
Article:
Bedaf, S., Marti, P. and De Witte, L. (2019) What are the preferred characteristics of a service robot for the elderly? A multi-country focus group study with older adults and caregivers. Assistive Technology: The Official Journal of RESNA, 31 (3). pp. 147-157. ISSN: 1040-0435

https://doi.org/10.1080/10400435.2017.1402390

What are the Preferred Characteristics of a Service Robot for the Elderly? A Multi-Country Focus Group Study with Older Adults and Caregivers

Bedaf, S., Marti, P., & de Witte, L. What Are The Preferred Characteristics Of A Service Robot For The Elderly? A Multi-Country Focus Group Study With Older Adults And Caregivers. Revised version submitted at *Assistive Technology: The Official Journal of RESNA.*

Abstract

This multi-perspective study focuses on how a service robot for the elderly should behave when interacting with potential users. An existing service robot and a scenario were used as a concrete case which was discussed and analyzed during focus group sessions with older adults (n=38), informal caregivers (n=24) and professional caregivers (n=35) in the Netherlands, France and the UK. A total of seven topics—privacy, task execution, environment, appearance, behavior, visitors and communication—were explored. The results showed that some of the characteristics mentioned were unique to a user group, but several were cross-cutting. Overall, potential users expected the service robot to be customizable in order to match the users' needs and preferences. Also, high expectations concerning its functioning and behavior were expressed which sometimes could even be compared to the qualities of a human being. This emphasizes the complexity of the development of service robots for older adults and highlights the need for a personalized and flexible solution. One size does not fit all, and specific attention should be paid to the development of the robot's social behavior and skills beyond a mere functional support for the person.

Introduction

Independent living may become challenging when ageing, especially when one experiences problems with activities related to self-care, mobility and/or interpersonal interactions & relationships [1]. Most older adults prefer to stay at home as long as possible and do not want to move to a care institution. Assistive technology (AT) can play an important role in supporting elderly persons' remaining independent in their own homes, for example by implementing smart home technologies and accessibility adaptations of the home. Robotics is a relatively new field within AT that has been given increasing attention as robots have the potential to support care and independence (of older adults) in many ways [2]. Technical ambitions seem to be guiding the current developments of these robotics solutions [3, 4]. This is unfortunate because, is success is to be achieved in bringing robots to the market, the needs and wishes of the target group should be taken as a starting point [4]. When developing a robot for older adults, older adults should be active participants in the design process [5]. Additionally, it is important to assess the expectations and needs of the other stakeholders involved, e.g. the family and caregivers [6].

Older adults would like an assistive robot to compensate for the activities they are no longer capable of performing [7, 8]. Several studies have been conducted on *what* type of tasks a robot for older adults should perform [9–11]. However, more attention needs to be given to *how* a robot should execute these tasks as the social skills a robot may possess plays an important role in its acceptance [12, 13]. Also, matching the robot's role, appearance and behavior to the needs and wishes of all stakeholder involved may increase the acceptance [6]. A study by Dautenhahn et al. [14] revealed that people preferred the robot to be a robot-companion (note: no older adults were included in that study). And, although humanlike communication was found to be desirable for a robot-companion, humanlike appearance was found to be less essential. Another study shows that, in order to reduce the barriers to acceptance, a robot designed to provide physical and healthcare assistance should have a serious appearance [6]. Wu et al. [5] found that most participants (aged 65+) preferred assistive robots to be discrete and small with human traits.

In setting up this study, we focused on the question of what characteristics a service robot for older adults should possess in order to be found acceptable by potential users. In order to make this question more concrete, an existing service robot, the Care-O-bot® 3 (see Figure 1) [15], was used to function as a reference point, as well as the initial scenario of fetching a drink that was created by the European ACCOMPANY (Acceptable robotiCs COMPanions for AgeiNg Years) project [16, 17]. Focus group sessions were conducted with older adults, informal caregivers and professional caregivers in the Netherlands, the United Kingdom and France, surveying what characteristics a service robot should possess while executing the scenario in order to be found acceptable. This study distinguishes itself in terms of the number of stakeholders involved, the multi-perspective and multi-competence variability of the participants, their geographical origins and the use of a concrete case to guide the discussion. This paper presents the views and thoughts of the participants and discusses what this might mean for future robot development.

The Care-O-bot® 3

An existing service robot, the Care-O-bot 3® (see Figure 1), was used to function as a reference point. The Care-O-bot 3® is a high-tech research platform that can be used as a robust, close-to-product research and development platform [15]. This robot has a machine-like appearance and is equipped with omnidirectional drives, a seven-degrees-of-freedom manipulator, a three-finger gripper and a tray that can be used to carry objects. The 'head' contains range and image sensors enabling object learning and detection and three-dimensional supervision of the environment in real time. The robot can move autonomously, can fetch, carry and manipulate objects in everyday environments.

Figure 1: Care-O-bot® 3.

The Care-O-bot® 3 has been used in several projects (i.e. Cogniron, DESIRE, WIMI-Care, BRICS, SRS, AUTOPnP and R3-COP [15]). Of these projects, only the WIMI-Care project [15] and the SRS project [18] targeted older adults. The WIMI-Care project focused on residents of a home for the elderly. The SRS project focused on the development and prototyping of a remote-controlled, semi-autonomous robot that could be operated by the children or relatives of the elderly user in order to provide active support in a domestic environment.

