Determinants of Attitude to a Humanoid Social Robot in Care for Older Adults: 
A Post-Interaction Study

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Background: While there is a growing body of research examining opinions on social robots in elderly care, there is a lack of comprehensive studies investigating the underlying factors influencing these opinions. The Godspeed Questionnaire Series (GQS) measures perceptions related to human-robot interactions (HRIs). The Comprehensive Geriatric Assessment (CGA) is widely used to evaluate physical, cognitive, and social functions of older patients. The EASYCare 2010 Standard (EC) is a tool for assessing unmet needs in older individuals. TIAGo, a social humanoid robot, integrates perception, navigation, and HRI capabilities. This study aimed to identify the determinants of perception following interactions between older individuals and TIAGo, utilizing the GQS, selected CGA items, and EC.

Material/Methods: We analyzed a database of opinions from older individuals who interacted with TIAGo, based on the Users’ Needs, Requirements, and Abilities Questionnaire. We examined the relationships between the robot’s roles (companion/assistant/useful device), its assistive/social functions, and various characteristics of the older participants.

Results: The study included 161 participants (mean age: 75.2±9.8 years), comprising 89 women and 113 institutionalized individuals. Positive correlations were observed between the robot’s role, its functions, and the participants’ perceptions across most evaluated parameters (Anthropomorphism, Animacy, Likeability, Perceived intelligence, Perceived safety). Only a few individual correlations were found for other parameters.

Conclusions: The primary determinant of older individuals’ opinions was their perception of the robot. Therefore, involving older adults in the co-design process of such robots is crucial. Additionally, a paradigm shift is needed in the study of humanoid social robots, focusing on successful aging rather than deficits associated with aging.

Keywords: Aged • Geriatric Assessment • Needs Assessment • Patient Care • Robotics

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/941205

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Background

Aging of societies presents an increasing challenge [1]. The rising percentage of older people, especially the “oldest-old,” needs attention on many levels since a substantial fraction of these persons require support in everyday functioning [2,3]. Simultaneously, the ability to employ working-age people, particularly trained caregivers, is more and more limited, which means that securing this support is increasingly difficult [4]. The current paradigm of “aging in place” requires that all possible actions be taken to enable the aging persons to live in their homes for as long as possible instead of institutionalization [5,6]. One of the ways to achieve this goal, given the shortage of potential caregivers, which is not likely to improve anytime soon, may be a deployment of technological solutions [7], therein, especially the ones using socially-assistive robots [8].

Older people constitute a heterogeneous societal group with widely differing characteristics of health and independence [9]. This also means that the abilities and needs of individual persons differ, sometimes significantly. Since there reportedly is no “one-size-fits-all” technological solution for the analyzed area [10], investigating the determinants of perception and acceptance of robots in elder care may be a good way to provide tailored interventions that meet the future users’ needs and expectations and thus enhance the chances for a successful implementation. Although there are numerous acceptance studies related to older subjects in the literature [11,12], to the best of our knowledge, no effort has so far been undertaken to comprehensively analyze the results of the geriatric assessment as potential determinants of attitudes to robots in care for older adults.

We previously analyzed the attitudes of various stakeholders to the TIAGo robot (PAL Robotics, Barcelona, Spain): first, by presenting them with a static picture of a humanoid social robot and then by letting the potential users interact with it. We developed and validated a dedicated assessment tool – the Users’ Needs, Requirements, and Abilities Questionnaire. With its help, we observed consistently high acceptance of the idea of using social robots in care for older people. We also demonstrated that a real-world interaction with the machine influences some of the aspects of potential users’ opinions. In the current study, we focused on factors widely used in clinical and care practice: sociodemographic and self-assessment items, as well as selected scores from the Comprehensive Geriatric Assessment and needs assessed with a dedicated tool (EASYCare Standard 2010). Therefore, this study aimed to analyze these factors and users’ perceptions as potential determinants for the attitudes of older adults toward the roles and functions of the robot.

