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Mobile Service Robots for Older Adults' Mobility: Investigation of Their Attitude for Daily Assistance in Residential Environments

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Abstract

Background: As the world's aging population increases, care of older adults has become inevitable. Regarding older adults' care, mobility is the biggest struggle for older adults, whose bones and muscles deteriorate. The solution is to provide independence in built environments where older adults live and experience during their daily lives. Technological investigations raise the focus on care services within social assistive technologies. With the increasing need for older adults' care faced by governments, understanding practical solutions is crucial for social robot development. Aim: This research aims to examine the impact of the appearance of mobile service robots, explore changes in older adults' attitudes, and assess the potential mediating factors in the relationships between age and education. Another objective is to analyze the mobility tasks for daily life activities on the attitude of older adults towards service robots. Method: A survey design was created, with a sample of 19 from Antalya and Kocaeli, aged over 65, divided into 12 women and 7 men. First, older adults conducted a survey to elaborate on their mobility problems. Later, older adults were asked to complete another three-part survey to assess their attitudes toward mobile service robots and their daily activities. All data were collected by using self-reported questionnaires in their residential environment. These data were analyzed through descriptive analysis to create Interpersonal Circumplex. The relation between age and attitude was calculated through the Pearson Correlation. Independent Samples t-Test explored older adults' attitudes toward service robots in daily activities. Findings: The findings revealed that the mobile service robots' appearance affected the older adults' attitudes, whereas age was the mediator that impacted older adults' attitudes, unlike education. Results: Moreover, the results demonstrated that older adults having difficulty in daily activities needed more privacy and were more distant from the mobile service robots.

Keywords:

SARs · Mobile Service Robots · Mobility · Daily Life Activity · Older Adults' Attitude

*Sorumlu yazar.

Introduction

The world population continues to age rapidly. According to the World Health Organization (WHO), aging is a crucial and inevitable process. Christoforou et al. (2019) indicate that this aging process varies from person to person due to social (the promotion of dialogue between patients and their carers), financial, physiological (improvement of vital signs), and psychological (relaxation, and motivational factors) (Kumar et al., 2017). For this reason, this issue has become a central issue for health professionals and governments (Fiorini et al., 2021). Because of the increase in the older adults' population, the development and application areas of care services for older adults are also expanding (Pedersen et al., 2018). Older adults in assisted living facilities and nursing home residents struggle to maintain their social connections and psychological well-being, particularly when their physical and cognitive abilities deteriorate (Cooper et al., 2020).

As people age, there is a demand for assistive technologies that can support older adults in their daily lives (Kyrarini et al., 2021). The main reason is mobility tasks, which are the biggest challenges for older adults (Cunningham et al., 2020). The muscles, bones, and joints undergo physiological changes that affect mobility and which can ultimately impact their independence at home (Wu et al., 2021). In this case, mobile service robots (MSRs) from Socially Assistive Robots (SARs) are an option to solve this problem to assist older adults with mobility tasks in residential areas for their daily activities (Christoforou et al., 2019; Kittmann et al., 2015). However, there needs to be more research on the impact of MSRs on older adults' attitudes toward mobility tasks in residential areas. The existing literature (Fischinger et al., 2016; Mendez et al., 2022; Zafrani et al., 2023) generally focuses on the technological aspects of SARs on the perception of older adult users.

On the other hand, this study aims to investigate the impact of mobile service robots (MSRs) on the attitude of older adults toward mobility tasks in residential areas. This is to see the older adults' attitudes toward the mobile service robot types, Ro-bear, Care-O-Bot, and Kompai, created for movement and assistance features. It explores the potential concerns of using MSRs for mobility tasks in residential areas from the perspective of older adult users. The preferences for the appearance of the robots according to older individuals' attitudes are defined to determine the role of mobile service robots in mobility tasks. Identifying factors influencing their attitudes is measured using three scales to assess the relations. Consequently, the study contributes to developing assistive technologies that can improve the quality of life of older adults for their daily activities in residential areas.

Reviewing Literature

For the literature strategy, thematic analysis was used by classifying themes and codes. This study has three themes: service robots, service robots in residential environment, and mobility requirements for daily living activities (Figure 1). Theme 1 emphasizes that several types of robot

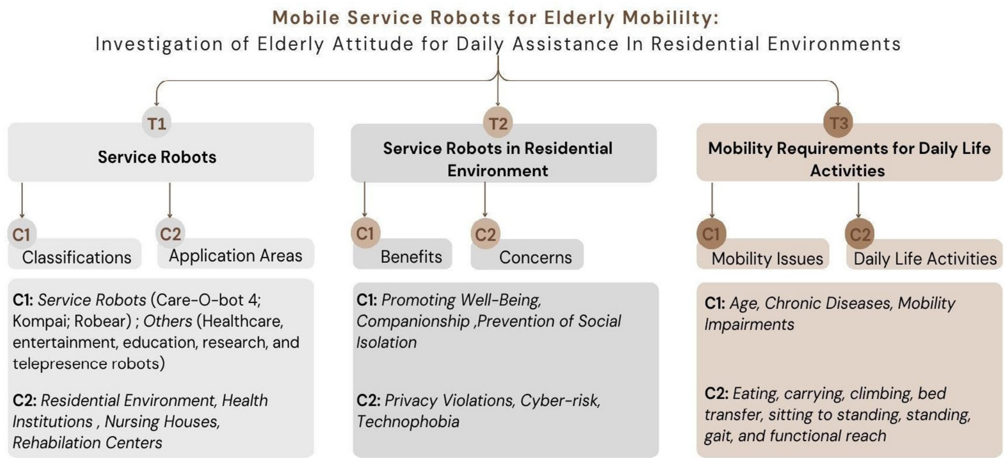

Figure 1: The Thematic Analysis Diagram of the Study (Authors, 2023).

categories, especially service robots, offer significant potential to assist the daily activities of older adults in residential areas. After that, theme 2 shows the attitude of older adults against the assistance of mobile service robots in their homes regarding benefits and concerns. The final theme is theme 3, which discusses how mobility is essential for everyday life but can be difficult for older adults with physical limitations due to age or disease. Mobile service robots may be a solution to promote the welfare of older adults.

