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Factors Contributing to Korean Older Adults' Acceptance of Assistive Social Robots

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Abstract: This study investigated the factors contributing to older adults' acceptance of assistive social robots. A survey was conducted to find factors explaining and predicting older adults' acceptance behavior of assistive social robots. Three factors of older adults' needs for assistive social robots were found (advanced needs, social needs, and physiological needs) which integrated Maslow's five levels of basic human needs. According to older adults' self-reported scores, the most important needs were physiological needs, followed by advanced needs and social needs. A regression analysis showed that the advanced needs and social needs significantly influence older adults' use intention of assistive social robots. The results can assist in the future design of assistive social robot functions and features targeting the older population.

Keywords: older adults; assistive social robots; acceptance; factors



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1. Introduction

The continued growth of the older population presents a sizeable market opportunity for the robotics and artificial intelligence industries, as well as challenges to provide appropriate systems and products for this group [1]. According to the Technology Thematic Research report 'Robotics', the robotics industry is projected to grow at a compound annual growth rate of 16% between 2018 and 2025, with annual growth peaking at 17% in 2022 [2]. Such a high-growth industry can assist in meeting the increasing demands for technologies for physical and social assistance of older adults in their daily lives.

In recent years, robots across the globe have evolved from early factory robots to various types of robots designed to interact with human beings in their daily lives [3]. Robots have been proposed as a way to assist older adults to stay healthy and safe in hospitals, nursing homes, rehabilitation centers, and their own homes. Robots have great potential to increase independence and improve health outcomes in the aged and relieve the burden for caregivers [4]. Robots in the current market can provide assistance with physical tasks, such as "My Spoon Robot" and "Sanyo Bath Robot"; social companionship, such as "Paro"; and information services, such as "ElliQ".

Robot design, functionality, and acceptance by humans must be fully considered in order to increase their effectiveness among the target older adults [5]. The objective of this study was to investigate the factors contributing to older adults' acceptance of assistive social robots, the perceived importance of these factors, and the relationship between these factors and older adults' use intention of assistive social robots. The research findings can be used for assistive social robot design targeting the older adult market and to predict older adults' assistive social robot acceptance behaviors.

2. Literature Review

2.1. Aging Effects and Related Issues

It is well recognized that as people age, they tend to experience various physical and cognitive aging effects. Physical aging effects include decreased vision; increased sensitivity to light; poor hearing abilities; and weakened muscles, ligaments, bones, joints, and other body tissues which reduce moving abilities [6]. Cognitive aging effects include poor perception abilities; difficulties in memory; decreased ability to process information; and decreased learning ability [7]. Along with aging effects, a decline in social status due to retirement [8] and family structure change due to children gaining independence [9] can cause psychological problems, such as depression, loneliness [10], inferiority, and anxiety [11].

For older adults, safety is another serious concern. Older adults are vulnerable to accidents which can cause serious injury [12], as well as relatively light accidents in their home, due to physical and cognitive aging and various diseases [13]. According to a report by the Korea Consumer Agency in 2017, the proportion of older adults' risk of accidents relative to all ages increased every year since 2014. It was reported that 49.7% of older adults' accidents occur during their day-to-day activities; 60.5% of the accidents occur in their home, followed by on the roads or sidewalks, in lodgings, and in restaurants. The bedroom is the most common location for accidents to occur in the home, followed by the bathroom and the living room. In particular, slipping and falling accidents account for the largest proportion [14].

2.2. Older Adults' Acceptance of Assistive Social Robots

The growth and development of the robotics industry has produced many robot products and systems to help older adults in their daily lives. They can support basic activities, such as eating, bathing, and moving [15]. Many products and systems are designed with functions that consider older adults' characteristics and needs [4]. These technologies are believed to be feasible solutions to the issues of population aging [16]. As the first step in designing robots for older adults, older adults' needs for the robots' functions and features should be considered. According to Davis' technology acceptance model, perceived usefulness is the principal factor contributing to use intention of innovations, which has been verified in multiple studies as a major variable predicting technology acceptance [17–19]. To make older adults feel that the robots are useful, the first consideration must be for the needs of older adults [20,21]. Maslow's theory of human beings' basic needs can be a reasonable starting point for considering the functions and features that the assistive social robots should have. Maslow found that all human beings have five levels of needs, including physical survival needs, physical safety needs, love and belonging needs, self-esteem needs, and self-fulfillment needs [22]. These needs are ranked in a hierarchy from the lowest level, physical survival needs, to the highest level, self-fulfilled needs.

