CUSTOMER ACCEPTANCE OF HUMANOID SERVICE ROBOTS IN HOTELS: MODERATING EFFECTS OF SERVICE VOLUNTARINESS AND CULTURE

Purpose

The current study proposes a research model integrating TAM3 constructs and human aspects of humanoid service robots (HSRs), measured by the Godspeed questionnaire series (GQS), and tested across two hotel properties in Japan and the US.

Design/methodology/approach

Potential participants were approached randomly by e-mail invitation. A final sample size of 395, across two hotels, one in Japan and the other in the US, was obtained and the data were analyzed using structural equation modelling.

Findings

The results confirm that perceived usefulness (PU), driven by subjective norms and output quality, and perceived ease of use (PEOU), 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 re-using it.

Implications

The findings have practical implications for the hospitality industry suggesting multiple attributes of an HSRs that managers need to consider before deploying them in their properties.

Originality

The current study proposes an integrated model determining factors that affect the re-patronage of HSRs in hotels.

Keywords: humanoid service robots; technology acceptance model; godspeed questionnaire; service voluntariness; anthropomorphism

1. INTRODUCTION

The hospitality sector has seen the use of humanoid service robots (HSR hereafter) (Ruiz-Equihua *et al*., 2023; Shin, 2022) which are endowed with capabilities like facial and vocal recognition, analytical capacity, social skills, multilingual proficiency, smooth movements, detection of obstacles and the ability to avoid them (Ruiz-Equihua *et al*., 2023; Tung and Law, 2017). HSRs are "system-based autonomous and adaptable interfaces that interact, communicate, and deliver services to an organization's customers" (Wirtz *et al*., 2018, p. 909). Such robots are critical for frontline service processes in various facilities (Guan *et al*., 2022; Wan *et al*., 2018; Zhang *et al*., 2021). To understand how HSRs can improve human-robot interaction (HRI), much academic research has been conducted recently (e.g., Ivanov *et al*., 2019; Kuo *et al*., 2017; van Pinxteren *et al*., 2019). Post the COVID-19 pandemic, service robots are playing an important role in non-human interventions (Choi *et al*., 2022; Shin, 2022).

Previous relevant studies have largely focused on robot designs and the challenges of adoption, specifically due to the non-human aspects of HSRs (Lu *et al.*, 2019; Ruiz-Equihua *et al*., 2023). This presents some important gaps. First, limited research systematically examines how consumers/tourists react to various facets of HSRs that are a combination of human and machine-like traits. Also, previous studies examine the adoption of service robots in the hospitality sector (e.g., Choi *et al*., 2022; Guan *et al*., 2022), however, insights after the pandemic, on consumers' re-patronage intentions are limited (e.g., Fu *et al*., 2022). Second, most existing works focus on the advantages of adopting HSRs to enable contactless service with little attention to the barriers to their re-use. It is argued generally that service robots' human-like characteristics improve perceptions of their warmth and trustworthiness (Tussyadiah and Park, 2018; Smith *et al*., 2016). However, this may not always be true and may produce reverse effects (Liu *et al*., 2022). Finally, there is a limited investigation into the role of culture in the reactions people have towards such service robots (Filieri *et al*., 2022). Previous works argue that culture can influence attitudes

toward service robots and that Asian customers have higher robot acceptance (Choi *et al*., 2021). However, the findings are mixed and a comprehensive work examining people's intention to engage with HSRs across cultures is missing (Bartneck, 2009b).

This study develops an exhaustive set of attributes that define HSRs using the integration of the improved technology acceptance model (TAM3; Venkatesh and Bala, 2008) and the GQS (Bartneck *et al*., 2009a). After a systematic literature review to explore HSR adoption and use in different hospitality establishments, the study identifies key variables that determine technology acceptance and users' willingness to adopt. Following the proposed model, quantitative data from 395 participants, across Japan and the US, helped validate the model. Besides the integrated framework, the work offers methodological progress in this domain with the data collection process executed with individuals who have significant experience with robots at hotels.

2. LITERATURE REVIEW

2.1. Service robots in hospitality

The applications of robotics, with the integration of AI, big data, and service automation tools, contribute to the creation of smart travel experiences. Currently, service robots are used to deliver a wide range of services in the hospitality field (Ivanov and Webster, 2021; Shin, 2022) including check-in and check-out, greeting, cooking, cleaning, escorting, butler services, and in-room delivery in hotels (Guan *et al*., 2022; Lu *et al*., 2019; Zhang *et al*, 2022). Van Doorn *et al*. (2017) assert that robots can create automated social interactions that can make guests feel accompanied by another social entity (Zhang *et al*, 2022). Service robots in the hospitality sector can also be responsible for simple tasks, like those of maintenance, security, transport and luggage storage, household services, driving, and serving in restaurants, as well as tasks with higher added value such as guidance, entertainment, and financial investment advice (Choi *et al*., 2022).) Advanced robotics is expected to enable providers to offer their services with greater productivity,

efficacy, and efficiency, and to create a competitive advantage for hospitality companies (Cha, 2020; Khoa *et al*, 2023; Kuo *et al*., 2017).

