# Acceptance of Social Robots by Aging Users: Towards a Pleasure-Oriented View

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**Abstract.** The aging population is getting larger and the demands for social robots in providing home-based care services is increasing. As social robots are new technology and have not fully reached domestic fields, this study explored aging adults' acceptance of social robots in a domestic environment. This study adopted the adapted UTAUT to develop aging adults' acceptance. The model in this study involved both utilitarian use and pleasure-oriented use of social robots perceived by aging adults. A questionnaire survey involving 277 valid responses was conducted. This study examined that both pleasure expectancy and the four influencing constructs in UTAUT showed significantly positive effects on user adoption of social robots. In addition, based on the results, aging adults slightly did not think they could get pleasure from social robots whereas they had slightly preference to accept social robots. Implications were discussed for future work.

**Keywords:** Aging adults · Social robots · Home-based elderly care
UTAUT

## 1 Introduction

The aging population is getting larger in China and this results in an increasing demand for elderly care. Population aging is a complex issue which concerns both aging adults and their families. Due to Chinese traditional culture, elderly care depends largely on families. In China, there is a tendency of miniaturization for the sizes of families [1] which will lead to a fact that in a typical core family, two adults (both spouses) should take care of four aging adults (both parents) and at the same time the couple should raise their child/children. Family miniaturization, cultural traditions and the one-child policy in China have caused enormous pressure on the care of aging adults for Chinese society and families. Relying merely on families could not satisfy the demand of elderly care.

Many smart devices and systems have been developed to improve the quality life of aging adults in order to relieve the elderly care pressure, such as wearable devices which detect falls [2], smart home technologies and systems which monitor security [3] and healthcare monitoring systems [4]. Among them, robots show potential in help aging adults both physically and psychologically [5].


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On one hand, robots provide utilitarian services for aging adults, such as cleaning house [6], providing information [7] and guiding users in unfamiliar places [8]. On the other hand, some researchers suggested that robots also provide hedonic and pleasure-oriented services [9, 10]. For example, robot can play with [11] and accompany aging adults [12] to reduce their feelings of social alienation and loneliness. In this context, social robots which have both utilitarian functions and pleasure-oriented functions seems to be an important part of home-based elderly care system in the future.

The robots interact with human being via human social rules are considered as social robots [13]. On one hand, social robots have utilitarian functions, such as performing household working. On the other hand, social robots have pleasure-oriented functions, such as interacting with users and building relationships with them. The social robots with pleasure-oriented functions attract users and satisfy users' human social expectation. Users will find the interaction enjoyable and be willing to keep the relationships with social robots. Therefore, it is important to investigate the pleasure-oriented use of social robots in order to get a more comprehensive view of its role in aging adults' acceptance and usage of social robots.

Users' acceptance of technology affects their usage. Among the acceptance models developed by previous studies, the Unified Theory of Acceptance and Usage of Technology (UTAUT) was one of the most accepted models. As an extension of the Technology Acceptance Model (TAM) [14], UTAUT was firstly proposed by [15]. UTAUT indicated that usage behavioral intention and use behaviors of information system were affected mainly by four factors, involving performance expectancy, effort expectancy, social influence and facility conditions. During the fifteen years after the model was proposed, it has been revised to multiple transformation, such as mobile commerce acceptance [16], online banking [17] and interactive whiteboards among teachers [18]. In the field of intelligent robots, extant studies have tried to explain users' acceptance of robots following UTAUT [i.e., 9, 19–21]. UTAUT defined that usage contains two steps – users firstly generated the usage intention and then performed the use behaviors. The constructs of performance expectancy, effort expectancy and social influence directly affected usage intention and indirectly affected use behaviors, whereas only the construct of facility conditions directly affect use behaviors. Use behaviors were usually measured through usage frequencies or duration. However, in this study, because social robots have not reached into home-based care system, this means that it is difficult to obtain data of usage behaviors.

Among the studies following UTAUT, [22] adapted UTAUT – all four constructs directly affect user adoption which measures users' subjective acceptance of technology through questionnaire items. The model of [22] achieved good reliability, validity and model fitness.

Hence, this study aimed to explored the roles of both utilitarian use and pleasure-oriented use of social robots in aging users' acceptance and adopted the adapted UTAUT by [22] to develop aging adults' acceptance of social robots in a domestic environment.