Method

To determine the ideal characteristics a service robot should possess when interacting with potential users, a specific robot (i.e. the Care-O-bot® 3) and scenario (i.e. the initial scenario of the ACCOMPANY project) were used as a concrete case. The scenario used was formulated by the ACCOMPANY consortium (i.e. the University of Hertfordshire, United Kingdom; University of Birmingham, United Kingdom; University of Warwick, United Kingdom; Fraunhofer, Germany; Zuyd University of Applied Sciences, the Netherlands; University of Amsterdam, the Netherlands; University of Twente, the Netherlands; University of Sienna, Italy; and Maintien en Autonomie à Domicile des Personnes Agées, France). This ACCOMPANY project was a three-year project that aimed to develop the Care-O-bot® 3 further in order to facilitate the independent living of older adults. The improved version of this service robot should assist older adults in carrying out problematic daily tasks on their own. When formulating the initial scenario, the activities most challenging to the independence of older adults (i.e. activities related to self-care, mobility and/or interpersonal interaction & relationships) [1] as well as the feasibility of the technical development within the ACCOMPANY project were taken into account. As it was clear that the Care-O-bot® 3 would only be able to perform a (small) subset of the problematic activities identified, the choice was made by the ACCOMPANY consortium to focus on the fetch-and-carry task of going to the kitchen and getting something to drink. This scenario combines mobility-related activities with a self-care activity. The scenario is described below.

> The user sits on the sofa in the living room and watches TV. The robot has noticed that the user has been sitting there for 2 hours and has not had anything to drink for a while (in fact for 5 hours). The robot approaches the user and reminds the user of the need to have something to drink and offers to fetch a drink from the kitchen. The user confirms and the robot goes into the kitchen, picks up a small bottle of water, brings it to the user and places the bottle on the table. The robot suggests bringing a large bottle next time, so that the user can drink whenever he/she likes. The user confirms and enters water on the shopping list.

Participants

Focus group sessions were conducted in the Netherlands, the United Kingdom, and France. During these sessions the scenario was presented to three different types of potential users: 1) older adults with no cognitive decline who need some support to remain independent in their own homes, 2) informal caregivers and 3) professional caregivers. Separate focus groups were held for each of the three target groups, so that perspectives of the different groups could be captured. Participants were recruited through home care organizations. Additionally, informal caregivers were also contacted through personal networks of the researchers. Older adults were selected based on three criteria: 1) aged 60+, 2) living at home and 3) receiving home care. Older adults with a medical indication that could cause cognitive decline were excluded. Informal caregivers had to be taking care of an independently living older person on at least a weekly basis or to have taken care of an independently living older person on a weekly basis in the past year. Professional caregivers worked closely with independently living older persons on at least a weekly basis.

Procedure

The focus groups were hosted by three different facilitators in three participating countries (i.e. the Netherlands, the United Kingdom, and France). All facilitators were native speakers. A detailed topic guide was produced to ensure consistency based on a shared understanding of the purpose and goals of the study. The focus groups were carried out in separate groups of 3-10 participants and consisted of two parts:

1. *Verbal explanation of the initial scenario*: The tasks the robot performs in the initial scenario were explained verbally to the participants (i.e. robot reminds the user to drink, fetches the drink in the kitchen and carries it to the user in the living room). It was mentioned specifically that these tasks were only a starting point, as a service robot should be able to execute more relevant and complex tasks in the future. After this explanation, participants were asked to two questions:
    - How should this robot execute such tasks?
    - What should such a robot look like?
2. *Storyboard of the initial scenario*: A storyboard of the scenario was created so participants could experience the visualized interactions by empathizing with the user and reflect on this from his or her own experience [19]. Each participant was given seven pictures (printed as one picture per A4 paper format) showing a graphic version of the initial scenario (see Figure 2). While showing each picture to the participants, the researcher gave a more detailed explanation of the action depicted. Participants were asked to give feedback per picture using semi-structured questions from the topic guide concerning how the robot should execute the action depicted. Seven main topics were discussed: 1) privacy, 2) task execution, 3) environment, 4) appearance, 5) behavior, 6) visitors and 7) communication.

The duration of the focus groups varied between 1.5 and 2 hours. All data was audio-recorded.

