adding the contemporary feature to the ETL. The revelation that loneliness can increase the intention to use service robots, potentially as a coping mechanism, provides new insights into how psychological states shape service demands.

Second, our research embedded the important psychological factor, i.e. loneliness, into the framework for service robot adoption. Our findings demonstrate that loneliness positively influences the intention to use service robots, calling for further research exploring the psychological factors influencing technology adoption beyond the technological factors such as usefulness and ease of use (Davis, 1989).

Lastly, our research contributes to a deeper understanding of the role of psychological factors in service encounters and opens up new avenues for research on the relationships between psychological motives and different types of service with the assistance of technology (Mende et al., 2019). This insight challenges the simple dichotomy of technology as inherently beneficial or harmful to social connections and suggests a more nuanced approach to understanding the long-term implications of human-robot interactions on social dynamics (Turkle, 2011; Shrum et al., 2023). Specifically, in today's digital environment characterized by an overwhelming flow of information, customers with limited emotional energy may gravitate toward the simpler and more predictable interactions provided by technology, such as service robots. The environmental element in SCT emphasizes individuals' adaptivity within the service context (Bandura, 2001).

5.2. Practical implications

Our research findings offer several important practical implications. First, service providers should consider the customers' psychological state when designing and deploying services. With the aid of service robots, lonely customers may be more receptive to non-human service. While service robots can provide a space to avoid human contact, study found lonely customers' over-reliance on these technologies for its non-threatening form might potentially exacerbate feelings of social isolation in the long term (Xie and Wang, 2024). Therefore, it is highly dependent on whether customers have the need for interaction. Some lonely customer may prefer a passive coping strategy, that is to avoid human contact, preserving their emotional energy (Gross, 2015). For these customers, stable, simple functioning service robots can help them to enjoy more of the service by not talking to others. Therefore, on one hand, businesses need to consider how they can segment the customers and provide a balanced approach, offering both robotic and human service options to cater to diverse customer needs and preferences (Wirtz et al., 2023). On the other hand, they should make sure that service robots have the least malfunction potentials which could cause even worse customer experience (Roy et al., 2024).

It is also noticeable that contemporary customers within the digital environment often experience information overload which provide valuable insights for user interface design and service environment management. When customers experience high information overload, even customers with a high need for interaction may be more accepting of robotic service. Businesses operating in such environments (e.g., airports, large retail stores) might find greater success in implementing service robots when the environment is particularly hustle and bustle. We argue the need for a contingency-based approach to robot design, aligning capabilities and personalities with specific service contexts (Balaji et al., 2024; Söderlund, 2023).

Finally, our findings have implications for mental health professionals and social service providers. The link between loneliness and increased acceptance of service robots suggests that individuals' interaction preferences could serve as an indicator of their psychological state. While not a diagnostic tool, observing changes in an individual's preference for human versus robotic interactions could potentially flag changes in their social well-being, prompting further assessment or support.

5.3. Limitations and future research directions

While our study provides valuable insights, there are several avenues for future research. First, we focused primarily on loneliness as a predictor of service robot use intention, future studies could explore additional psychological factors such as social anxiety, personality traits, or social skills to create a more comprehensive model of antecedents. Second, future research could test actual behavior through field experiments or observational studies could provide insights into whether intentions translate into action. Research could also investigate the long-term effects of service robot interactions on well-being, addressing concerns about replacing human interactions with robotic ones. Moreover, exploring other contextual factors beyond information overload, such as cultural values or prior technology experience, could enhance the generalizability of findings. Furthermore, differentiating between types of service robots and levels of anthropomorphism could offer valuable insights for robot design. Finally, employing longitudinal designs could help establish causal relationships and reveal potential feedback loops between service robot use and loneliness, providing a more dynamic understanding of these relationships.

CRedit authorship contribution statement

Min Yan: Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Qionglei Yu:** Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Data curation, Conceptualization. **Zhibin Lin:** Writing – review & editing, Writing – original draft, Validation, Conceptualization. **Yu Ye:** Writing – review & editing, Validation, Conceptualization.

Declaration of competing interest

On behalf of all the co-authors, I would like to confirm that we have no conflicts of interest to declare. Each co-author has thoroughly reviewed the manuscript and agrees with its content. We certify that the submission is entirely original and has not been submitted for consideration to any other publication. Furthermore, we confirm that there are no financial interests or relationships that could be perceived as influencing the research presented in this manuscript.

