Participatory Design in Socially Assistive Robots for Older Adults: bridging the gap between elicitation methods and the generation of design requirements

Adi Bulgaro*, Ela Liberman-Pincu, Tal Oron-Gilad, Senior Member, IEEE

*Corresponding author: adibul@post.bgu.ac.il

Abstract
Research on older adults’ interaction with socially assistive robots (SARs) is evolving. Participatory design (PD) strategies can support designers in developing SARs that meet older adults’ needs, capabilities, and preferences. Still, there is a gap between PD elicitation methods and the generation of design requirements. We aim to bridge this gap using new PD tools. Utilizing PD methods, we first learned the elderly’s daily routines, habits, and wishes by interviewing older adults and stakeholders. Then we began reconstructing the needs to form design requirements and evaluate them with older adults. Two focus groups were conducted to understand the visual design features of SARs in two ways: Choosing from an existing repository of “off the shelf” robots and Ideation and design of a SAR using a toolkit that we developed. For the interviews, we used thematic analysis to discover meanings repeated in the text. The interviews revealed differences in the robot’s perception between men and women and different requirements for older adults, caregivers, and relatives. Outcomes of the focus groups emphasized the need for the SAR to express human characteristics and be reliable. By utilizing the toolkit, older adults further expressed their wishes for the visual design.

Keywords - Human-robot interaction, participatory design, socially assistive robots, older adults, toolkit

Statement and declarations
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Data Availability
The datasets generated during and/or analyzed during the current study are not publicly available due to the need to approve the research thesis first, and complete additional manuscripts but are available from the corresponding author on reasonable request.
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1 Introduction

Robots for elder care is an evolving field starting to gain momentum [1]. The hope is that future robots will complement or partially replace the caregiver workforce, a need that is growing significantly due to the world's aging population. The increase in the elderly population will be accompanied by those who will need intensive support [2]. They discuss in detail the caregiving needs of older adults in the US and also the demographic and societal trends affecting the demand for and supply of caregivers. They claim that while the need for caregiving is growing rapidly, the size of caregiver families is getting smaller over the years. Due to these trends the reduction in family caregivers is growing. Those demographic changes will lead to limited support to elders from their family caregivers. Already in 2008, nearly half of the elderly population relied on outside help. In the upcoming years, this demand may reach levels at which traditional care will not be able to cope anymore with the demand [3].

Solutions are necessary to help the elderly maintain their health and functionality despite the anticipated shortage of caregivers. This becomes even more apparent during epidemics like COVID-19, which require social distancing. Assistive robots can support older adults in daily activities [4]. However, the adoption of assistive robots into the elderly population is not broad, and further, many robotic systems available now are not fit for eldercare. The acceptance of the robot by the user highly depends on the quality of interaction [5]. HRI affects the user's perception and experience from the robot [6]. In an older study, Broadbent et al. [7] looked at responses of the elderly to healthcare robots. They found that it is possible to increase the acceptance of healthcare robots by correctly evaluating the needs of the user. After adjusting the needs, it is possible to adjust the role of the robot, its appearance, and the behavior to suit these needs [8]. Allowing mass customization (a process in which the user actively modifies aspects of a product by selecting predefined modules) positively affects users’ acceptance of the SAR [9].

When testing the ARI robot for assisting older adults, Cooper et al. [10] claimed that older adults prefer aging at home rather than nursing homes. Therefore, they suggest focusing on finding new assistive technologies that can meet their needs, including finding solutions to support and expand independent living among adults. At the same time, they argue that the deployment in the world of assistive robots, trying to meet these needs, is still rare.

Consequently, the level of acceptance of robotic solutions is low, yet there is an enormous potential of robots to assist improve health outcomes on older adults, help older adults maintain their independence, and relieve caregivers [7]. In their study of the use of the PAL Robotics ARI robot, they found that touchscreen interaction provided reliability. Still, speech and gestures provided more natural communication means for most people, especially older adults who are not technology prone and lack familiarity with new technologies such as touchscreens or tablets. In Olatunji et al. [11], the authors point out particular requirements for future mobile and manipulator robots to be used in older adults’ homes (see also [12]).