However, a key barrier to the adoption of service robots in the hospitality industry has been the lack of 'human-like' characteristics (Blut *et al*., 2021). There is a relatively limited focus on impediments to the continued usage of such technologies (Fu *et al*., 2022). One of the first works to examine user resistance to continuous usage was by Kim and Kankanhalli (2009) who defined user resistance as the users' opposition to the reuse of novel technologies like HSRs. Such resistance is due to technostress, the stressful customer experiences due to engagement with new technologies and is an important reason for technology discontinuation (Ali *et al*., 2016; Maier *et al*., 2015). If the actual performance of such technologies underweighs expectations, it may lead to customer dissatisfaction with the concomitant intention to discontinue using it (Alohali *et al*., 2020, Jia *et al*., 2017).

2.2. Technology Acceptance Model 3 and Godspeed questionnaire

Many of the studies regarding consumers' behavioural intentions toward robots are based on existing technology acceptance models (Wirtz *et al*., 2018). Despite the diverse application of TAM to study service robot adoption across service contexts, its application in the context of HSRs is still limited and warrants more efforts to understand the process of HSR's continued use in hospitality (Lu *et al.,* 2019; Tung and Law, 2017). With robots engaging in interactions with humans, there is an additional dimension about the human-like aspects which ensures trust-evoking interactions (Ivanov *et al*., 2019). The focus of contemporary research needs to examine the socio-psychological dimension of robot–human interactions leading to repeat adoptions. Hence, variables like social image, subjective norms, anxiety, and perceived enjoyment, part of TAM3, become pertinent.

As a tool to measure the human-like appearance of HSRs, the Godspeed Questionnaire Series (GQS; Bartneck *et al*., 2009a) evaluates how robots are perceived by humans. This scale is

used to assist developers in creating embodied social agents (Ho & MacDorman, 2010). The test encompasses 24 items where the participants are asked to state their opinion on five aspects of robots: anthropomorphism (five items), animacy (six items), likeability (five items), perceived intelligence (five items), and perceived safety (three items). While several studies (e.g., Tussyadiah & Park, 2018; Bartneck *et al*., 2009b; Yu, 2020) have used the GQS to explain human-robot relationships, besides Tussyadiah and Park (2018) and Yu (2020), no other studies have used the GQS parameters to examine the human-like aspects of service robots and their effects on adoption.

2.3. Role of Culture

In addition, Ivanov *et al*. (2019) argue that most of the works on service robots are anchored in Asia, given the strong cultural acceptance of robots in hospitality. In the past, Li *et al*. (2010) have analysed culture as a moderator in the relationship between robotic embodiment and task on user outcomes. They found cultural differences with Chinese and Koreans reporting higher engagement compared to Germans. Similarly, Haring *et al*. (2015) did a similar comparison between Japanese and Australians for the effect of robot morphology and user ratings. The Japanese users provided higher ratings for robots with human elements of anthropomorphism, intelligence, and safety. However, beyond these, there are limited works that replicate these findings and hence, Ivanov *et al*. (2019) call for greater cross-cultural research in this domain.

3. PROPOSED FRAMEWORK

Consistent with the TAM formulations (Davis, 1989), its proposed relationships are adapted to the context of the adoption of HSR by customers in hotels context, and both PU and PEOU are considered the central constructs in the proposed model. Similarly, re-patronage intention is defined as the user's willingness to interact with a social robot during a subsequent service encounter (Davis, 1989).

3.1. PEOU, PU and Re-patronage Intention

Abou-Shouk *et al.* (2021) found that customers have a positive disposition towards robots because of the functionality (PU), efficiency and ease of use (PEOU) of robots in hotels (Guan *et al*., 2022). Service robots and AI can perform tasks at a specific time and generate effort-saving advantages. The customer's PU influences their predisposition to participate in the service delivery process. Recently, Guan *et al*. (2022) found that PU of robot technologies have a significant impact on hotel customers' preference, while Shin and Jeong (2020) found that guests have a positive attitude toward using a robot concierge and a subsequent influence on their intention to re-adopt. Hence, it is argued that customers' perception of the effort required to use technology, empowered by AI and automation, will have a significant influence on the re-patronage of an HSR (Abou-Shouk *et al.,* 2021). Based on this, we propose:

H1: PEOU of the HSR has a positive effect on the PU of the service.

H2: PEOU of the HSR has a positive effect on the re-patronage intention of the customer.

H3: PU of the HSR has a positive effect on the re-patronage intention of the customer.