Material and Methods

Ethics Statement

The study was based on the analysis of a database of older people’s opinions about the use of robots in eldercare after interacting with the robot. The study was approved by the Bioethics Committee of Poznań University of Medical Sciences (Protocol No. 711/18). All studied subjects gave their consent for participation after receiving a full explanation of the nature of the study.

The Procedure of the Study

The investigation involved 161 older subjects with an average age of 75.2±9.8 years, including 59 aged at least 80 years (36.6%). In the participating group, there were 89 women (55.3%); 113 people lived in long-term care institutions (70.2%), and 48 were participants of daycare units, living in the community.

The inclusion criteria were at least 60 years of age, cognitive status ensuring understanding of questions and providing adequate answers, as well as the completeness of the data record for the current analysis.

The TIAGo Robot

During the study, the subjects had an opportunity to interact with the TIAGo robot (Figure 1). We used a customized version of the TIAGo, equipped with a range of sensors (an RGB-D camera for depth recognition, a thermal camera for following humans, an RFID antenna for tracing lost objects, a laser scanner, environment sensors, and radar sensors), a microphone, a loudspeaker, and a touch tablet for communication with the user. The robot used a wireless network to communicate with a remote computer (AIS – Ambient Intelligence System) connected via the Internet to a cloud-based Networked Care Platform. During the interaction, the participants could select options from cognitive games, reminders, safety measures, physical exercises, dietary recommendations, audio/video connectivity, news, and weather, as well as presentation of environmental values (eg, temperature, humidity, air pressure, air quality) [13].

The interaction sessions lasted from approximately 60 to 150 minutes, until every participant felt they had sufficient time to operate the machine, and included 11-23 older subjects, depending on the number of persons willing to interact and their degree of interest. Detailed rules for the data collection on the role of the robot in care for older adults were presented in a previous paper based on a study conducted in 6 long-term care institutions [13].
Methods

The Users’ Needs, Requirements, and Abilities Questionnaire

The opinions on the use of the robot in care for older adults were analyzed using the Users’ Needs, Requirements, and Abilities Questionnaire (UNRAQ). The questionnaire has been validated, and its good psychometric properties have been demonstrated [14]. It consists of affirmative statements grouped in 4 areas (A – Interaction with the robot and technical issues, B – Assistive role of the robot, C – Social aspects, and D – Ethical issues), to which the respondents are expected to respond on a 5-point Likert scale (I completely disagree, etc.). In the current study, the scores of the following statements were examined:

1. The robot should be a companion of the elderly person;
2. The robot should be an assistant to the elderly person;
3. The robot should be a useful device for the elderly person (something to be used when needed, with no other interaction).

Opinions on assistive and social functions were also analyzed. In the UNRAQ, there are 13 statements describing the assistive functions and 6 describing the social ones (a detailed description of the tool can be found in [14]). Mean scores of assistive and social functions were calculated for each participant – for the social functions, the calculation scheme was as follows:

\[ C = \frac{(C1 + C2 + C3 + C4 + C5 + C6)}{6} \]

where C was the resulting mean value for opinions on the social functions of the robot and C1,..., C6 represented numerical scores of the 6 individual statements on the Likert scale (1-5) for a given person. Analogous calculations were performed for the assistive functions.

Godspeed Questionnaire Series

The perception of the robot was measured with the Godspeed Questionnaire Series (GQS). GQS consists of 5 scales that assess features such as Anthropomorphism, Animacy, Likeability, Perceived intelligence, or Perceived safety of robots on a scale of 1 to 5 [15]. It has been broadly used in research on humanoid robots, as shown in the meta-analysis by Weiss and Bartneck [16].

The participants were also asked to fill out a basic personal data form and to declare their computer skills, ease of use of technology, and feeling of loneliness, and also to provide self-assessment of health and physical independence, all rated on a scale of 1 to 5.