Social Assistive Robots (SARs)

Social robots are assistive technology that helps healthy people, older adults, and those with cognitive disabilities keep their freedom and enhance their well-being (Alonso et al., 2019). Mahdi et al. (2022) categorized Social Assistive Robots according to their service, healthcare, entertainment, education, research, and telepresence ability. Some assistive robots might be utilized in households to help with daily tasks such as cooking, cleaning, and dining, as well as handovers, in which the robot provides an object ordered by the end-user (Cooper et al., 2020). Assistive Robots for older adults can generally be divided into rehabilitation robots and assistive social robots, which have two sub-groups: service robots and companion groups (Kachouie et al., 2014). Rehabilitation robots focus on physical assistive technologies, intelligent wheelchairs, prosthetic limbs, and exoskeletons, which do not often include communication capabilities (Cooper et al., 2020). Essential independent living functions like eating and bathing, moving about and navigating, or monitoring are supported by service robots (Kittmann et al., 2015), which this study emphasizes. Lastly, companion robots aim to improve older individuals' physical and mental health (Shibata et al., 2011). This paper focuses on the attitudes of older adults with mobility issues toward mobile service robots from socially assistive robots.

Mobile Service Robots

Among the different types of robot categories, service robots, especially mobile service robots, offer significant potential to assist daily activities with their broad range of capabilities, such as transporting items, detecting people or objects, and training the mind (Asgharian et al., 2022). Several extended mobile service robots have been found in the literature: Care-O-Bot, The Robovie-II, The Pearl robot, Personal Robot 2 (PR2), The Bandit II robot, Kompaï, The HealthBot, The SCITOS A5 robot, Pepper, RAMCIP, Hobbit, TIAGo, ARI (Asgharian et al., 2022; Cooper et al., 2020; Kachouie et al., 2014; Kittmann et al., 2015; Shibata et al., 2011; Zsiga et al., 2018). Some mobile service robots are excluded due to limited applications. This study focuses on three popular mobile service robots with different appearances and provides extender applications by their functions to use older adults' care. These robots are classified as Care-O-bot, Kompai, and Robear.

Care-O-bot Robots

A multifunctional service robot named Care-O-bot can help individuals with their daily activities. Care-O-bot has four generations; the last version, which is the 4th in Figure 2, was released in 2015 by the Fraunhofer Institute for Manufacturing Engineering and Automation. Care-O-bot 4 robots can perform various tasks involving delivering and collecting items, independent living for older adults, monitoring or tracking, welcoming customers, and assisting in retail stores or museums (Moyle, 2019). It can independently and safely navigate the environment, interact with older individuals, and direct them as they perform activities. The robot could identify individuals, understand human speech and gestures, and communicate with users (Graf et al., 2009; Kittmann et al., 2015).

Figure 2: Care-O-bot robots 1999, 2004, 2009, and 2015 (Kittmann et al., 2015).

KOMPAÏ Robots

A social assistance mobile platform called Kompaï (Figure 3) was created in three versions by the French company KOMPAÏ Robotics (Kompairobotics, 2020). The Kompaï robot offers various services, including social integration, cognitive stimulation, day and night surveillance, mobility support, fall detection, agenda management, shopping list management, and health management (Shishehgar et al., 2018). The Kompaï robot can also understand speech, travel around unfamiliar settings, detect accidents, and recognize potentially dangerous circumstances (Wu et al., 2014). The robot has little handles to assist older adults in standing and may be controlled by voice commands and a touch screen. The third edition of the Kompaï platform has been modified for accessibility (Zsiga et al., 2018).

Figure 3: Kompaï Robots 2009, 2016, 2019 (Kompairobotics, 2020).

Robear Robots

Robear was designed by scientists from RIKEN and Sumitomo Riko Company Limited as a robot that can transport humans (Figure 4) (Bedaf et al., 2017; Christoforou et al., 2019). The robot has features for helping with everyday activities for older people to help them maintain their independence, social connections, and active lifestyles (Bedaf et al., 2017). It is a large, plastic caring bear designed to help people with movement issues and is especially beneficial for individuals who require lifting, transferring, and moving throughout the day (Wiederhold, 2017). The robot helps older adults live independently and interact with others (Zsiga et al., 2018). Due to its size and weight, it can perform jobs like getting patients out of bed and actively helping caregivers with physically challenging chores (Trobinger et al., 2021).

The robot can pick up a patient from the floor, a difficult task that caregivers must frequently perform (Bedaf et al., 2017). Robear has actuator units that allow the joints to move rapidly, and its back drivability allows gentler movement (Riken, 2015). Theoretically, the robotic bear is strong enough to lift a patient from a hospital bed while remaining soft enough to comfortably transport a sensitive human body (Wiederhold, 2017). However, the technology is still not commercially accessible, and the notion has to be proven in real-world settings (Bedaf, 2017).