The basic level of Maslow's human beings' basic needs theory is the need for physical survival. According to data from the Naver (a Korean online platform known as 'the Google of Korea') big data portal DataLab, the key word search volume for health information among users aged 60-years or over had approximately doubled between 2016 and 2018 [23]. Technology can provide medical and health information and also monitor older adults' health condition [24]. Wearable devices can track older adults' physiological signals and monitor their health conditions [25]. These devices can assess sounds, images, body motion, ambient parameters (light, temperature, humidity, etc.), vital signs (blood pressure, respiration, body temperature, heart/pulse rate, body/weight/fat, blood oxygenation, ECG, etc.), sleep patterns, and other health parameters and daily activities to detect emergency situations [15]. Safety needs are the next basic need that should be fulfilled after physical survival. Since a considerable amount of older adults' accidents occur at home through slips and falls, assistive social robots and intelligent technologies can be used to detect such accidents [13]. Healthy aging comprises several factors, including physical and mental health, social integration [15], personal independence [26], positivity of self-perception, and

self-efficacy [14]. As mentioned, aging effects and changes in the status of social activities can lead to a deterioration of social ties and networks [27]. Technology can increase social interaction, enhance communication [28], and, if implemented well, can lead to a sense of wellbeing, autonomy, social integration, and advanced needs [24].

3. Methodology

A survey was conducted to evaluate the importance of different aspects of the functions and features of assistive social robots and how they contribute to older adults' use intention of said assistive social robots. The importance of various factors was evaluated via the average rating scores of survey questions answered by older adults. A regression analysis was used to determine the influence of each factor on older adults' intention to use assistive social robots.

3.1. Conceptual Model and Research Questions

A conceptual model was developed based on Maslow's theory of human beings' basic needs and motivation theory, as shown in Figure 1. This study proposed that older adults' needs for assistive social robots can be similarly divided into five levels. The first level (physiological needs) can be related to functions and features to improve the health conditions of older adults. The second level (safety needs) can be related to functions to keep older adults from dangers and harms. The third level (social belonging) involves feelings of belongingness, which can be related to functions for improving communication and connections between older adults and their families and friends. The fourth level (self-esteem) refers to needs of recognition, importance, and respect from others, which can be related to functions that allow older adults to be proud of themselves. The fifth level (self-actualization) refers to the realization of older adults' full potential, which can be related to functions that assist older adults in self-improvement and social contribution. This study investigated how the functions and features of these five levels can contribute to older adults' acceptance of assistive social robots. Accordingly, there were two research questions.

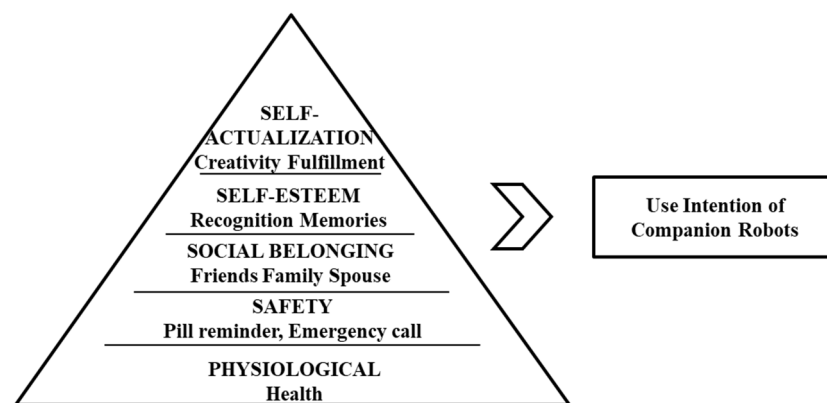


Figure 1. The concept model of this study.

Research question 1: What kind of functions and features of assistive social robots are perceived to be important by older adults?

Exploring these factors can explain older adults' acceptance of assistive social robots, which is an essential step in their design. It was also pondered whether the factors found by this study would be consistent with Maslow's theory of human beings' basic needs. Older adults' self-reported perceived importance of these factors would be useful information in order to consider what functions assistive social robots should provide.

Research question 2: What kind of functions and features can contribute to older adults' acceptance of assistive social robots?

This research question can be answered by examining the results of a regression analysis. The regression analysis results can explain which factors influence older adults use intention of assistive social robots and to what extent.

