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Empirical Research Article

Public Perceptions of the Appropriateness of Robots in Museums and Galleries

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Abstract

This research explores the public's perceptions of the appropriateness of the use of robots in museums and galleries. Using data from an international survey of 1589 participants, the data show that the perceived appropriateness of robot implementation in museums and galleries is driven largely by perceptions of the usefulness and emotional skills of robotic technologies, and their perceived advantages compared to human employees. Additionally, the findings suggest that the general attitudes towards service robots in tourism shape the attitudes towards robots in museums and galleries in particular. Furthermore, the findings reveal that the demographic characteristics of visitors are not related to their perceptions of robots in museums and galleries.

Keywords

robots; attitudes towards robots; acceptance of robotic technologies; museums; art galleries

1. Introduction

Robots are increasingly present in manufacturing and service industries and are transforming societies (Ivanov, 2021). Robots have moved out of manufacturing, especially in the automotive industry where they had been used for decades (Robotics Industries Association, 2017) and are now being used broadly in the travel, tourism, and hospitality industries (Ivanov et al., 2017; Tung & Au, 2018; Tuomi et al., 2021), including in museums and galleries (Faber et al., 2009; Virto & López, 2019). The use of robots in the service context is expected to increase in the near future because of the increased technological capabilities of new technologies and the decrease in available labor in developed countries (Webster, 2021).

Within museums and galleries, robots are or could be used for the provision of information about the exhibits, cleaning the floors, disinfection of premises, as guards, or to participate in educational programs for visitors (e.g., school children), among other applications. Robots can not only improve the operations management of museums and galleries by automating dirty, dull, dangerous, and repetitive tasks (e.g., cleaning of the floors) but they could enhance the visitor experience as well by making the visit to a museum funny and entertaining. There is a growing but still limited literature on robots in museums and galleries. The early publications on robots in museums largely focused on the engineering aspects of robots (Burgard et al., 1999; Thrun et al., 2000). Later studies focused on the social aspects of robotics in museums and galleries and delved into topics such as human-robot interaction (Gehle et al., 2017; Iio et al., 2020; Velentza et al., 2020), service quality of robot museums (Kim et al., 2015), the educational aspects of the use of robots in museums (Del Vacchio et al., 2020; Nourbakhsh et al., 2003), robot usage patterns (Del Duchetto et al., 2019), robots acceptance (Fuentes-Moraleda et al., 2021), and attitudes towards robots (Nomura et al., 2006; Pitsch et al., 2011), among other topics. Research so far has indicated that visitors accept to use robots as guides in museums and galleries (Iio et al., 2020), and are satisfied with their interactions with the robots (Kim et al., 2015). Age is influencing robot acceptance although previous studies show mixed results. On the one hand, Fuentes-Moraleda et al. (2021) and Pitsch et al. (2011) found that younger visitors are more positive towards robot use in a museum setting. On the other hand, Nomura et al. (2006) reported that while perceptions towards robots differed by age, younger respondents did not necessarily like the robots more than older respondents.

The review of the literature reveals that no study has investigated visitors' perceptions of the appropriateness of robot use (application) in museums and galleries. The topic is important because previous studies revealed that perceived appropriateness is positively linked to robot use intentions (Ivanov & Webster, 2019). Therefore, if visitors consider that robots are suitable to serve in museums and galleries they are likely to use them and will not resist the implementation of robots in museums and galleries. More specifically, this research note looks at the role of perceived robot functionality, usefulness, emotional skills, advantages and disadvantages compared to human employees, attitudes towards robots, and demographic characteristics of respondents, and aims to evaluate their relationship with the perceived appropriateness of robot use in museums and galleries. The usefulness, functionality and emotional skills of robots facilitate the human-robot interaction and the intentions to or the actual use of robots (Stock-Homburg, 2021; Tussyadiah et al., 2017; Zhong et al., 2021). For example, previous studies have found that robots' usefulness is positively related to the perceived value of service robots (de Kervenoael et al., 2020) while functionality is positively associated with the