3.2. Social Image and PU

In the technology adoption domain, social image is theoretically different from subjective norms or social influence. While subjective norms or social influences are used by individuals to establish a positive image within a referent group, social image is the outcome of the process (Rejón-Guardia *et al*., 2020). People adopt innovative services, such as service robots, in the hope to create social status and a social difference. Social image, thus, refers to the conviction of an individual that endorsement of specific behaviour, like using an HSR, that significantly improves service quality is going to enhance his/her perception in the referent group. In the present case, social image is the outcome of the collaborative use of robot technology with high PU by a group

of people which creates social respect for the user (Rejón-Guardia *et al*., 2020; Venkatesh and Bala, 2008). Thus, we hypothesize:

H4: Social image derived from the consumption of HSR has a positive effect on the PU of the service.

3.3. Output quality and PU

Previous studies empirically demonstrate that perceived output quality has a positive influence on the PU of a technology (Davis *et al.*, 1992; Venkatesh and Davis, 2000). In the context of service robots, Lu *et al*., (2019) defined output quality as the degree to which robots can provide consistent and dependable service to consumers. They also noted that service robots could be more competent than human substitutes, in turn, accelerating service speed and avoiding inefficient social interaction. A good output quality, in terms of tasks completed efficiently aligned with customer instructions, defines the usefulness of an HSR (Lee *et al*., 2018). Therefore, we hypothesize:

H5: The output quality of a service robot has a positive effect on the PU of the service.

3.4. Subjective Norm, PU, and Re-patronage Intention

Subjective norm refers to the favourable/ unfavourable points of view of others considered important to an individual (Venkatesh and Davis, 2000). Venkatesh and Davis (2000) found that subjective norms significantly affect consumer decisions when individuals have little knowledge/experience with a system/technology or when the referent's power status is relevant to the individual. Hence, an individual's social network opinions can help decide whether a technology is useful or worth using (Lu *et al*., 2019). Existing studies indicate that subjective norms have a significant influence on an individual's behavioural intentions (Zhuang *et al*., 2021). The stronger the role of subjective norms, the higher the intention to adopt and reuse new technologies. We, therefore, propose:

H6: Subjective norms of an individual have a positive effect on the PU of HSRs.

H7: Subjective norm of an individual has a positive effect on the re-patronage intention of customers for an HSR.

3.5. Perceived Enjoyment and PEOU

Perceived enjoyment refers to how the use of a technology or a system is perceived as a source of joy and pleasure for the user (Novack *et al*., 2000). Perceived enjoyment is a strong outcome of the actual usage of a hedonic product/service/technology, which in turn has a strong influence on the individual's PEOU for that system. The same is applicable in the context of service robots. Perceived enjoyment when interacting with service robots is one of the most significant factors affecting the perceived ease of use of robots. Zhou and Feng (2017) suggested that perceived enjoyment, as the intrinsic motivation to use service robots, shapes the affective experience with a service robot, and that lack of enjoyment may give the impression that using the system is more difficult. We therefore hypothesize:

H8: Perceived enjoyment from the use of HSR has a positive effect on its PEOU.

3.6. Anxiety and PEOU

Studies using TAM3 indicate that if customers have negative feelings towards the use of robotic technology, or if people are very anxious about it, they will be less likely to find the technology easy to use and less likely to adopt the technology. Huang *et al*. (2021) found that the anxiety generated by the robot may prevent people from interacting with it, leading to reduced PEOU. Such anxiety may arise from different kinds of potential threats: physical HRI threat (safety and reliability), human work threat (automated robots replacing humans), identity and autonomy threat (robots controlling human lives), and existential threat (machines threatening human existence; Neubaum *et al*., 2014). Hence, we hypothesize:

H9: Anxiety against HSR has a negative effect on the PEOU of the service.

3.7. Anthropomorphism and Re-patronage Intention

Huang *et al*. (2021) describe anthropomorphism as the level of human characteristics present in an object (Zhang *et al*., 2021). Such characteristics include having human-like physical and intellectual competencies. In general, previous studies indicate that human appearance was more likely to elicit positive perceptions and attitudes (Huang *et al*., 2021; Mende *et al*., 2019; Ruiz-Equihua *et al*., 2023). Indeed, anthropomorphism with physical objects increases their sense of effectiveness and resultant emotional attachment (Mende *et al*., 2019; Zhang *et al*., 2021). Therefore, a humanoid robot form has always been considered the obvious strategy for the successful integration of robots into service environments (Ruiz-Equihua *et al*., 2023; Tussyadiah and Park, 2018). Hence, we propose:

H10: The level of anthropomorphism in an HSR has a positive effect on the re-patronage intention of customers.

