Attitudinal and Intentional Acceptance of Domestic Robots by Younger and Older Adults

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Abstract. A study was conducted to examine the expectations that younger and older individuals have about domestic robots and how these expectations relate to robot acceptance. In a questionnaire participants were asked to imagine a robot in their home and to indicate how much items representing technology, social partner, and teammate acceptance matched their robot. There were additional questions about how useful and easy to use they thought their robot would be. The dependent variables were attitudinal and intentional acceptance. The analysis of the responses of 117 older adults (aged 65-86) and 60 younger adults (aged 18-25) indicated that individuals thought of robots foremost as performance-directed machines, less so as social devices, and least as unproductive entities. The robustness of the Technology Acceptance Model to robot acceptance was supported. Technology experience accounted for the variance in robot acceptance due to age.

Keywords: Domestic Robots, Older Adults, Technology Acceptance.

1 Introduction

As robots are entering the domestic environment, a question to ask is: Will people be accepting of robots in their homes? This is an important and interesting question because robots have the potential to assist their human owners in many ways, but at the same time may be perceived as altering the social environment of the home. Robots would be considered disruptive technologies, as they would not simply be new versions of existing technologies. Disruptive technologies are often not accepted as readily as incremental innovations [9], [10].

This question about robot acceptance is particularly relevant to older adults. Robots are currently being designed to help older adults live in their homes longer, by helping them to perform activities such as medication management and to provide emergency monitoring [4]. There is a need to understand, first, what older adults' perceptions are of a robot in their home and second, what variables can predict whether older adults would be accepting of such a robot.

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1.1 Robot Acceptance

In the Technology Acceptance Model (TAM), acceptance is defined as a combination of attitudes, intentions, and behaviors towards a technology [6]. In the model, perceived usefulness and perceived ease of use of a technology are incorporated into consumers' attitudes about the technology. These attitudes predict intentions to buy or use the technology and actual behaviors involving acquiring and using the technology [7].

The relationship between perceived usefulness and perceived ease of use and technology acceptance has been demonstrated for numerous information technologies [11], [17]. The acceptance of a robot for the home, however, may involve alternative predictors. Other expectations about a robot, for example its social abilities, may be more predictive of attitudinal and intentional acceptance of that robot. Robots may also carry out tasks in which they behave as teammates with their human owners [5]. Thus, variables that are generally predictive of acceptance of humans as social partners (e.g., friendliness) and as teammates (e.g., motivated) may be more predictive of acceptance of robots than those describe in the TAM.

1.2 Older Adults and Robots

Several research projects are currently underway to design robots for the older adult population [1]. In the future, robots may help older individuals learn new skills, manage finances, and remember to take their medication, among other things. A robot may be especially effective for these types of activities because it can be socially engaging, and an intelligently dynamic device [3], [12], [16]. Although there are many potential benefits of assistive robots in the home for older adults, older individuals might not be as accepting as younger adults of such a device in the home. Older adults may be especially concerned about how difficult a new device will be to learn [8]. On the other hand, older adults appear willing to accept technology if it allows them to live independently in their home [15]. Consequently, if older adults perceive a robot in their home as helpful rather than intrusive, they may be just as accepting of it as younger adults.

Despite the growing interest in developing robots for older adults, few studies have investigated this age group's acceptance of robots. The studies that have been conducted have generally measured responses of older adults to specific robots with limited functionality [2], [13], [14]. For example older adults expressed excitement with a nurse-robot that helped them navigate through a building [13]. These studies provide evidence that older adults may accept certain robots in certain situations. They do not, however, reveal more general attitudes and perceptions older individuals have about robots, which could be used to predict acceptance for a wider variety of robot types in the context of the home. There is a need to understand the relationship between older adults' expectations of domestic robots and their acceptance of them.

1.3 Overview of Study

An exploratory survey study was used to understand younger and older adults' prototypical characteristics of domestic robots and the relationship between these characteristics and robot acceptance. Acceptance was limited to attitudinal and intentional acceptance because most robots designed for domestic use are still in the research and early development phase. It was predicted that perceived robot characteristics related to social partner and teammate acceptance would add significant predictive power to acceptance over that explained by perceived usefulness, and perceived ease of use alone. Additionally, there were two possible predicted patterns of age-related differences in robot acceptance. If older adults thought of robots as beneficial to them, they were predicted to be as accepting as younger adults of a robot in their home; if they did not see the benefit, they were expected to be less accepting than younger adults of a robot in their home.

