Investigating the Suitability of Social Robots for the Wellbeing of the Elderly

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Abstract. This study aims to understand if, and how, social robots can promote wellbeing in the elderly. The existing literature suggests that social robots have the potential to improve wellbeing in the elderly, but existing robots focus more on healthcare and healthy behaviour among the elderly. This work describes a new investigation based on focus groups and home studies, in which we produced a set of requirements for social robots that reduce loneliness and improve psychological wellbeing among the elderly. The requirements were validated with the participants of our study. We anticipate that the results of this work will lead to the design of a new social robot more suited to improving wellbeing of the elderly.

Keywords: Wellbeing, elderly, social robots.

1 Introduction

With old age, major life challenges are increasingly likely to occur. Elderly people are at greater risk of social isolation compared to the general population, because of the increased likelihood of health problems, and major life-events (e.g., death of relatives and friends) [1]. As a result, the psychological wellbeing of millions of older people is detrimentally affected in the UK[1].

Psychological wellbeing is not simply an absence of ill-being [2-4]. It is about lives going well: the combination of feeling good and functioning effectively. Feeling good involves having positive emotions of happiness and contentment, interest, engagement, confidence and affection [2]. Functioning effectively involves the development of one's potential, having some control over one's life, having a sense of purpose, and experiencing positive relationships [2]. The science of wellbeing is concerned with what makes people flourish, i.e., they "have enthusiasm for life and are actively and productively engaged with others and in social institutions" [2, 5]. A study in 2002 reported that only 17% of the US adult population was flourishing [6].

[1] Age UK (http://www.ageuk.org.uk/).

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Better psychological wellbeing leads to better physical health [2]. Yet much of the existing healthcare robots and literature about social robots for the elderly focuses on devices that can provide assistance or support to people with physical or mental health problems. This work focuses on the promotion of positive psychological wellbeing, for people who are physically and mentally healthy. Our study aims to understand if, and how, social robots can help improve this form of wellbeing in the elderly. We examine whether there are social robots currently available which might reduce loneliness and improve psychological wellbeing among the elderly, and whether they can be designed to be acceptable and desirable to people. Our research questions are:

- What devices are currently available and are they able to reduce loneliness and improve psychological wellbeing?
- If current devices are inadequate, can requirements be elicited for a social robot that can reduce loneliness and improve psychological wellbeing?

The remainder of the paper describes our approach to answer the research questions. We first assess the literature and existing social robot devices. Then, we conduct focus groups with the elderly, in which we present participants with existing social robots and elicit their feedback on each robot. We report on home studies in which the elderly participants live with the social robots and document their experiences with the robots. Based on the results of the focus groups and home studies, we identify the needs of the elderly and map their needs to requirements. We then conduct a final focus group to validate the requirements.

2 Literature Review

In this study we regard a social robot as "an autonomous or semi-autonomous robot that interacts and communicates with humans by following the behavioral norms expected by the people with whom the robot is intended to interact" [7]. Among the different kinds of social robots, service-type robots are designed to provide functional help; companion-type robots are designed to enhance psychological wellbeing [8].

Social robots are widely studied in the fields of Socially Assistive Robotics (SAR), Socially Interactive Robotics (SIR) and Assistive Robotics (AR) [9]. In these fields, a number of areas are important foci for research: embodiment (bodily presence), personality, empathy, engagement, adaptation (the robot's ability to learn about the user and adapt its capabilities according to the user's personality, needs and preferences), and transfer (the ability of a robot to bring about long-term behavioural change in the user) [10, 11]. In previous studies, participants have found that physical robots are more "watchful" and enjoyable than virtual ones [12].

Existing social robots focus on providing companionship, entertainment (albeit often aimed for adults), communication, and healthcare (Table 1). Social robots specifically developed for the elderly focus on companionship or healthcare, which is only one aspect of psychological wellbeing. Other aspects, such as sense of purpose and interest, are not specifically investigated.