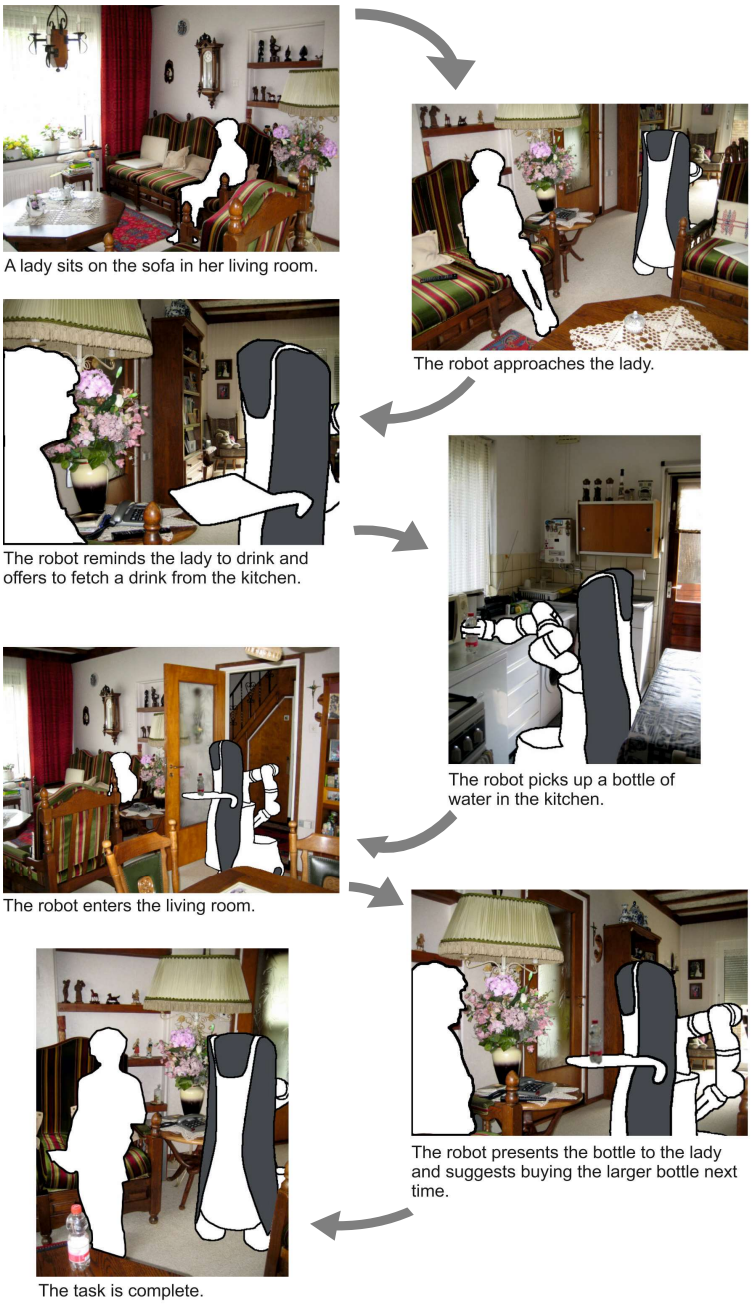

Figure 2: Storyboard of the scenario.

Data analysis

Detailed summaries of the qualitative results of the focus groups for each country were composed from the audio recordings by the corresponding researcher from each site and translated into English. The first author clustered the comments per main topic (i.e. privacy, task execution, environment, appearance, behavior, visitors and communication) and looked for commonalities, differences, interrelationships and how often opinions were shared. These were then combined into one table providing a topic-oriented view of the results showing the commonalities and differences between the views expressed by the older adults, informal caregivers and the professional caregivers. A topic point was included in the table if it was discussed during a session and if the majority agreed with the statement. However, it is important to note that the different opinions of the various stakeholders are qualitative statements and not simple yes/no answers.

Results

A total of 97 persons participated in 18 focus group sessions (see Table 1). The mean age of the older adults was 75.0 years. All older adults were still living at home and received some form of care assistance (e.g. home care, careTV, day care). Informal caregivers took care of (one of) their parents, their spouse, a neighbor or their aunt. Professional caregivers' professions ranged from care workers, nurses and psychologists to managers.

Table 1: Overview of number of participants divided per research site.

	Older adults		Informal caregivers		Professional caregivers	
	Male	Female	Male	Female	Male	Female
The Netherlands	8	4	-	6	1	12
France	-	21	4	10	1	18
United Kingdom	3	2	1	3	1	2
Total	38		24		35	

During the first part of each session, the initial scenario was explained verbally to the participants (i.e. the robot reminds the user to drink, fetches the drink in the kitchen and carries it to the user in the living room). Participants agreed that a robot performing this scenario had potential. When discussing how this robot should execute these tasks, participants agreed that the robot should execute the tasks according to the preferences of the user. When discussing what this robot should look like, different opinions were expressed within the focus groups. Some wished the robot would look like a machine, while others wanted the robot to have human features. Overall, the results did not reveal remarkable differences across the three different countries, only between the different categories of stakeholders. The data of all older adults in the Netherlands, the United Kingdom and France were therefore combined. The same was done for the data of all informal caregivers and for the data of all professional caregivers. All results were then combined into one table providing an overview of the commonalities and differences among the different stakeholders (see Table 2). Overall, all participants preferred the robot to be adaptable to the personal preferences of the user in relation to the seven topics that were brought into the discussion (i.e. execution, visitors, environment, appearance, behavior, communication and privacy).

Table 2: Overview of the commonalities and differences between the views of older adults, informal caregivers and professional caregivers concerning the seven topics that were brought into the discussion.

Theme	Topic		Older adults	Informal caregivers	Professional caregivers
Execution	The robot should approach the user according to the preferences of the user (e.g. the speed, the side from which it approaches the user, the type of warning signal used).		X	X	X
	The user should take the initiative.		X		X
	The robot should take the initiative.	Only when the user has given permission for this.	X[1]		X
		Approach the user at fixed times.		X	
	The robot should be able to recognize objects.		X	X	X
	The robot should only perform those tasks the user can no longer can perform.			X	X
	The robot and user should perform tasks together.				X
	The robot should know the day rhythm of the user (may differ per day depending on many different factors).				X
	The robot is allowed to provide reminders.				X
	The robot is not allowed to handle medication.				X
Visitors	The role of the robot should change.		X	X	
	The robot should act like a butler.		X	X	X
	The robot should not interrupt.		X	X	X

[1]Only a small minority agreed with this.