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intentions to use robots (Tussyadiah et al., 2017). Additionally, people expect and appreciate emotionally-programed robots (Chuah & Yu, 2021) and emotions are important in creating a museum visitor experience (Nowacki & Kruczek, 2021). The perceived advantages and disadvantages of robots to human employees reflect respondents' opinion towards the alternative service providers (humans or robots) and studies have shown that they are positively and negatively, respectively, related to the perceived appropriateness of robot application in passenger transport (Webster & Ivanov, 2021). Furthermore, Ivanov et al. (2018) found that the perceived advantages of robots compared to humans have a positive relationship with the attitudes towards the use of robots while the negative effect of the disadvantages is eliminated when general attitudes towards robots are considered. Considering the above, the following hypotheses are formulated:

- H1: Perceived robot usefulness is positively related to the appropriateness of robot use in museums and galleries.
- H2: Perceived robot functionality is positively related to the appropriateness of robot use in museums and galleries.
- H3: Perceived emotional skills of robots are positively related to the appropriateness of robot use in museums and galleries.
- H4: Perceived robot advantages compared to human employees are positively related to the appropriateness of robot use in museums and galleries.
- H5: Perceived robot disadvantages compared to human employees are negatively related to the appropriateness of robot use in museums and galleries.
- H6: The attitude towards service robots in travel, tourism and hospitality is positively related to the appropriateness of robot use in museums and galleries.

2. Methodology

To learn about the attitudes of people towards robots in the various components of the travel, tourism, and hospitality sectors, a major online survey was fielded from March 2018 to October 2019. The survey was developed in English with the input of experts in the field and then translated into 11 other languages (German, French, Spanish, Portuguese, Russian, Turkish, Arabic, Korean, Japanese, Chinese Simplified, Chinese Traditional) by native speakers, since the intention was to gain as much of a global response as possible. The online survey was distributed through social media and invitations by email and all respondents were required to be over 18. The permission to field the survey was granted by the IRB of the lead author's university, which also approved the incentive provided to the respondents. During the fielding of the survey, responses were collected from about one hundred countries. Some of the key characteristics of the sample used in this paper are presented in Table 1.

To learn about how respondents perceived the use of service robots in museums, they were asked to respond to several prompts with a seven-point scale (1=extremely inappropriate, 7=extremely appropriate). The survey asked respondents, "*Please indicate which activities do you personally consider as appropriate to be performed by service robots in travel, tourism, and hospitality*." Respondents were provided two options in which these technologies could be used in a museum environment, as Table 2 illustrates: "*Providing information about the exhibits*" and "*Robot tour guide in the museum/gallery*."

Using a seven-point level of agreement scale, respondents were also asked a number of other questions related to several constructs (Table 2): perceived usefulness of service robots in tourism, the perceived service robot functionality, the perceived emotional skills of robots, the perceived advantages of robots, and the perceived disadvantages of robots compared to human employees. To learn about general attitudes towards robots, respondents were asked "*What is your personal attitude towards service robots in travel, tourism and hospitality*?" and were given a seven-point scale ranging from "1=extremely negative" to "7=extremely positive." There were also several demographic attributes measured (gender, age of respondent, the education level of the respondent, the self-proclaimed level of economic wellbeing of the respondent, and whether a person is a frequent traveler). Factor analysis, regression and paired samples t-test were used for data analysis.

Table 1. Sample's characteristics

Characteristic		Total	Share
Gender	Female	858	54.0
	Male	731	46.0
Age	18-30	776	48.8
	31-40	386	24.3
	41-50	242	15.2
	51-60	121	7.6
	61+	64	4.0
Education	Secondary or lower	218	13.7
	2 year / Associate degree	107	6.7
	Bachelor	507	31.9
	Postgraduate (Master, Doctorate)	431	27.1
Economic wellbeing	Much less wealthy than average for the country	46	2.9
	Less wealthy than average for the country	101	6.4
	Slightly less wealthy than average for the country	168	10.6
	About the average for the country	519	32.7
	Slightly more wealthy than average for the country	457	28.8
	More wealthy than average for the country	237	14.9
	Much more wealthy than average for the country	61	3.8
Times stayed in hotels during the last 12 months	None	171	10.8
	1-3 times	738	46.4
	4-6 times	379	23.9
	7 times or more	299	18.8
	Missing	2	0.1
Country of residence	United States of America	392	24.7
	Bulgaria	319	20.1
	China	76	4.8
	Taiwan	61	3.8
	India	59	3.7
	United Kingdom of Great Britain and Northern Ireland	58	3.7
	Turkey	46	2.9
	Italy	43	2.7
	Russian Federation	36	2.3
	Portugal	34	2.1
	Malaysia	31	2.0
	United Arab Emirates	25	1.6
	Brazil	22	1.4
	Spain	22	1.4
	France	20	1.3
	Germany	20	1.3
	Other (83 countries)	323	20.3
	Missing	2	0.1
Total		**1589**	**100.0**