Table 1. Main Features of Existing Social Robots (See below for table key and robot URL)

Robot name	Main Focus	Type	Material	Target	Emotions?	Responds to:	Connectivity	Behaviour
Aibo [8]	E	Aml (dog)	P	A	☺	T, So, Si, Sp	W, B	Sp, So, Mo
CareBot	H	Rbt	P	All	☻	Si, Sp	W	L, Sp, Mo
CompanionAble [13]	C	Rbt	P	E	☺	T, Sp, Si	I	L, Mo, Sp
FurReal Cat	E	Aml (cat)	F	C	☺	T	/	So, Mo
Hasbro I-Cat	E	Dvt (cat)	P	A	☺	T, So	/	L, Mo, So
Heart Robot	C	Hmd	C	All	☺	T	/	L, Mo
Homie [14]	C	Aml (dog)	F	E	☺	Sp, T	B, S	L, Sp, So
Hopis [13]	H	Aml (dog)	C	All	☻	/	W	Sp
Huggable [15]	C	Aml (bear)	F	C	☺	T, So, Si	I	Sp
iCat [8]	C	Aml (cat)	P	All	☺	T, Sp	U	L, Sp, Mo
KASPAR [16]	H	Hmd	R	D, C	☺	T, So, Si Mo, Sp	U	Mo
Keepon	H	Dvt (snowman)	R	C	☺	So, Si	/	Mo
Mood Lamp	E	Dvt (mushroom)	P	C	☺	To, So	B	L, So
Nabaztag	T	Dvt (rabbit)	P	A	☺	Sp	I, R	L, Sp, Mo, So
NeCoRo [17]	C	Aml (cat)	F	All	☺	T, So, Si	/	So, L
Nursebot [13]	H	Rbt	P	E	☺	To, Sp, Si	I	L, Mo, Sp
Paro [18, 19]	C	Aml (seal)	F	All	☺	T, So, Si, Sp	/	So, Mo
PC Mascot	T	Dvt (parrot)	P	A	☻	/	U	L, Sp, Mo
Pleo	C	Aml (dinosaur)	R	All	☺	T, So, Si		So, Mo
Probo [20]	C	Aml (elephant)	C	C	☺	T, So, Si, Sp	/	L, Mo, Sp
Robosapien	E	Hmd	P	C	☻	T	Ir	Sp
Teddy Phone	T	Dvt (bear)	F	A	☻	So	T	So, Mo
USB Robot Owl	E	Dvt (owl)	P	A	☻	/	U	Mo
Wakamaru-bot [13]	C	Hmd	P	E, D	☺	Si, Sp	I	Sp
Yorisoi Ifbot	C	Hmd	P	E	☺	Sp	I	L, Sp, Mo

KEY	
Main Focus	H: healthcare, C: companion, E: entertainment, T: communication
Type	Aml: animal, Hmd: humanoid, Rbt: robot, Dvt: device-type
Material	C: cloth, P: plastic, F: fur, R: rubber
Target	All: all ages, E: elderly, D: disabled, A: adults, C: children
Expresses emotion?	☺: yes, ☻: no
Responds to / Behaviour	Sp: speech, T: touch, L: light, Si: sight, So: sound, Mo: movement
Connectivity	W: WiFi, I: Internet, R: RFID, B: Bluetooth, Ir: Infrared, U: USB, T: phone line, S: SMS

URL: CareBot (www.geckosystems.com), CompanionAble (www.companionable.net), Hasbro FurReal Cat, Hasbro Mood Lamp, and Hasbro I-Cat (www.hasbro.com), Heart Robot (www.heartrobot.org.uk), Huggable (robotic.media.mit.edu/index.html), KASPAR (kaspar.feis.herts.ac.uk), Keepon (beatbots.net), Nabaztag (www.nabaztag.com), PC Mascot (www.parrotchronicles.com/reviews/pcmascot/pcmascot.htm), Pleo (www.pleoworld.com), Robosapien (www.wowwee.com), Teddy Phone (no longer available), USB robot owl (www.thinkgeek.com), Yorisoi Ifbot (www.techdigest.tv/2009/01/ces_2009_yoriso.html)

A recent review of social robots for the wellbeing of the elderly found that most studies: (1) use Paro and Aibo (other robots should be investigated), (2) are conducted in Japan (but robot perception is culturally dependent), (3) are conducted with elderly people in nursing homes (but not with those still living in their own house, despite a growing number of these) [8].

To summarise, although some social robots have been designed to provide companionship for the elderly, few have been designed specifically to improve psychological wellbeing among the elderly. Those that have been investigated in this respect (such as Paro and Aibo) do not necessarily meet all the needs of the elderly, e.g., they do not provide mental challenges, improve social interaction, or they are too heavy or large [8]. The lack of suitable devices designed specifically to improve psychological wellbeing among the elderly suggests the need to understand the requirements for a wellbeing robot for the elderly.

