Pak. j. life soc. Sci. (2024), 22(2): 6367-6377 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences

www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2024-22.2.00480

RESEARCH ARTICLE

Path Analysis of the Impact of Perceived Attributes of Service Robots on Customer Experience: A Case Study of Luxury Hotels in Shanghai

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ARTICLE INFO

Received: Jul 18, 2024

Accepted: Sep 25, 2024

Keywords

Service robots
Perceived attributes
Customer
Hospitality
experience
Value co-creation
intention

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ABSTRACT

With the advancement of artificial intelligence technology, the use of service robots in the tourism industry has gradually increased, especially in luxury hotels. This study explores the impact of the perceived attributes of service robots—including anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety—on customer hospitality experience and value co-creation intention. An online survey was conducted with guests from 11 luxury hotels in Shanghai. The data were analyzed using descriptive statistics, reliability analysis, confirmatory factor analysis (CFA), and structural equation modeling (SEM). The results indicate that the attributes of "perceived intelligence" and "perceived safety" have a significant impact on customers' experience perception, while "anthropomorphism" and "animacy" have a smaller effect. The findings not only enrich the theoretical framework of service robot perceived attributes but also provide guidance for hotel management practices, emphasizing the importance of enhancing service robot attributes to improve customer experience. Additionally, this study offers valuable insights for the future application of service robots in the hotel industry and provides references for policy development and technological optimization.

INTRODUCTION

1.1 Research Background

With the continuous advancement of artificial intelligence technology, the application of robots in the tourism sector has become increasingly common, with intelligent services emerging as a significant trend in the industry (Tung & Law, 2017). Robotics and AI bring a wide range of potential benefits to the tourism industry, including cost reduction, increased productivity, enhanced reliability, scalability, improved compliance and safety (Wirtz et al., 2018), revenue generation, customer retention, and even heightened creativity among managers (Khatri, 2020). As a key component of the tourism sector, the hotel industry faces high labor demands for service personnel, making robots an effective means to improve operational efficiency in restaurants and establishing them as a primary application scenario for service robots (China Robotics Industry Development Report, 2022). Historically, hotel service research focused on interactions between employees and customers. However, the advent of robots has introduced a new dynamic: interactions now involve employees, customers, and robots, creating a triadic interaction model. This shift presents a new research question for hotel service management: How do the attributes of service robots affect this triadic interaction, and how do they influence customers' hospitality experience?

In 2022, the total revenue of China's robotics industry exceeded 170 billion RMB, with the production of service robots reaching 6.458 million units. In the first half of 2023, the

production of service robots reached 3.53 million units, a year-on-year increase of 9.6% (China Reform News, August 7, 2023, p. 002). For example, in the case of delivery robots, according to data from the service robot manufacturer "Yunji Technology," its hotel concierge robot "Run," in operation since 2015, has been deployed in over 500 mid-to-high-end hotels across China by the end of 2022, serving over 1.3 million people. This includes international hotel groups like Marriott, InterContinental, Hilton, and Ascott, as well as domestic chains such as ShouLian, Fuli, Jinjiang, and Kaiyuan. The robot has also successfully entered markets in South Korea, Singapore, Australia, North America, and Taiwan, and supported smart services at the 2022 Beijing Winter Olympics and the National Convention Center (Source: Yunji Technology official website). Service robots have become standard equipment in many international hotels, representing a new opportunity for competitive advantage (Qiu et al., 2020). The emergence of service robots signifies a shift in value co-creation methods within the service ecosystem (Choi et al., 2020). Effectively managing service robots to enhance customer service experience is a pressing research issue in the industry.

1.2 Research Significance

1.2.1 Theoretical Significance

This research enhances and supplements the service robot perceived attributes scale from a social attributes perspective. The technological attributes of service robots include two categories: performance parameters that customers cannot perceive and value attributes that customers can perceive. The former, such as power, speed, and charging time, have little impact on ordinary customers without technical knowledge (McCartney & McCartney, 2020). In contrast, the latter, i.e., perceived attributes, affect customers' perceptions and behaviors during interactions with service robots and collaborations between employees and robots. Currently, the God-speed scale is widely used to measure robot attributes, but its applicability in the hotel industry context is limited. This study systematically reviews the perceived attributes of service robots in existing literature and, based on their application in hotel service scenarios, enhances and supplements the perceived attributes scale from a social attributes perspective. This aims to provide a reference for future research on service robot application management and impact. The study enriches research on how perceived attributes of service robots affect customer hotel experiences and extends the scope and social exchange theory in the hotel industry (Mariani & Borghi, 2021). Empirical testing clarifies the path relationship between service robot attributes and hotel experiences, offering valuable insights for future research in this field.