Comprehensive Geriatric Assessment

The study included selected elements of Comprehensive Geriatric Assessment (CGA) and needs assessment for each subject. Within the CGA, evaluations of cognitive functions, mood, and functional capacity were performed. An overview of CGA assessments has been given by Parker et al [17], and an example of CGA implementation can be found in Conroy et al [18].

Mini-Mental State Examination

Cognitive functions were measured using the Mini-Mental State Examination (MMSE), according to Folstein [19]. The results were adjusted for age and education [20]. Only people who scored at least 15 on the MMSE scale were included in the analysis, as it is accepted that subjects meeting this criterion are able to understand questions and provide adequate answers [21,22].

Geriatric Depression Scale

Mood was assessed using the 15-item Geriatric Depression Scale (GDS), which is a screening tool for depression; positive screening: scores above 5, out of 15 possible [23].

Barthel Index, Lawton scale

The Barthel Index (BI) was used to evaluate independence in activities of daily living (ADL) [24]. The possible score is 0-100 points, and higher scores mean greater independence. Independence in the instrumental activities of daily living (IADL)
was measured using the Lawton scale, which includes 8 activities [25]. Each of them is rated on a scale of 0/1, where 1 means that it is performed independently.

**EASYCare Standard 2010**

Unmet needs were assessed with the EASYCare Standard 2010 (EC) tool. The authors have experience in using this questionnaire from previous studies [26-29]. This tool includes 49 items reflecting 49 needs in 7 domains:

- Domain 1: Seeing, hearing, and communicating (4 items);
- Domain 2: Looking after yourself (13 items);
- Domain 3: Mobility (getting around) (8 items);
- Domain 4: Safety (5 items);
- Domain 5: Accommodation and finances (3 items);
- Domain 6: Staying healthy (prevention) (7 items);
- Domain 7: Mental health and well-being (9 items).

The particular strengths of this tool are its summarizing indexes: Independence score, Risk of breakdown in care, and Risk of falls, derived from the analysis of needs in the above domains [30]. For each participant, the number of areas in which needs were present, as well as the total number of needs from all areas (with the maximum possible count of 49), were also calculated.

**Data Analysis**

The following factors were taken into account as possible determinants of the analyzed opinions about the robot as a potential caregiver for older adults:

1. Demographic data: age, gender, education, and place of residence (care homes, community);
2. Declarative statements of the participants regarding computer use, ease of use of technology;
3. Statements concerning participants’ sense of loneliness, as well as self-assessment of health and independence;
4. CGA elements: i.e, MMSE, GDS, Barthel and Lawton scores;
5. Results from the EC questionnaire – values of the summarizing indexes, the number of domains from which the respondents reported needs, the number of needs per domain, and the total number of needs;
6. Perception of the robot according to the GQS, i.e, the average result of the respondents’ assessment of the robot in the areas of Anthropomorphism, Animacy, Likeability, Perceived intelligence, and Perceived safety.

**Statistical Analysis**

Statistical analysis was performed with STATISTICA 13 software (TIBCO Software, Poland). Normality was analyzed with the Shapiro-Wilk test. Due to lack of normality of some of the studied parameters, non-parametric tests were used in further analyses. For binary data, the analysis was done with the χ² (chi-square) test with Yates correction for small groups; for others, the Spearman coefficient was used as a measure of correlation in data. Values are thus presented as means±SD and median or percentage, where applicable.

P<0.05 was considered statistically significant.

**Results**

**Characteristics of the Studied Group**

The largest group of respondents had secondary education (62 people, 38.5%); only 27 (16.8%) had education above secondary, including 17 with higher education (10.6%).

The respondents declared (on a scale of 1-5) their computer use skills only at the level of 1.7±1.3 (median 1) because as many as 120 people (74.2%) reported that they did not use a computer at all, and only 17 (8.7%) had no problem with that. Notably, for the ease of use of technology, the average score was 3.2±1.6 (median 3). On a scale of 1-5, the subjects assessed their health status at 3.1±1.0 (median 3), fitness at 3.2±1.0 (median 3), and loneliness at 2.6±1.5 (median 3).