2 Method

2.1 Sample

Questionnaires were sent to 2500 younger adults (18-28 yrs) and 2500 older adults (65-86 yrs) in the Atlanta Metropolitan area and surrounding counties using an age-targeted list with a 65% hit rate. Forty-three packets were returned as undeliverable. Of the total questionnaire packets sent, 177 included completed questionnaires from individuals in the targeted age groups (110 packets contained only sweepstakes entry forms and 23 respondents were not of the correct age). The effective response rate was 5.6%.

The response sample was composed of 60 younger adults (M = 22.7 yrs, SD = 3.2) and 117 older adults (M = 72.2 yrs, SD = 5.7). The younger and older adult samples were 21.7% and 53% male, respectively. Participants indicated living independently either in a house, apartment, or condominium. There were no older adults who indicated living in a nursing home or assisted living facility.

2.2 Questionnaire

A separate page was included with the questionnaire instructing participants to imagine that someone gave them a robot for their home and to draw and describe this robot. This page was to be filled out before participants began the questionnaire. The questionnaire contained four sections: 1) Views about Robots, 2) Robot Tasks, 3) Technology/Robot Experience, and 4) Demographics. The Robot Tasks section of the questionnaire will not be discussed in this paper.

Views about Robots. The first part of the section contained 48 Likert-type items of possible robot characteristics. The items were developed through an extensive literature review of variables predictive of technology/machine, social partner, and teammate acceptance. The instructions were for participants to indicate how much each item matched the characteristics of the robot they had imagined in their home from 1 = “not at all” to 5 = “to a great extent”.

The second part of the section included four statements about perceived usefulness (performance, productivity, effectiveness and usefulness) and four statements about perceived ease of use (easy to learn to use, easy to become skilled at, easy to get technology to do what user wants, and overall ease of use) The instructions were for participants to indicate how much they agreed with each of the eight statements about the robot they imagined in their home. A Likert scale was used from 1 = "strongly disagree" to 5 = "strongly agree".

The last part of the section contained items about the attitudinal and intentional acceptance of the robot that participants had imagined in their home. There were three 5-point scales for attitudes (Bad-Good, Unfavorable-Favorable, and Negative-Positive) and three 5-point scales for intentions (No Intention-Strong Intention, Unlikely-Likely, and Not Buy It-Buy It). Participants were instructed to circle the number on each scale representing their attitudes about the robot and their intentions to buy the robot if it were available for purchase.

Technology and Robot Experience. The technology and robot experience parts of the questionnaire consisted of 20 technology items and six robot items, respectively. Participants were asked to indicate on a Likert-type scale how often they had used each technology in the past year from 1 = "not at all" to 5 = "to a great extent (several times a week. The robot items were categories of existent robots: manufacturing, lawn mowing, mopping, vacuum cleaning, guarding, and entertaining. Participants were asked to indicate how much experience they had with each on a Likert-type scale from 1 = "no experience with this robot" to 5 = "I have and use this robot".

2.3 Procedure

The questionnaires and supporting materials were mailed to residents in the Atlanta area. Recipients were given four weeks to complete and return the questionnaire. A reminder postcard was mailed two week after the initial mailing. Recipients could mail back a sweepstakes entry form to win one of fifty $50 checks.

3 Results

3.1 Technology and Robot Experience

Participants were each given a technology experience score from the mean of their responses to the frequency of using 18 technologies in the past year. Home medical device and non-digital camera were excluded due to a lack of significant correlations with the other items. A score of 1.0 on the technology experience scale would indicate no experience and a score of 5.0 would indicate daily experience with the items that were presented. An ANOVA with age (younger, older) as the grouping variable showed younger adults (M = 4.05, SD = .44) as having significantly more experience with technology than older adults (M = 3.38, SD = .66), $F(1, 175) = 48.9$, $p < .01$, $\eta_p^2 = .22$.