Adopting a user-centered design approach can significantly contribute to robot designers in setting requirements and improving the integration of robotic systems for the elderly [13]. Studies involving older adults often did not provide them with the
means to express their thoughts and preferences in their own language and priorities [14]. Participatory design (PD) techniques are one way to extract user needs, identify the robots’ essential characteristics and set meaningful use cases [15]. However, only a few research articles that include the elderly in the design process were found. Rogers et al. [4] suggest that involving the elderly in the robotic design process is highly valuable. In addition, they claim that adopting different methods of PD with diversion of the participating older adults may be most effective in understanding the elderly’s perspectives, concerns, and wishes. PD method also gives the elderly the opportunity to connect their experiences, abilities, limitations, and preferences to the design requirements of robots. Those types of design adjustments can support successful aging [4].

Developers of healthcare robots tend to use a bottom-up approach in their design process, where they first start by defining features of the interface and then map them for a possible implementation [16], [6]. When considering the visual and interaction design of the robot, it is perceived as something that can be adapted later to the personality of the designated users, their needs, and personal taste [17], since the older population is diverse, and their needs change dramatically with age. The challenge is to find and develop tools to provide older adults with means to convey their insights and desires. Further, many stakeholders in eldercare, e.g., family caregivers (primary and secondary) and professional caregivers. Each group can contribute from their perspective of preferences and requirements to identify common themes and needs and specific use cases. Therefore, designers should consider the common needs for the robotic systems for older adults together with the unique requirements of each group of stakeholders [18]. Recently, Bradwell et al. [19] provided design recommendations for socially assistive robots for health and social care based on a group activity with 232 stakeholders, mainly healthcare professionals but also healthcare students and other professionals. Utilizing eight lunches and exhibitions of robots followed by round table discussions, commercially available SARs were available for participants to approach, engage and discuss. Their results revealed that key stakeholders were open towards using SARs. Furthermore, they identified potential uses, indicating the possibilities they found for SARs. At the same time, they proposed considering design improvements to ensure usefulness. Specifically, they noted the need for improved mobility for uneven floors, improved voice recognition, better ease of use, autonomous charging, soft and friendly aesthetics, non-robotic design to improve friendliness and androgynous appearance. The authors claim that a physical demonstration of various types of SAR is the strength of their study, allowing more comprehensive attitude formation from participants than focusing on only one type of SAR. Examining multiple SARs in a focus group like the one in Bradwell et al.’s study is a good addition beyond the studies that have been done so far, but there is still another dimension that is missing. The participants were not actively participating in the design but rather grading existing designs. Thus, participants could not fully express their feelings beyond the discussion about the existing designs and another step is still missing.

In the current study, we aimed to examine a particular group of older adults, those who live alone, at home, or independently in an assisted living facility. Adopting a PD approach, we used two elicitation methods: 1) interviews with three groups of stakeholders followed by 2) focus groups with older adults. The thematic analyses outcomes of the interviews led to the development of the focus groups. Lee et al. [14] used two separate focus groups, one to draw from existing commercial robots and the second for users’ drawings on how to integrate robots into daily lives and include the
elderly in the use case design process. Rather than dividing our focus groups by topic as in [13] we combined the two parts of their focus groups into one – we first examined existing robots and applications to identify needs and preferences, and then captured the participants’ robot design features. To achieve this, we developed a unique toolkit to provide the older adults with means to convey their design insights.

2 Method

The research consisted of two main phases: interviews with potential users, caregivers, and family members; followed by focus groups and activity (see Figure 1). To understand and clarify the needs and expectations from an assistive robot of the elderly who lives alone, we began our study with structured interviews with three groups of stakeholders. The interviews were aimed to understand the desired relationship/s between the older user and the robot, what interaction the user aspires to reach when using a robot and how the other stakeholders foresee this interaction. Structured interviews were conducted with 24 participants from three groups of stakeholders (14 Elders, 5 Caregivers and 5 Relatives). With the insights from the interviews, we mapped the elderly’s daily routine. From the elder’s daily routine, we identified difficulties and needs they may experience. Interviewing the family members and caregivers, provided us with another perspective of elderly needs and caring for the elderly. The data derived from the interviews were analyzed using thematic analysis [20]. This analysis was done with the aim of identifying common topics, patterns or ideas that have arisen repeatedly in the interviews (see Figure 2). Following, two focus groups (10 elders) were conducted to provide a more detailed examination of existing SARs by older adults and to utilize our PD tool to create new concepts for robots.