Application Areas of Mobile Service Robots

Mobile service robots for older individuals have numerous uses and can be employed in various settings based on their functionality and purpose.

Figure 4: Robear Robot (Riken, 2015).

These mobile service robots can help older adults with their daily activities to increase their quality of life in their homes (Kang et al., 2023). It benefits older people who live alone and may not have family or caretakers to aid them (Bulgaro et al., 2022). Furthermore, the most common areas where mobile service robots are preferred are health and nursing institutions to assist caregivers in helping older adults (Plöthner et al., 2019). For example, mobile service robots can be utilized in hospitals to aid medical caregivers with health monitoring and medicine administration responsibilities (Bishop et al., 2023; Jin & Choi, 2022).

Nevertheless, mobile service robots do not only help caregivers by monitoring the patients but also have the opportunities to give physical and mental wellness (Persson et al., 2021). This is because mobile service robots have the potential to reduce loneliness, reinforce interpersonal communication, and enhance mood while reducing stress (Zöllick et al., 2021). Consequently, mobile service robots may be used in residential environments and health and rehabilitation centers beside nursing houses with several purposes to help older adults with or without the help of caregivers.

Mobile Service Robots in Residential Environment

Mobile service robots have started to take a crucial role in the residential environment to assist older adults in their daily activities (Christoforou et al., 2019). Socially assistive technology (SAT), including mobile service robots, has potential benefits in promoting well-being for older individuals living at home (Kang et al., 2023). One of the biggest reasons for this is the difficulty of movement due to the weakening of muscle movements due to age (Wu et al., 2021). In these situations, service robots can support their motion and movement by supporting their mobility (Shishehgar et al., 2018). In addition, many older individuals live with caregivers or alone, but service robots also act as companion to accompany them (Chen et al., 2019). The conversational function is essential for older adults at risk of social isolation (Kang et al., 2023). Regardless, although service robots provide convenience by doing multiple activities people need at home, there are some concerns about their technical abilities (Shareef et al., 2021). These concerns may vary from the young to the senior generation (Mendez et al., 2022). It may be because young people are more involved with technology, but older adults still feel more distant from technology. One of the biggest reasons for this is the fear of technological devices breaking and the risk of giving unexpected reactions and injuries (Coco et al., 2018).

On the other hand, there may be some security issues caused by significant privacy violations (Shareef et al., 2021; Zafrani et al., 2023). It is because several socially assistive robots have advanced sensors, mics, and cameras (Romero-Garcés et al., 2022). Nonetheless, some people may believe that these components put the privacy of the home at cyber risk because of the feeling of being watched (Christoforou et al., 2020; Romero-Garcés et al., 2022). That may be why they have boundaries to acquire the robot in their homes. As a result, although there is no detailed research on older people's attitudes toward service robots, some studies (Coco et al., 2018; Fischinger et al.,2016; Zafrani et al., 2023) show that fear and trust are two of the most significant factors in older adults wanting an assistive robot in their homes.

Mobility Requirements for Daily Life Activities

Mobility is a crucial mechanism for a person to shift his position or location by creating movement and motion. (Soubra et al., 2019). However, mobility ability may change according to age, physical health, and chronic diseases (Maresova et al., 2019). This situation may negatively impact the life quality of the older adults (Fiorini et al., 2020). That is why older adults with mobility impairments fear falling and standing up to do their daily duties (Erdem & Emel, 2004). In this point, Social Assistive Robots (SARs) are considered a potential mobile service robot alternative to promote older individuals' welfare in their daily lives and help families by reducing their caregiving responsibilities (Fiorini et al., 2020).

In residential environments, older adults with limited body mobility need assistance with daily activities such as eating, dressing, getting in or out of a bed or chair, taking a bath or shower, and using the toilet (Kachouie et al., 2014). For instance, eating activity requires arm support for restricted body movement. For this purpose, an experiment was conducted with the service robot holding a spoon with yogurt and a fork pinching a French fry (Canal et al., 2016). However, although this is an eating solution, carrying activity in residential areas could be more effective. Daily physical activities at home, such as changing rooms and walking through neighborhoods, require mobility necessities (Yan et al., 2020). Smart walkers are examples of walking mobility services for disabled or older adults (Kyrarini et al., 2021). Most older adults have difficulties doing location shifts and climbing stairs for daily routines (Kachouie et al., 2014). Changing physical position includes mobility issues, such as bed transfer, sitting to standing, standing, gait, and functional reach, which refers to movement in an upright position (Atoyebi et al., 2019). This research concentrates on mobility issues, which are the most encountered problems in residential environments: climbing stairs and transferring the bed to a chair and back.

Methodology
Research Questions & Hypotheses

The research questions were created by taking the base of the themes explained above. Three research questions bring the research to the desired and planned point. In that case, the research questions are as follows:

RQ1: How does the appearance type of service robots influence the attitudes of older adults?
RQ2: How do older adults' attitudes differ against service robots in residential environments according to their age and education?
RQ3: Which mobility task for daily life activities impacts the attitude of the older adults towards the service robots?

In response to these research questions, the following hypotheses are formulated:

H1: Unlike animal and technical-like robots, human-like service robots negatively affect older adults' attitudes.
H2: The positive attitudes of the older adults about service robots in residential environments differ according to their education but not their age.
H3: Older adults with the problem of climbing the

stairs have a different attitude to service robots than older adults with transferring the bed to the chair and back.