Similarly, each participant was given a robot experience score derived from the mean of their responses to familiarity with six types of robots. On this robot experience scale, a score of 1.0 would indicate no experience and a score of 5.0 would indicate extensive experience with the robots. Participants indicated minimal experience with robots (M = 1.92, SD = .74). An ANOVA, with age (younger, older) as the grouping variable showed younger adults (M = 2.20, SD = .73) reporting slightly, but significantly, more robot experience than older adults (M = 1.77, SD = .71), $F(1,175) = 14.3$, $p < .01$, $\eta_p^2 = .08$.

3.2 Robot Characteristics

The robot characteristic variables were submitted to a principle axis factor analysis (kappa = 4). Three factors were retained after examination of the scree plot. The factor analysis was rerun with seven items removed (complex, dependent, independent, interesting, pointless, simple, and static) due to these items not meeting the criterion of a factor loading greater than .4. The resulting pattern matrix is presented in Table 1. The three factors were labeled "performance-oriented traits", "socially-oriented traits", and "non-productive traits". Each participant received a mean score on each of the factors. Items with negative loadings were reverse scored. Six outliers were removed from analysis. Younger adults had mean performance-oriented, socially-oriented, and non-productive mean scores of 4.08 (*SD* = .54), 3.08 (*SD* = .98), and 1.41 (*SD* = .44), respectively. Older adults had mean scores of 3.84 (*SD* = .80), 2.81 (*SD* = .96), and 1.41 (*SD* = .44) on these factors, respectively.

Paired t-tests, with Bonferroni correction of .0167, were conducted to assess differences in the means of the robot characteristics factors. Participants ascribed significantly more performance-oriented traits (*M* = 3.92 *SD* = .73) to their imagined robots than socially-oriented traits (*M* = 2.89 *SD* = .98), $t(173) = 14.65$, $p < .01$; significantly more performance-oriented traits than non-performance traits (*M* = 1.41 *SD* =.43), $t(174) = 32.3$, $p < .01$; and significantly more socially-oriented traits than non-performance traits, $t(173) = 16.71$, $p < .01$.

Age-related differences in performance-oriented traits were examined separately from the other two factor scores, as a covariance matrix indicted a difference in variances between younger and older adult scores on this scale. The ANCOVA indicated that age did not have a significant effect on scores, $F(1, 167) = .13$, $p = .71$. There was no significant effect of robot experience, $F(1,167) = .28$, $p = .60$ on scores. Technology experience had a significant relationship with these scores, $F(1,167) = 7.24$, $p = .01$, $\eta_p^2 = .04$, with more experience related to higher scores.

A MANCOVA was performed on the other two factors, socially-oriented traits and non-productive traits, with age group (younger, older) as the grouping variable and robot experience and technology experience as covariates. Box's M test was non-significant, *Box's M* =.63, $p = .891$. Again, age did not have a significant effect on scores, Pillai's Trace statistic $F(2,166) = 2.48$, $p = .087$. Robot experience, $F(2,166) = .746$, $p = .476$, and technology experience, $F(2,166) = 2.57$, $p = .079$ did not have significant relationships with trait scores.

3.3 Technology Acceptance Model Variables

Participants were assigned mean scores for ease of use and usefulness. The scores of seven participants were not included due to Mahalanobis distances exceeding the criterion, which was set at 2(2, *N* = 180) = 9.21 at $p < .01$. Younger adults had a mean usefulness score of 4.41 (*SD* = .75) and a mean ease of use score of 4.05 (*SD* = .78); older adults' mean scores were 4.07 (*SD* = .86) and 3.87 (*SD* = .94), respectively. A paired t-test, with Bonferroni correction of .025, indicated usefulness scores (*M* = 4.18, *SD* = .84) as being significantly greater than ease of use scores (*M* = 3.83, *SD* = 85), $t(166) = 4.00$, $p < .01$. The scores of the two variables were significantly correlated, $r(167) = .54$, $p < .01$.