3.2. Questionnaire Construction

Paper-based questionnaires with larger font (12 pt) and line spacing (1.5 times) were used. The statements in the questionnaire were designed to be simple and short, with a seven-point Likert scale for each statement (“totally disagree”, “disagree”, “slightly disagree”, “neutral”, “slightly agree”, “agree”, and “totally agree”). The questionnaire contained three parts. The first part collected participants’ demographic information and experience of using information technology devices (e.g., computer, mobile phones, and ATM) and intelligent technologies (e.g., social robots, chat bots, and voice personal assistant). The second part of the survey evaluated the perceived importance of different aspects of functions and features of assistive social robots and their contribution to older adults’ use intention of assistive social robots. One question was asked for each aspect of the functions and features listed in Table 1.

Table 1. Survey questions designed according to Maslow’s theory of human beings’ basic needs.

Levels	Items	Questions
Physiological	Doing exercise	I would like the robot to guide me doing exercise.
	Health information	I would like the robot to provide health information.
	Personalized health recommendation	I would like the robot to give health recommendation based on my daily habit.
Safety	Emergency	I would like the robot to make an emergency call if it thinks there is an emergency situation (e.g., heart rate abnormality, slipping and falling accidents).
	Medication Reminder	I would like the robot remind me to take my pills.
	Home Safety monitoring	I would like the robot to help me keep a safe environment at home (e.g., gas leak warning, fire warning).
Social Belonging	Chatting with families	I would like to video chat with my family through the robot.
	Family news in time	I would like the robot to let me know recent news in my family (e.g., show me photos on their Kakao story, Instagram they just posted.)
	Keep touch with friends	I would like the robot help me to keep in touch with my old friends.
Self-esteem	Proud memories	I would like the robot to show me the memories I used to be proud of.
	Affirmation	I would like the robot to praise me for the tasks I have completed.
	My Life Records	I would like the robot to record and sort my daily life records.
Self-Actualization	Self-improvement	I would like the robot to guide me to be a better me.
	Social Contribution	I would like the robot to help me to contribute to the society
	Smart life style	I would like to live a more creative and smart life through the help of the robot.

The third part of the survey was to collect information about the subjects’ willingness to use assistive social robots that would have the functions and features, which had been rated as important. There were three questions measuring the willingness to use assistive social robots, including “I am interested in using assistive social robots designed for senior citizens”, “I intend to use assistive social robots designed for senior citizens”, and “I intend to use the assistive social robots designed for senior citizens frequently”.

3.3. Subject and Data Collection

Although older adults are commonly defined as being over the age of 65 years old in developed countries, the subjects’ age in this study ranged from 60 to 75 years old because

those in the 60- to 65-year old range would be major users in the coming years. A factor analysis was used as a method of data analysis, meaning that a reasonable sample size was necessary. Gorsuch recommended that the subject-to-item ratio should be larger than 5 [29]. Since there were 15 items for factor analysis in this study, the recommended number of subjects for the study was set at 75.

The older adults were recruited from institutions including Yeonsu Library, Ganghwa Library, and Ju-an Senior Cultural Center. A face-to-face survey was conducted. The functions and capabilities of assistive social robots and their applications in the field of elderly care were introduced to the participants before the survey. A researcher was available to assist the subjects and to answer questions while filling out the questionnaires. A total of 75 subjects participated the survey; however, there were 9 participants younger than 60 years old and 4 participants older than 75 years old. Thus, there were 62 subjects' data being analyzed in this study, including 26 males (41.9%) and 36 (58.1%) females. Although the number of subjects was less than the recommended number for factor analysis, examining the results of the data analysis indicated that factor analysis was an appropriate method for this study. The average age of the subjects was 66.68 years old with a standard deviation (SD) of 4.61 years. The minimum age was 60 years old, and the maximum age was 75 years old. There were 5 subjects who had master or Ph.D. degrees, 30 subjects who had bachelor degrees, and 27 subjects who had high school or secondary school education.

4. Results

4.1. Descriptive Statistics

Eight items were listed in the questionnaire related to participants' experience using digital devices, including: (a) computer, (b) mobile phone, (c) ATM, (d) fax, (e) printer, (f) digital camera, (g) scanner, and (h) others. Out of the 62 participants, 48 (77.4%) used computers; 61 participants (98.4%) used mobile phones, 41 participants (66.1%) used ATMs, 30 participants (48.4%) used faxes, 32 participants (51.6%) used printers, 24 participants (38.7%) used digital cameras, 11 participants (17.7%) used scanners, and 1 participant (1.6%) used others. In regard to participants' experiences of using robotic and intelligent technologies, eight items were listed in the questionnaire, including: (a) robot cleaner, (b) AI voice assistant, (c) telemedicine, (d) AI speaker, (e) social robot, (f) digital assistive social, (g) Chat bot, and (h) others. Out of the 62 participants, 57 (96.6%) used robot cleaners, 24 participants (40.7%) used AI voice assistants, 34 participants (57.6%) used telemedicine, 27 participants (45.8%) used AI speakers, 13 participants (22.0%) used social robots, 7 participants (11.9%) used digital companions, and 3 participants (5.1%) used chat bots.