The average MMSE score of the respondents was 23.3±4.1 points (median 24). Only 31 subjects scored below 20 points. The average GDS score was 3.8±2.8 points (median 3); 37 people scored above 5 points, which indicated the presence of symptoms of depression. The average value of BI was 82.2±20.5 points (median 90); none of the respondents was extremely dependent (score of 20 points or less). On the Lawton scale, the subjects obtained an average of 4.9±2.4 points (median 5).

As for the assessment of needs, according to the EC questionnaire, the existence of needs was found on average in 5 domains (5.1±1.4, median 5). All the respondents had unmet needs – the lowest number of needs was 3, reported in domain 7 (occurrence of pain and loss of a loved one, low self-assessment of health). The average number of reported needs was 15.8±6.8, median 15, and in terms of individual domains, the mean values were as follows:

- Domain 1 – 0.9±0.9 (median 1), out of 4;
- Domain 2 – 3.7±2.8 (median 3), out of 13;
- Domain 3 – 3.1±2.4 (median 3), out of 8;
- Domain 4 – 0.8±1.2 (median 0), out of 5;
- Domain 5 – 0.7±0.6 (median 1), out of 3;
- Domain 6 – 2.2±1.0 (median 2), out of 7;
- Domain 7 – 4.1±1.8 (median 4), out of 9.

For the EC summarizing indexes, the Independence score had an average value of 23.6±20.6 points (median 20), the Risk
functions of the robot

Less than secondary (n=72)

Females (n=89) and therefore being more independent, had lower expectations in dependence on the ADL scale (ie, people with a higher value, was found between the scores of the robot as an assistant and the capacity factors, only an inversely proportional relationship of technology, Loneliness, Health status, Fitness). For function self-assessment parameters (Computer use, Ease of use ple on the role of the robot in care for older people with any We observed no relationship between the opinions of older peo functions of the robot (Table 1).

Table 1. Opinions of participants (n=161) on the role of the robot in care for older adults and its functions, grouped by sociodemographic parameters (mean±SD).

<table>
<thead>
<tr>
<th></th>
<th>The robot should be</th>
<th>Functions of the robot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A companion of the older person</td>
<td>An assistant of the older person</td>
</tr>
<tr>
<td>Age (years)</td>
<td>60-79 (n=102)</td>
<td>4.4±1.1</td>
</tr>
<tr>
<td></td>
<td>At least 80 (n=59)</td>
<td>4.1±1.4</td>
</tr>
<tr>
<td>Gender</td>
<td>Females (n=89)</td>
<td>4.0±1.0</td>
</tr>
<tr>
<td></td>
<td>Males (n=72)</td>
<td>4.5±0.9</td>
</tr>
<tr>
<td>Education</td>
<td>Less than secondary (n=72)</td>
<td>4.4±1.1</td>
</tr>
<tr>
<td></td>
<td>At least secondary (n=89)</td>
<td>4.1±1.3</td>
</tr>
<tr>
<td>Place of living</td>
<td>Community (n=48)</td>
<td>4.0±1.5</td>
</tr>
<tr>
<td></td>
<td>Institution (n=113)</td>
<td>4.4±1.1</td>
</tr>
</tbody>
</table>

SD – standard deviation; n – number of respondents.

of breakdown in care was 3.9±2.1 (median 4), and the Risk of falls was 1.8±1.4 (median 2): 42 people (26.1%) had increased risk of falls (score greater than 2).

The mean scores of the Godspeed Questionnaire Series, measuring the perception of the robot, were as follows: Anthropomorphism was 3.0±0.9 (median 3.0), Animacy was 3.2±1.1 (median 3.2), Likeability was 4.3±0.9 (median 4.8), Perceived intelligence was 4.4±0.7 (median 4.6), and Perceived safety was 3.0±0.9 (median 3.0).