Participant & Setting

The non-probability sampling method selected the elements from the sampling frame for this study. To reach the participants, convenience sampling was preferred. The population of the study is older adults with mobility problems who live in Türkiye. In Türkiye, Antalya, and Kocaeli cities were selected since they are among 10 crowded cities in Türkiye (TURKSTAT, 2022). To frame the population and focus on representative samples, older people who have difficulties with mobility tasks and are above 65 are participants. The research is limited with 19 participants because of some causes. The main reason for limiting the research to 19 participants is that they were selected according to the convenience sampling method to have participants with mobility issues below 14 scores on the Elderly Mobility Scale (EMS). This situation limited the number of participants to create a focus group. The participants who gained below 14 points from EMS were excluded. The setting of the study is the residential environments of the participants because it was conducted in an in-person survey. In addition, the participants with mobility problems are above 65, so being able to contact people in these age groups with high mobility issues is restricted.

Procedure

Exploratory research is used because this topic was not investigated in depth. For this research, the qualitative and quantitative methods are used as a mixed method by benefitting from the survey instrument (Figure 5). This study was a two-stage survey and had four main instruments: Elderly Mobility Scale (Yu et al., 2007), Semantic Differential Scale (Funakoshi et al., 2008), the Negative Attitude towards Robots Scale (Nomura et al., 2006), and Barthel Index (Mahoney & Barthel, 1965). Those four instruments are divided into two stages: first and second stage. Step one is conducting first-stage tests. The first stage test has two data collections (Demographic data collection and EMS). The demographic questionnaire includes gender, age, marital status, education, and area of residence. Then, a second data collection instrument Elderly Mobility Scale (EMS), was used to select the study's focus group by filling out the demographic questionnaire and EMS. The second part of the study begins after EMS is conducted and results are calculated.

The third phase of the study contains the second stage tests: Semantic Differential Scale, Negative Attitude towards Robots Scale (NARS), and Barthel Index (BI). This phase contains data gathering related to older adults' attitudes towards robots' appearances and assessment of functional independence—the Semantic Differential Scale experiments with three pictures of robots with adjective pairs. NARS and BI have a grading system. After completing the three instruments of the second part, the data collection is finalized.

Instruments

Elderly Mobility Scale (EMS)
The scale was developed by Yu et al. (2007) and contains seven items: lying to sitting, sitting to lying, sitting to standing, standing, gait, timed walk (6 meters), and functional reach. Scores under 10 generally depend on mobility maneuvers that require help with basic Activities of Daily Living (ADL), such as transfers, toileting, and dressing. Scores between 10 and 13, generally, are borderline in terms of safe mobility and independence in ADL; for instance, they require some help with some mobility maneuvers. Scores over 14 generally can perform mobility maneuvers alone and safely and are independent in basic ADL (Yu et al., 2007).

By comparing results with the Functional Independence Measure and Barthel Index, the EMS's concurrent validity was evaluated by Nolan et al. (2008). At 0.948 and 0.962, respectively, the EMS scores had a strong correlation. The Modified Rivermead Mobility Index and the EMS were also shown to be correlated (Spearman's rho = 0.887; Nolan et al., 2008). Thus, Elderly Mobility Scale is reliable to provide a scale for evaluating mobility that considers gait, balance, and essential position changes.

Semantic Differential Scale
It includes a *rated adjective pairs questionnaire* with pictures of three service robots. In order to use the semantic differential technique, two bipolar or opposing adjectives must be placed at either end of a scale (Albert & Tullis, 2022). Among the adjective pairs generated by Funakoshi et al. (2008), the most related ten adjective pairs are determined as: *Aggressive - Defensive, Wicked - Innocent, Inaccessible - Accessible, Sociable - Unsociable, Irresponsible - Responsible, Careless - Careful, Unsafe - Safe, Unfriendly - Friend-*