3 Focus Groups and Home Studies

This study aims to understand if, and how, social robots can help improve wellbeing in the elderly. A user-centered approach, which consisted of 3 focus groups and 9 home studies, was used to identify the design requirements for the social robot. Ten existing social robots from Table 1 were selected and where feasible acquired for the study. The selection of robots represented a range of different robot types: "animal-type" (Pleo, Huggable and FurReal Cat), "device-type" (Keepon, Mood Lamp, I-Cat, Nabaztag, and Teddy Phone), and "humanoid" (Robosapien and Heart). These robots have different materials (fur or smooth), functionalities (walking, speaking, or Internet enabled), and interaction methods (touch, light, or sound).

Six elderly participants were recruited by the Social Care Workforce Research Unit[2] to participate in the study and represented people from a range of different backgrounds (Table 2). The participants were not too elderly or confined to home so that they could travel to the focus groups.

[2] A multi-disciplinary national centre at King's College London for research into issues relating to the social care workforce (https://www.kcl.ac.uk/schools/sspp/interdisciplinary/scwru/).

Table 2. Participants and Home Study

ID	Sex	Age Range	Former Occupation	Home Study Device(s) and Duration
P1	F	76-85	-	FurReal Cat (5 days), Mood Lamp (7 days)
P2	M	76-85	Mechanical engineer	Pleo (17 days), Mood Lamp (7 days)
P3	M	66-75	Patent examiner	N/A (Only took part in focus groups)
P4	F	76-85	Therapist	Pleo (7 days), Nabaztag (7 days)
P5	F	Unknown	-	I-Cat (7 days), Teddy Phone (7 days)
P6	F	66-75	Theatre producer	FurReal Cat (7 days)

In Focus Group 1, the participants were briefed about the purpose of the study to understand if, and how, social robots can help improve wellbeing in the elderly. In three consecutive sessions a selection of existing robots was presented and discussed. Where possible the robots were physically presented. For Keepon, Huggable, and Heart robot, publically available video demonstrations were shown instead. For each device, the main capabilities were shown, and participants were given the opportunity to interact with and handle the devices. We asked the participants to discuss their opinions about each robot in terms of what they thought of the robot, what they liked and disliked about it, how the robot could help them, how it could be improved and whether they wanted the robot in their homes. They also discussed what their ideal robot would do and what it would look like. At the end of the focus group, participants were asked if they were prepared to participate in home studies with robots, and if so, which robots they preferred.

Home studies were conducted after Focus Group 1, in which the participants lived with the social robots and documented their daily experiences. Robots were assigned to the participants based on their preferences (e.g., P2 was assigned Pleo as it was in his top 3 preferences, P6 was assigned FurReal Cat as she disliked cats and was curious about her reaction to a robot cat) and the technology in their homes (e.g., P4 was assigned Nabaztag because she was the only participant with Wi-fi). Five participants took part in the home study (Table 2). The duration and number of home studies were constrained by the availability of the participants, and the practicality of having them provide daily notes. The McCarthy and Wright framework [21] was used to record the experience of the participants.

For each home study, the participant completed a pre-study questionnaire about their impressions on the robot. For example, if the robot was Pleo, they were asked to rate from 1 – 'completely untrue' to 5 'completely true' the following questions: (1) Pleo looks/feels/sounds attractive to me, (2) I find Pleo interesting/stimulating, (3) I find Pleo entertaining/fun, (4) I feel attached to Pleo, (5) I think Pleo could enhance my sense of wellbeing, and (6) I would like to own Pleo. We also conducted a semi-structured interview with the participant about their anticipated experience with the device, and the impact of the device on their behaviour and relationship with others.

For each day the participant lived with the device, they were asked to enter the following details in the diary forms we provided: how many times they noticed or engaged with the device, any positive and negative experience they had with the device, what surprised them about the device, if they found any technical or practical problems with the device, and other thoughts and observations they have about the device. At the end of each home study, we asked the participant to complete a post-

study questionnaire with the same questions as the pre-study questionnaire described above. We also conducted a post-study interview with the participant to elicit their responses to the device and their experiences engaging with the device. For participants who conducted home studies with two devices, the new device was given to them on collection of the old device and the process was repeated.

In Focus Group 2, for each robot used in the home studies in turn, the participants shared their experiences in their home studies, in terms of the ability of the robot to provide companionship, its functionality, and its ability to provide entertainment. The participants also discussed the advantages and disadvantages of current social robots, and what is needed for future social robots. Following the second focus group, results were collated and analysed from the literature review, focus groups, and home studies. A set of overall requirements was generated from this data.

In Focus Group 3 (which occurred several weeks later), each requirement was presented in turn to the participants. An open discussion was conducted with the participants to gather their feedback and assessment of the requirements. Specifically, the discussion points focused on the user profile for such a device, context of its use, user needs and desired user experience, functional and maintenance requirements.