Determinants of Results Obtained for the Role of the Robot in the Care of Older Adults

Older people rated the role of the robot as a useful device significantly higher than that of a companion (4.6±0.9 vs 4.3±1.2; P<0.0005). The robot as an assistant was assessed in between (4.5±1.0).

In terms of demographic parameters, only gender was found to be related to the assessment of the companion role of the robot – the rating of men was higher in this respect (P<0.05, Table 1). Education was found to be significant for the social functions of the robot (P<0.05).

We observed no relationship between the opinions of older peo on the role of the robot in care for older people with any of the self-assessment parameters (Computer use, Ease of use of technology, Loneliness, Health status, Fitness). For functional capacity factors, only an inversely proportional relationship was found between the scores of the robot as an assistant and independence on the ADL scale (ie, people with a higher value, and therefore being more independent, had lower expectations towards the robot as an assistant; r =-0.1800, P<0.05). This was additionally reflected in the relationship between the assessment of this role and the independence score index of the EC questionnaire (P<0.05; Table 2). This phenomenon is a reflection of the strong negative correlation between the Barthel Index and the Independence score (r=-0.8763, P<0.0001, data not shown).

A detailed analysis of the role of the robot in the context of the number of needs reported by the participants in the domains of the EC questionnaire revealed a weak positive correlation between the number of needs in domain 5 (Accommodation and finances) and higher results in terms of the robot as a useful device (r=0.1745, P<0.05).

A relationship between the role of the robot declared by the participants and the perception of the robot assessed with the Godspeed Questionnaire Series was found. The only exception was the Anthropomorphism series, for which no relationship with the useful device perspective was observed (Table 3).

Determinants of Results Obtained for the Robot’s Assistive and Social Functions

Older subjects (the whole studied group) rated the robot’s assistive functions significantly higher than social functions (4.6±0.7 vs 4.4±0.8; P<0.01). However, with increasing scores of assistive functions, the scores of social functions also increased (r=0.5109, P<0.0001).

For sociodemographic parameters, only education was found to be related to the opinions expressed about the robot as a useful device; the assessment of people with higher education levels was lower (P<0.05).
### Table 2. Assessment of the correlation between the participants' opinions (n=161) on the role of the robot and the robot's functions in care for older adults grouped by self-assessment, functional capacity, and needs analysis.

<table>
<thead>
<tr>
<th></th>
<th>The robot should be</th>
<th>Functions of the robot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A companion of the older person</td>
<td>An assistant of the older person</td>
</tr>
<tr>
<td></td>
<td>Assistive functions</td>
<td>Social functions</td>
</tr>
<tr>
<td>Self-assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer use</td>
<td>$r=0.0648$</td>
<td>$p=0.3945$</td>
</tr>
<tr>
<td>Ease of use of technology</td>
<td>$r=0.0720$</td>
<td>$p=0.3453$</td>
</tr>
<tr>
<td>Loneliness</td>
<td>$r=-0.008$</td>
<td>$p=0.9133$</td>
</tr>
<tr>
<td>Health status</td>
<td>$r=-0.0638$</td>
<td>$p=0.4044$</td>
</tr>
<tr>
<td>Fitness</td>
<td>$r=0.01311$</td>
<td>$p=0.8642$</td>
</tr>
<tr>
<td>Functional capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE</td>
<td>$r=0.0556$</td>
<td>$p=0.5110$</td>
</tr>
<tr>
<td>GDS</td>
<td>$r=0.0647$</td>
<td>$p=0.4394$</td>
</tr>
<tr>
<td>IADL</td>
<td>$r=-0.0449$</td>
<td>$p=0.1192$</td>
</tr>
<tr>
<td>ADL</td>
<td>$r=0.1220$</td>
<td>$p=0.1453$</td>
</tr>
<tr>
<td>Needs analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independence score</td>
<td>$r=0.0975$</td>
<td>$p=0.3519$</td>
</tr>
<tr>
<td>Risk of breakdown in care</td>
<td>$r=0.0948$</td>
<td>$p=0.2437$</td>
</tr>
<tr>
<td>Risk of falls</td>
<td>$r=-0.0360$</td>
<td>$p=0.6589$</td>
</tr>
<tr>
<td>Number of needs in domain 1</td>
<td>$r=0.0556$</td>
<td>$p=0.5126$</td>
</tr>
<tr>
<td>Number of needs in domain 2</td>
<td>$r=0.0810$</td>
<td>$p=0.3397$</td>
</tr>
<tr>
<td>Number of needs in domain 3</td>
<td>$r=-0.0310$</td>
<td>$p=0.7154$</td>
</tr>
<tr>
<td>Number of needs in domain 4</td>
<td>$r=-0.0315$</td>
<td>$p=0.7106$</td>
</tr>
<tr>
<td>Number of needs in domain 5</td>
<td>$r=0.1245$</td>
<td>$p=0.1406$</td>
</tr>
<tr>
<td>Number of needs in domain 6</td>
<td>$r=0.0588$</td>
<td>$p=0.4888$</td>
</tr>
<tr>
<td>Number of needs in domain 7</td>
<td>$r=0.1063$</td>
<td>$p=0.2132$</td>
</tr>
</tbody>
</table>