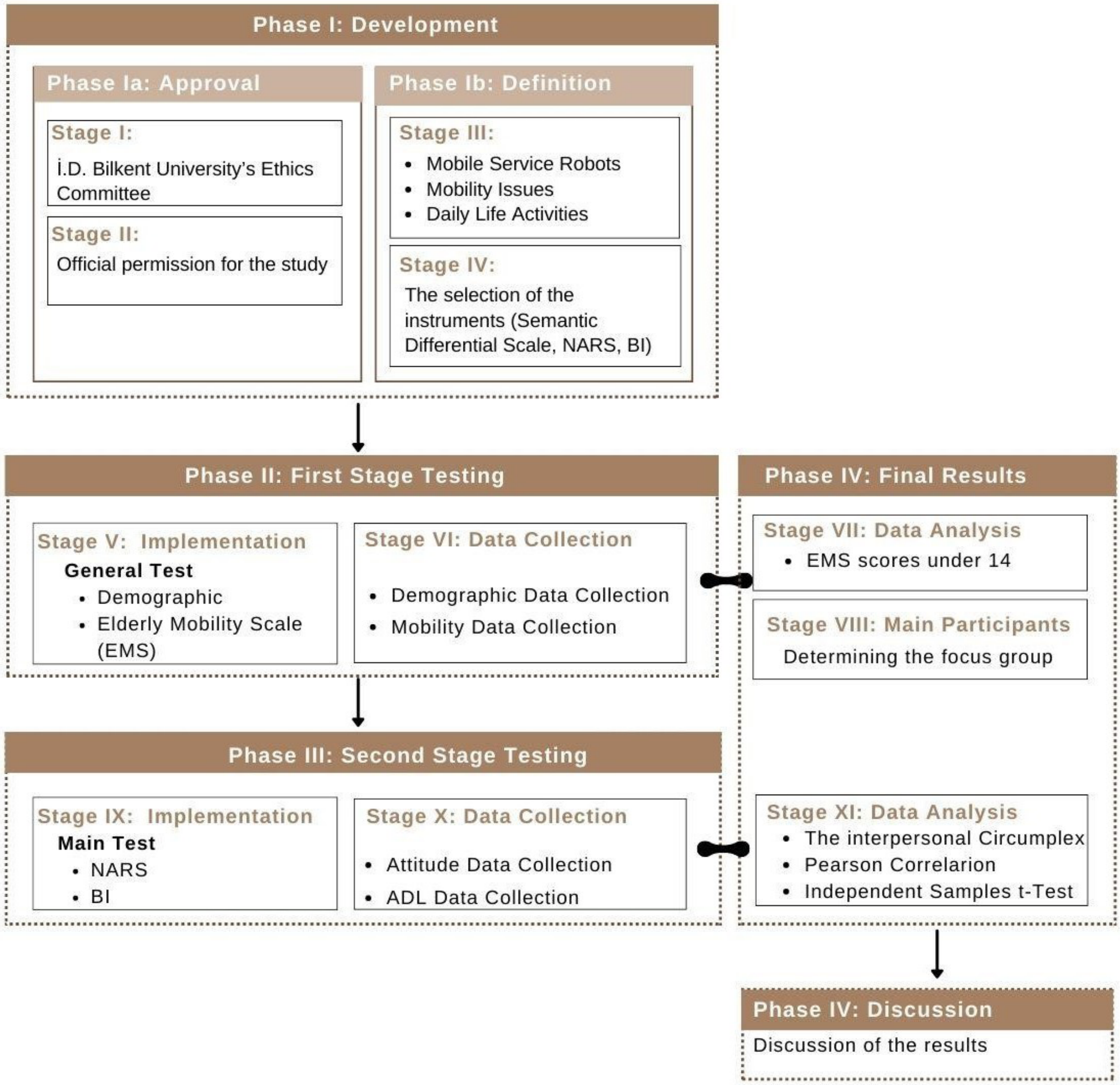

Figure 5: The Procedure Map of the Study (Authors, 2023).

ly, Gloom - Excited, Scary - Cute. Between these adjective pairs, a 5-point Likert scale is used. The Semantic Differential Scale by Funakoshi et al. (2008) is conducted in Turkish. To avoid having different connotations, the two authors translated the adjectives twice.

Negative Attitude towards Robots Scale (NARS)
NARS is one measure of assessing a person's attitude toward robots and is used to forecast when a human would want to engage with robots or not. NARS was created in Japan by Nomura et al. (2006) to assess people's overall hostility toward robots. NARS initially includes three subscales (interaction, influence, emotions) to measure people's attitudes toward robots. It consists of 14 items, rated from 1=I strongly disagree to 5=I strongly agree (Likert scale). The data is collected by in-person survey. According to the study with Japanese subjects (Nomura et al., 2006), the first subscale Cronbach's alpha value is 0.78, the second subscale is 0.78, and the third subscale is 0.65. Nomura et al. (2006) gave Erebak and Turgut (2018) their approval for the scale's Turkish translation. Thus, this study conducted NARS in Turkish translation of study. According to the reliability analysis findings by Erebak and Turgut (2018), the scale's overall Cronbach's alpha value is 0.83. For sub-dimensions, the first dimension's Cronbach's alpha value was 0.79, the second dimension was 0.83, and the third dimension was 0.71.

Barthel Index (BI)
Barthel Index (BI) was developed by Mahoney and Barthel (1965) for older adults' mobility problems through seven functional activities, including bed mobility, transfers, and bodily reaction to perturbation. The fundamental objective is to achieve a certain level of independence from any kind of assistance, verbal or physical, however modest and

for whatever cause. Any help should be considered (Mahoney & Barthel, 1965). The Barthel Index has 10 items with different weights measuring basic ADL. Two items regarding bathing and grooming; six items regarding feeding, dressing, controlling one's bladder, controlling one's bowel, toilet use (getting onto and off the toilet), and stair climbing (ascending and descending stairs). Two items regarding transferring (moving from a wheelchair to the bed and vice versa) and mobility (walking ability on a level surface) (Yi et al., 2020). This study excluded two items related to controlling one's bowel and bladder. According to Shah (1989), the 10-item has an alpha internal consistency coefficient ranging from 0.87 to 0.92. The Barthel measure was rated as having a correlation coefficient of .73 to .77 with a motor ability index. The Barthel Index was determined to be a simple-to-use and reliable instrument.

Data Collection & Analysis

The data were collected by a structured two-stage survey applied to the participants from Antalya and Kocaeli city in Türkiye. Both qualitative and quantitative (mixed) methods are used for data collection. The first step of the data collection process is determining the main participants whose daily living activities are adversely affected by dependence due to mobility issues. The surveys are applied in participants' residential environments. The first-stage data collection process is completed with 24 participants with a convenient sampling method for two weeks. The second-stage data collection is conducted on 17 participants who were eliminated by the first questionnaire. All data collection processes took place in participants' residential environments. Especially for the second stage of the data collection process, since it aims to gain insights into older adults' attitudes towards mobile service robots in residential environments, data was collected in their own homes.