1.2.2 Practical Significance

The practical significance of applying service robots in luxury hotels is reflected in several aspects. Firstly, the application of service robots in the hotel industry is still in the exploratory stage, and hotel managers and staff may not fully understand their attributes. This research, by supplementing and improving the service robot perceived attributes scale, helps hotel managers better understand these attributes and provides a decision-making basis for developing scientific management measures. Secondly, research on human-robot collaboration can enhance the strategic importance of human resource management in the hotel industry, helping operators optimize existing resources more intelligently and offering new perspectives for the organizational structure and policy development of hotel human resources management. Additionally, this research inspires the government and related departments to develop comprehensive plans for hotel informatization, providing decision-making references for designing, laying out, and managing service functions related to service robots in China in the future. By analyzing the mechanisms through which service

robots impact hotel experiences, this study promotes human-robot collaboration, enhances customer hotel experiences and value co-creation intentions (Gaur et al., 2021). As a new technological application, service robots help reduce service heterogeneity, allowing hotels to provide higher levels of standardization or homogeneity in service delivery. Furthermore, by exploring the mechanisms through which service robots affect hotel experiences, this research can better understand human-robot collaboration mechanisms, improve hotel service quality and customer experiences, assist in establishing a better hotel brand image, and provide feasible suggestions for the high-quality and sustainable development of the hotel industry. These findings also offer references and insights for other similar robot service scenarios in the hotel industry.

2.LITERATURE REVIEW

2.1 Perceptual Attributes of Service Robots and Their Application in the Tourism Industry

The perceptual attributes of service robots play a crucial role in the tourism industry, encompassing aspects such as Anthropomorphism, Animacy, Likeability, Perceived Intelligence, and Perceived Safety. Anthropomorphism endows robots with human-like appearance and behavior, enhancing customers' intimacy and acceptance (Jung et al., 2018). Animacy, through natural movements and reactions, improves the interactive experience, making the service process more lively and engaging (Niculescu et al., 2013). Likeability involves the design of the robot's appearance and voice tone, which can enhance customer pleasure and satisfaction (Seo, 2022). Perceived Intelligence refers to customers' evaluation of the robot's ability to handle complex tasks, with intelligent services improving efficiency and meeting customer needs (Shin & Jeong, 2022). Perceived Safety focuses on the stability and safety of the robot's operation, ensuring customer security during use (Akalin et al., 2022). In the tourism industry, these attributes are widely applied in areas such as hotel front desk services, room services, guide services, scenic spot security monitoring, and traffic guidance. For instance, anthropomorphic robots provide a warm welcome at hotel front desks, while robots with animacy and perceived intelligence offer interesting and efficient explanations at scenic spots (Chen, 2020). The optimization of these perceptual attributes not only enhances service quality but also significantly improves customers' overall experience.

2.2 Social Exchange Theory

Social Exchange Theory, proposed by Homans, is an important sociological framework aimed at explaining the impact of interpersonal behavior and relationships on social structure. The theory is based on the fundamental assumption that all human participants engage in the exchange of tangible and intangible resources. This theory is widely used in psychology and sociology to explain resource exchange between individuals and groups. In sociology and economics, Social Exchange Theory is regarded as a highly influential middle-range theory, with its core view that social behavior is a process through which individuals exchange resources with others to obtain specific benefits (Kim & So, 2022).

In studying the impact of service robots' perceptual attributes on customer hospitality experiences, Social Exchange Theory provides a theoretical foundation for understanding the interaction between service robots and customers. The theory posits that the formation and maintenance of social relationships are based on the principle of reciprocity, where individuals seek to maximize benefits and minimize costs in interactions (Rasheed et al., 2023). In the interaction between service robots and hotel customers, customers expect to gain certain value through interacting with robots, while robots seek to receive

corresponding rewards by providing services. Specifically, perceptual attributes of service robots, such as anthropomorphism, friendliness, and safety, directly influence customers' hospitality experiences. These experiences, in turn, affect customers' willingness to co-create value with the robots. Therefore, Social Exchange Theory provides a solid theoretical framework for this study, helping to understand how the perceptual attributes of service robots influence customers' value co-creation intentions through their hospitality experiences (Khairy et al., 2024). Additionally, the application of this theory extends its relevance to research on luxury hotel customer experiences.