The focus groups dealt with the practical design of a robot. The focus group discussions included the topics that arose from the interviews. Its goal was to understand the requirements of the robot and how such a robot should express these requirements. When sharing stakeholders in the design process, it improves the design of the developers along with increasing user acceptance [4], [21] are using the term "User Modelling" to express features describe a group of users. They claim that user modeling can be learned from user communications, and because of it, the design is considered dynamic. There are only a few research articles that were using the
participatory design method, whereas our uniqueness was to let the participants the ability to design by themselves using a tool. In each focus group, the participants created their ideal robot using a pre-prepared toolkit of robot parts (see Figure 3). Insights from the first focus group were implemented for adjusting and improving the procedure of the second focus group (specifically, we added more guided questions following the design of the robot with the toolkit, to better understand the outcomes of the design and allow the participants to explain their choice). From the entire process, we derive themes and design requirements for robotic designers of assistive robots for the elderly.

2.1 Structured Interviews

2.1.1 Participants

When it comes to older adults, in most cases, there are people in their lives who care for them, like family members and professional caregivers. Therefore, the use of assistive robots will be in their interest as well [1]. Stakeholders behold useful knowledge for developing robots, and still, the elderly are the main users who need to be empowered in the design process [14]. That's why we decided to question more older adults than other stakeholders, but it was still important not to ignore the opinions and knowledge of the other stakeholder groups. In our opinion, the most valuable stakeholders are the people closest to the elderly, therefore, the additional groups we chose to interview are people with an adult parent (relatives) and professional caregivers. Members of these three groups took part in the interviews: older adults, relatives, and professional caregivers. The interviewees were recruited independently by contacting older adults, with the necessary profile – living alone and over the age of 70, by telephone. The recruit was made through our relatives and acquaintances who connected us to potential interviewees. Also, we recruited interviewees from assisted-living homes and directly contacted neighbors living nearby. There were no connections between and among the participants of the three groups, but it is possible that in the group of the elderly some were acquainted due to the proximity of living or hanging in common places.
**Elderly.** Fourteen interviewees (four males and ten females) from the city of Beer-Sheva in the south region of Israel, aged 71-85 participated. All interviewees were older adults who live alone. Three older adults live in an assisted living facility, and eleven in their own homes.

**Relatives.** The relative interviewees included five people (three men and two women) who have older parents that live alone, aged 48-57, also from Beer-Sheva. These interviewees were not related to the participants from the elderly group.

**Professional Caregivers.** The caregivers group included five professional caregivers (four women and one man) aged 38-50, three who came from foreign countries and two who live and work in a daycare facility for older adults in Beer-Sheva.

### 2.1.2 The interview process

The interviews were conducted in the spring of 2021, in a comfortable environment for the interviewees - at home or in the assisted living home. We built an interview guide that contained the same question base for all interviews. We conducted the interviews by going through the questions from the interview guide. Whereas, at the beginning of every interview, each participant was presented with the subject of the research. The elderly participants were asked to specify their daily routine (see Figure 7), and the interviewer asked questions that helped focus the interview on the necessary information. Following these questions, the elderly participants were asked about their difficulties and challenges. The closing questions of the interview combined questions about the possibility of integrating robots into the elderly participant’s life. The differences between the interviews of the elderly and the other two groups were reflected in questions aimed to understand the difficulty and challenges they see for the elderly and what they feel could have helped the older adults they know. The interviews lasted between 40 minutes to an hour.

### 2.1.3 Thematic analysis of the interviews

To analyze the interviews, we used thematic analysis. Thematic analysis analyzes qualitative data by which ideas or patterns can be extracted from the text. According to [22], thematic analysis is a method rather than a methodology and therefore it is very flexible. We used the necessary phases from the process of thematic analysis. First, we re-read the interviews to get to know them on a deeper level. Then we coded the interviews by finding repeating sentences or meanings and highlighting them with colors to create a legend of relevant titles. Following, we were able to identify the main themes and the subjects in the text that were related to each of them.