Table 1. Factor Weights[1] and Communalities Based on a Principle Axis Analysis with Promax Rotation for 41 Items of Robot Characteristics

Item	Original item category[2]	Performance-oriented traits	Socially oriented traits	Nonproductive traits
Efficient	Tech/machine+	0.81		
Reliable	Tech/machine +	0.78		
Precise	Tech/machine +	0.75		
Helpful	Teammate+	0.75		
Coordinated	Tech/machine +	0.71		
Useful	Tech/machine +	0.69		
Safe	Tech/machine +	0.64		
Quiet	Social-	0.63		
Calm	Teammate +	0.62		
Sturdy	Tech/machine +	0.62		
Agreeable	Teammate +	0.58		
Confident	Teammate +	0.54		
Trustworthy	Teammate +	0.53		
Serious	Social-	0.48		
Dynamic	Social +	0.45		
Unfeeling	Social -		-0.85	
Compassionate	Social +		0.71	
Unimaginative	Teammate -		-0.71	
Unsocial	Social -		-0.70	
Expressive	Social +		0.69	
Friendly	Social +		0.63	
Dull	Social +		-0.63	
Playful	Social +		0.60	
Creative	Teammate +		0.60	
Lifelike	Social +		0.57	
Artificial	Social -		-0.54	
Boring	Social -		-0.49	
Motivated	Teammate +	.0.43	0.46	
Talkative	Social+		0.45	
Unpredictable	Tech/machine -			0.67
Wasteful	Tech/machine -			0.66
Chaotic	Teammate -			0.66
Risky	Tech/machine -			0.61
Demanding	Teammate -			0.58
Clumsy	Tech/machine -			0.58
Selfish	Teammate -			0.54
Nervous	Teammate -			0.52
Lazy	Teammate -			0.51
Breakable	Tech/machine -			0.47
Careless	Tech/machine -			0.46
Hostile	Teammate -			0.45

[1] Factor weights <.4 suppressed; [2] Plus sign denotes positive trait and minus sign denotes negative trait in original category.

A MANCOVA with age group (younger, older) as the grouping variable, ease of use and usefulness as dependent variables, and technology and robot experience as covariates was conducted. The analysis indicated a non-significant effect of age on scores, Pillai's Trace statistic $F(2,159) = .14$, $p = .87$. Technology experience had a significant relationship with scores, $F(2,159) = 6.57$, $p = .002$, $\eta_p^2 = .08$. Univariate tests indicated significant relationships between technology experience and ease of use, $F(1,160) = 6.05$, $p = .02$, $\eta_p^2 = .04$, and technology experience and usefulness, $F(1,160) = 12.68$, $p < .001$, $\eta_p^2 = .11$, with more technology experience related to higher scores for both. Robot experience was not significantly related to scores, $F(2,159) = .38$, $p = .68$.

3.4 Attitudinal and Intentional Robot Acceptance

Each participant was given mean attitudinal and intentional acceptance scores. Younger adults had a mean attitudinal score of 4.13 (*SD* = .94) and a mean intentional score of 3.57 (*SD* = 1.18); older adults' mean scores were 3.19 (*SD* = 1.20) and 3.07 (*SD* = 1.37), respectively. A paired t-test indicated that the mean score of attitudinal acceptance (*M* = 3.99, *SD* = 1.11) was significantly greater than the mean score of intentional acceptance (*M* = 3.25, *SD* 1.32), $t(177) = 8.85$, $p < .01$.

A MANCOVA was performed with age group (younger, older) as the grouping variable, acceptance (attitudinal, intentional) as dependent variables, and technology and robot experience as covariates. The analysis indicated that age did not have a significant effect on robot acceptance, Pillai's Trace statistic $F(2, 170) = .32$, $p = .72$. Technology experience was found to have a significant relationship with robot acceptance $F(2, 170) = 3.74$, $p = .03$, $\eta_p^2 = .04$. Univariate tests indicated technology experience having a significant relationship with attitudinal acceptance scores, $F(1, 171) = 4.12$, $p = .04$, $R^2 = .04$ and intentional acceptance scores, $F(1, 171) = 7.09$, $p = .01$, $R^2 = .09$, with more technology experience related to greater acceptance. Robot experience was not significantly related to acceptance, $F(2, 170) = 3.74$, $p = .53$.