4.2. Factors Analysis and Comparison

The Kaiser–Meyer–Olkin (KMO) and Bartlett's test showed that the KMO measure of sampling adequacy was 0.819, while the p -value in Bartlett's test was <0.001 , indicating that factor analysis was an appropriate method. A principal component analysis was used as the extraction method. The factors with an Eigenvalue of more than 1.0 were extracted. Kaiser normalizing Varimax rotation was conducted on the items, and a threshold of 0.5 loading was used to conclude when a particular item belonged to a certain factor. A model comprising of 14 items and three factors was found to be the best model. The first item of the physiological needs was eliminated to fit in to the best model. All loadings for each item and each factor are shown in Table 2. Three factors accounted for 69.3% of the overall variance. The three levels of older adults' needs of assistive social robots generated by factor analysis were deemed: Factor 1: Advanced needs; Factor 2: Physiological needs; and Factor 3: Social needs. The newly generated three levels of needs of assistive social robots integrated Maslow's five levels of basic human needs. Maslow's first level of physiological needs and second level of safety needs have been combined into one factor: physiological needs. Maslow's third level of social belonging needs remained as an isolated level: social

needs. Maslow's fourth level of self-esteem needs and fifth level of self-actualization needs have been combined into one factor: advanced needs.

Table 2. Factor analysis results.

No	Items	Factor 1	Factor 2	Factor 3
		Advanced Needs	Physiological Needs	Social Needs
1	Self-esteem_2	0.801	0.156	0.085
2	Self-esteem_3	0.787	-0.122	0.301
3	Self-Actualization_2	0.775	0.152	0.161
4	Self-Actualization_3	0.764	0.198	0.272
5	Self-esteem_1	0.611	0.248	0.280
6	Self-Actualization_1	0.586	0.533	0.019
7	Safety_1	0.170	0.841	-0.008
8	Physiological_3	0.356	0.818	-0.030
9	Physiological_2	0.274	0.795	0.096
10	Safety_2	-0.053	0.740	0.220
11	Safety_3	-0.087	0.572	0.458
12	Social Belonging_1	0.215	0.152	0.875
13	Social Belonging_2	0.269	0.014	0.852
14	Social Belonging_3	0.358	0.123	0.806

The internal consistencies of the three factors are shown in Table 3. The overall internal consistency of the questionnaire is 0.890, indicating a good internal consistency. The subjects' self-reported scores on the perceived importance of the above three factors are shown in Figure 2. The scores reflect how important older adults thought of each feature and what they wanted from assistive social robots. Ranking in order of importance started with physiological needs on top, followed by advanced needs, and social needs. A repeated measures ANOVA was used to test the differences among the mean values of the three factors. Bonferroni testing results show that the mean value of the physiological needs (mean = 5.96, SD = 0.80) are statistically significantly higher ($p < 0.001$) than the mean value of the advanced level (mean = 5.37, SD = 0.90), and also statistically significantly higher ($p < 0.001$) than the mean value of the social level (mean = 5.00, SD = 1.29). The mean value of advanced needs (mean = 5.37, SD = 0.90) are statistically significantly higher ($p = 0.033$) than the mean value of social needs (Mean = 5.00, SD = 1.29).

4.3. Factors Contributing to Older Adults' Acceptance of Assistive Social Robots

A regression analysis was performed to investigate how the three factors (mean = 5.34, SD = 1.14) affect older adults' intention to use assistive social robots. Use intention was determined by asking three questions to older adults' regarding interest (mean = 5.29, SD = 1.33), use intention (mean = 5.44, SD = 1.15), and subjective predicted use frequency (mean = 5.29, SD = 1.18) of assistive social robots. The results show that older adults' advanced needs and social needs significantly influence their use intention (R value = 0.781, R square = 0.610, adjusted R square = 0.589), which explains 61.0% of the total variation. A Durbin-Watson test showed a DW value of 1.802, meaning that the factors are independent of each other. The influence of older adults' advanced needs and social needs on their use intention of assistive social robots is shown in Figure 3.