### 2.2 Focus Groups

#### 2.2.1 Participants

Ten participants, living alone aged 75-80, participated in the first and second focus groups (3 women and 2 men in each). Both focus groups included a convenience sample of participants living in the southern region of Israel.

#### 2.2.2 The focus group process and tools

All five participants sat together with the experimenter and had a discussion with the help of the preprepared interview guide. A focus group meeting lasted 80 minutes.
In the beginning, participants were presented with the purpose of the discussion, which is to characterize a practical robot design that is supposed to help the daily lives of elderly who live alone. The interview guide included partition to three contexts of use that arose significantly from the interviews: household, healthcare, and social robots (see Table 2); the discussion was divided into these three contexts (see Table 1).

### Table 1 - Flow of a focus group.

**Section 1: Help in household chores**

| A. Activities that convey the characteristics | Contact us by first name, making a thorough job with responsibility. Speaks pleasantly, should updated about what he is going to do next. |
| B. The connection with the user | To be able to talk to it and get a response, a good communication is important, Option of dialogue. |
| C. Location at the house | Stand somewhere there is a space. It should not run after me, let it be in one place. |

**Section 2: Medical help**

| A. Activities that convey the characteristics | Ring an ambulance, have first aid, have a defibrillator, get out of the house to get help. |
| B. The connection with the user | Communicate and ask how you feel, pay attention to the vitals and communicate with necessary people. |
| C. Location at the house | Mobile, walk all day and follow us. Turn around at home to check on me. |

**Section 3: Social help**

| A. Activities that convey the characteristics | Reading my paper for me, has knowledge on width information, be able to talk with it on every field, play music, turn the TV, call my family with video. |
| B. The connection with the user | Must communicate, for a dialog |
| C. Location at the house | Most of the time stay in one place and from time to time to check on me. |

For each context, the participants were asked to describe the features that the robot needs to convey. They were presented with a list of features (responsible, reliable, likeable, friendly, other etc.) and were asked to decide what features best suit a robot in the relevant context of use we discussed in the group. Then we asked them to describe suitable visual and physical features. Following the discussion, they were asked to find a robot that best represents the features they brought up from a robot repository. The robot repository was built from the analysis of the interviews (see Figure 4; Figure 5; Figure 6). We presented 4-5 robots that exist in the market today and are designed to assist in the specific activity for every context. Participants were asked to choose the robot that most represents the characteristics they raised earlier. This process was repeated for the three contexts of use.

In the last stage of the focus group, participants were asked to create their own robot.
design using a toolkit we made for them. The toolkit included physical prints of parts of robots built from a market survey conducted prior to this study, which examined the visual characteristics of existing robots, and thus the components were built in favor of the focus group [9], [23]. The parts represented the preferred shapes, screens, wheels, and colors that matched the results from the survey (see Figure 3).

3 Interview Outcomes and Results
3.1 Summary of interviews results

Using the insights from the thematic analysis we divided the interview outcomes into themes. From this process, two main themes emerged. The first, relates to the daily needs of elderly who live alone and is comprised of 6 sub-themes: (1) Needs, (2) Unresolved needs, (3) Solutions the elderly found, (4) Needs from the past, (5) Needs following medical treatment, (6) Lack of the need to get help. The second theme relates to the elderly’s attitude towards technology and is comprised of five sub-themes: (1) Fears from robots, (2) Fears the robot should moderate, (3) Criticism of using technology, (4) Difficulties past, (5) Finding solutions for others or the future (See Figure 2). The detailed outcomes from the thematic analysis are summarized in Table 4, for the first major theme, and in Table 5 for the second one.