3.8. Animacy and Re-patronage Intention

Animacy is another characteristic when designing robots (White and Katsuno, 2021). It is defined as the fact of considering objects as individuals who move at their own will and who can interact (Blut *et al*., 2021). Since robots can manifest physical behaviours and reactions to stimuli and language skills, they can be perceived as realistic (Bartneck *et al*., 2009b). According to Bartneck *et al*. (2009a), robots with an animated appearance usually attract users' attention more than robots with inanimate forms. Ultimately, realistic ‘life-like’ robots can emotionally engage users, which will influence their behaviour to adopt and re-use the services of such robots (Blut *et al*., 2021). Hence, we hypothesize:

H11: Animacy of the HSR has a positive effect on the re-patronage intention of customers.

3.10. Likeability and Re-patronage Intention

Likeability is the measure of people's first impressions when meeting third parties (Bartneck *et al*. 2009a). First positive impressions (e.g., sympathy) often lead to a positive evaluation. The likeability of a service robot and the extent to which consumers value the service robot should influence their judgment of the robot (Bartneck *et al*., 2009a). However, the effect of the likeability of a robot on its re-use is unclear. Some studies report that the likability of a robot may also be negative if it feels 'uncannily' human and has an uncomfortable face, posture, gestures and voice, and consequently, people may not like to further interact with such a system (Mende *et al*., 2019). To obtain clarity on this effect, we propose:

H12: The likeability of an HSR has a positive effect on the re-patronage intention of customers.

3.11. Perceived Intelligence and Re-patronage Intention

Perceived intelligence of robots refers to the perceived ability of robots to acquire and apply knowledge and skills in different service environments (Bartneck *et al*., 2009b). The perceived intelligence of robots is critical to their acceptance (Tussyadiah and Park, 2018). According to Saari *et al*. (2022), the robot should be functional, able to perform its task, meet the expectations of users, and adapt themselves to their environments; else, it will be considered unnecessary. The more human-like a robot is perceived to be, the more intelligence is ascribed to it, and higher satisfaction from the service delivery is evoked leading to re-patronage (Blut *et al*., 2021). Thus, we hypothesize:

H13: Perceived intelligence of the HSR has a positive effect on the re-patronage intention of customers.

3.12. Perceived Safety and Re-patronage Intention

Perceived safety describes the perception of the level of danger perceived by the user when interacting with a robot and its level of comfort during the interaction (Blut *et al*., 2021). Gaining a positive perception of safety is an essential condition for robots to be accepted as partners,

companions, or co-workers (Bartneck *et al*., 2009b). As per Li *et al*. (2022), robots should be designed to increase the sense of predictability during interactions, thereby reducing perceived risk and danger. Thus, we hypothesize:

H14: Perceived safety of the HSR has a positive effect on the re-patronage intention of customers.

3.13. Moderating Role of Voluntariness

As per Venkatesh and Davis (2000), acceptance of technology reflects an individual's psychological evaluation of the voluntariness of technology usage. The TAM model, on which updated models like TAM2 and TAM3 are based, discusses the intention to adopt a technology, influenced by external/internal factors, individual's attitude, and the technology's PU and PEOU (Islam *et al*., 2013). Hence, it is inferred that when technology use is voluntary, the antecedents of adoption/use will be more carefully evaluated by the consumers and may have weaker effects on the outcomes, compared to when the technology use is mandatory (Lu *et al*., 2019; Shin and Dai, 2022). Hence, we hypothesize:

H15: The relationships across the model are moderated by voluntariness of the HSR's use, such that higher voluntariness will weaken all the relationships.

3.14. Moderating role of culture

Culture is an important variable that affects preferences for appearance and expressions of emotions, which also extends to individual responses to robots (Papadopoulos and Koulouglioti, 2018). In the extant literature, it generally found that people of specific Asian origin (e.g., Chinese, Japanese, South Korean) tend to prefer more natural expressions of emotions from a service robot (see Papadopoulos and Koulouglioti, 2018). The preference for expressions of the robots with Asian people, compared to other nationalities, is mixed and inconsistent. For example, while some works suggest that Asians prefer more human-like robots, compared to Europeans, there are other

works which find that the same is higher for Americans (e.g., Bartneck, 2009b). With most works pointing towards Asians having a higher preference for robots than other cultures, we propose:

H16: The relationship across the model is expected to vary across cultures, such that they will be higher for Asian people compared to other cultures.

The overall conceptual model is shown in Figure I.

Insert Figure I here

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4. RESEARCH DESIGN

4.1. Measurement scales

The TAM3 variables have been operationalized through standard measurement scales. PU, PEOU, and re-patronage intention items were adapted from Davis (1989). Subjective norms, social image, output quality, and voluntariness of the technology use were adapted from Venkatesh and Davis (2000). For perceived enjoyment, we opted for Venkatesh and Bala's (2008) scale, and for anxiety, we opted for Venkatesh *et al*.'s scale (2003). The items in the GQS were adapted from Bartneck *et al*. (2009a) for the five dimensions: anthropomorphism (five items), animacy (six items), likeability (five items), perceived intelligence (five items), and perceived safety (three items). All scales were measured with a five-point Likert scale ranging from [1] = Strongly disagree to [5] = Strongly agree. The draft questionnaire was shown to two marketing professors and three doctoral scholars to ensure content validity and suitability. A sample of 30 respondents was used to pilot-test the questionnaire to identify any language and/or typing errors. The final items are depicted in Appendix A1.