Table 3. Internal consistency of each part of the questionnaire.

Factors	Initial Eigenvalue	% of Variance after Rotation	Cumulative % after Rotation	No. of Items	Cronbach's Alpha
1_Advanced Needs	5.823	41.594	41.594	6	0.861
2_Physiological Needs	2.299	16.418	58.013	5	0.842
3_Social Needs	1.583	11.306	69.319	3	0.891

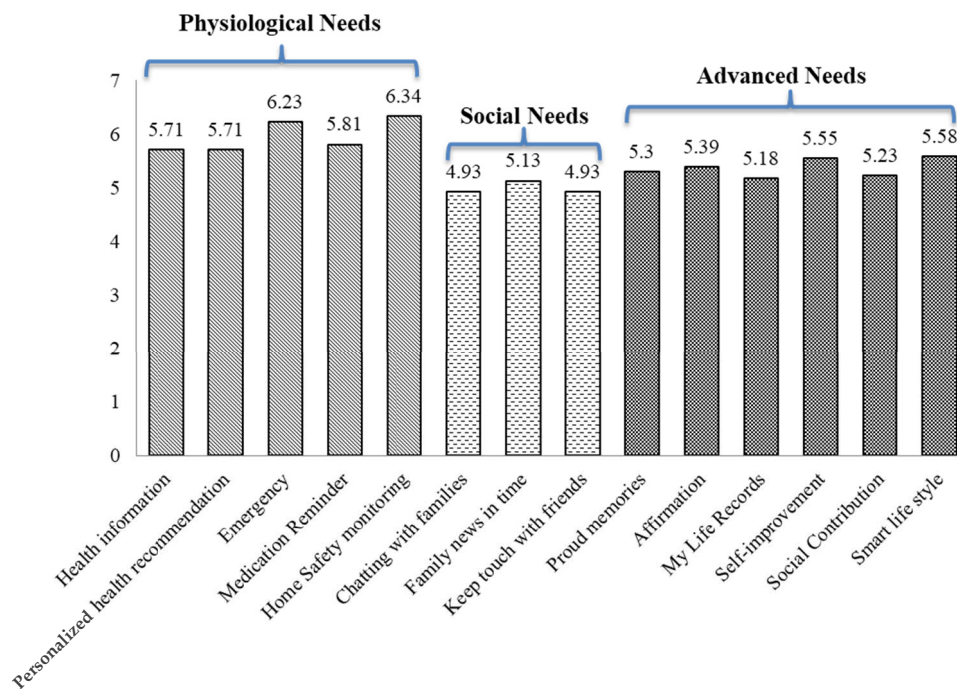


Figure 2. Older adults’ perceived importance of each aspect of assistive social robots.

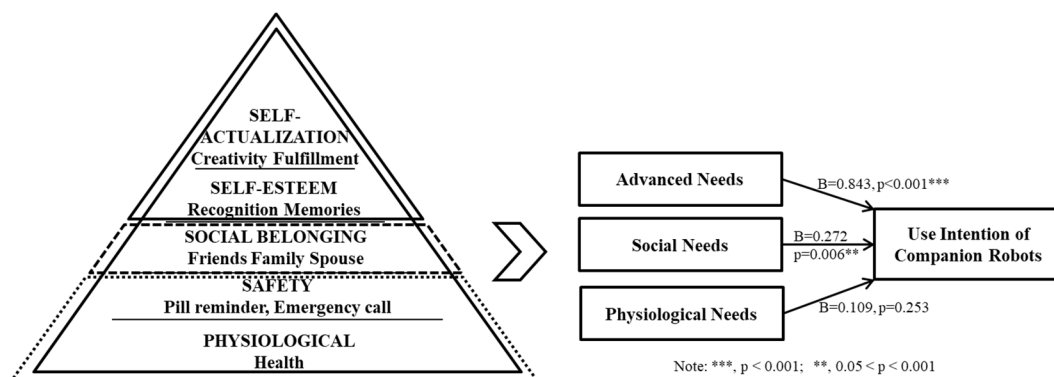


Figure 3. Regression analysis result between older adults’ needs and their use intention of assistive social robots.