Another outcome of the interviews was the creation of daily-routine charts of the elderly. In each interview, we asked about the adult's daily routine. By understanding daily activities, that the elderly performs, we have tried to better understand what each elderly participant experiences during the day and to identify places that can help us understand how it will be possible to help older adults. In Figure 7, we show an example of a daily routine from one of the interviewees. From each interview, we analyzed the details and then drew conclusions. In the routine presented in Figure 7, one can see that the interviewee opens the morning with a morning routine that includes taking medication and breakfast, then talking to friends, watching videos of the family on WhatsApp, and watching TV. Later, the interviewee eats lunch and is available for recreational activities of sewing. Throughout the interview, the interviewee noted that she talks to people and communicates with the outside world through voice communication. The interviewee's need to communicate with her surroundings, avoid silence through the TV or through speech stood out throughout this interview.
3.2 Differences between stakeholder groups

The interviews raised insights into the perceived differences in needs among the interviewed groups. From the caregivers’ perspective, the elderly need someone who can listen to them, some daily activity that will keep them busy, cognitive support, medical support, and close supervision. As far as the relatives, they presented requirements for supervision and monitoring the older adult. Most of the relatives who participated presented an opinion that implied that their older family member is alone during the day for long periods of time. They were concerned about whether their parent was functioning well. They were also concerned about scenarios where their parent is falling at home, and if they’re not taking their medications, etc. Their requirements included first aid in case of need, receiving vital measures from their parent, entertaining them during the day, and so on. As far as the elderly, most of them presented a need for help with household chores and tasks; cleaning and cooking, physical help like supporting in arising when sitting or lying on the bed, assisting in the shower, and carrying groceries from the store. In addition, they wanted reminders for tasks, events, or objects they forgot where they put, as well as social help. Hence, there are many requirement differences among the groups.

Dividing the design requirements into physical and social requirements, we can delve deeper into this subdivision to understand how many participants presented each type of need (see Table 2). Physical needs were more apparent in the interviews with the elderly participants, and very few of them expressed social needs. On the other hand, most caregivers presented both physical and social needs for the elderly from their point of view.
3.3 Gender differences

The words that were repeated most in the interviews, the words were varied and reflected different needs that combined physical and social needs (as noted in 3.2). The words that came up most were interaction, conversation, love, play, etc. (see Figure 8).

Regarding the differences between men and women, it is evident from the word clouds that there are differences in needs and perspectives (see Figure 8.b; Figure 8.c). For example, when interviewing women, the words that came up most frequently called for warmth and love, and the most prominent words are sister, talk, and love. In contrast, when interviewing men, the words that came up most frequently called for action and therefore the most highlighted words were go, play, and outside.

![Figure 8: Clouds of words: (a) Cloud of words for Needs for all interviews, (b) Women's needs, (c) Men's needs](image)

4 Focus Group Outcomes and Results

4.1 Selected robots

At the end of each section in the focus group (see Table 1), the group was asked to select one commercial robot suitable, in their opinion, for the context of use and the features that were raised in the group discussion (see Table 3). Samsung’s "Bot Handy" robot was chosen to help with home chores in both focus groups for household chores. According to the participants, the robot was chosen because it looked stable and good. They thought it could help well at home. They also mentioned that this robot is close to what they imagined. It didn't seem too big to them so it wouldn’t take too much space but also not too small so it can help in a good way.

![Table 2: The division into stakeholder groups by needs and requirements](image)
In the context of medical help, there was unanimity between the two groups selecting the robot. In the first group, the chosen robot was the "Robear" which is an experimental medical robot. This robot is designed in the shape of a bear and was developed medically to help the elderly in homes. It's designed to lift people, carry them out of bed, and help in standing up. The robot was chosen because it appeared as a strong and stable robot that could assist if necessary. It also seemed authoritative to them and one that could perform various tasks.

On the other hand, the second focus group chose "Zenbo" as their medical robot. This robot has basic medical monitoring functions such as measuring physiological. When asked to explain why they chose this robot, they explained they connected to it most and appreciated its movement ability, which they think is important when it comes to a robot made for medical purposes. There was still a reference to the "Robear" robot in the second focus group; the participants mentioned that they wouldn't pick this robot due to its oversized dimensions. In the context of social support, both focus groups selected "buddy", a sociability robot that aims to win the hearts of its users. It is designed to present a wide range of emotions and convey it by interacting with the user. The participants chose this robot because it seemed cute, nice-looking, sociable, small, and didn't seem to take much space.

