© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

A Review on Usability and User Experience of Assistive Social Robots for Older Persons

Isa Halim[1*], Adi Saptari[2], Puvanasvaran A.Perumal[1], Zulkeflee Abdullah[1], Shariman Abdullah[1], Mohd Nazrin Muhammad[1]

[1]Human-Machine Interaction System Research Group, Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, MALAYSIA

[2]Department of Industrial Engineering, President University, Jl. Ki Hajar Dewantara, Kota Jababeka, Cikarang Baru, Bekasi 17550, INDONESIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2022.14.06.010
Received 20 April 2021; Accepted 18 February 2022; Available online 10 November 2022

Abstract: In the advancement of human-robot interaction technology, assistive social robots have been recognized as one of potential technologies that can provide physical and cognitive supports in older person's care. However, a major challenge faced by the designers is to develop an assistive social robot with prodigious usability and user experience for older persons who were known to have physical and cognitive limitations. A considerable number of published literatures was reporting on the technological design process of assistive social robots. However, only a small amount of attention has been paid to review the usability and user experience of the robots. The objective of this paper is to provide an overview of established researches in the literatures concerning usability and user experience issues faced by the older persons when interacting with assistive social robots. The authors searched relevant articles from the academic databases such as Google Scholar, Scopus and Web of Science as well as Google search engine for the publication period 2000 to 2021. Several search keywords were typed such as 'older persons' 'elderly', 'senior citizens', 'assistive social robots', 'companion robots', 'personal robots', 'usability' and 'user experience'. This online search found a total of 215 articles which are related to assistive social robots in elderly care. Out of which, 54 articles identified as significant references, and they were examined thoroughly to prepare the main content of this paper. This paper reveals usability issues of 28 assistive social robots, and user experience feedback based on 41 units of assistive social robots. Based on the research articles scrutinized, the authors concluded that the key elements in the design and development of assistive social robots to improve acceptance of older persons were determined by three factors: functionality, usability and users' experience. Functionality refers to ability of robots to serve the older persons. Usability is ease of use of the robots. It is an indicator on how successful of interaction between the robots and the users. To improve usability, robot designers should consider the limitations of older persons such as vision, hearing, and cognition capabilities when interacting with the robots. User experience reflects to perceptions, preferences and behaviors of users that occur before, during and after use the robots. Combination of superior functionality and usability lead to a good user experience in using the robots which in the end achieves satisfaction of older persons.

Keywords: Socially assistive robots, companion robots, elderly care, usability, user experience

Corresponding author: isa@utem.edu.my
2022 UTHM Publisher. All right reserved.

1. Introduction

Over recent years, the number of older persons aged 65 years and over in the world's population has increased significantly. According to the Department of Economic and Social Affairs of United Nations, the number of citizen aged years 65 years and over is approximately 9.1 % of the total population and is projected to hit almost 12 % by 2030, 15.9 % by 2050 and up to 22.6 % by 2100. Europe and North America collectively account for the highest proportion of elderly citizens (18 % of the total population) which is expected to rise to nearly 30 % by 2100 [1]. Older persons face many difficulties which include physical limitations such as mobility difficulties [2-3] and mental health problems such as depression [4], anxiety [5], and loneliness [6]. In parallel with the rising number of older persons around the world and the difficulties that they faced, demand for physical and psychological assistance such as assistive social robots are increasing.

A recent study revealed that an assistive social robot is one of the effective solutions to reduce depression and loneliness, thus improving quality of life among the older persons [7]. The assistive social robots can be referred as a supportive device which developed through artificial intelligence technology and having social intelligence and skills that allow them to communicate with human in a socially acceptable fashion [8-9]. There are several reasons why assistive social robots are so needed now and in the future. The primary reason is that assistive social robots provide multi-services such as safety monitoring, health-promoting exercises, social interaction or support, physical helps such as bathing and companionship [10-14]. The older persons can use the robot to support their daily life activities such as walking, physical exercise and lifting of object. A study observed that older persons liked the communication abilities of assistive social robots and they were active in physical interactions with the robot, for example, when the robot listened to them or responded to their touch [15]. Fig. 1 shows an older person aged 80 years amused while interacting with an assistive social robot, Paro.

Fig. 1 - An older person with an assistive social robot, Paro

Nowadays, robotics research institutions and robot manufacturers play a vital role in the development of functional and well-accepted robots to ensure older persons' wellbeing [16]. As a result, assistive social robots are getting more attention and interest from the older persons because they can deploy the robot to remain independently in their home environment, instead of being institutionalized in old folk homes or nursery homes [17-18]. Broekens et al. [19] found that the assistive social robots have positive effects on older persons' health, reduced stress levels, more positive mood, decreased depression and increased interaction with others.

As pointed by several studies [19-23] there will be a tremendous shortage on staff and qualified healthcare personnel in nursing. Furthermore, there is a case of communication difficulties between care providers and the older persons which may affect the quality of care. For example, many older persons, particularly the Chinese, only communicate in their own dialects with minimal communication skills in English or Bahasa Malaysia [21]. Hence the availability of assistive social robots can solve the issues concerning high demand on caregiving, shortage of caregiver personnel and communication breakdown between caregivers and older persons. Research and development on assistive social robots for the use of elderly can be generally divided into three types: companion, service and companion and service combo robots, as summarized in Table 1.