## 2 Research Model

Performance expectancy reflects users' belief of performance improvement by using social robots. Effort expectancy is defined as the perceived ease of using social robots. Social influence reflects the effects of others' opinions on users' behaviors, such as friends, spouses and families. Facility conditions mean users' belief of getting support from organizational and technical infrastructures on their behaviors. According to UTATU and adapted UTAUT, performance expectancy, effort expectancy, social influence and facility conditions positively affect user adoption [15, 22]. Thus, we hypothesize:

**Hypothesis 1**. Performance expectancy has a positive effect on user adoption of social robots.
**Hypothesis 2**: Effort expectancy has a positive effect on user adoption of social robots.
**Hypothesis 3**: Social influence has a positive effect on user adoption of social robots.
**Hypothesis 4**: Facility conditions has a positive effect on user adoption of social robots.

This study defined the perceived pleasure of aging users from using social robots as pleasure expectancy. Pleasure expectancy positively affects their acceptance [9]. Thus, we have:

**Hypothesis 5**: Pleasure expectancy has a positive effect on user adoption of social robots.

The research model is shown in Fig. 1.

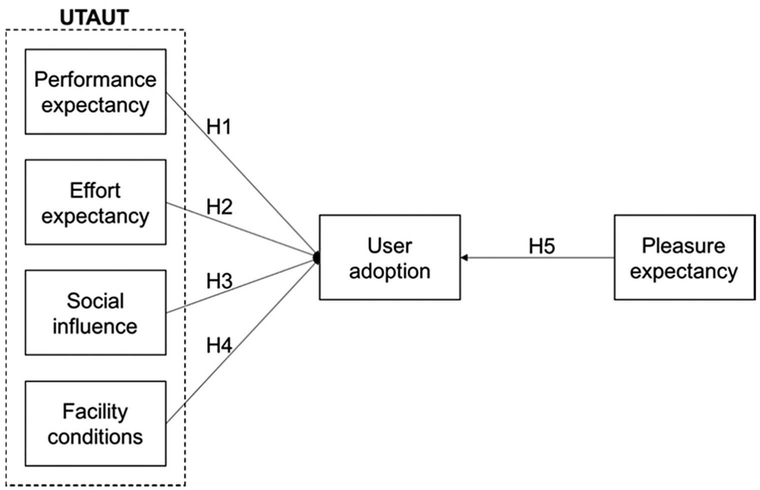


**Fig. 1.** Research model.

# 3 Method

## 3.1 Questionnaire Design

This study adopted a questionnaire survey to test the research model. The research model included six constructs and each construct was measured using multiple items which were derived from previous studies.

The construct of pleasure expectancy was adapted from [23] which tested users' acceptance of online retailing. Three items about enjoyment in the sub-scale of playfulness were chosen. The evaluation objects of the three items were changed from online retailing to social robots in order to fit this study. An example of the items in the construct was "Using social robots gives me enjoyment".

The items in the construct of user adoption in [22] were based on specific scenarios of using mobile banking which did not fit this study. Hence, this study followed [22] to develop new items for the construct. Targeting the utilitarian use and pleasure-oriented use of social robots, this study developed two items to state the scenarios of using social robots respectively, involving "I will use social robots to help me to do housework" and "I will use social robots to accompany myself". In addition, this study developed two items to generally state the positive effects of using social robots on life quality, involving "I will use social robots to improve my life quality" and "Social robots will make me live better".

Both [15, 22] involved four influencing constructs in UTAUT model, involving performance expectancy, effort expectancy, social influence and facility conditions. After comparing the details of the statement of the two instruments and their applicability for this study, we adapted the constructs of social influence and facility conditions from [15], whereas we adapted the constructs of performance expectancy and effort expectancy from [22]. We will explain the reasons of the selection.

For the construct of performance expectancy, both [15, 22] contained four similar items with each other. However, one item "If I use the system, I will increase my chances of getting a raise" did not fit the scenarios of using social robots in a domestic environment. Hence, this study did not adopt this item and kept the other three items, such as "I feel social robots are useful".

For the construct of effort expectancy, both studies contained four items which fitted this study. Hence, this study adopted all four items and changed the evaluation objects to social robots.