Appendix

Table A

Literature Review on Service Robot Adoption and Loneliness

Domain	Authors	Theory	Method	Findings
Service robot acceptance in frontline service	Lin and Mattila (2021)	The theory of consumption values, and service robot acceptance model (sRAM)	Qualitative and SEM	Perceived privacy, functional benefits of service robot, and robot appearance positively influence consumers' attitude towards adoption of SR. Functional benefits and novelty had an impact on the individuals' anticipated overall experience. Attitude and anticipated overall experience, in turn, enhanced consumers' acceptance of service robot.
	Song & Kim 2022	Computers-Are-Social-Actors theory	SEM	Retail Service Robot (RSR) facilitators such as usefulness, social capability, and appearance influence attitudes toward Human-Robot Interaction (HRI) positively, which in turn, predict anticipation of better service quality and greater acceptance of RSRs, and demonstrate the moderating role of anxiety toward robots between RSRs' facilitators and attitudes toward HRI.
	Kim et al., 2022	Social exchange theory	Two empirical studies	Perceived intelligence, perceived social presence, and perceived social interactivity on trust, leading to usage intentions. Rapport, trust, and uniqueness neglect are mediators in the relationships between human–robot attributes and usage intentions.
	Wong and Wong, 2024	Service robot acceptance model	SEM	The findings show the positive effects of subjective norms, appearance, perceived trust and positive emotion on both attitude toward HRI and engagement. In addition, social capability impacted attitude toward HRI, whereas perceived usefulness affected engagement
	Said et al., 2024	Technology acceptance model 3	SEM	Perceived usefulness, driven by subjective norms and output quality, and perceived ease of use, driven by perceived enjoyment and absence of anxiety, are the immediate direct determinants of users' re-patronage intentions for HSRs. Results also showed that users prefer anthropomorphism, perceived intelligence and the safety of an HSR for reusing it.
	Soliman et al., 2024	The technology Readiness Index 2.0, cognitive appraisal theory, and attachment theory	SEM	The results indicate that attitudes toward service robots are affected by optimism and insecurity. Customers' discomfort and insecurity influence robot-related anxiety, which in turn impacts their emotional expectations. Attitudes toward service robots affect positive and negative emotional expectations while positive emotions impact brand perceptions that in turn impact service robots' use intentions.
	Huang et al. 2024	Cognitive–affective–conative framework	A mixed-method approach combining qualitative and quantitative	Willingness-to-pay for robotic service is not affected by brand perceptions or use intentions. Five cognitive evaluations (i.e. cuteness, coolness, courtesy, utility and autonomy) significantly influence consumers' positive affect, leading to customer acceptance intention. Four cognitive evaluations (cuteness, interactivity, courtesy and utility) significantly influence consumers' negative affect, which in

(continued on next page)

Table A (continued)

Domain	Authors	Theory	Method	Findings
Loneliness and Robot	Yoganathan et al., 2021	Social presence and social cognition theories	Experiments	turn positively affects consumer acceptance intention. Anthropomorphizing service robots positively affects expected service quality, first-visit intention, willingness to pay, and increasing warmth/competence inferences. These effects are contingent on the absence of human frontline staff. Humanoid robots increase psychological risk, but this poses no threat to expected service quality when consumers' need for human interaction is controlled for.
	Holthöwer and van Doorn (2023)	Human social presence	Experiments	Consumers feel less judged by a robot (vs. a human) when having to engage in an embarrassing service encounter, such as when acquiring medication to treat a sexually transmitted disease or being confronted with one's own mistakes by a frontline employee. As a consequence, consumers prefer being served by a robot instead of a human when having to acquire an embarrassing product, and a robot helps consumers to overcome their reluctance to accept the service provider's offering when the situation becomes embarrassing.
	Yu and Fan, 2024	Friendliness–dominance model and attraction theory	Experiments	Individuals experiencing greater loneliness hold generally less favourable attitudes toward the idea of adopting robotic companionship. Lonelier individuals show a higher inclination to bond with robots that act submissive rather than dominant ones
	Marriott and Pitardi 2024	Para-social relationship (PRS) theory	Mixed method	Users of AI friendship apps have well-being benefits from the relationship with the AI friend and, at the same time, find themselves being addicted to using the app. Users' loneliness and fear of judgment, together with AI sentience and perceived well-being gained, increase addiction to the app, while AI ubiquity and warmth reduce it.
	Khoa and Chan 2023	information processing theory	Experiments	Solo customers are more likely than joint customers to perceive frontline anthropomorphized robots as offering rapport but also as being eerie, leading to different service evaluations (attitudinal and behavioural outcomes). The rapport (eeriness) mechanism is strengthened (weakened) when the robot is of in-group favouritism, the service process deprives customers of control, and customers have a hedonic consumption goal.
This study		Evolutionary theory of loneliness	SEM	The study provides new insight into the underlying mechanisms shaping service preferences among a distinct segment of customers (i.e. lonely customers). The findings argue lonely customers' greater tendency to avoid human service may serve as coping strategies, which is mediated by customers' cognitive perception (need for interaction), showing effect of reduced desire for social interaction in lonely customers' service robot use intention. Finally, the study contributes to the domain by demonstrating the influential role of information overload, a common phenomenon in the digital environment, highlighting the external influence on the relationship between customer social cognition and technology adoption.

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