2.3 Current Research on Customer Hospitality Experience

Customer hospitality experience is an important research field that covers customers' perceptions of service quality and their evaluations of the overall experience during consumption. In recent years, as consumer demand continues to evolve, researchers have increasingly focused on how to improve service quality and customer satisfaction by enhancing customer hospitality experiences. Research in this field can be divided into several main directions: the components of customer experience, influencing factors, and how to enhance customer loyalty and satisfaction by improving customer experience.

Pijls et al. (2017) divided customer hospitality experience into three main dimensions: Inviting, Care, and Comfort. They believe that these dimensions have a significant impact on customers' overall experience in different service environments. In the luxury hotel industry, personalized service and high-quality customer interaction are considered key to enhancing the customer experience. Moreover, with the advancement of technology in recent years, service robots, as an emerging form of service, have also attracted widespread attention for their impact on customer experiences (Lu et al., 2020). Positive customer experiences can significantly increase customer loyalty and repurchase intentions (Mustikasari et al., 2021). For example, Rane et al. (2023) found that high-quality service experiences effectively increase customer satisfaction and positively influence their loyalty. Related studies have also pointed out a significant positive correlation between customers' perceived value of the service and their satisfaction with the experience (Paulose & Shakeel, 2022).

2.4 Current Research on Tourism Robot Services

One of the key issues in current research on robots in the hotel and tourism fields is how to encourage customers to use robots. The acceptance of service robots has been widely studied, and theoretical models are gradually being refined. This research originates from traditional models such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). Lu, Cai, and Gursoy (2019) argue that the process of AI and robotic service is simpler than general technology use, and certain elements in traditional models, such as perceived availability, are no longer applicable. New elements, such as social influence and perceptual attributes, have been incorporated into the model. Comparatively, Gursoy, Chi, Lu, et al. (2019) proposed a layered AI Technology Acceptance Model (AIDUA), which includes the initial, second, and third stages and has been tested in service and hotel environments. On the other hand, de Kervenoael et al. (2020) found that empathy and information sharing are also major motivations for customers to use robot services. Compared to other technology services, AI and robotic services are closer to traditional human services, requiring fewer customer skills, and human-robot interaction is more social in nature. Therefore, emotional factors such as positive emotions and empathy have received significant attention in the study of acceptance of this new type of service. Additionally, issues such as trust have also been discussed in research on robot use (Gonzalez-Aguirre et al., 2021).

In contrast, research on the psychological and behavioral impact of introducing high-tech, such as robots, on employees and customers is gradually gaining attention. Although the introduction of hotel robots significantly reduces the demand for human resources, it also increases hotel employees' intentions to leave. Li et al. (2019) found that perceived organizational support and organizational competition climate moderate the impact of AI and robot use on employees' turnover intentions in hotels.

4.RESULTS

4.1 Descriptive Statistical Analysis

Table 1 provides an overview of the demographic characteristics of the respondents. The gender distribution is relatively balanced, with males accounting for 48.193% and females making up 51.807%. Regarding age, the majority of respondents are 55 years old or older, representing 25.904% of the sample. The next largest group is the 45-54 age group, comprising 20.633%. Respondents aged 25-34 make up 19.578%, while those aged 35-44 account for 18.675%. Respondents aged 24 or younger represent 15.211%. In terms of marital status, the majority of respondents are currently single, accounting for 84.187%, while 15.813% are married. Regarding educational background, the highest proportion of respondents hold a master's degree, at 53.765%, followed by bachelor's degree holders at 31.325%. Those with a diploma or lower education level make up 8.434%, while respondents with a doctorate or higher account for 6.476%. As for occupation, government officials and employees of state-owned enterprises represent the largest group, accounting for 38.253%, followed by students at 32.078%. Business owners make up 16.416% of the respondents, while those working in private companies and other professions account for 2.861% and 10.392%, respectively. Regarding monthly income levels, respondents with an income between 9,001 and 12,000 RMB constitute the largest group at 34.337%, followed by those earning over 12,000 RMB, who make up 25.602%. Respondents with a monthly income between 6,001 and 9,000 RMB account for 21.988%, while those earning less than 6,000 RMB represent 18.072%. These demographic details provide a comprehensive understanding of the sample population, ensuring that the study's results are based on a diverse and representative data set.