4.2 Designing their Ideal robot - the first focus group

When asked to create their own robot design, participants decided to create a robot using a dark color scheme, in contrast to their declared preferred color, white. The results showed that there's a gap between what people think they need and what they actually want. Nevertheless, they did add eyes to the screen and created symmetry of two arms, so it did match the additional preferences that they presented in section 4.1 (see Figure 9).
4.3 Designing their Ideal robot - the second focus group

When the second group built their ideal robot, they chose a white and blue color scheme as their declared preference of color in the discussions. They explained their choice by saying that blue indicates reliability. They noted that in their opinion, the robot should combine all three contexts of use but at the same time asked to make a simple robot without many functions that will make it difficult to manage. One participant noted that it may still be worth incorporating many functions, thus making the grandchildren come more often to help with the use of the robot. When considering the appearance and functionality, the choice of different hands was premeditated. They sought to design two different hands, one hand was the active one (i.e., the hand that will do the action itself) and the other hand, that is shorter will be used to assist and support the active hand (For example, the active hand will pick an object, and the supporting hand will support holding it while the robot moves). When looking at the legs, they were placed in a way that could show the mobility of the robot. Different eye colors were suggested emphasizing that the robot sees the world optimistically with "pink eyes" and performs actions with the other eye. The distance between the eyes indicates the ability to see in all directions (see Figure 10).

4.4 Comparisons between outcomes of the two focus groups

When comparing the outcomes of the two groups, it's possible to see differences but also some similarities. A noticeable difference is in the robot's colors, where the first group chose a dark color scheme, and the second group chose a white and blue combination. But there are still some identical components; Both robots have a distinct face and a buffer between the head and the body. When asked what the purpose of the buffer was, participants explained it was a bow tie to make the robot cuter. In addition, both groups chose the same body structure, and the two robots have two hands and a component (wheels or legs) that indicates mobility.

![Figure 9 – First focus group's ideal robot](image1)

![Figure 10 - Second focus group ideal robot](image2)
5 Discussion

This research presents an examination of ways to elicit needs and integrate the elderly population into the design process of a socially assistive robot. Our focus was on using a participatory design method that leads to an iterative process with the elderly. The main goal was to integrate the elderly from the basics of defining requirements all the way to an actual design of a 2D robot schema. First, we conducted interviews with three groups of stakeholders to understand the demands and needs of the elderly from several different perspectives and analyzed those interviews. Then we conducted two focus groups that combined those requirements and gave the elderly a place to express themselves in the design of the robot itself as well.

In the interviews, we chose to interview three groups of stakeholders – elderly, caregivers, and relatives. We started by analyzing the interviews through thematic analysis and found two main themes. Each of the themes was split into several sub-themes. We found that there are different approaches of stakeholders to robots. There are elderly people who are afraid of robots and there are elderly people who actually see the robot as a lifeline if necessary (physically and mentally) and as something that can be used in case of difficulty. On the other hand, there were those who expressed a lack of need for help or found solutions for different situations that happen to them on a daily basis but did not define them as problems or difficulties. Others criticized the use of robots and there were also those who found solutions for other older people who may need it, such as people who are older than them or disable ones. Similar findings were described in [24], a study that explored the difficulties and needs of adults with Mild Cognitive Impairment (MCI) and their attitudes regarding the use of a robot for elder care. They found that the elderly reported some difficulties in their daily lives, but those that found adapting way to handle did not see themselves as in need of help. In addition, they testified that they did not need or want a robot now, and some even balked at such use. However, they did see it as effective for the future when they would need help.

The interviews of three groups of stakeholders enable us to find and map additional needs and requirements that can arise when looking from different perspectives. As Östlund et al. [25] claim, older adults do not tend to be involved and aware, and if they are, their participation is limited [26]. After questioning all stakeholders, we found that there are different requirements from the robot between the stakeholders’ groups (see Table 2). Previously, Johnson et al. [18] found that older adults’ desires from the robot are related to general help that would make them feel independent and free, while the caregivers wanted aid related to actions of health, safety, and monitoring. When we compared gender differences, the results showed differences between men and women when considering needs (Figure 8). Orji [27] showed that accepting technology has a different meaning depending on gender and that women are less open to technology than men. We did not find that women are less open, but we did find different requirements and expectations.