4.4. Other Factors That May Have an Impact

In order to investigate whether subjects’ other characteristics had influence on their rating of the three factors, non-parametric tests were conducted to determine if there were differences due to gender and educational background. The results show that there are significant differences between the genders on their perceived importance of the factors of physiological needs ($Z = -2.538, p = 0.011$) and social needs ($Z = -2.200, p = 0.028$). The advanced needs were perceived as more important by female subjects (Mean = 5.62, SD = 0.85) than male subjects (mean = 5.01, SD = 0.86). The advanced needs of assistive social robots integrated Maslow’s human basic needs of self-esteem needs and self-actualization needs. It was found in previous studies that women had lower levels of self-concept [30] and self-esteem [31] than men, regardless of age, ethnicity [32], and social class [33]. Female older adults’ lower self-concept and self-esteem could be an explanation for their need for assistive social robots to provide such corresponding functions. In addition, the factor of social needs was perceived as more important by female subjects (mean = 5.30, SD = 1.16) than male subjects (mean = 4.60, SD = 1.38). It is found in the literature that compared to men, women preferred and more frequently used text messaging, social media, and online video

calls [34]. There are no statistically significant differences found for subjects' perceived importance of the factors when comparing groups with different educational backgrounds.

A correlation analysis was conducted on the subjects' age and their perceived importance of the factors, their experiences of using digital devices and their perceived importance of the factors, and their experiences of using robotic and intelligent technologies and their perceived importance of the factors. No significant difference can be found in these tests, meaning that the subjects' age and their experience of using digital devices and using robotic and intelligent technologies does not significantly influence their perceived importance of assistive social robots' functions and features on their advanced needs, social needs, and physiological needs.

5. Discussion and Conclusions

The survey results answer the two research questions in this study. Factor analysis results show that there are three levels of older adults' needs for expecting functions and features of assistive social robots. They are physiological needs, social needs, and advanced needs. These groups explain 69.3% of the total variance. These three factors that contribute to older adults' acceptance of assistive social robots are consistent with Maslow's five levels of human basic needs. According to older adults' self-report scores, the factor of physiological needs was perceived to be the most important need factor. This factor includes the first and second levels of Maslow's basic human needs: physiological and safety needs. The results imply that assistive social robots should have functions and features to help older adults with healthcare and to stay safe. The next perceived important factor was advanced needs, which include the highest two levels of Maslow's model (self-esteem and self-actualization). The last perceived important factor was social needs.

According to the regression analysis, the factors that significantly influence older adults' intention to use assistive social robots are advanced needs and social needs, which are not the two factors with the highest self-rated scores of perceived importance. In fact, the factor with the highest score of (self-rated) perceived importance is physiological needs. This result is slightly confusing at first glance, but can be explained. First, the advanced needs significantly influence the use intention of assistive social robots and was the second most important factor perceived by older adults. A similar result can be found in the literature. Boulton-Lewis et al. found that Australian older adults who were interested in learning, keeping up to date, valuing communication, and feeling younger were more likely to learn and use new technologies [35]. Weatherall found that New Zealand older adults began using computers because technology was associated with modern life [36]. For the factor of social needs, it is generally agreed that social ties play a beneficial role in the maintenance of psychological well-being [37]. A sense of belonging has recently been described and defined as a specific interpersonal process that influences health [38]. Social isolation is a major and prevalent health problem among older adults, leading to numerous detrimental health conditions [39]. From the result of this study, it can be shown that social need is a determinant of older adults' intention to use assistive social robots. Related functions and features would increase older adults' willingness to use assistive social robots. In regard to the last factor, physiological needs, both health and safety are basic human needs. Though the older adults in this study gave this factor the highest score in perceived importance, it does not significantly influence their intention to use assistive social robots. This can be explained by recognizing that functions related to health and safety are considered to be required functions. Although they do not significantly influence the intention to use assistive social robots, the absence of these functions will have a negative effect on how older adults would evaluate the product or system.

Older populations offer a sizeable market opportunity for robotic and intelligent technologies, but also present challenges in providing appropriate products and services. The implications of the results of this study can be useful for industrial stakeholders from the very beginning of the product design phase. The results of this study demonstrate which factors are perceived to be important to older adults and the factors that significantly

influence older adults' intention to use the products. In summary, among the three factors contributing to older adults' acceptance of assistive social robots, physiological needs were perceived to be the most important factor by older adults, followed by advanced needs and social needs. The functions and features of assistive social robots within these aspects should be provided to older adults. Second, the factors of advanced needs and social needs significantly influence older adults' use intention of assistive social robots. These results can be used as a reference to make assistive social robotic products that stand out by capturing the functionality that older adults perceive to be necessary and that influence their intention to adopt the technology.

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