3. Findings

Table 2 illustrates the factor analysis results while Table 3 presents the discriminant validity matrix. The results show the constructs have very high internal consistency (all Cronbach alpha values in Table 2 are greater than 0.7 and composite reliability values are higher than 0.8) and discriminant validity (all square roots of AVE on the diagonals of Table 3 are greater than the respective bivariate correlations in the cells below the diagonal). The findings show that respondents were most receptive to the provision of information in museums (m=5.57) followed by the use of robots as tour guides (m=5.09). The difference between the two means is statistically significant (paired samples t-test: t=14.531, p<0.001).

Table 2. Exploratory factor analysis

Constructs and items	Mean	Standard deviation	Item loadings	Cronbach alpha	Composite reliability	Variance extracted	KMO	Bartlett
Perceived appropriateness of robot use in museums and galleries [a]				0.826	0.954	85.454	0.500	1108.533***
Providing information about the exhibits	5.57	1.603	0.924					
Robot tour guide in the museum / gallery	5.09	1.816	0.924					
Perceived usefulness of service robots in tourism [b]				0.948	0.977	82.792	0.914	7550.622***
Service robots will be useful to me during my trip	4.78	1.485	0.914					
Service robots will improve my travel experience	4.49	1.586	0.903					
Service robots will increase the convenience of the travel	4.72	1.531	0.897					
It will be worth using service robots in a tourism/hospitality setting	4.69	1.563	0.907					
Overall, I think service robots will be useful for my travel	4.76	1.578	0.928					
Perceived service robots functionality [b]				0.803	0.924	71.973	0.707	1543.784***
Service robots will have the physical features necessary to provide services	4.70	1.492	0.826					
Service robots will have the functionalities necessary to provide services	5.02	1.326	0.868					
Service robots will have the overall capabilities necessary to provide services	4.82	1.427	0.851					
Perceived emotional skills of robots [b]				0.791	0.944	82.736	0.500	884.731***
Service robots will be friendlier than human employees	3.70	1.697	0.910					
Service robots will be more polite than human employees	4.28	1.663	0.910					
Perceived advantages of robots compared to human employees [b]				0.823	0.906	58.795	0.830	2619.541***
Service robots will provide more accurate information than human employees	4.71	1.536	0.759					
Service robots will make fewer mistakes than human employees	4.78	1.468	0.777					
Service robots will be able to provide information in more languages than human employees	6.00	1.197	0.728					
Service robots will be faster than human employees	5.15	1.413	0.771					
Service robots will deal with calculations better than human employees	5.70	1.309	0.797					
Perceived disadvantages of robots compared to human employees [b]				0.735	0.869	55.856	0.761	1269.446***
Service robots will not be able to do special requests (r)	3.15	1.543	0.796					
Service robots will only be able to deal with/operate in standard situations (r)	2.79	1.355	0.739					
Service robots will not understand if a guest is satisfied with service (r)	3.27	1.611	0.738					
Service robots will misunderstand a question/order (r)	3.43	1.419	0.713					

Notes: 1. Extraction method: Principal Component Analysis; Rotation method: Varimax with Kaiser Normalization; 2. Coding: [a] 1-Extremely inappropriate, 7-Extremely appropriate; [b] 1-Strongly disagree, 7-Strongly agree; (r) – reverse coding; 3. Sources for statements: *Perceived appropriateness* – developed by the authors; *Perceived advantages* and *Perceived disadvantages* – based on Ivanov et al. (2018); *Service robots' functionality* – adapted from Tussyadiah et al. (2017); *Perceived usefulness* – adapted and expanded from Venkatesh and Davis (2000); 4. *** Significant at p<0.001

Table 3. Discriminant validity matrix

	Appropriateness	Usefulness	Functionality	Emotional skills	Advantages	Disadvantages
Perceived appropriateness of robot use in museums and galleries	**0.9244**					
Perceived service robots usefulness	0.581***	**0.9099**				
Perceived service robots functionality	0.449***	0.629***	**0.8484**			
Perceived emotional skills of service robots	0.403***	0.526***	0.527***	**0.9096**		
Perceived advantages of robots compared to human employees	0.438***	0.592***	0.669***	0.517***	**0.7668**	
Perceived disadvantages of robots compared to human employees	0.206***	0.328***	0.297***	0.250***	0.172***	**0.7474**