4.2. Data Collection

The population of the study is all those people who have experienced hotel service robots. The same was chosen as it allows respondents to have some experience of HSRs across various service encounters (Fernandes and Oliveira, 2021). The sampling frame of the study was guests of a specific hotel in Japan (Asia) and the US (West), with the hotel chain comprising three properties in Japan and one in the US. While the Japan hotel property had an extensive deployment of HSRs, the same was limited in the case of the US property. With the support of the hotel group management, the database of all customers who had stayed at any of these properties in the last six months was procured. The database consisted of 10286 unique past customers who had stayed at the hotel in the past.

The database of each hotel was arranged in alphabetical order with the first names of the respondents, and a random number generator was used to shortlist 1500 respondents (the maximum number allowed as per the hotel's decision) from this database. These potential participants were approached by e-mail invitation, sent by the hotel, to seek their participation, with the provision of a surprise gift voucher from the hotel for a randomly selected respondent. There were two qualifying questions: 1) The respondents experienced the HSR services during their stay, and 2) The respondents were conversant in English. In the email, it was mentioned that the study was for academic purposes only and that their identity will be kept confidential. In total, 570 (367 for Japan property) respondents qualified and provided informed consent. Next, these respondents were sent the online questionnaire, hosted on a professional online data collection software. In total, after two reminders at an interval of one week each, 411 respondents (284 for the Japan property) submitted their responses, with 396 respondents (209 for the Japan property) completing the questionnaire in all respects, with respondents taking 13 to 17 minutes to fill the questionnaire. The entire data collection process was completed within five months, between August 2021 and December 2021.

A check of outliers using Cook's method reported only one vagary in the data and hence, a final sample size of 395 (207 for the Japan property) was obtained, making the overall response rate 26.33%. It is common for respondents to drop out of the questionnaire in cross-sectional research. To check if the data loss was systematic, we compared the demographic characteristics between the respondents who were part of the analysis and those who were not (Ployhart and Vandenberg, 2010). After classifying respondents into two groups (Group 1 included participants: 395; Group 2 deleted participants: 15), we checked whether the groups differed in age, gender, occupation, or education proportions. We found no differences concerning any of these characteristics implying no systematic loss of information.

To test the cross-cultural moderation hypotheses, people of the specific country where the property was located were considered. Of the 207 respondents for the Japanese property, 178 were Japanese. Similarly, of those 188 respondents from the US property, 134 respondents were non-Japanese and belonged to various countries. The sample profile is given in Table I.

Insert Table I here

While the sample is almost balanced in gender, there is a heavy skew in the age group of 20-30 years with most respondents being university students. The skew of the sample in terms of age and occupation is not surprising as modern technology industries, including robotics and AI, are focusing on younger individuals since they are tech-savvy and initial adopters (Schepers and Wetzels, 2007). They like virtual/non-human assistants and display positive dispositions towards novel technologies.

5. RESULTS

As suggested by Anderson and Gerbing (1988), we opted for a two-step approach. The first step consisted in checking the validity of the measurement model through a confirmatory factor

analysis (CFA), followed by a structural regression model using covariance-based structural equation modelling (CBSEM) software AMOS24. Finally, the multi-group analysis (MGA) was used in AMOS24 to check for moderation analyses.

5.1. Measurement model (overall data)

The normality check for the entire dataset reported that skewness and kurtosis values were within the recommended range of -2.00 to +2.00 and of -7.00 to +7.00, respectively (Hair *et al*., 2010). Further, to check for multicollinearity amongst the primary variables (those in the main model), all the variables were placed in a regression system as independent variables, with Vol1 (an item of the moderator voluntariness of the technology) as the dependent variable. The variance inflation factor for each variable was found below 5.0 (the lowest being 1.2 for Anx4 and the highest being 3.7 for PEU4) indicating the absence of multicollinearity issues.

Before proceeding with the CFA, we checked for the presence of common method bias (CMB) in the entire dataset (both luxury and non-luxury) using the Harman one-factor method with the principal component analysis in SPSS26; the single largest factor accounted for only 27% of the total variance, respectively, thus implying a lack of CMB. To check the reliability of the adopted measurement scales, we referred to individual factor loadings, Cronbach's alpha, and internal consistency. Factor loadings are all greater than 0.7 (Hair *et al*., 2014). For internal consistency, the composite reliability index (CR) (Fornell and Larcker, 1981) was used. CR values for all scales of the research model range between 0.88 and 0.95, above the minimum acceptable value of 0.70 as recommended by Fornell and Larcker (1981). The Cronbach's alpha coefficients were also above the threshold of 0.70 (Hair *et al*., 2010). For convergent validity, the average variance extracted (AVE) was checked and its value was found to be greater than 0.5 for all constructs (please see Table II; Henseler *et al*., 2015, Fornell and Larcker, 1981). Discriminant validity was established by using the Fornell and Larcker (1981) criterion as shown in Table III.