The collected data were analyzed and finalized using Statistical Package for Social Sciences (SPSS) with version 22. After entering 63 variables in the questionnaire, quantitative data obtained from the participants were entered. For the analyses to be analyzed correctly, suitable data collection tools for the instruments and hypotheses used were selected (Table 1). Firstly, descriptive analysis was conducted for the first five questions that included the demographic characteristics of the participants. After that, the hypotheses started to be tested depending on the context of the hypothesis. The Interpersonal circumplex was created according to the mean and standard deviations of the results for the Semantic Differential Scale consisting of adjective pairs. In addition, The Pearson Correlation was chosen to examine the correlation between age and the attitudes of the older people with education toward robots. Finally, Independent Samples *t*-Test was used to examine older adults' attitudes toward service robots in daily activities.

Results

The methodology consists of two stages: the first and second tests. This section includes the results obtained during these phases, and the discussion part discusses the findings with the hypothesis and previous studies. The data acquired from Sections A, C, D, and E were analyzed quantitatively. In comparison, Section B was examined qualitatively for the first stage.

The Findings of the First Stage

The first stage consists of two sections. In the first section, demographic characteristics questions were given to determine whether the participants were suitable. The questions were given to 24 people, but according to the results of this section, five people were excluded because they were an inconvenience to the study. According to the results of the selected samples, there are 19 study participants; 12 are women, and 7 are men. 57.9% of the answers to the study are in the 65-74 age range (Table 2). On the other hand, there are no single people regarding marital status.

This study focuses on older adults with mobility problems. Hence, getting data from this sample group is crucial to achieving its goal. To create a focus group, Elderly Mobility Scale was given, and the result shows that 19 people were eligible to take the second-stage test because they scored below 14 for EMS. It means they have mobility problems and can handle them with assistance. According to the results of EMS, most participants (N=12; M=1,89; SD=1,823) had difficulties with functional reaching. On the other hand, only 5 of them (N=5; M=1,63; SD=1,63) required help transitioning from sitting to lying. The findings indicate that physical performance declines with age, with the oldest age group suffering the most.

The Findings of the Second Stage

The second stage has three sections: Section C, Section D, and Section E. For Section C, three different service robots include adjective definitions over human-like, technical-like, and animal-like. According to the robot pictures, the participants chose their proximity to the adjective pairs to show their attitudes toward the appearance of the service robots (Figure 6). The results here showed that none of the participants (N=0; M=0,00; SD=1,58) demonstrated the "social or asocial" approach to the human-like robot, Kompai. On the other hand, 14 people (N=14; M=1,11; SD=1,05) used the adjective "defensive" for Kompai. In addition, 16 people (N=16; M=-1,47; SD=0,62) used the adjective "aggressive" for the technical-like robot Care-O-bot, while no one marked positive adjectives. As the final appearance of the robot, Robear, all participants (N=19; M=-1,82; SD=0,39) used the adjective "cute" for the animal-looking robot.

<table>
<tr><th>Hypotheses</th><th>Variables</th><th>Instruments</th><th>Methods</th><th>Data Collection</th></tr>
<tr><td>H1</td><td rowspan="3">Independent: Service robots

Dependent: Attitudes of older adults
Mediator 1: The appearances

Mediator 2:
*Age
*Education</td><td>Semantic Differential Scale</td><td>Experiment</td><td>The Interpersonal Circumplex</td></tr>
<tr><td>H2</td><td>The Negative Attitudes Towards Robots Scale (NARS)</td><td>Survey</td><td>Pearson Correlation</td></tr>
<tr><td>H3</td><td>Barthel Index (BI)</td><td>Survey</td><td>Independent Samples t-Test</td></tr>
</table>

Table 1: Data Analysis Methods of the Study (Authors, 2023).

On the other hand, section D includes the negative attitude scale towards robots. According to the information obtained here, most of the participants agreed with the items "I would hate the idea that robots or artificial intelligence were making judgments about things" (M=-4,59; SD=0,61) and "I would feel uneasy if robots really had emotions." (M=-4,59; SD=0,71) (Table 3). According to the age groups, all (N=19) do not accept the statement, "I feel that in the future, society will be dominated by robots." (M_{age}=2,47; SD_{age}=1,46). In addition, in the 65-74 age group, the results of "I would feel very nervous just standing in front of a robot." indicates that they disagreed with the statement and took a positive approach (M_{age}<65-74>=2,89; SD_{age}<65-74>=1,45). Based on the education variable, only illiterate people approached the item positively, "I feel that in the future, society will be dominated by the robots." and agreed with the correctness of the sentence ($M_{education}$<Illiteracy>=3,50; $SD_{education}$<Illiteracy>=0,70).

The Pearson Correlation was used to see the relationship between the older adults' attitudes regarding age and education. The items of NARS show that the age factor is related to negative attitudes. The analysis shows a statistically significant relationship between age and attitude (*p-value=* *<0.05; p=0.056*). Thus, NARS01, NARS02, NARS04, NARS05, NARS05, and NARS07 items have no statistically significant correlation with age. Moreover, NARS03 and NARS12 items have a statistically significant correlation. However, the education factor has no statistically significant correlation with NARS items ($p\text{-}value_{\text{all items}} > 0.05$).