Theme	Topic		Older adults	Informal caregivers	Professional caregivers
	The robot is no longer allowed to give reminders.		X		
	The robot should become passive (i.e. wait for orders).		X		
	The robot should be in the background.				X
	Human contact is more important than the robot.				X
	The robot is no longer required.				X
	The robot should continue to execute high priority tasks (e.g. related to medication intake).			X	
	The robot should recognize and greet visitors.			X	
	The robot should be careful with (private) information.			X	
	The robot should have priority when driving around (i.e. persons should make way for the robot).				X
Environment	The home needs to be adapted (e.g. remove rugs, less furniture)		X	X	X
	Older adults are willing to adapt the home.		X		
	Older adults are unwilling to adapt the home.				X
	The robot would not fit in the home at all (e.g. doors too small, thresholds everywhere, small rooms).		X		X
	The robot should have its own place.		X	X	X
	The robot should not follow the user everywhere.			X	X
Appearance	The robot looks too big, too complex, too modern, too machine-like, unfriendly etc.		X	X	X
	The robot looks threatening to the user.		X	X	X
	The robot should look more friendly, calm, nice, etc.		X	X	X
	The robot should be more humanlike.		X		X
	The robot should have nice colors.		X		
	The robot should be smaller and slimmer.		X		X
	The appearance does not have to be adaptable to the user's preferences.		X		
	The appearance should be adaptable to the user's preferences.			X	
Behavior	The robot should be friendly.		X	X	X
	The robot should behave in a way that is comparable to a human being.		X		X
	The robot should possess emotions and values similar to those of a human being.		X		
	The robot should make eye contact.				X
	The robot can be compared to a butler or companion.				X
	The robot is a machine without any feelings.			X	
	The robot should address the user by his/her first name.		X	X	
Communication	The way the user and robot communicate should depend on the personal preferences and capabilities of the user (e.g. buttons, speech, yes/no questions, touchscreen).		X	X	X
	It is expected that the robot can talk and understand speech.		X	X	X
	The voice of the robot should not be irritating.		X		
	The robot should act as a human being.		X		X
	It should be possible to have a meaningful conversation with the robot.		X		X
	The robot should be polite (e.g. say *please* and *thank you*).				X
	The robot should give feedback to the user.				X
	The robot should be able to recognize people and greet them.			X	
Privacy	The robot should be careful with (private) information.			X	
	What should the robot monitor?	Food and beverage intake.	X	X	X
		Activities.			X
		The user should give permission for this.	X	X	X
	Which information should be stored?	Food and beverage intake.			X
		Activities.			X

Theme	Topic		Older adults	Informal caregivers	Professional caregivers
		Only out-of-the-ordinary activities.	X		X
		Video/images.	X		X
		The user should give permission for this.	X	X	X
		The care organization		X	X
	Who can have access to the robot?	Contact person.			X
		The general practitioner.	X		
		The user should give permission for this.	X	X	X
	Data should be stored externally.			X	X
	Medical background, personal information and day rhythm of the user should be entered into the robot.				X
	The robot should provide additional medical information to the general practitioner.		X		
	The robot should provide an overview at the end of the day.				X
	The robot is allowed to have a camera.		X		X
	The robot should not have a camera.			X	
	Older adults may not trust the robot.				X

Older adults

Execution – Elderly participants found it very important that the way the robot executed a certain task would match the user preferences. It was even suggested by one participant that the robot could be trained by the user (i.e. learning the user's preferences over time) in order to have a perfect match. This would include the way the robot should approach the user (e.g. the speed, the side from which it approaches the user, how nearby the robot stops, the warning signals it uses to announce its presence), meaning the robot should be adaptable per user. Elderly participants also found it very important that the user should be in charge. A small minority also agreed that the robot could be allowed to take the initiative, but only if the user had given permission. The participants also expected the robot to be extremely smart, as it was expected it would be able to recognize objects.

Visitor – Having visitors would influence the role of the robot according to the participants (e.g. the robot should go on stand-by modus). Also, the day schedule would need to change in this situation (e.g. robot would not be allowed to remind the user to exercise or to go to the toilet when having visitors over). The majority of the elderly participants also preferred that the robot be rather passive when having visitors (i.e. it should wait for orders). Several mentioned that they wanted the robot to adopt the role of a butler. Nevertheless, it was important that the role of the robot would the user preference.

Environment – The robot presented in the graphical scenario would not be capable of operating in the homes of the elderly participants without some adaptation (e.g. removing rugs, having less furniture); for some, it would not even fit in their homes at all (e.g. doors too small, thresholds everywhere). Nevertheless, elderly participants were willing to adapt their interiors to the robot (some had already adapted their homes as they used a walking frame or wheelchair). The elderly participants also found it important that the robot have its own place, so it would not interfere with the daily activities of the user when not being used. They envisioned the robot waiting at this spot until it received an order from the user (butler role).

Appearance – Different opinions were expressed as to what the service robot should look like. Some elderly participants wished the robot would look like a machine while others envisioned it having human features (e.g. a face, blinking eyes). The Care-O-bot® is a rather machine-like robot, and after seeing the graphical visualization of the scenario the majority of the elderly participants disliked the looks of the service robot as they found its look was too complex, too modern and/or too machine-like. They wished the robot would look friendlier (e.g. by being more humanlike, having nice colors). Additionally, the appearance of the robot did not have to be adaptable to the user preference according to the elderly participants.

Behavior – Elderly participants wished the robot would behave in a way that was comparable to a human: they liked the idea of the robot's possessing emotions and values similar to those of a human being. In order to make the robot more personal, it was suggested that the robot could address the user by his/her first name.

Communication – When talking about communication with the robot, elderly participants also wanted the robot to behave somewhat like a human being. The majority expected the robot would be able to talk and wished they could have a meaningful conversation with the robot. This means they expected the robot would be so well developed that it could understand what the user is saying and could respond in a proper manner. However, it was also important that the voice of the robot not be irritating. When people age, they often experience loss in hearing or eyesight. It was therefore also important that the possibility be given to users to communicate in a different manner with the robot tailored to their personal preferences (e.g. gestures, buttons, speech).

Privacy – The elderly participants wanted the user to have a say in which data would be stored on the robot and who could have access to this data. The elderly participants from the Netherlands as well as from the United Kingdom agreed that the doctor (i.e. the general practitioner of the user) should always have access to the data. These elderly participants stated that they did not always tell everything to their GP or they sometimes forgot to tell things. By giving their GP access, he/she can notice if something out of the ordinary occurs, as elderly people do not always notice irregularities themselves. The elderly participants envisioned that the robot could provide additional medical information to the GP from which the user could benefit. However, data access by others would have to depend on the user. The elderly participants did not want the robot to store all information automatically. Only when an out-of-the-ordinary action occurred (e.g. a fall, missed medication) would it be necessary to store this information. Again, this all could vary between users, which highlights the importance of the robot matching the personal preferences of the user. Participants had no concerns about the use of cameras and did not foresee any problems with the temporary storing of images.