In all cases, the square root of AVE values was found larger than the inter-construct correlation for a focal construct.

The overall fit of the CFA model was evaluated using fit indices including Standardized Root Mean Square Residual (SRMR), Goodness of Fit Index (GFI), Normed Fit Index (NFI), Incremental Fit Index (IFI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). The fit indices were found to be satisfactory, with $\chi 2/df=2.83$, SRMR=.06, GFI=.90, NFI=.91, IFI=.91, CFI=.90, and RMSEA=.05.

Insert Table II AND III here

Since the study also involved comparing the model across groups (hotels in Japan and the US, for manipulating voluntariness, and Japanese and non-Japanese respondents, for manipulating culture), it was prudent to establish the measurement model invariance before comparing the structural models for the moderation checks. Two measurement invariances were evaluated, one for the entire data across the hotel in Japan and the one in the US (all respondents for each hotel were considered) and another for data across the two hotels, but only for people who were either Japanese (in the Japan hotel) or non-Japanese (in the US hotel). The results of the invariance were established using multi-group analysis in AMOS 24, with the results depicted in Table IV. The results show that the measurement model was invariant across both runs.

Insert Table IV here

5.2. Assessment of the structural model

Following the validation of the measurement model, we tested the structural model with the overall data. To begin, we tested multicollinearity to avoid any concerns with the model results. As a rule, a variance inflation factor (VIF) value greater than 10 indicates the presence of multicollinearity. In our case, the VIF values are between 1.323 and 2.884 which indicates the absence of multicollinearity between the variables of the model. The fit indices for the structural model were found to be satisfactory, with $\chi 2/df=2.89$, SRMR=.05, GFI=.91, NFI=.91, IFI=.91, CFI=.92, and RMSEA=.05. The results of the model are reported in Table V below. In our study, we found that PEOU has a positive effect on PU (β=.298, $p<.01$) and re-patronage intention (β=.228, $p<.01$)., confirming hypotheses H1 and H2. Hypothesis H3 is also confirmed as perceived usefulness is found to positively influence re-patronage intention (β=.372, $p<.01$).

Next, the link between social image and PU was insignificant (β =.077, $p>.01$), and thus, hypothesis H4 is not supported. The relationship between output quality and PU of the service robot is significant (β =.351, $p<.01$), confirming hypothesis H5. We found that subjective norm played a dual role: the first is manifested in its direct effect on PU (β =.157, $p <.01$) and the second in its direct positive effect on the re-patronage intention to adopt HSRs (β=.224, $p<.01$). Thus, hypotheses H6 and H7 are supported. The positive relationship between perceived enjoyment (β=.542, $p<.01$) and anxiety (β = -.131, $p <.01$) on PEOU is well confirmed, supporting hypotheses H8 and H9.

Next, we found that anthropomorphism positively affected the acceptance of HSRs (β=.137, $p<.01$), implying that hypothesis H10 is supported. The effect of animacy and likeability on re-patronage intention was not found to be significant (β=.063, $p>.01$; β =-.039, $p>.01$), implying hypotheses H11 and H12 were not supported. Finally, perceived intelligence and safety had a positive influence on the re-patronage intention of HSRs (β=.139, $p<.01$; β=.119, $p<.01$), confirming support for hypotheses H13 and H14.

The overall model includes the moderating variables, the voluntariness of technology (low/high) and culture (Japanese/non-Japanese). First, to check if the voluntariness of technology use was significantly different across the two hotels, the mean values of the construct (with items aggregated) were compared using an independent sample t-test. The mean value for Japan was 3.14 while for the US was 4.56, with the mean values significantly different (t=3.68, p=.00). Next, MGA was used in AMOS to test the difference in specific paths across the model, signified by the critical ratio (CR), which is a t-value. A CR value above 1.96 suggests the paths are different across the two groups.

Just like in the case of measurement invariance evaluation, two MGA analyses were executed. One with all the data across both hotels (for voluntariness) and two with only the data of Japanese people in the Japan hotel and non-Japanese people in the US hotel. Table IV shows the results that most of the path values for the high voluntariness condition (the US hotel) were lower than those for the low voluntariness condition (Japan hotel), except for that of the social image to PU (both path values for the sub-groups are non-significant) and likeability to re-patronage intention (both path values for the sub-groups are non-significant). Hence, hypothesis H16 is largely supported. Similarly, it was found that for Japanese people, most path values for the model were higher than for non-Japanese people, except for the same paths as for voluntariness where path values were non-significant for both sub-groups. Hence, hypothesis H17 is also largely supported. The overall summary of results is provided in Table V.