$\text{n}$ – number of respondents; $P$ – the $P$ value; $R$ – the Spearman coefficient; MMSE – Mini-Mental State Examination; GDS – Geriatric Depression Scale; IADL – Instrumental Activities of Daily Living; ADL – Activities of Daily Living.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

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posed; still, to the best of our knowledge, no comprehensive study has been performed that considered subjective and objective factors such as sociodemographic data, self-assessment items (Computer use, Ease of use of technology, Loneliness, Health status, and Fitness), as well as functional capacity and care needs of older persons, combined with the aspects of perception of the robot. In the current study, we performed such analyses, which followed an interaction of older subjects with a humanoid social robot (TiGo).

As for the robot’s roles, that of a useful device was scored better than a companion. This, on the one hand, may signal the distribution of needs and expectations versus a social robot, but, on the other hand, it may also be easier for the future robot’s users to envision the machine in practical activities rather than those associated with companionship. These observations are in line with our previous findings [13,14] and other authors’ results [31]. In general, the question of companionship is a complex one; a longitudinal study showed that the relationship with a socially-assistive humanoid robot might even evolve into friendship [32]; such a phenomenon has been suggested by other studies as well [33,34]. We also demonstrated better attitudes to the robot’s assistive functions than the social ones, which additionally strengthens our observation regarding the roles of the robot (companion/assistant/useful device), similar to the observations of Chu et al, whose respondents showed a higher level of acceptance to the distribution of needs and expectations versus a social robot [35].

Our results show that perception measured with the GQS was the most important factor for the roles and functions of the robot. Also, a systematic review provided by Shourmasti et al underlined the meaning of perception for the attitude toward acceptance of prospective users. The question about factors that influence the acceptance of robotic solutions is repeatedly being posed; still, to the best of our knowledge, no comprehensive conclusion can be drawn.

Table 3. Correlations between the participants’ opinions (n=161) on the role of the robot and its functions in care for older people, grouped on the perception of the robot according to Godspeed Questionnaire Series.

<table>
<thead>
<tr>
<th>The robot should be</th>
<th>Functions of the robot</th>
</tr>
</thead>
<tbody>
<tr>
<td>A companion of the older person</td>
<td>Assistive</td>
</tr>
<tr>
<td>Antropomorphism series</td>
<td>r=0.3092</td>
</tr>
<tr>
<td>Animacy series</td>
<td>r=0.2581</td>
</tr>
<tr>
<td>Likeability series</td>
<td>r=0.4221</td>
</tr>
<tr>
<td>Perceived intelligence series</td>
<td>r=0.4166</td>
</tr>
<tr>
<td>Perceived safety series</td>
<td>r=0.3518</td>
</tr>
</tbody>
</table>