Informal caregivers

Execution – Informal caregivers immediately stated that it was important not to create passive older adults and that it was important for older adults to do as much for themselves as possible. So whenever a user was still capable of performing a task, they wanted the user rather than the robot to execute that task. Like the elderly participants the informal caregivers also wanted the robot to approach the user according to the preference of the user (i.e. the speed, the side from which it approaches the user and the type of warning signal the robot uses to announce its presence). And while the majority of the elderly participants wanted the user always to be in control of the robot, informal caregivers also wished the robot could sometimes take the initiative. However, they would only allow the robot to approach the user at fixed times based on a day schedule. Such a day schedule for the robot should always be made in consultation with the user and her personal preferences. A specific task that the informal caregivers would allow the robot to execute (without a day schedule) was the recognition of objects on the floor. Informal caregivers found this extremely important for safety (older adults may trip over objects on the floor) and practical reasons (the robot should be able to drive around without bumping into objects).

Visitor – The informal caregivers were concerned about how the robot would act when a visitor was present in the home. Informal caregivers form the Netherlands and the United Kingdom liked the idea that the robot would recognize visitors and greet them; however, they also expressed the concern that this could potentially become annoying. It was also found to be important that the robot not interrupt too much when visitors were present (e.g. during a conversation). And while elderly participants wanted the robot to wait for orders when the user was having visitors, informal caregivers suggested that the robot should continue to execute high-priority tasks (e.g. related to medication intake). However, the concern was also expressed that the robot needed to be very careful with private information when having visitors over. Informal caregivers also wished that the robot would react to the situation of having visitors by changing its role. Here also the term butler was mentioned. However, no clear view was expressed by the informal caregivers as to what the role of the robot should be in the absence of visitors.

Environment – The informal caregivers thought, similarly to the elderly participants, that it was important that the robot have its own place in the home and not follow the user everywhere, as this could become annoying. They

also foresaw that the homes of users needed to be adapted as the current robot would not be able to drive over thresholds (rugs also needed to be removed) and was too big to maneuver through the home (remove furniture).

Appearance –Different opinions were expressed about what such a service robot should look like. Some informal caregivers wanted it to look like a machine; others wanted the robot to have a face, and some used terms like 'friendly-looking'. After seeing the graphical visualization of the initial scenario, informal caregivers agreed that the current version was too big, unfriendly and ugly and might look threatening to the user. They preferred that the robot look more calm and nice. Some informal caregivers also wished that the appearance of the robot would be somehow adaptable to the user preferences; however, it remained unclear how this could be achieved.

Behavior – The informal caregivers agreed that the robot needed to be friendly. They also wanted the robot to use the user's first name in order to make it more personal. The majority saw the robot as a machine without any feelings and while the elderly participants wanted to see more humanlike behavior in the robot, no such wishes were expressed by the informal caregivers.

Communication – The way in which the user would be able to communicate with the robot should really depend on the user's preferences and abilities (e.g. loss in hearing or eyesight), according to the informal caregivers. Many different options for mode of communication were mentioned during the focus group sessions, including a keyboard, yes/no questions, gestures, touchscreen, open-ended questions, buttons and speech. The majority of the informal caregivers expected that the robot would be able to talk and to understand speech. However, informal caregivers did not like the idea of having an actual conversation with the robot, but rather, saw potential in using the robot as a device to contact others (e.g. via Skype connection). Informal caregivers also wanted the robot to be able to recognize people (e.g. visitors) so it could greet them (become more personal).

Privacy – Informal caregivers were extremely concerned about the privacy of the user (more than the older adults). Privacy-related issues that were discussed included who should have access to the robot, who should be able to control the robot, what the robot should monitor (e.g. food and beverage intake) and what types of information should be stored. Informal caregivers wanted the user to have a final say on these issues and envisioned that the permission of the user should always be obtained. Informal caregivers also wanted the robot to be careful with personal information, especially when the user was having visitors over. And although elderly participants expressed no concerns about the usage of cameras, informal caregivers preferred that the robot have none.

Professional caregivers

Execution – The views of the professional caregivers concerning the execution of the initial scenario were in line with the views expressed by the informal caregivers. The professional caregivers also immediately stated that older adults should not become passive (similar to the informal caregivers) and that the robot should only perform those tasks the users no longer can perform themselves in order to maintain the abilities they still have ('use it or lose it'). It would be ideal if the user and the robot could perform tasks together. When performing a task together, the robot would only need to perform that part of the task the user cannot perform. For example, when the user is still able to make a cup of coffee but unable to carry the cup of coffee to the living room, the robot should do that latter part of the task for the user. When discussing the storyboard, professional caregivers also expressed the wish that the user as well as the robot would be able to take the initiative (which also depends on the person). And in order to do so, it would be important that the robot know the day rhythm of the user. However, the professional caregivers added that this day rhythm could differ from one day to another depending on many different factors (e.g. warm weather would require the user to drink more). Professional caregivers also thought it would make the robot more personal and easier to accept if it would be able to recognize the favorite cup of the user and other objects. Additionally, they would allow the robot to provide reminders, but not to handle the medication of the user, as this would be too difficult and elderly users could easily fool the robot. When approaching the user it would be very important that the robot use some kind of warning signal, matching the personal preference of the user, indicating it is moving (e.g. light signals for people with hearing problems and sound signal for visually impaired users). It should also move fluently and should not come too close to the user (i.e. there should always be an arm's-length distance between user and robot).