Section E gives the results of the Barthel Index (BI) with eight items. An Independent Sample *t*-Test was used to figure out the effect of BI on NARS. According to results obtained, the participants with feeding problems have a statistically significant difference (*p-value*=0.028<0.05) with NARS01. Therefore, the participants may feel uneasy if they were given a job where they had to use robots related to feeding. Also, with the significance of NARS07 (*p-value*=0.043<0.05), participants may feel uneasy if robots had emotions in doing feeding activities. In addition, the participants who have bathing (*p-value*=0.035<0.05),

Individual-level Variables	*N*	**Percent (%)**
Gender		
Male	7	36,8
Female	12	63,2
Other	0	
Age Group		
65-74	11	57,9
75-85	6	31,6
86 and above	2	10,5
Marital Status		
Single	0	0
Married	9	47,4
Divorced	1	5,2
Widowed	9	47,4
Education Level		
Illiteracy	2	10,5
Literacy	4	21,1
Pre-school	1	5,3
Middle-school	2	10,5
High-school	5	26,3
Bachelor Degree	3	15,8
Master's Degree and above	2	10,5

Table 2: Distribution of participants in terms of demographic characteristics (Authors, 2023).

grooming (*p-value*=0.048<0.05), toilet use (*p-value*=0.048<0.05), and transfer (bed to chair and back)(*p-value*=0.012<0.05) have a statistically significant difference with NARS03. Thus, participants may feel very nervous standing before a robot while doing the activities: bathing, grooming, toilet use, and transfer. Also, according to the statistically significant difference between NARS08 and stairs activity (*p-value*=0.043<0.05), the participants would not depend on robots to climb the stairs.

Discussion

This section discusses the findings in the context of the research objectives and relevant literature. The study aimed to investigate (i) the effect of the appearance of mobile service robots on the older adults' attitudes, (ii) whether education and age have different impacts on older people, and (iii) which mobility problems, such as climbing stairs and transferring the bed to the chair and back have different effects or not. According to the revealed results, technical-like mobile service robots affected older adults' attitudes negatively. In contrast, animal-like and human-like mobile service robots have positive impacts. However, human-like mobile service robots have lower positive attitudes. Furthermore, age has different impacts on older people, unlike education level. Moreover, older adults with the problem of climbing the stairs have a positive approach to mobile service robots; however, they do not have the same attitudes toward transferring the bed to the chair and back. Additional to these results, the findings indicate that physical performance decreases with the age of the participants, namely the oldest age group suffering.

Similarities and differences were observed by comparing all findings with the previous investigation regarding the research scope. The finding advocates the study of Lehmann et al. (2020), who also conducted the discussion of the appearance of the robots based on the "uncanny valley." However, there is a lack of the impact of animal-like robots on older adults' attitudes. This study includes animal-like robots on older people and proves the investigation of Broadbent et al. (2009). In this approach, animal-like robots like Robear have almost the same positive impacts.

Based on the results, the findings indicate that age is the primary mediator affecting older adults' attitudes toward mobile service robots. However, this study contradicts the conclusions of Huang and Liu (2019), who defend the education level as a mediator for older adults' attitudes. These discrepancies can be attributed to age and education level differences in the other approaches of several fields. The interpretation of the main reason why education is thought to be a significant factor is that educated people are more open to technology and innovative approaches. However, according to the results, this does not have a negative or positive effect on older people's attitudes towards robots. The findings reveal evidence that older individuals showed a negative attitude towards mobile service robots for daily life activities with privacy. These findings are parallel with the investigation of Caine et al. (2012), who forward the same thought for privacy concerns. Also, Liu and Liu (2009) stated that older people with climbing and transferring mobility problems are open to using robots. This study also showed that this is the equivalent outcome for mobile service robots.

Conclusion

This research examines mobile service robots with the older adults' attitudes toward mobility issues considering daily living activities, which is a practical issue in aging in residential environments. The study discovered that physical ability reduces with increasing age. Moreover, the study revealed that climbing stairs activity is less favored among the study participants, and they demonstrate discomfort in feeding activities assisted by robots with emotions. Notably, most participants consider an animal-like robot, Robear, "cute." The findings help assistive technologies comprehend how to develop robotic systems for older adults while considering aging, user preferences, and emotional factors.

In conclusion, the present study sheds light on mobile service robots for older adults' mobility to understand older attitudes toward daily assistance in residential environments. The findings partially support the initial hypotheses. Hypothesis 1 was rejected because human-like robots have a lower positive effect on older adults' attitudes.