Table 1. Essential Information

		Frequency	Percent
Gender	Male	320	48.193
	Female	344	51.807
Age	24 years or below	101	15.211
	25-34 years	130	19.578
	35-44 years	124	18.675
	45-54 years	137	20.633
	55 years or above	172	25.904
Marital Status	Married	105	15.813
	Currently Single	559	84.187
Education Level	Diploma or below	56	8.434
	Bachelor’s degree	208	31.325
	Master’s degree	357	53.765
	Doctorate or higher degree	43	6.476
	Student	213	32.078
	Government official/State-owned enterprise	254	38.253
	Owns a business	109	16.416

Occupation	Private company	19	2.861
	Other	69	10.392
Monthly Income Level	Below 6000 yuan	120	18.072
	6001-9000 yuan	146	21.988
	9001-12000 yuan	228	34.337
	Above 12000 yuan	170	25.602

4.2Descriptive statistics

The descriptive statistics of the factors analyzed in this study provide valuable information about the central tendencies and variability of the collected data, as shown in Table 2. The mean scores of different factors reflect the overall perception levels of the respondents. For example, the mean score for the "Perceived Intelligence" factor is 3.664, with a standard deviation (SD) of 0.886, indicating a generally positive perception of the intelligence of service robots. The "Perceived Safety" factor has a mean score of 3.592 (SD = 0.839), showing that respondents generally feel that using service robots is safe. On the other hand, the "Trust" factor has the lowest mean score of 2.808 (SD = 1.018), highlighting a relatively low level of trust in service robots. This suggests that trust is an area that may need further improvement (Rogers et al., 2020).

The mean scores for the factors "Anthropomorphism," "Animacy," and "Likeability" are 3.428 (SD = 1.217), 3.294 (SD = 1.031), and 3.390 (SD = 1.094), respectively, reflecting moderate perception levels in these areas. The "Customer Hospitality Experience" factor has a mean score of 3.154 (SD = 1.001). These descriptive statistics highlight the diverse perceptions of respondents regarding different attributes of service robots. The standard deviations indicate the degree of variability in the responses, with most factors showing a fairly wide distribution, suggesting considerable variation in individual experiences and perceptions among participants.

Table 2 Descriptive Statistics Results

Factor	N	Min	Max	Mean	SD
Anthropomorphism	664	1.000	5.000	3.428	1.217
Animacy	664	1.000	5.000	3.294	1.031
Likeability	664	1.000	5.000	3.390	1.094
Perceived Intelligence	664	1.200	5.000	3.664	0.886
Perceived Safety	664	1.000	5.000	3.592	0.839
Custome Hospitality Experience	664	1.230	4.850	3.154	1.001

4.3 Reliability and Validity Analysis

Table 3 indicates that most factors exhibit high internal consistency. Specifically, the Cronbach's α values for Anthropomorphism, Likeability, Perceived Intelligence, and Customer Hospitality Experience are particularly high, at 0.949, 0.915, 0.901, and 0.955, respectively. These results suggest that the items within these constructs are highly reliable and consistently measure the intended variables. Animacy also shows strong reliability, with a Cronbach's α value of 0.896, surpassing the commonly accepted threshold of 0.7, indicating very good internal consistency. The Cronbach's α value for Perceived Safety is 0.800, demonstrating acceptable reliability.

Overall, the reliability statistics suggest that the questionnaire used in this study is a robust tool for measuring the perceived attributes of service robots and their impact on customer hospitality experience. The high Cronbach's α values for most variables enhance the

consistency and reliability of the data, thereby ensuring the trustworthiness of the study's findings. In summary, the results of the reliability analysis confirm that the questionnaire employed in this research is a reliable and consistent tool for assessing the perceived attributes of service robots and their influence on customer hospitality experience.

Table 3. Reliability Statistics

Study variables	Number of questions	Cronbach's α
Anthropomorphism	4	0.949
Animacy	5	0.896
Likeability	5	0.915
Perceived Intelligence	5	0.901
Perceived Safety	3	0.800
Custome Hospitality Experience	13	0.955

The validity test results shown in Table 4 indicate that the data is highly suitable for factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.928, which is considered excellent. Specifically, a KMO value exceeding 0.9 suggests that the sample size and the correlations among the variables are highly appropriate for factor analysis (Ledesma et al., 2021). This high KMO value indicates that the correlations among the items are strong enough to justify confidence in the factor analysis results.