Insert Table V here

Finally, since the study sample was skewed towards the younger demographic, it was checked if the sample bias, though expected, had any role to play in the results. The primary measurement and structural models were compared across two partitions: 1) young (20-30 years)

and the others and 2) students and others. Such partitioning allowed sufficient sample size across each partition. In both cases, both the measurement and structural models were found to be statistically invariant, implying that age and profession had an insignificant role in driving the model.

6. DISCUSSION AND CONCLUSIONS

6.1. Conclusions

This work provides an integrated approach to combine various TAM3-derived attributes with GQS-derived ones, those related to the appearance of HSRs, to determine the antecedents to re-patronage intention for such robots in hospitality services. One key novel outcome of the study's model is that for HSRs, there are three dimensions to determining their utility for the hospitality industry: overall efficiency (measured by TAM variables and prominent outcomes of self-service technologies; Shin and Dai, 2022), social implications of using HSRs (additional variables in TAM3), and the physical appearance of the HSR. The three dimensions, as part of the unique conceptualization in this work, indicate a combination of 'machine-like' efficiency and 'human-like' characteristics that robots need to possess to achieve effective human engagement as well as cost-based efficiencies (Blut *et al*., 2021).

The findings highlight the importance of social network opinions in the consumption of HSRs, with subjective norms significantly affecting HSR's PU and re-patronage intention. Such opinions can help decide whether HSR-based services are useful or worth using again, even though at a personal level there may be inhibitions (Lu *et al*., 2019; Schepers and Wetzels, 2007; Zhuang *et al*., 2021). However, the lack of effect of the social image, the perception that using HSRs creates social status, on the PU of service robots, contradicts extant literature and represents an interesting insight of this work (e.g., Rejón-Guardia *et al*., 2020; Venkatesh and Davis, 2000). This may be because HSRs may not necessarily be considered prestige goods by users for them to have any implications on the social status of a user.

Another important finding is the positive influence of perceived enjoyment and the negative influence of anxiety on PEOU, which proves the importance of pleasure and the absence of any 'fears' in the concept of robots (Bahri-Ammari *et al*., 2019; Venkatesh and Bala, 2008). This is possible by introducing ‘human-like’ features in the HSR appropriately. For example, the positive influence of anthropomorphism on adoption intention to adopt HSR suggests that anthropomorphism, if done reasonably well to reflect human characteristics in HSR, may favour the acceptance of robots and more positive attitudes (Christou *et al*., 2020; Ruiz-Equihua *et al*., 2023; Tussyadiah and Park, 2018). Interestingly, the lack of a link between animacy and likeability on re-patronage intention is contrary to expectations (Bartneck *et al*., 2009b; Tussyadiah and Park, 2018) and suggests that ‘overtly-animated’ robotic agents may cause a negative disposition towards the HSR. The above argument is further supported as perceived intelligence and perceived safety are found to positively affect re-patronage intentions (Tussyadiah and Park, 2018).

Next, the multi-group analyses reveal that when people have a choice for technology, in this case, HSR in hospitality, a strong cognitive deliberation may be done by the user on all facets of the HSR, including antecedents to re-patronage intention considered in this work, leading to weakening of the influences (Shin and Dai, 2022). Finally, in line with previous works (e.g., Papadopoulos and Koulouglioti, 2018) it is found that Japanese people have a stronger preference to use HSRs in hospitality due to the general 'level of comfort' with robots. Hence, fully HSR-based automation should be the focus of hotels in the East-Asian part of the world, with HSRs being an option for human interventions in Western world hotels.

6.2. Theoretical implications

This work offers multiple theoretical contributions. First, this work adds to the recent academic conversation about how humanoid robots improve, or otherwise, HRI, which in turn has implications for their adoption in various hospitality services (Ruiz-Equihua *et al*., 2023; van Pinxteren *et al*., 2019). Considering service robots as anthropomorphized non-human agents,

referred to as HSR, this study combines the traditional tenets of the acceptance of a new technology enshrined in TAM3 (Venkatesh and Davis, 2000), with those discussed in the GQS, to propose an integrated and exhaustive framework that holistically explains the drivers of adoption, or otherwise, of HSR in the hospitality industry. By bringing in a variety of variables, including functional (output quality), social (subjective norms, social image), emotional (perceived enjoyment, anxiety), and visual (anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety), this work advances the discourse beyond general service robot applications to specific HSR characteristics that would make them more acceptable to the customers and the industry. In this way, this works adds value to extant HSR literature by independently examining the 'machine-like' and 'human-like' characteristics of an HSR that reduce technostress and drive their re-patronage (Blut *et al*., 2021; Maier *et al*., 2015). Such an enquiry is currently missing in the existing literature which has more focus towards initial adoption (e.g., Song *et al.*, 2022).