Though there were no major differences between the professional caregivers of the different countries, one item was only mentioned by professional caregivers from the United Kingdom and provides an interesting, constrasting view: these professional caregivers wanted the robot to bring the user a drink even when the user indicated he/she did not want anything. So, on one hand, they agreed that the robot should be adjustable to the wishes of the user and should not be pushy, but on the other hand they also wanted the robot to bring the user a drink even if the user said no. They thought it was very important that older adults drink enough during the day, and they reasoned that older adults will drink it anyway when it is given to them. Additionally, professional caregivers indicated it was important to clarify to the user what can be expected from the robot, because, if the robot did not match the first expectations of older adults, the older adults would refuse to use it. Some of the professional caregivers also stated that older adults are very suspicious when it comes to new technology because they are not used to it and it would be difficult to convince them to use the robot. However, older adults themselves showed no concerns about using new technology.

Visitors – When the user was having visitors over, professional caregivers wanted the robot to act even more like a butler and to stay mostly in the background, as they considered human contact to be more important than the robot. Some even stated that the robot would not be needed when there were visitors as the visitors could help the elderly user (e.g. with making coffee). Some therefore suggested the robot could have an on/off button. However, some were afraid this could become dangerous as an elderly user could forget to turn the robot back on or switch the robot off at will. When the robot was driving around, the professional caregivers wanted the robot to have priority, meaning that whenever a person was in the way of the robot the person should make way for the robot.

Environment – Due to its size, the robot pictured in the scenario would not be able to operate in the homes of many older adults as they tend to have lots of furniture, knickknacks and rugs in their homes. The professional caregivers indicated it would also be challenging for the robot to operate in the houses of older adults on account of doorsteps, doors and small spaces (especially the kitchen, which is often small). Therefore, it was felt, the homes of older adults should be adapted to the robot. Some professional caregivers thought this would become an issue, as they thought many older adults would be unwilling to do so (thought the elderly participants stated they would not mind adapting their homes to the robot). Professional caregivers also wanted the robot to have its own place in the home and not to follow the user around everywhere. The robot's place, they opined, should be chosen cooperatively with the user.

Appearance – The majority of the professional caregivers wanted the robot to look more like a human being (e.g. have two arms and a face). This would also give the robot a friendlier and more personal look, as opposed to the present model which looked like a machine (which for some was no problem). The current robot was also found to be too big, which could be intimidating for an elderly user. A smaller and slimmer version would look friendlier, according to the professional caregivers.

Behavior – Professional caregivers were more in line with the elderly participants than the informal caregivers when it comes to how the robot should behave as they also wanted to see humanlike behavior in the robot (e.g. the robot should be friendly, polite, make eye contact). The majority of the professional caregivers compared the robot to a butler, and some even thought of it as a companion.

Communication – Lots of different ways to communicate with the robot were discussed (e.g. buttons, screen, speech), and professional caregivers thought this should depend on the preference and capabilities of the user. Professional caregivers also found the reaction of the robot to be very important. They wanted the robot to give feedback to the user, to be polite (e.g. say 'please' and 'thank you'), and some even thought it would be nice for the user to have a social talk with it (e.g. ask questions about their day). Finally, professional caregivers expected it would be easier for the user to talk to the robot if it could act like a human being (e.g. if it had a name, was able to make eye contact, had human features).

Privacy – The privacy of the user was an important concern for the professional caregivers. According to them, the permission of the user always has to be obtained before someone (e.g. caregiver, contact person) can have access to the data gathered by the robot. They also wanted the permission of the user to be required for allowing the robot to store information (e.g. food intake of the user, activity monitoring). Overall, professional caregivers

wanted the robot to store only functional and significant information (i.e. the robot should be able to detect any abnormal behavior patterns). They also wished they could receive an update at the end of the day that showed this information, (as in the form of a printout. One professional caregiver wished for the robot to be able to record video if this was requested by the family (it was unclear if permission of the user should also be required in this case). Different opinions were expressed about where the data should be stored. Some wanted the data to be stored on the robot (so that it would not leave the house), while others thought it would be better to store the data externally (e.g. at the care organization). Additionally, professional caregivers thought it was necessary that the medical background of the user, eating/drinking habits and day rhythm be entered into the robot by the care staff so the robot would be adjusted to the user's needs and wishes. Some of the professional caregivers also expressed their worries that older adults would not trust a robot (elderly participants did not express any such trust issues).

Discussion

This study has enabled us to explore how a service robot for older adults should behave in order to be found acceptable by potential user groups (i.e. older adults, informal caregivers and professional caregivers). Focus group sessions with older adults, informal caregivers and professional caregivers were conducted in three different countries (i.e. the Netherlands, the United Kingdom and France) in order to get insight into the wishes, difficulties and challenges of designing a service robot for older adults from a user perspective. An existing service robot, the Care-O-bot® 3, and the initial scenario developed by the ACCOMPANY project functioned as a concrete case to guide the discussion. The usage of such a concrete case made it possible for the multiple stakeholders to project themselves into the story, which resulted in rich data. Studies like this are complex to organize and analyze, but essential in order to receive a deeper understanding of how a service robot should behave when interacting with potential users.

Many different opinions were expressed during the focus group sessions. Although we expected to find cultural differences no major differences could be found in the views recorded among the target groups of the different countries. The wish for the robot to behave in conformity with the wishes of the user turned out to be the leading desire in all three target groups. All stakeholders agreed that a service robot for older adults should match the personal preferences of the user on many different aspects in order to be found acceptable (e.g. how to communicate with the robot, how the robot should execute a task, what data should be stored, who can have access to the data). This requires the robot to be extremely flexible and also smart. This need for customizability was also found in a study of Beer et al. [7] in which older adults highlighted the importance of a robot being capable of performing certain tasks in a specific manner to meet the individual preferences of the user (e.g. laundry that needed to be folded and sorted in a certain way). Other studies reveal the need for a personalized service robot: 'one robot for all' will not be accepted by consumers [12, 13].