Notes: 1. The diagonal cells indicate the square root of AVE. Bivariate Pearson correlations in the cells below the diagonal. 2. Levels of significance: *** p<0.001

Table 4. Regression analysis

Dependent variable: *Perceived appropriateness of robot use in museums and galleries*	**Model 1**			**Model 2**			**Model 3**			**Model 4**		
	Unstandardized Coefficients	**Standardized Coefficients**	**t**	**Unstandardized Coefficients**	**Standardized Coefficients**	**t**	**Unstandardized Coefficients**	**Standardized Coefficients**	**t**	**Unstandardized Coefficients**	**Standardized Coefficients**	**t**
	B	**Beta**		**B**	**Beta**		**B**	**Beta**		**B**	**Beta**	
Constant	-0.002 [0.020]		-0.087	-0.002 [0.020]		-0.112	-0.338 [0.095]		-3.549***	-0.296 [0.135]		-2.187*
Usefulness	0.464 [0.027]	0.464	17.055***	0.445 [0.028]	0.444	15.612***	0.411 [0.030]	0.410	13.744***	0.410 [0.030]	0.410	13.707***
Functionality	0.096 [0.027]	0.096	3.506***	0.059 [0.030]	0.059	1.941	0.051 [0.030]	0.051	1.702	0.051 [0.030]	0.051	1.692
Emotional skills	0.112 [0.025]	0.112	4.502***	0.098 [0.025]	0.098	3.850***	0.095 [0.025]	0.095	3.763***	0.100 [0.026]	0.100	3.927***
Advantages				0.085 [0.029]	0.085	2.917**	0.067 [0.030]	0.067	2.264*	0.066 [0.030]	0.066	2.231*
Disadvantages (r)				0.001 [0.022]	0.001	0.043	0.000 [0.022]	0.000	-0.016	0.002 [0.022]	0.002	0.077
Attitude towards service robots in travel, tourism and hospitality							0.064 [0.018]	0.091	3.607***	0.065 [0.018]	0.091	3.606***
Gender										-0.037 [0.042]	-0.019	-0.894
Age										0.001 [0.002]	0.012	0.520
Education										-0.004 [0.018]	-0.005	-0.207
Economic wellbeing										-0.024 [0.017]	-0.032	-1.446
Travel frequency										0.018 [0.009]	0.046	2.080*
Model summary:												
R	0.598			0.601			0.606			0.608		
R2	0.358			0.362			0.367			0.370		
Adjusted R2	0.357			0.360			0.364			0.365		
F-Statistic	291.088***			177.104***			150.888***			83.004***		
Standard error of the estimate	0.8018			0.8001			0.7971			0.7966		
ΔR2	0.358			0.004			0.005			0.003		
ΔF	291.088***			4.291*			13.007***			1.344		

Notes: 1. Standard errors in square brackets; 2. Coding: *Gender*: 0 – Female. 1 – Male; *Economic wellbeing* – 1 – Much lower than the average for the country; 7 – Much higher than the average for the country; 3. *** Significant at p<0.001. ** Significant at p<0.01. * Significant at p<0.05; 4 (r) – reverse coding;

Four different OLS regressions were run to determine what is associated with the perceived appropriateness of robot use in museums and galleries, with the findings of the regressions reported in Table 4. All four regressions have high explanatory power and explain over 35% of the variation of the dependent variable.

The first regression includes as explanatory variables only constructs related to robots per se, i.e. their usefulness, functionality and emotional skills. The results from the regression illustrate that the perceived appropriateness of using robots in museums is positively associated with all three of the independent variables. The second regression adds two variables that compare robots to human employees, namely: the perceived advantages and disadvantages of robots. When these variables are added, the perceived functionality of service robots drops from its statistically meaningful relationship with the dependent variable. The perceived advantages of service robots have a positive while the robot disadvantages have no relationship with the perceived appropriateness of robot use in museums and galleries. These findings are further supported in the next two models. In the third and the fourth regressions, we see that the perceived appropriateness of the use of robots in museums and galleries is associated with the perceived usefulness of service robots in tourism, the perceived emotional skills of robots, the perceptions of the advantages of robots compared to human employees, and attitudes towards service robots in travel, tourism, and hospitality. While the fourth regression adds the demographic variables into the analysis, we see very little impact of the demographics, apart from the mild influence of travel frequency upon perceptions of the use of robots in museums and galleries. However, the third and fourth models seem to be nearly identical, since the change in the R-squared value is negligible and not statistically significant.