Table 2. Regression of Technology Acceptance Model (TAM) Scores and Robot Characteristic Scores on Attitudinal Acceptance Scores

		Attitudinal Acceptance					
		Coefficients			Model Summary		
Model	**Variables**	β	*t*	*p*	R^2	*F*	*p*
TAM	Usefulness	.37	4.83	<.01	.32	38.2	<.01
	Ease of use	.27	3.52	<.01			
Robot Characteristics	Performance-oriented	.19	2.05	.04	.14	9.2	<.01
	Socially-oriented	.13	1.60	.11			
	Non-productive	-.17	-2.00	.05			
TAM + Robot Characteristics	Usefulness	.35	4.25	<.01	.33	15.8	<.01
	Ease of use	.25	3.06	<.01			
	Performance-oriented	-.03	-0.32	.75			
	Socially-oriented	.08	1.15	.25			
	Non-productive	-.08	-1.03	.30			

3.5 Predictors of Attitudinal and Intentional Robot Acceptance

A hierarchical multiple regression analysis was performed to investigate predictors of attitudinal and intentional robot acceptance. Model summaries are presented in Table 2 and Table 3. The analysis indicated usefulness and ease of use as significantly predicting attitudinal acceptance scores. The addition of the robot characteristic variables did not significantly increase the amount of variance explained in attitudinal acceptance over that explained by the TAM-related variables, R^2*-change* = .01, *F-change* (3, 158) = .88, p = .45. Attitudinal acceptance scores explained a significant amount of variance in intentional acceptance scores, $R^2 = .34$, $F(1,162) = 82.17$, $p < .01$. The addition of the TAM-related variables significantly increased the amount of variance explained in intentional acceptance scores. R^2*-change* = .07, *F-change* (3, 158) = 9.69, $p < .01$. The addition of the robot characteristic variables into the model did not explain significantly more variance in scores over those explained by attitudinal acceptance scores, usefulness, and ease of use, R^2*-change* = .02, *F-change* (3, 157) = 1.64, p = .18.

Table 3. Regression of Attitudinal Acceptance Scores, Technology Acceptance Model (TAM) Scores, and Robot Characteristic Scores on Intentional Acceptance Scores

		Intentional Acceptance					
		Coefficients			Model Summary		
Model	**Variables**	β	*t*	*p*	R^2	*F*	*p*
Attitudinal Acceptance	Attitud. acceptance	.58	9.07	<.01	.34	82.2	<.01
TAM	Usefulness	.34	4.40	<.01	.30	35.4	<.01
	Ease of use	.28	3.66	<.01			
Attitudinal Acceptance + TAM	Attitud. acceptance	.40	5.37	<.01	.41	37.0	<.01
	Usefulness	.19	2.50	.01			
	Ease of use	.18	2.35	.02			
Robot Characteristics	Perform.-oriented	.24	2.78	.01	.18	12.1	<.01
	Socially-oriented	.19	2.38	.01			
	Non-productive	-.10	-1.21	.23			
Attitudinal Acceptance + TAM + Robot Characteristics	Attitud. acceptance	.38	5.16	<.01	.43	19.4	<.01
	Usefulness	.17	2.04	.04			
	Ease of use	.14	1.82	.07			
	Perform.-oriented	.07	0.80	.42			
	Socially-oriented	.11	1.65	.10			
	Non-productive	.01	0.13	.90			

4 Discussion

The results suggest that participants imagined robots mostly as helpful, purposeful devices, less as socially-intelligent devices, and least of all as uncontrollable or wasteful devices. Age not did not have a significant effect on the characteristics that participants indicated their robot as having, when technology and robot experience were accounted for. The results suggest younger and older adults with comparable technology experience will have similar expectations of robots as performance-oriented machines. Of course self-selection bias may have played a part in this result, with only individuals having positive views of robots returning the questionnaire..

A regression analysis revealed that usefulness and ease of use were predictive of participants' attitudinal acceptance of a robot in their home; usefulness, ease of use and attitudinal acceptance were predictive of intentional acceptance. The results provided evidence for the robustness of the Technology Acceptance Model. Overall it appears that younger and older adults would be willing to accept a robot in their home, as long as it benefits them and is not too difficult to use.

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