It is important to note that the different opinions of the various stakeholders are qualitative statements and not simple yes/no answers. For some topics (i.e., *Visitors* and *Environment)* the viewpoints of all stakeholders show great overlap, however for other topics stakeholders did not always agreed upon each other. When looking at the data from a stakeholder's viewpoint a more nuanced representation of all opinions expressed can be given. For example: the viewpoints of the older adults showed most consensus with the viewpoints of the professional caregivers concerning the topics *Communication*, *Behavior* and *Appearance*, while the informal caregivers had more common ground with the professional caregivers on *Execution* and *Privacy.*

Caregivers also highlighted the importance of the robot being able to recognize the user's favorite cup and other objects as people are also often attached to their rituals. This would make the robot more personal in their eyes. Design for ritual is also a new and emerging field of study. It focuses on the idea that meaning emerges in interaction and that robot behavior should not be completely established beforehand. The robot behavior should be adaptable and sensitive to rituals that develop in time. This was also confirmed by the elderly participants as they suggested that the robot could be trained by the user (i.e. learning the user's preferences over time) in order to have a perfect match. One size does not fit all. This study indicates that a service robot 'designed for all' seems to be an unfit solution.

Before participants were shown the storyboard of the initial scenario, the opinions on what a service robot should look like were almost equally divided between machinelike and humanlike. However, after seeing the scenario storyboard the elderly participants and the professional caregivers wanted the robot to have human features (e.g. face, blinking eyes, two arms) as they disliked the current look of the Care-O-bot® 3. It was reasoned that human features would make the robot look friendlier. It has been documented in the Human-Robot Interaction literature that humanlike appearance creates expectations of humanlike intelligence and skills of the robot [20]. These expectations for humanlike intelligence and skills of the robot were also discussed during the focus group meetings. For example: elderly participants and professional caregivers both wished (and sometimes even expected) that it would be possible to have a meaningful conversation with the robot, meaning the robot should be able to understand the user and respond in a proper manner. However, it should be taken into account when designing a robot with natural language interaction that the robot should not produce sentences more complex than those it can understand, so the user is aware it has only a partial knowledge of the language; it is important the robot should repeat only what it has understood and should turn to the interlocutor if it cannot solve a problem [21]. Norman therefore suggests that robots should be designed in such a way as to demonstrate their 'being imperfect' and clearly show their limitations rather than being too similar to the human being it is trying to imitate.

Older adults also preferred the robot to be rather passive (i.e. the robot should follow orders given by the user), while informal caregivers and professional caregivers were more keen on having the robot and user perform tasks together in order to keep older adults active. This dilemma between respecting the autonomy of the user (i.e. the robot obeys all commands given by the user) and the promotion of independence in the long term (i.e. the robot is programmed to maintain the abilities the user still has) is also discussed in a previous study [12]. In this study, the older adults preferred the robot to be rather passive and obedient, even when knowing this could encourage passiveness.

Professional caregivers expected it would be difficult to convince older adults to use the robot. They thought that older adults would be very suspicious about using new technologies and would not trust the robot. This was, however, not confirmed by the elderly participants. This is in line with previous results in which elderly participants seemed to be open to the idea of having a robot and did not express any concerns towards using it [7, 21].

Study limitations

The inclusion of the participants involved elements of both convenience and self-selection, which may have affected the data gathered, as people of a specific type were interested in participating in this study (i.e. the older adults who took part in the focus group sessions may have been more open to new technology than seniors who were unwilling to participate). The inclusion criteria were also rather broad as older adults only had to meet three criteria, and no criteria were included concerning the gender balance of the sample. This resulted in an overrepresentation of females.

This study was conducted by three researchers (no observer was present) at three different sites (i.e. the Netherlands, France and the UK). Even though a detailed topic guide was produced to ensure consistency, the data are likely to have been influenced by the differences among the three researchers. Due to budget and time constraints sessions were not transcribed verbatim, and only detailed summaries were created by the corresponding researchers from each site. This may have led to biased results. The focus groups were also conducted in the respective local languages (Dutch, French and English). Detailed summaries of the sessions were written in English. During this process valuable data may have been subtly altered or distorted. The table and the diagram were solely created by the first author, which might have led to biased results. A step for future research would be to present the target users with the results presented in Table 2 for verification.

The expected differences between the needs and wishes of the stakeholders of the three different countries were not found in the available data. This does not mean that there are no cultural differences among the three different countries concerning how people wish a service robot should behave. The data may not be complete, and more detailed in-depth research may be needed.

Conclusion

In this study we have explored how a robot for older adults should behave when interacting with potential users through focus group sessions with older adults, informal caregivers, and professional caregivers in the Netherlands, the United Kingdom and France. When confronting the various stakeholders with a concrete case, many different perspectives were expressed. And although people often expect that older adults are not open to using new technologies, elderly participants did not express any concerns towards using a service robot at home.

Further, it became apparent that 'design for all' may not be suitable for the development of a service robot for older adults in the home environment. Potential users all agreed that a service robot needed to be personalized in order for it to match the personal preferences of each individual user. This certainly makes the development complex since it has to deal with much variety (e.g. the different needs, preferences and home environments of potential users). Also, the stakeholders expressed high expectations concerning the robot's functioning and behavior. Participants sometimes even expected the robot to perform tasks with the similar qualities of a human being (e.g. have a meaningful conversation). This again pointed up the complexity of developing a service robot and the importance of the development not only of the functional features to perform activities, but also of the social behavior of such a robot.