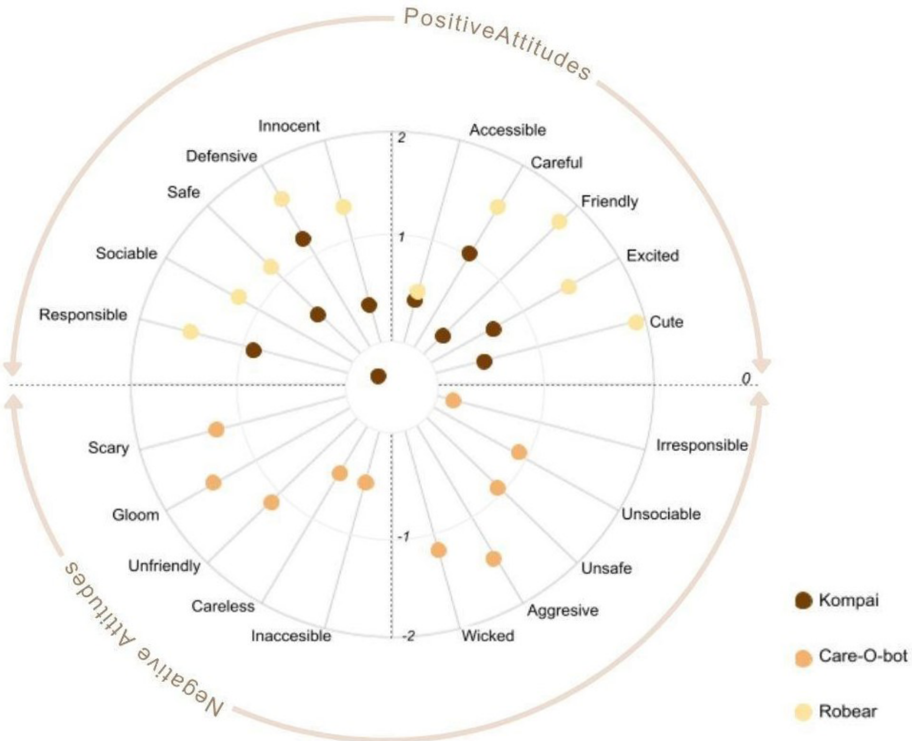

Figure 6: Attitudes distribution of older adults towards three different service robots according to appearance (Authors, 2023).

Item No	Questionnaire Items for NARS	Mean	SD
NARS01	I would feel uneasy if I was given a job where I had to use robots.	4,29	0,985
NARS02	I would feel nervous operating a robot in front of other people.	4,29	1,047
NARS03	I would feel very nervous just standing in front of a robot.	3,47	1,375
NARS04	I would feel paranoid talking with a robot.	3,82	1,286
NARS05	I would hate the idea that robots were making judgments about things.	4,59	0,618
NARS06	I would feel uneasy if robots really had emotions.	4,59	0,712
NARS07	Something bad might happen if robots developed into living beings.	4,12	0,781
NARS08	I feel that if I depend on robots too much, something bad might happen.	3,94	1,029
NARS09	I am concerned that robots would be a bad influence on children.	3,53	1,231
NARS10	I feel that in the future society will be dominated by robots.	2,47	1,463
NARS11	I would feel relaxed talking with robots.*	2,12	1,364
NARS12	If robots had emotions I would be able to make friends with them.*	1,76	0,97
NARS13	I feel comforted being with robots that have emotions.*	1,94	1,197

*Inversed item.

Table 3: Descriptive Analysis for each item of NARS (Authors, 2023).

Also, Hypothesis 2 was rejected, as a significant relationship was found between age and the older adults' attitude toward mobile service robots, not education. As a final, Hypothesis 3 was supported because it indicated that older adults with climbing and transferring problems generally favor mobile service robot usage. The findings contribute to the human-robot interaction field by considering older adults' mobility. It is the expectation that this research will encourage further exploration and advance knowledge by filling a gap in the literature. The novelty of the approach of this investigation lies in the main issues of older people that they can encounter in their daily life activities. This study adds to the growing body of research on the impacts of mobility issues in the field. It should not be forgotten that the results of this research are based on the participants' attitudes. That is why the results are interpreted according to their attitudes and perceived responses. This research provides predictions for the future robot and older adults' relations and the possible attitude of older adults.

Implications & Limitations of the Study

Social robots' physical appearance has been found significant by many researchers (Asgharian et al., 2022; Ihamäki & Heljakka, 2021; Van Der Plas et al., 2010). This investigation provides implications by revealing the increase in mobility issues as older people age, affirming the need for mobile service robots. However, the study found that reliance on mobile service robots differs among mobility issues, especially for climbing stairs activity; personal mobile service robots are required. By covering issues with aging, user attitudes, and affective considerations, these insights can direct the creation of mobile service robots that target the particular needs of older users, enhance usability, and increase user acceptance. In addition, the finding suggests that the physical appearance of mobile service robots influences older adults' attitudes, which provides implications for social assistive technologies.

The study is limited to older people with mobility problems and may not be generalizable to other older populations. The scope of the study excluded various demographic questions such as previous occupations and the number of electronics in their home. Considering those demographic factors may also reveal significant results. According to the procedure of the study, the older adults are shown three different appearances of robots which is challenging to imagine doing daily activities with the robots. In this study, actual robot use could not be assessed. It requires further study to clarify the complex assessments and judgments older individuals make when determining older adults' attitudes toward various health issues. Long-term research must be conducted on how older adults can use mobile service robots and how daily activities alter from older people to different demographics.

Recommendations for Future Studies

To overcome the limitations of this study and enhance the knowledge of mobile service robots for older adults' care, several directions might be investigated. Future research should be conducted on many participants, including older adults with various health issues, cognitive disabilities, and psychosocial difficulties. Thus, researchers can know how these characteristics affect the attitudes and usefulness of robots among older adult groups by including a more varied sample. In addition, future research should take into account demographic features more. An in-depth examination of these demographic factors may provide significant facts about the preferences and attitudes of older adults.

For further studies, it is essential to conduct research that entails actual interaction with robots in a natural environment for a deeper understanding of the mobility issues of older adults. Gaining knowledge on how older adults with mobility issues engage with robots in their daily living activities can influence the design of future mobile service robots. Researchers may obtain real-time input and discover practical implementations by examining actual robot operations. Studies conducted over an extended period are necessary to understand how mobile service robots assist daily living activities. Thus, longitudinal studies may provide insight into the overall influence of robotic assistance on older adults with mobility issues, potential changes in attitudes and behaviors, and usefulness.

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