n – number of respondents; p – the P value; R – the Spearman coefficient.
the robot and mitigation of the uncanny valley effect [36]. In almost all of the Godspeed Questionnaire Series studied by us, statistically significant relationships were observed for the roles of the robot (companion/assistant/useful device) and the assistive and social functions, which, in general, signals high importance of perceptive factors in considering an introduction of a humanoid social robot in the care of older adults. A successful implementation should thus be preceded by a thorough analysis of how the robot to be introduced is perceived by its future users. We noted no significant relationship between the role of the robot as a useful device and the Anthropomorphism series, which may signal that for this (rather utilitarian) role, a human-like appearance is not essential. The only further exceptions were observed for 2 kinds of functions of the robot: for the assistive functions, no relationship was found with the Anthropomorphism series (with, possibly, a similar explanation as above), and for the social functions – with the Perceived safetv series, related mainly to the effect of the robot on feelings such as anxiety, agitation, calmness, or quietness. A possible interpretation of this phenomenon is that the participants did not view the machine as being credible in this regard, which seems to result from the current level of technological capabilities that may be viewed as insufficient for successful implementation of social functions, as also indicated by other authors [37-39]. Studies analyzing human–robot interaction (HRI) showed that anthropomorphism did not influence trust versus a social robot [40] and stressed the multifaceted nature of the robot’s perception by older adults, which makes the possibility of the robot’s customization essential [41]. Another general point, which may play a role in studying perceptions of the robot, results from the fact that they are likely to vary by country/geographical region [42]; it is thus vital to investigate the factors of the robot’s perception locally.

Socio-demographics did not seem to be important factors of attitude toward the TIAgo robot, with the exception of gender (men assessed the companion role higher than women) and education (better-educated participants’ scores for social functions were lower). While May et al observed that males tended to have a more positive attitude towards mechanical–appearing robots in public environments than women [43], no influence of gender was found on attitudes, acceptance, and trust toward social robots by Naneva et al [44]. The difference noted by us for the companion role of the robot may, at least partially, result from men’s better imagination of robotic companionship, as demonstrated by Carradore for social assistance [45] and Chen et al for gerontechnologies [46]. As for the lower rating of social functions by participants with higher education levels, the key point seems to be the better awareness of the limitations of contemporary robotic technologies and their consequences for the full implementation of social components of the robot’s hardware and software. Age was not an influencing factor in our group, similarly to the findings of Naneva et al [44]. Neither was the place of living (community or care institution), for which one might expect differences in some of the studied variables; however, we previously demonstrated that there is a cluster of residents of care homes with good independence characteristics [9], from which a large part of our participants may have stemmed.

We also uniquely analyzed elements of CGA related to functional capacity and the care needs of the participants. It is difficult to directly compare our results (based on participants living both in the community and in care institutions) with the literature since available studies dealt with particular groups of subjects (eg, with dementia or depression), lacked real-world interaction with the robot, or included residents of particular settings only. However, in a Hong Kong questionnaire study that did not involve interaction with the robot, functional status did not influence the attitude toward technology [46]. Chen et al performed a 14-week study in long-term care residents with dementia using the Kabochan – a small humanoid robot – and also observed no influence of parameters of functional capacity on attitude toward the robot [47]. The results of our earlier study suggested that neither cognitive status nor independence in ADL influenced a change in acceptance of a humanoid social robot before and after interaction [13]. In the current study, no effect of the analyzed variables (MMSE, GDS, ADL, and IADL) was observed, with the exception of the ADL score being a determinant of the assistive role of the robot. This means that less independent participants tended to value the robot as an assistant higher than their more independent counterparts did.