Additionally, Bartlett's Test of Sphericity further supports the suitability of the data for factor analysis. The approximate chi-square value of this test is 23,019.935, with 946 degrees of freedom, and a significance level of 0.000. The significant result ($p < 0.05$) indicates that the correlation matrix is not an identity matrix, confirming that there are significant correlations among the variables (Ledesma et al., 2021).

Table Error! No text of specified style in document.**. KMO and Bartlett's Test**

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.928
Bartlett's Test of Sphericity	Approx. Chi-Square	23019.935
	df	946
	Sig.	0.000

4.4 Confirmatory Factor Analysis

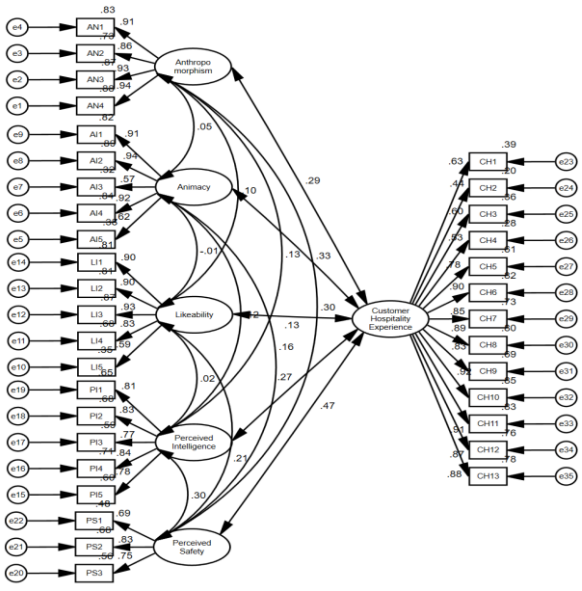

Figure 1. The Measurement Model for the Confirmatory Factor Analy

Table 5 presents the fit indices for the measurement model, comparing the results with the reference standards. The results indicate that the model has an excellent fit: the chi-square to degrees of freedom ratio (χ^2/df) is 2.905, significantly below the threshold of 3, suggesting good model fit. The Root Mean Square Error of Approximation (RMSEA) is 0.059, which is well below the standard of 0.08, indicating a good fit as well. Additionally, all indices (NFI, CFI, RFI, IFI) exceed the recommended value of 0.9, with specific values ranging from 0.903 to 0.936, demonstrating a strong fit between the model and the data. These indices collectively validate the model's validity and reliability within the research context. Figure 1 shows the measurement model of the Confirmatory Factor Analysis.

Table 5 Model fitting indicators

Indicators	χ2/df	NFI	RMSEA	CFI	RFI	IFI
Judgment criteria	<3	>0.9	<0.08	>0.9	>0.9	>0.9
value	2.905	0.911	0.059	0.936	0.903	0.936

Table 6 presents the results of the path analysis within the structural equation model, focusing on the hypothesized relationships between various constructs related to customer experiences with service robots. Each row in the table corresponds to a hypothesis (H1 to H6) about the directional influence of one construct on another, including path estimates, standardized coefficients (β), standard errors (S.E.), critical ratios (C.R.), p-values (P), and whether each hypothesis is supported. Key constructs include Anthropomorphism (AN), Animacy (AI), Likeability (LI), Perceived Intelligence (PI), Perceived Safety (PS), and Customer Hospitality Experience (CH). The results reveal strong support for most hypotheses:

H1 *posits that Anthropomorphism (AN) affects Customer Hospitality Experience (CH), and the results support this hypothesis. The path coefficient (β) is 0.294, with a standard error (SE) of 0.043, a critical ratio (C.R.) of 6.624, and a p-value less than 0.001. This indicates that Anthropomorphism has a significant effect on Customer Value Co-Creation Intention (CI) through Customer Hospitality Experience.*

H2 *proposes that Animacy (AI) affects Customer Hospitality Experience, and this hypothesis is also supported. The path coefficient (β) is 0.328, with an SE of 0.022, a C.R. of 6.809, and a p-value less than 0.001, showing that Animacy plays an important role in Customer Hospitality Experience.*

H3 *explores the impact of Likeability (LI) on Customer Hospitality Experience, and the results support this hypothesis as well. The path coefficient (β) is 0.131, with an SE of 0.025, a C.R. of 3.124, and a p-value of 0.002, indicating that Likeability significantly affects Customer Value Co-Creation Intention through Customer Hospitality Experience.*