For the construct of social influence, [15] involved four items. [22] just kept two of them and removed the other two items from [15], involving "The senior management of this business has been helpful in the use of the system" and "In general, the organization has supported the use of the system". Due to the small size of the construct, the reliability of the construct in [22] might be negatively affected. Hence, considering that the closest connections for Chinese aging adults were their children who would be the most important persons in teaching aging adults using technology products, this study kept all four items in [15] and revised the two removed by [22] into "My children would be helpful in the use of social robots" and "In general, my family would support the use of robots".

For the construct of facility conditions, [22] removed one items from the four items in [15], which was “The system is not compatible with other systems I use”. This statement could be revised to adapted to this study. Hence, we kept this item and revised it into “Social robots are not compatible with my house”.

All the items of the six constructs were measured using a 5-point Likert scale with “1 = strongly disagree” and “5 = strongly agree”.

In addition, responders’ demographic information, involving age, gender and levels of education were measured. Their previous experience with robots and perceived themselves’ computer skills were also measured using a 5-point Likert scale as shown in Table 1.

**Table 1.** Profile of responders.

| Measure | Item | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 99 | 35.74 |
| | Female | 178 | 64.26 |
| Age | 57–60 | 94 | 33.94 |
| | 61–65 | 93 | 33.57 |
| | 66–70 | 62 | 22.38 |
| | 71–74 | 28 | 10.11 |
| Level of education | Under high school degree | 115 | 41.52 |
| | High school degree | 123 | 44.40 |
| | Bachelor degree | 32 | 11.55 |
| | Master degree or above | 7 | 2.53 |
| Experience with robots | Extremely inexperienced | 32 | 11.55 |
| | Inexperienced | 143 | 51.62 |
| | Neutral | 88 | 31.77 |
| | Experienced | 13 | 4.69 |
| | Extremely experienced | 1 | 0.36 |
| Computer skills | Extremely poor | 4 | 1.44 |
| | Poor | 92 | 33.21 |
| | Neutral | 142 | 51.26 |
| | Advanced | 37 | 13.36 |
| | Extremely advanced | 2 | 0.72 |

### 3.2 Responders

Based on the fact that in China the government-regulated retirement age for women is 55 years old and that for mem is 60 years old, the younger aging adults aged from 57 years old to 74 years old were considered as potential responders of the questionnaire survey [24].

This study distributed the questionnaires in two communities in Beijing and a total of 418 questionnaires were collected. Among the collected questionnaires, 277 were valid, taking up 66.27% of the total. The average age of the responders who contributed valid questionnaires was 63.42 years old (standard deviation = 4.69), ranging from 57 years old to 74 years old. Among the valid questionnaires, 99 were answered by male responders, taking up 35.74% of the total valid responds, whereas the other 178 were answered by female responders, taking up 64.26%.

Most of the responders held a degree of high school or lower, taking up more than 80% of the total valid responds; this was in line with the common sense of the academic qualifications of the aging adults in this age group. More than 80% of the responders thought they were inexperienced or had a neutral level of experience with robots; this was in line with the fact that social robots had not been applied in home-based elderly care and few aging adults ever had close contact with robots. More than half of responders reported that they had a neutral level of computer skills.

The distribution of the ages, levels of education, experience with robots and computer skills of the responders is listed in Table 1.

## 4 Results

The research model was analyzed by AMOS and SPSS. The results of descriptive statistics analysis are listed in Table 2.

**Table 2.** Profile of responders.

| Measure | Average | Standardized deviation |
|---|---|---|
| Pleasure expectancy | 0.27 | 0.70 |
| Performance expectancy | 3.66 | 0.65 |
| Effort expectancy | 2.53 | 0.51 |
| Social influence | 3.31 | 0.44 |
| Facility conditions | 2.16 | 0.55 |
| User adoption | 3.26 | 0.59 |

Based on the results, the average score of the construct of user adoption was 3.26, slightly higher than 3.0 (neutral level); this suggested that responders have slightly preference to accept social robots. The average score of the construct of pleasure expectancy was 0.27, slightly lower than 3.0; this suggested that responders slightly did not think they could get pleasure from using social robots.

Next, this study first analyzed the measurement model to test its reliability and validity and then analyzed the structural model to test the hypotheses [25].