Finally, the methodology and approach used in this study can be used as an example for future studies in which a deeper understanding of the needs and wishes of potential users is required. It is important for these kinds of set-ups to include multiple stakeholders and to use a concrete case for discussion. Through the usage of a storyboard a shared understanding of the situation among participants can be established which enables them to project themselves in the story. Nevertheless, it should also be noted that this approach is complex to organize as it requires a strict protocol on how the study must be conducted, how data must be collected, presented and analyzed when working with multiple research sites.

References

[1] Bedaf, S., Gelderblom, G. J., Syrdal, D. S., Lehmann, H., Michel, H., Hewson, D., Amirabdollahian, F., Dautenhahn, K., & de Witte, L. (2013). Which activities threaten independent living of elderly when becoming problematic: inspiration for meaningful service robot functionality. Disability & Rehabilitation: Assistive Technology, 9(6), 445–452. doi: 10.3109/17483107.2013.840861.

[2] Bekey, G., Ambrose, R., Kumar, V., Sanderson, A., Wilcox, B., & Zheng, Y. (2006). WTEC Panel Report on International Assessment of Research and Development in Robotics. World Technology Evaluation Centre.

[3] Butter, M., Rensma, A., Boxsel, J. V., Kalisingh, S., Schoone, M., Leis, M., ... & Thielmaan, A. (2008). Robotics for healthcare: final report. DG Information Society, European Commission, Brussels.

[4] Bedaf, S., Gelderblom, G. J., & de Witte, L. (2015). Overview and Categorization of Robots Supporting Independent Living of Elderly People: What Activities Do They Support and How Far Have They Developed. Assistive Technology: The Official Journal of RESNA, 27(2), 88-100. doi: 10.1080/10400435.2014.978916.

[5] Wu, Y.H., Fassert, C., & Rigaud, A.S. (2012). Designing robots for the elderly: appearance issue and beyond. *Archives of gerontology and geriatrics*, *54*(1), 121-126. doi: 10.1016/j.archger.2011.02.003.

[6] Broadbent, E., Stafford, R., & MacDonald, B. (2009). Acceptance of healthcare robots for the older population: review and future directions. *International journal of social robotics*, *1*(4), 319-330. doi: 10. 1007/s12369-009-0030-6.

[7] Beer, J.M., Smarr, C.A., Chen, T.L., Prakash, A., Mitzner, T.L., Kemp, C.C., & Rogers, W.A. (2012). The domesticated robot: design guidelines for assisting older adults to age in place. In *Proceedings of the seventh annual ACM/IEEE international conference on Human-Robot* Interaction (pp. 335-342). ACM. doi: 10.1145/2157689.2157806.

[8] Frennert, S., Östlund, B., & Eftring, H. (2012). Would granny let an assistive robot into her home?. Social Robotics, 128-137. doi: 10.1007/978-3-642-34103-8_13.

[9] Faucounau, V., Wu, Y.H., Boulay, M., Maestrutti, M., & Rigaud, A.S. (2009). Caregivers' requirements for in-home robotic agent for supporting community-living elderly subjects with cognitive impairment. *Technology and Health Care*, *17*(1), 33-40.

[10] Pigini, L. (2011). Tele-Operated Robots in Elderly Care at Home: A Survey on Needs and Perceptions of Elderly People and Caregivers. *Assistive Technology Research Series, 29*, 542 – 549. doi: 10.3233/978-1-60750-814-4-542.

[11] Smarr, C.A., Prakash, A., Beer, J.M., Mitzner, T.L., Kemp, C.C., & Rogers, W.A. (2012). Older adults' preferences for and acceptance of robot assistance for everyday living tasks. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 56, No. 1, pp. 153-157). Sage CA: Los Angeles, CA: SAGE Publications. doi: 10.1177/1071181312561009.

[12] Bedaf, S., Draper, H., Gelderblom, G.J., Sorell, T., & de Witte, L. (2016). Can a service robot which supports independent living of older people disobey a command? The views of older people, informal carers and professional caregivers on the acceptability of robots. *International Journal of Social Robotics*, *8*(3), 409-420. doi: 10.1007/s12369-016-0336-0.

[13] Dautenhahn, K. (2007). Socially intelligent robots: dimensions of human–robot interaction. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*(1480), 679-704. doi: 10.1098/rstb.2006.2004.

[14] Dautenhahn, K., Woods, S., Kaouri, C., Walters, M.L., Koay, K.L., & Werry, I. (2005). What is a robot companion-friend, assistant or butler?. In *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 1192-1197). IEEE. doi: 10.1109/IROS.2005.1545189.

[15] Fraunhofer IPA (2016, October 21). Retrieved from http://www.care-o-bot.de/en/care-o-bot-3.html

[16] ACCOMPANY (2016, October 20). Retrieved from http://accompanyproject.eu

[17] Amirabdollahian, F., Op Den Akker, R., Bedaf, S., Bormann, R., Draper, H., Evers, V., … & Hu, N. (2013). Assistive technology design and development for acceptable robotics companions for ageing years. *PALADYN: Journal of Behavioural Robotics*. doi: 10.2478/pjbr-2013-0007.

[18] SRS (2017, March 3). Retrieved from http://srs-project.eu/

[19] Van der Lelie, C. (2006). The value of storyboards in the product design process. *Personal and* ubiquitous computing, 10(2-3), 159-162. doi: 10.1007/s00779-005-0026-7.

[20] Goetz, J., Kiesler, S., & Powers, A. (2003). Matching robot appearance and behavior to tasks to improve human-robot cooperation. In *Proceedings of the 12th IEEE International Workshop on Robot and Human Interactive Communication (ROMAN)* (pp. 55-60). IEEE. doi: 10.1109/ROMAN.2003.1251796.

[21] Norman, D. A. (1994). How might people interact with agents. Communications of the ACM, 3(7), 68 – 71. doi: 10.1145/176789.176796.