In general, the regressions illustrate that the best indicator of positive perceptions towards the use of robots in museums and galleries is the usefulness of service robots (H1), followed by the emotional skills of robots (H3), general attitudes towards the use of robots in the travel sector (H6), the advantages of robots relative to humans (H4), and the frequency by which a person travels, as shown by the impact of the standardized coefficients in Model 4. Therefore, hypotheses H1, H3, H4 and H6 were supported, while H2 and H5 were not.

4. Discussion and Conclusion

The findings of this research illustrate several noteworthy theoretical implications. First, the data show that perceptions of the usefulness of robots in tourism seem to be most closely associated with the perceived appropriateness of the use of robots in museums and galleries. Therefore, if museum visitors consider that robots will be useful in their travel experience, they will support their implementation in museums and galleries. In that regard, the findings indirectly support previous studies (de Kervenoael et al., 2020; Tussyadiah et al., 2017) that found that the perceived usefulness of robots is driving their acceptance and adoption.

Second, it seems that people with more positive opinions about the emotional skills of robots are also supportive of using robots in museums and galleries. This supports the findings of previous research in that it indicates that consumers do expect and appreciate emotionally-programed robots (Chuah & Yu, 2021). While visitors understand that they are dealing with a machine, they have some expectation that the manufacturers will have designed the machinery to exhibit and interpret human emotions. This suggests that future iterations of robots will not only have to deliver a service but also have to interact with humans in ways that humans expect to be treated by a human, to some extent and echoes previous findings (Fuentes-Moraleda et al., 2021) with regards to the use of robots in museums.

Third, what is especially interesting is that those who are most likely to see the advantages of robots compared to humans are more likely to be supportive of using robots in museums and galleries, although the disadvantages play no role in opinions of using robots in museums and galleries. This suggests that people are willing to discount the disadvantages of robots relative to humans in terms of the use of robots in museums and galleries, although they do not do so with regards to the advantages of robots over humans. In that sense, the findings reveal that respondents focus on the positive aspects of robots rather than the negatives. Therefore, the findings support the results of Webster and Ivanov (2021) who found the same relationship between perceived advantages and disadvantages of robots to humans and the appropriateness of robot use in passenger transport for information provision but does not support Webster and Ivanov's (2021) findings of the use of robots as autonomous vehicles. This outcome seems to stem from the information characteristics of the robot-delivered activities in museums and galleries that were analyzed in the paper, namely *Providing information about the exhibits* and *Robot tour guide in the museum/gallery*.

Fourth, demographics play very little role in conditioning the perceptions of the use of robots in museums and galleries. The only demographic variable that seems to play any role in terms of conditioning opinions on the topic was whether individuals are self-reported frequent travelers. However, even this variable has only a weak relationship with opinions on robots in museums and galleries. The other demographic variables had no influence, which contradicts previous studies that found that gender or age played a major role in shaping the perceptions towards robots (see, for example (Hudson et al., 2017; Ivanov et al., 2018)).

From a managerial perspective, the findings reveal that the marketing communications of cultural institutions such as museums and galleries that implement robots need to emphasize the usefulness of robots and their emotional skills as they are positively related to the perceived appropriateness of robot use. Furthermore, robot manufacturers and travel-related businesses would be wise to look into the attitudes towards robots, since convincing the public of the benefits of using robots in tourism will likely make it easier to incorporate robots into museums and galleries since there will be less suspicion and resistance to it from the public.

The main limitations of this paper are its quantitative approach and focus on the potential use of robots due to the very limited number of social robots that had been in service at the time of data collection. Future research may adopt a qualitative approach to delve deeper into visitors' perceptions of robots in museums and galleries. Additionally, research needs to elaborate on the experiences of visitors when they actually use robots and their authenticity (Seyitoğlu, 2021). Finally, research can focus on robot use in other service sectors within or outside the tourism and hospitality industry.

Declaration of competing interests

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