4 Results

The results from our study indicate that the participants were mostly unsatisfied with the social robots. Most of the robots did not meet the participants' expectations: out of the nine home studies, six had a lower post-study score compared to their pre-study score. In the final questionnaire, only P1 (on FurReal Cat), P4 (on Nabaztag), and P5 (on I-Cat) provided a score of more than 20 out of a maximum of 30.

The participants expected animal-type robots (Pleo and FurReal Cat) to behave like real animals. They compared these robots with house pets, both favourably and unfavourably. P4 found herself talking to Pleo, anthropomorphising, and caring for it. She reported feeling responsible for its welfare, and "extricated it when it became entangled with a chair leg." Her affection towards Pleo was evident in the post-study interview, referring to Pleo as "a clever little dinosaur." P2's experience with Pleo was less positive. He initially referred to Pleo as "he" but after the study reverted to "it." He felt that Pleo was "not sufficiently lifelike" and became bored of it after a few days. This is consistent with a study by Shibata [22], which found that unfamiliar animal-type robots are more acceptable to humans than human-type or familiar animal-type, as people are less able to compare them unfavourably with the actual animal. However, our study found that unfamiliar animal-type robot Pleo was still compared unfavourably with animals. For example, P2 compared Pleo to a puppy, which, unlike Pleo, would give a "personal response" to its owner.

Several participants said that they saw the potential of such devices in encouraging conversation in those who are lonely or housebound. The device's effect on the participants' self image is crucial to their acceptance of the device. P5 and P6 disliked the toy-like appearance of Teddy Phone and FurReal Cat respectively. P5 comments' in the first three days of having the Teddy Phone were positive: she found its moving face "very novel" and described it as "entertaining" and "friendly to look at." However, she felt that it was "a bit childish" when a guest asked her why she had a

Teddy Bear. P1, P5 and P6 mentioned the possession of social robots has to maintain their self-image as independent. This is consistent with Broadbent et al.'s [13] findings that older adults may not use assistive robots if they feel that this portrays them as "disabled, dependent, weak or feeble."

Several participants mentioned the importance of being able to control the devices. P5 wanted I-Cat to have a volume control but was otherwise very positive about the simple device; P6 wanted to be able to stop FurReal Cat from "yowling" using a vocal command. P6 did not like cats and was allergic to them, a response mirrored in the artificial cat. Her ratings in the post-study questionnaire for FurReal Cat were very low. She found the loud meowing of the cat very irritating and distracting, and stopped touching it because she felt it evoked an allergic reaction similar to that of real cats. By the end of the study she no longer wanted to interact with it. This observation is consistent with a study by Shibata et al., which found that those who do not like animals or pets in general tend not to engage with robotic animals [23].

Similar to Broadbent et al.'s study of healthcare robots [13], we found that one design is unlikely to suit everyone. A customisable experience is essential, for example of gender, voice, shape, for improved perceived user autonomy. For instance P4 did not like one of the voices used by Nabaztag, but in other ways was very happy with this device. Likewise her objections to the touch of Pleo might have been overcome by using a different surface material.

Based on the focus groups and interviews with the participants, the target user for the social robot should be over 75 (i.e., the older elderly) and in need of intellectual stimulation, companionship, and empathy. The user may have limited independence, and is possibly housebound with limited mobility. The user may have moderate visual or auditory impairment and/or motor impairment. The user may have limited social contact and be somewhat isolated. The user may have little or no cognitive/speech impairment. The device should be used in the home environment or in a care home. The device should usually be used by one person, but a friend, relative, or care person may set up the device and communicate with the user using the device. The functional, user experience and maintenance requirements are summarised as follows.

Functional Requirements. All participants wanted the robot to respond to voice and touch. They agreed that devices must respond to voice in order to be a satisfactory companion but were divided as to what such a response entailed. One participant suggested that the robot could respond by talking back, but another was strongly against this. A participant suggested that voice response could be as simple as the FurReal Cat meowing if one spoke to it. The robot should respond to the user and the environment (audio or visual recognition). It should recognise and respond to user's emotions/mood (possibly from their tone of voice), and influence or alter its "mood" in some way by its response. For example, P3 wanted something he could shout at, and that would know he was shouting at it.