### 4.1 Measurement Model

Cronbach alpha and item-to-total correlations were used to assess the internal consistency reliability. The results are shown in Table 3. The values of item-total correlations ranged from 0.559 (for one item of the construct of social influence) to 0.827 (for one item of the construct of user adoption), whereas the values of Cronbach Alpha ranged from 0.817 (for the construct of social influence) to 0.909 (for the construct of user adoption). The values of item-total correlations which are higher than 0.50 are acceptable [26], whereas the values of Cronbach Alpha which are higher than 0.70 are acceptable [27].

**Table 3.** The results of internal reliability and convergent validity.

| Construct | Items | Internal reliability | | Convergent validity | | |
|---|---|---|---|---|---|---|
| | | Cronbach Alpha | Item-total correlation | Factor loading | Composite reliability | Average variance extracted |
| Pleasure expectancy | 3 | 0.865 | 0.740 | 0.806 | 0.860 | 0.672 |
| | | | 0.738 | 0.814 | | |
| | | | 0.762 | 0.839 | | |
| Performance expectancy | 3 | 0.854 | 0.766 | 0.752 | 0.802 | 0.575 |
| | | | 0.736 | 0.762 | | |
| | | | 0.679 | 0.760 | | |
| Effort expectancy | 4 | 0.888 | 0.802 | 0.803 | 0.867 | 0.620 |
| | | | 0.674 | 0.766 | | |
| | | | 0.737 | 0.770 | | |
| | | | 0.813 | 0.810 | | |
| Social influence | 4 | 0.817 | 0.559 | 0.678 | 0.828 | 0.547 |
| | | | 0.651 | 0.776 | | |
| | | | 0.693 | 0.765 | | |
| | | | 0.649 | 0.734 | | |
| Facility condition | 4 | 0.901 | 0.806 | 0.841 | 0.903 | 0.701 |
| | | | 0.778 | 0.812 | | |
| | | | 0.738 | 0.821 | | |
| | | | 0.796 | 0.873 | | |
| User adoption | 4 | 0.909 | 0.801 | 0.848 | 0.923 | 0.749 |
| | | | 0.827 | 0.865 | | |
| | | | 0.785 | 0.889 | | |
| | | | 0.767 | 0.859 | | |

Factor loadings, composite reliability (CR) and average variance extracted (AVE) were measured to examine the convergent validity of the model. The results are shown in Table 3. Factor loadings of all items ranged from 0.678 (for one item of the construct of user adoption) to 0.889 (for one item of the construct of user adoption); all were larger than 0.70 and significant at .001. CRs ranged from 0.802 (for the construct of performance expectancy) to 0.923 (for the construct of user adoption); all exceeded the recommended lower threshold value of 0.7 [28]. AVEs ranged from 0.575 (for the construct of performance expectancy) to 0.749 (for the construct of user adoption); all exceeded the recommended lower threshold value of 0.50 [29].

Confirmatory factor analysis (CFA) was also used to examine the convergent validity of the instrument. The results indicated that the ratio of the chi-square statistic to the degree of freedom ($\chi^2$/d.f.) was 2.423; this was lower than the recommended upper threshold value of 5 [30]. The goodness-of-fit (GFI) was 0.864; this exceeded the recommended lower threshold value of 0.80 [30].

These results indicated that the internal consistency reliability and the convergent validity of the instrument was acceptable.

### 4.2 Structure Model

Besides $\chi^2$/d.f. and GFI, this study also tested other fit indices of the model, involving root mean square residual, adjusted goodness-of-fit index, Tucker-Lewis index, normed fit index and comparative fit index; all satisfied the recommended threshold values of 0.005, 0.80, 0.90, 0.90 and 0.90 [28]. These indicated a good fit between the model and the data. The values of the fit indices are listed in Table 4.