H4 *posits that Perceived Intelligence (PI) affects Customer Hospitality Experience, and this hypothesis is supported. The path coefficient (β) is 0.267, with an SE of 0.031, a C.R. of 5.873, and a p-value less than 0.001, suggesting that Perceived Intelligence has a significant impact on Customer Value Co-Creation Intention through Customer Hospitality Experience.*

H5 *examines the effect of Perceived Safety (PS) on Customer Hospitality Experience, and the results strongly support this hypothesis. The path coefficient (β) is 0.469, with an SE of 0.031, a C.R. of 8.493, and a p-value less than 0.001, indicating that Perceived Safety significantly enhances Customer Value Co-Creation Intention through Customer Hospitality Experience.*

Table 6. Structural equation model path test

Hypothesis	Path	β	S.E.	C.R.	P	Results
H1	**AN→CH**	0.294	0.043	6.624	***	Accepted
H2	**AI→CH**	0.328	0.022	6.809	***	Accepted
H3	**LI→CH**	0.131	0.025	3.124	0.002	Accepted
H4	**PI→CH**	0.267	0.031	5.873	***	Accepted
H5	**PS→CH**	0.469	0.031	8.493	***	Accepted

Note: AN: Anthropomorphism; AI: Animacy; LI: Likeability; PI: Perceived Intelligence; PS: Perceived Safety; CH: Custome Hospitality Experience.
***: $p<0.001$

5 CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Research Conclusion

This study explores the impact of the five perceived attributes of service robots—Anthropomorphism, Animacy, Likeability, Perceived Intelligence, and Perceived Safety—on customer hospitality experience and value co-creation intention using structural equation modeling. The results indicate that these perceived attributes play a crucial role in shaping the overall customer hospitality experience.

Perceived Safety has the most significant impact on customer hospitality experience ($\beta = 0.469$, $p < 0.001$), indicating that the perception of safety provided by service robots is a core factor in enhancing the hospitality experience. Service robots that offer a sense of security contribute to a more reassuring and satisfying overall experience for customers. Animacy ($\beta = 0.328$, $p < 0.001$) adds dynamic and lively characteristics to service robots, further enhancing the customer's experience. Perceived Intelligence ($\beta = 0.267$, $p < 0.001$) also significantly affects the hospitality experience, with customers perceiving a higher level of efficiency and personalization in the service provided by intelligent robots.

Anthropomorphism ($\beta = 0.294$, $p < 0.001$) and Likeability ($\beta = 0.131$, $p = 0.002$), although having a slightly lower impact on the customer hospitality experience, remain significant. Anthropomorphism allows service robots to exhibit human-like traits, which helps establish emotional connections and enhances customer comfort. Likeability affects the acceptance and satisfaction of customers with the service robots, leading to more positive evaluations of the service.

This study extends the theoretical application of perceived attributes of service robots and validates their comprehensive role in customer interactions. The findings emphasize how different perceived attributes influence the overall customer experience in various ways.

For luxury hotels, these empirical results provide valuable insights into the specific areas for enhancing service robots' attributes. Hotel managers and service designers should focus on improving the perceived safety and animacy of service robots while also considering the impact of anthropomorphism and likeability on customer satisfaction. By addressing these areas, hotels can better meet customer expectations, thereby improving overall service quality and customer relationships.

Overall, this study not only enriches the understanding of how service robot attributes affect customer experience but also provides a solid foundation for applying these theoretical

insights to practical service design and management practices. By optimizing the five key perceived attributes of service robots, hotels can more effectively align service delivery with customer expectations, ultimately leading to improved service quality and enhanced customer relationships. These research findings lay the groundwork for future studies and practical applications.

5.2 Research Limitations and Suggestions for Future Research Directions

This study has some limitations in exploring the impact of service robot attributes on customer hospitality experience. First, while the study controlled for participant demographic variables, it did not account for other potential influencing factors such as individual differences, cultural background, and psychological states. Future research could consider expanding these potential influencing factors to obtain more comprehensive results. Second, although this study provided a detailed analysis of service robot attributes, it did not control for individual variations in perceptions and experiences of these attributes, which could affect the accuracy of the findings. Future studies could employ more precise experimental designs to explore the causal relationships between perceived attributes and customer experience. Finally, the geographical scope of this study was mainly confined to specific regions in China, which may not fully represent conditions in other regions or countries. Different cultural and social backgrounds may have varying impacts on the acceptance of service robots and customer experiences. Future research should broaden the geographical scope and conduct studies in diverse cultural and geographical contexts to enhance the generalizability and applicability of the findings.

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