The robot should provide one or more useful functions promoting wellbeing, such as facilitate communication with relatives, friends and carers, contact with the outside world, and promote creativity by intellectual stimulation. Participants wanted to be able to tell stories to the device (which could be transmitted to grandchildren or collated as memoires). This is consistent with the literature that the elderly enjoy activities that enable them to add value to society and connect them to others [24].

Participants welcomed the idea of combining animal-type and device-type properties in the way that 'Huggable' does, i.e. an animal-like robot which is comforting to hold, but also enables communication and other activities. Participants mentioned that communication robots could help the elderly stay in touch with younger relatives and with the world in general. There was consensus on the benefits of intellectual stimulation to wellbeing, and the participants agreed that some form of intellectual challenge such as learning to play music (which participants had unsuccessfully attempted with the Mood Lamp) or solve puzzles could be of benefit. An ideal robot could also provide accurate and reliable reminders, for instance to take pills, take exercise, or for appointments.

User Experience Requirements. The robot should be pleasing to touch or stroke, but the touch and feel should be customisable. Physical aspects of animal-like devices (e.g., purring and the sensation of fur when stroked) were found by some participants to be soothing and relaxing but were undesirable to others. Some participants found the rubber skin of Pleo, the mechanics under the skin of Pleo, and the synthetic feeling of the fur in FurReal Cat to be undesirable. The sounds made by the device or voices should be pleasing and not irritating, and should be customisable. Over-loud meowing of FurReal Cat was irritating for some. Although P4 enjoyed the quirky random comments from Nabaztag, she disliked a synthesised female voice used by Nabaztag for reminders.

The appearance of the device should not resemble a children's toy. Older people prefer robots with a serious aspect [13]. A participant mentioned being self-conscious when guests saw them with child-like robots such as Teddy Phone. All the participants described Heart as "creepy" and half of them said that the Furreal Cat was scary. These two robots may have suffered from the *uncanny valley* effect: when the robot looks too much like a living creature, it is no longer judged by the standards of a robot trying to act like a creature, but judged by the standards of normal behaviour for the living creature [25].

The robot should exhibit personality traits, such as curiosity and humour. P4 found the "witty unexpected comments" from Nabaztag entertaining (e.g., "I need a hug"). The personality of the robot is important for its acceptance. Most participants disliked Robosapien due to its rude "caveman speech" and "grotesque" built-in behaviours.

The robot should provide auditory and visual stimuli, i.e., changing colours or sounds, which provide a pleasing background but do not require attention. For example, participants liked the lights on Mood Lamp, I-Cat and Nabaztag. Devices that have a "presence" have the potential to provide companionship. Similar to Heerink et al. [26], we also found that improved social abilities in robots promotes improved sense of presence, which has a positive effect on perceived enjoyment by users. For example, P4 let Pleo roam around the space whilst occupied cooking the dinner. Despite being very busy and active, she willingly gave it time from her other commitments. Similar to P4, the other participants also reported talking to Pleo, FurReal Cat, and Nabaztag.

The robot should not require action to give a reaction. Unpredictability, i.e., not knowing what the robot is going to do next, was desired. The participants found it interesting to observe what Pleo would do next, and what Nabaztag would say next.

Maintenance Requirements. The device should be continuously powered, or require low-maintenance battery operation. In the home studies, participants found the short battery life of Pleo to limit their engagement. Participants commented that a device does not have to be able to move around to give pleasure or have a presence. The device should be robust (not easily damaged by dropping, not easily dirtied). Participants found the white fur for FurReal Cat impractical, as it may get dirty easily.

Device operation should be accessible for those with moderate visual, auditory or dexterity impairments. There should be no small switches or text to read, and voices from the robot should be clear and audible (Nabaztag required an expert to spend two hours installing and configuring it). Size and weight should be manageable for those with reduced mobility. Participants commented that devices such as Pleo might be too heavy for those with reduced mobility or strength. (Pleo's weight, which is 1.6 kg, should be the maximum). This is consistent with the existing literature: Paro was found to be too heavy to pick up and this limited interactions with elderly people [27]. Finally, the device should be independent and not require a lot of care and attention.

5 Conclusion

This study aimed to understand if, and how, social robots can help improve wellbeing in the elderly. We found that social robots have the potential to improve wellbeing in the elderly, but existing robots focus more on healthcare and healthy behaviour among the elderly. Based on our focus groups and home studies, we produced a set of requirements for social robots that reduce loneliness and improve psychological wellbeing among the elderly. The requirements were validated with the participants of our study. Future work involves mapping the requirements to design specification, making an initial prototype design and validating the design with the participants. Their feedback will be used to improve the design and a real prototype will be developed for testing.

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