**Table 4.** Fit indices of the model.

| Fit index | Scores | Recommended threshold values |
|---|---|---|
| Minimum fit function chi-square ($\chi^2$) | 506.397 ($p < .001$) | The lower, the better |
| Degree of freedom (d.f.) | 209 | |
| $\chi^2$/d.f. | 2.423 | <5 |
| Goodness-of-fit index (GFI) | 0.864 | >0.80 |
| Root mean square residual (RMSR) | 0.013 | <.005 |
| Adjusted goodness-of-fit index (AGFI) | 0.835 | >0.80 |
| Tucker-Lewis index (TLI) | 0.942 | >0.90 |
| Normed fit index (NFI) | 0.914 | >0.90 |
| Comparative fit index (CFI) | 0.948 | >0.90 |

This study next tested the model hypotheses. The standardized coefficient of all path and their significance are shown in Fig. 2. All the five influencing constructs showed significantly positive effects on the construct of user adoption. All hypotheses were supported (all sig. < .001).

## 5 Discussions

The results of CFA showed that the standardized coefficients of all the path were 1.000; this might be related to the model. This model actually was a linear regression model – all the five influencing constructs of pleasure expectancy, performance expectancy, effort expectancy, social influence and facility conditions were linear correlated to the construct of user adoption. Hence, the reported standardized coefficients in Table 4 were the results of a linear regression test. These indicated that the model has possibility of further improvement. There are two improvement directions. Firstly, after the

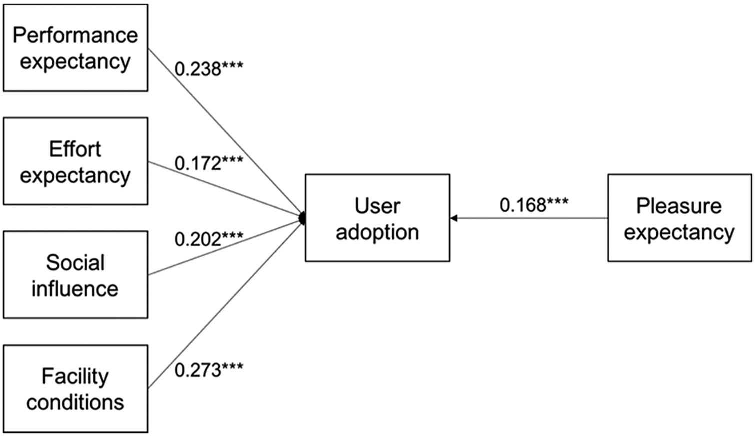


**Fig. 2.** Model estimation results (***$p$ < .001).

social robots are actually applied in the home-based elderly care system in the future, aging adults' intention to use social robots and their actual usage of social robots might be measured, and consequently the effects of the construct of pleasure expectancy on their intention and actual usage could be measured so as that the model might be more in line with UTAUT. Secondly, the relationships between the construct of pleasure expectancy and the constructs of performance expectancy, effort expectancy, social influence and facility conditions could be explored further. However, related literature is still insufficient. More work need to be done to explore the relationships among the constructs.

Although social robots have not reached in home applications, aging adults in this study still thought they had some knowledge of social robots through media campaigns –36.82% of the valid questionnaires reported that they had such knowledge (neutral, experienced or extremely experienced). The proportion of aging adults who thought they had knowledge about computer skills was much higher –65.34% of the valid questionnaire reported that they had neutral, advanced or extremely advanced computer skills, who could be considered to maintain a certain level of basic knowledge about using social robots. All these show that there is a certain possibility that social robots are applied in the field of home-based care system.

Aging adults had slightly preference to use social robots in a domestic environment but they did not think robots could provide them pleasure; this suggested that the images of social robots in aging adults tend more to provide functional services rather than companion or entertaining services.

## 6 Conclusions

Against the background of the rapidly aging population and the dramatic increasing elderly care pressure, the purposes of this study involved investigating Chinese aging adults' acceptance of social robots in a domestic environment and exploring the roles of both utilitarian use and pleasure-oriented use of social robots in aging users' acceptance. This study adopted an adapted UTAUT to develop aging adults' acceptance of social robots in a domestic environment. A questionnaire survey involving 277 valid responses was conducted. This study examined that pleasure expectancy together with other four influencing constructs in UTAUT showed significantly positive effects on user adoption of social robots – the model showed acceptable reliability, convergent validity and model fitness. In addition, based on the results, aging adults slightly did not think they could get pleasure from social robots and they had slightly preference to accept social robots. Further work could be conducted to investigate the effects of the perceived pleasure of social robots by aging adults on their usage intention and behaviors.

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