Regarding the focus groups, we found that participants chose robots with clear eyes or faces and with some mobile capabilities from the robot repository presented to them (see Table 3). This result is consistent with Kuo et al. [28], claiming that it's human tendency to assign human personality and characteristics to nonhuman beings. We also compared the ideal robot outcome of the toolkit in each focus group and found differences in the color selected (dark versus white and blue combination) but similarities with the parts chosen for assembling the robots (see Figures 9 and 10). In general, the analysis of the results indicates differences between men and women as
well as between groups of stakeholders. Yet, it seems that similarities can be found between different elderly groups. However, there will still be differences in the overall design even among groups of elderly with similar characteristics, sociodemographic background, and age.

6 Conclusion, limitations & future work

This study included interviews and focus groups to produce user design schemas and requirements. We found gaps between different groups of stakeholders, among the elderly participants and between genders. Therefore, it can be concluded that it is important to listen to varied populations and not focus on just one group. In addition, we can argue that elderly people have strong opinions about what they need.

With those conclusions, our study had some limitations. We sampled older adults that live alone. Our sample is only a segment of the population from the southern region of Israel. In addition, the participants who volunteered to participate represent a sample of convenience and are all from higher socioeconomic statuses. Due to COVID-19, it was difficult to form focus groups with older adults. On the other hand, the need to maintain social distancing and conduct the study during COVID-19 may have affected participants’ considerations, expectations, and requirements from a SAR.

Our future work will provide more insight into the results of this study. Until this point of the study, no real face-to-face interaction with robots has been tested, but next, we would like to conduct an experiment that will combine robot design with using its robotic capabilities. In addition, when we examine the interaction with a real robot, we will also want to examine whether the positions of the elderly population remain the same as those found in this study without the use of real robots.

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## 8 Appendix

### Table 4: Daily needs of an elderly living alone, the first main theme

| Theme: The daily needs of elderly who live alone | Subtheme: Needs | Subtheme: Unresolved needs | Subtheme: Solutions the elderly found |
| --- | --- | --- | --- |
| "I usually like watching TV, I have my shows, and my sister and sister in law calling me so I talk to them a lot." | "I fell in the shower, but there’s no way I’m not taking a shower, I live with it." | "My children help me to go up the stairs, they wait with me until I succeed to go up." |
| "I love being with people and on Saturday I go to my kids and see the entire family." | "I need someone to talk to me so I can forget about my blood pressure until it’s down." | "When my blood pressure is dropping, I try to take more pills to drink tea with lemon, but if that doesn’t help I’m going to bed." |
| "I go to gym classes to maintain a healthy lifestyle. I have an iPad and I play it and also on the computer." | "I don’t want any caretaker, I don’t trust them, a robot doesn’t steal from you." | "I fill my day with things to do so that I won’t feel lonely." |
| "I have a lot of interaction with friends in the assisted living facility, after lunch we sit and talk." | "Sometimes I don’t understand the bank on the phone or all sort of entities that have switched to give service on the phone." | "I have a diary and every night before bed I write my chores for the next day." |
| "I’m missing the feelings of warmth and love." | | "I get a newspaper every Sunday and every Friday." |
| "I’m passing the time around with food. I like to cook to pass the time." | | "If something is hard for me I just don’t do it, nobody can make me to do it." |

### Subtheme: Needs from the past

"I used to go to a daily care where they would give us physiotherapy and there were classes and I really enjoyed it."

"I love that my sister in law comes to sit with me in the afternoon, but she can’t come anymore."

"I was very active in the building, I used to clean the whole building, now both the old age and the surgery won’t let me. I’d like to be more active."

"I feel like I’m doing things, but I’m not the same person as I used to be."

"I really like to hang out and shop but I can’t any more. I have iron deficiency, and it weakens me."

"I used to go out to the theater."

### Subtheme: Needs following medical treatment

"I should always check that my sugar level is fine and know what’s going on with my blood pressure."

"I get up from my nap at 3 pm and make myself tea with cake to balance my sugar level."

"Because I’ve had a knee surgery, I need to walk around to strengthen my leg."

"Because of my illness, I’m not allowed to be in the sun, so I try to leave the house only when it’s early, in the winter or when the sun comes down."

"I’m taking pills so I have to eat because I have hypertension."