Robot acceptance studies published to date are grossly limited to the analysis of technology needs [48] that do not provide a full picture of the actual needs of older adults. An important value of our study is the inclusion of care needs resulting from a comprehensive assessment of unmet needs in various domains of the lives of older people. For this purpose, we used the EC questionnaire – its summarizing indexes depict the person’s functional status with 3 numbers (Independence score, Risk of breakdown in care, and Risk of falls). We also calculated the number of unmet needs in all 7 domains of the questionnaire. Our results showed that unmet needs only weakly affected the attitude of older people toward the robot. Independence score influenced the opinions about the assistive functions but, as explained in Results, this relationship is directly connected with the Barthel Index, which scores basic activities of daily living. A greater number of needs in domain 4 of EC (Safety) was related to a higher score of the robot as a useful device, which may indicate a belief that such a robot could ensure a sense of safety. Furthermore, a higher number of needs in domain 5 (Accommodation and finances) was associated with better scores of assistive functions, which again seems to signal that the robot could help satisfy these needs.
Still, our research confirms the importance of careful assessment of the needs of older individuals and matching technologies to them, which was also postulated by Broadbent et al [49].

Self-assessment scores (computer use, ease of use of technology, loneliness, health status and fitness) did not correlate with any of the studied roles and functions of the robot. It is, however, worth noting that, despite a low average score of computer skills (1.7±1.3 points, out of 5), ease of use of technology was declared on average at 3.2±1.6 points out of 5, indicating that even if older subjects may have had no experience with advanced technological devices, they were eager to use them. As one of our study participants put it in a remark box: “the robot, over time, will be like the cell phone – once complicated and used by few, now accessible and for everybody.” Over a decade ago, Broadbent et al stated that the older-old (75+ years) were more likely to give up and accept inconveniences rather than seek assistive solutions, compared with the younger-old (65-74 years) [50]. With the latter group now being the older-old, the ease of use of technology increasingly stops being an issue. Additionally, people who reach their retirement age nowadays are mostly familiar with various technological solutions.

Our study has certain limitations: its cross-sectional nature (which means that the results may point toward important relationships but cannot imply causality) and the relatively short time during which the users could interact with the TIAGo robot. Still, they had the opportunity to operate the robot as long as they considered it sufficient. Furthermore, as we demonstrated previously, such interaction influences some factors of attitude toward the robot; hence, there is undoubted value in performing a post-real-world-interaction study [13].

Future Directions

The opinions of older people about the projected roles and functions of the robot – after experiencing an interaction with the TIAGo robot – are shaped by multiple factors, including gender, education, ADL, and unmet needs. Still, undoubtedly, the main determinant of these opinions is the perception of the robot. Henceforth, virtually all aspects of perception (eg, anthropomorphism and likeability) appear to determine its role and functions in the eyes of potential end-users, which, in turn, may constitute an important factor in the success of the implementation of the robot in care for older adults.

Notably, we observed no relationship between the robot’s anthropomorphism and its strictly utilitarian role (that is, that of a tool) and its assistive functions, while there was such a relationship with the social aspects of its use. This indicates that studied subjects did expect specific features of the robot’s appearance when considering its social functions.

The lack of strong relationships between self-assessment values, CGA items, and unmet needs and attitudes toward robots in elder care seems to suggest that humanoid social robots require a study model that concentrates on successful aging rather than on deficits related to aging, as also suggested by other researchers [51,52]. A model of successful aging does not view it as a process of continuing losses and older adults as needing more and more assistance – which restricts the design of new technologies – but rather focuses on preservation of the user’s autonomy and making use of their resources. This approach can and should be applied to designing, implementing, and using socially-assistive robots.

Our results indicate the need for further research in the field, which may be viewed as an intersection of geriatrics/gerontology, psychology, and engineering, using validated research tools. At the same time, in the practical aspect, they confirm the necessity to involve older adults in the co-design of technological solutions [53].

Conclusions

The opinions of older people about the roles and functions of TIAGo were mainly due to their perception of the robot. Older adults should be involved in root design to improve quality of life rather than problems associated with aging.

Department and Institution Where Work Was Done

The work was mainly done in the Department of Occupational Therapy, Poznań University of Medical Sciences, Poland.

Acknowledgements

The authors would like to thank PAL Robotics, Barcelona, Spain, for customizing the TIAGo robot and making it available for the study.

Declaration of Figures’ Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.
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