The second contribution is added through the two boundary conditions in which the adoption of HSR in hotels may get affected. By establishing that greater voluntariness leads to more psychological evaluations about the use/disuse of an HSR, this work opens new research avenues in the hospitality literature about the right amount of HSR deployment and discusses the right balance between automation (cost-saving) and choice to the customer (value-generation) (Islam *et al*., 2013; Shin and Dai, 2022). The second boundary condition is cultural background, with Japanese-origin people, compared to non-Japanese ones, preferring more natural expression from a service robot (Papadopoulos and Koulouglioti, 2018). By empirically establishing the higher preference for HSR among the Japanese, and most East-Asian, people, this work attempts to settle the debate amongst works with mixed findings (e.g., Bartneck, 2009a). It also supports the work of Haring *et al*. (2015) and Li *et al*. (2010) who found cultural differences with Japanese, Chinese and Koreans (Asian region) reporting higher engagement with HSRs.

Finally, this is one of the few studies which deploys a methodology where respondents with substantial experience with service robots at a hotel property were interviewed (e.g., Ayyildiz *et al*., 2022). Such experiences are an aggregation of various types of service encounters across different types of robots in the same hotel, which curate an overall perception of the antecedents proposed in the model. Such a method, which is fast emerging as a popular protocol in the human-robot interaction domain, is superior to other methods involving technical analysis of a robot or an experiment where only one kind of encounter is administered (Ivanov *et al*., 2019). Also, this is one of the first studies implementing this method, followed by empirical analysis, in a cross-cultural context (Choi *et al*., 2021).

6.3. Managerial implications

This paper also offers suggestions for hotel management. First, this study suggests multiple attributes of an HSR that hotels need to consider before deploying them in their properties. These include functional, social, emotional and visual aspects of a humanoid robot. Interestingly, the lack of effect of social image (as a social implication) as a determinant of adoption implies that the adoption of robots is largely a personal decision, primarily driven by individual experiences, with social perception playing a role in people's choices. Hence, hotels need not worry too much about advertising service robots as ones favoured by a specific clientele to create a unique social image of HSR users and people from different 'walks-of-life' can be used for making video campaigns.

Second, two visual aspects of an HSR, likeability and animacy were also found to have a limited effect on the adoption intention. This suggests that while designing service robots, making the robot too human-like with an overt emphasis on a likeable face or animations/physical gestures should be avoided. It is possible that a too aggressive (in terms of responses) robot design may disenchant the customer and have negative effects on behaviour. The hotel should rather focus on service robots which are perceived to be more humane, safe, and intelligent. The importance of

anthropomorphism, but lack of animacy, in determining adoption suggests a mild/calm human-like design for robots with limited physical movements in response to customer queries/inputs.

Third, our results depict that perceived enjoyment and absence of anxiety create the notion of PEOU. This implies that it is important that the HSRs in hotels are designed such that consumers find them enjoyable and engaging as well as non-intimidating. Using AI systems to allow the robot to engage in interesting conversations with customers as well as give them interesting tasks (like puzzles, quizzes, and lesser-known facts) will increase the perceived enjoyment of the interaction. This, in turn, will make the customers comfortable with the robot. Finally, the re-adoption of HSRs is higher when the technology is non-mandatory. Hotel management should provide human-intervention-based service-delivery mechanisms to customers. Given the limited ubiquity of HSRs in hospitality, except in certain countries like Japan, it is imperative that hotels slowly make customers more comfortable with HSRs before making them mandatory. This will avoid customers from rejecting a hotel property altogether.

6.4. Limitations and Future Research

This research has some limitations which can be addressed by future research. The first limitation is that the study limits itself to the context of the adoption of HSRs in hotel industries. The model deployed two theories which capture the perceptions after the overall experiences with the HSRs have been derived. While this is a strength of the work, future areas of investigation can be to measure consumers' experiences with specific human-like behaviours of HSRs, like welcome messages, shaking of hands, responses to human voice inputs, and some others.

Second, the work only measures the simultaneous individual effects of the antecedents on PEOU, PU, and re-patronage intention. However, to measure the causal outcome of specific HSR design aspects on consumer response, it will be more prudent to deploy experimental design protocols. Future researchers can develop images, simulations or prototypes of HSRs where

specific features outlined in the study about their appearance, can be manipulated to measure the differential consumer response to the same. Third, the study considered only hotel properties which have deployed only one form of service robot: humanoid robot. There might be different types of robots in a non-human form that can be used by hotels, namely zoomorphic robots, mechanical robots, and robots with hybrid looks. Future studies can check for the relationships in this model and compare them across various types of robots to propose the best form of a robot to be used by hotel properties.

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