### Subtheme: Lack of the need to get help

"I don’t need help because I’m still not that old. I do things by myself."

"You have to do things on your own, don’t need an assistive robot."

"When I cook I look at the recipe and have to rest occasionally because of the waiting time in the recipe so I rest in the preparation and then I’m fine."

"I don’t need a robot I do things alone. It’ll just get in the way. I also don’t want it to talk to me because it will irritate me."

"I shower alone and dress alone, even though it’s hard, I try to do it myself."

"I clean once a week, there’s no reason to clean more than that because people barely come here anyway."

"I would like to go out at noon but it doesn’t matter to me I’m alone and I’m used to being alone."
| Subtheme: Fears from robots                                                                 | Subtheme: The fears robots should moderate                                                                 | Subtheme: Criticism of the use of technology                                                                 |
|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| "Yes the robot scares me because it can cause degeneration, it makes a man lazy."         | "If there’s a robot here, I’ll have someone who’s always here and keep me from falling."                     | "If there will be a robot I’ll get used to doing nothing. So a robot isn’t so good."                      |
| "I wouldn’t want that, I’m afraid of robots, it’s dangerous. Dangerous for the health, people needs to do things alone." | "Knowing that if I forget something, I could send the robot to do it."                                      | "What do I need a robot for? You have to do things on your own."                                        |
| "Depending on which robot, a robot doing things at home is fine but not robots who replace humans like they make in the world, I’m very afraid of it." | "I used to ride a bike, now I’m scared because I’ve grown up and I can suddenly fall and there’s no one to be with me in this." | "It’s great the fields technology progress today."                                                        |
| "The robot can break down and then I won’t know what to do with it so I just won’t use it." | "If it can help health, that’s what I need."                                                               |                                                                                                          |
| "I’ve seen movies where the robots have taken over and I’m afraid of it."                   | "It needs to smile all the time and to give a good mood."                                                   |                                                                                                          |
| "From a few movies I’ve seen, I don’t want them to get mad at me and I also don’t want it to break things." | "It needs to monitor my parent and update me that he has taken his medications and that everything is fine with him."  |                                                                                                          |
| "If the robot will help me outside the house, it can cause panic to the people around."    | "I need to know if my mother fell in the house."                                                           |                                                                                                          |
| Subtheme: Difficulties                                                                       | Subtheme: Finding solutions for others or the future                                                           |                                                                                                          |
| "My vision is weakening, so it’s hard for me to read books, but I really like to read."    | "When I will be older I think I would need help to get up."                                                | "When I will be older I think I would need help to get up."                                               |
| "I’d like the robot to be able to help me bend over. For example when I arrange the food in the refrigerator, it is difficult for me to bend to the low shelves or to put my clothes in the closet. Generally in all of the physical tasks I could use some help." | "I think that in older age I’d like a robot to remind me where things are."                                 | "I think that in older age I’d like a robot to remind me where things are."                                 |
| "I don’t do walks anymore because I’m more tired so I need to rest. I’m getting lazy to get out." | "Because I broke my shoulder bone it’s harder to cut vegetables and meat."                                | "There are people in a wheelchair or older people who may need more help I think I’m fine."               |
| "I like to go to the pool by foot, but it’s harder for me after the surgery."               | "When I’m making lunch prepering the food can be a little difficult to stand for so much time."              | "Maybe helping out in the shower, being able to help to get in there or help getting dressed but it’s not for me I’m trying to think about what other people who need help want." |
| "When I’m making lunch prepering the food can be a little difficult to stand for so much time." | "Because I broke my shoulder bone it’s harder to cut vegetables and meat."                                 |                                                                                                          |
| "I’m alone here at home and most of the time I spend alone so there can be some feeling of loneliness." | "I’m alone here at home and most of the time I spend alone so there can be some feeling of loneliness." |                                                                                                          |
| "It’s hard for me to get dressed and I don’t want to go out in pajamas, so I stay at home a lot." | "On sick days I have sometimes difficulty in standing in the shower, but I don’t give up."                 |                                                                                                          |
| "I’m missing my children, the vast majority don’t live in Beer-Sheva."                      | "I’m missing my children, the vast majority don’t live in Beer-Sheva."                                      |                                                                                                          |