Table 1 - Robot types, applications and examples in elderly care

Robot types	Applications	Robot examples
Companion robot	Social support – The robot acts as a communication partner to encourage the elderly to communicate, improving psychological such as treating loneliness, stress, boredom, anxiety and helplessness [24].	Kabochan [25], Mini [26], ENRICHME [27], Baxter [28], Furby [29], Buddy [30], Pepita [31], Personal Assistive RobOt-Paro [32-35], ElliQ [36], DarumaTO [37], EmotiRob [38], NeCoRo [39]; Follow Me [40], MITTHAR [41]. A companion robot, NAO is shown in Fig. 2.
Service robot	Support the physical and cognitive of the elderly. Assists older persons in their everyday lives, such as object lifting, fall detection (physical activity help), and reminding them of medicine consumption (cognitive support).	Robot-integrated smart home (RiSH) [42], ROBEAR [43], Hobbit [44], telemedicine robot [45], Care-O-bot [46], HERB [47], RIBA [48].
Companion and service combo robot	Provides a combination of social support, physical activity help, information services (e.g. recording, monitoring and storing health data) and communication medium (e.g. telephone, video conference).	Anna-Constantia [49], Zora [50], MOBISERV [51], PAMM [52-53], ALIAS [54], Robo Coach Xuan and Taizo [55], Robo MD [56], Florence [57], Flo [58], GiraffPlus [59], Cybi [60], Pearl [61].

However, only in some situations the assistive social robots have been considered as a remarkable solution. The assistive social robots have been commonly accepted for certain tasks such as monitoring, managing emergency situations, and handling of heavy or inaccessible objects. However, tasks requiring direct physical touch between the human and the robot was not fully appreciated [62]. Previous study pointed that the big challenge for designers of assistive social robots is the user acceptance issue [63]. In the recent research of Ke, C. [64], the acceptance level of assistive social robots was found to be low among older persons with dementia. Acceptance can be defined as subjective perceptions or willingness of users (e.g. older persons) to employ the assistive social robots in their daily life [22], [65- 66]. Acceptance of assistive social robots can be categorized into two fields: acceptance of the robot in terms of usefulness or ease of use (functional acceptance) and acceptance of the robot as communication partner (social acceptance) [22].

There are three main elements that should be taken into account when developing assistive social robots, namely functionality, usability and user experience. Functionality relates to technical specification of the robot such as the average speed of travel and the maximum load of lifting. Usability is the issue raised by older persons when interacting with the robot. The ISO DIS 9241-11 [67] defines usability as *"the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"*. The word usability also refers to "usefulness" and "ease of use" that drives users' satisfaction and frequency of use [68]. Finally, the user experience is about personal experience or feeling of an elderly before, during and after using the robot. The user experience is defined as the *"person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service. It includes user's perceptions and responses that result from the use and/or anticipated use of a system, product or service" and where "users' perceptions and responses include the users' emotions, beliefs, preferences, perceptions, comfort, behaviors, and accomplishments that occur before, during and after use"* [69]. A latest study pointed that user experience is one of key elements to enhance users' acceptance level towards a product [70]. Such three elements (functionality, usability and user experience) are mutually dependent. For example, robot functions include walking and reaching can have an impact on usefulness and ease of use which is related to usability. Additionally, robot appearance such as shape and materials can also affect user experience. The user experience focuses on the cognitive, socio-cognitive and affective aspects that a person experiences when engaging with the robot, such as enjoyment, aesthetics and a desire for repeated use [71]. A recent study pointed that older persons are impressed with a robot that having physical attractiveness and social likeability [72].

Abundant assistive social robots in the market have forced the developers to emphasize the usability and user experience in their machine design. A study reported an increase in the total number of assistive social robots by 42 million from 2016 to 2019. Out these, 8100 robots are classified as companion or service robots that are designed to assist in the execution of daily tasks at home [73]. Subsequently, a lot of research work has been published pertaining to assistive social robots. There are similar published review articles focusing on the use of assistive social robots for older persons, as summarized in Table 2. However, to the best authors' knowledge, there is a lack of a comprehensive literature to overview the issues on usability and user experience of such robots in the care for elderly. Moreover, a recent publication [71] stressed that information on usability tests of social assistive robots are rarely reported in the scientific literature.

The aim of this paper was to review the usability and user experience issues faced by the older persons when interacting with the assistive social robots. This information will certainly be providing a new insight to be taken into account by stakeholders in the field of human-robot interaction system to design and produce a well-accepted assistive social robot for the use of older persons.

Fig. 2 - A companion robot, NAO

Table 2 - Review articles and focuses of review related to assistive social robots in elderly care

Review articles	Objectives and focuses of review
[74]	Surveys the robot assistive technologies for supporting independent living of elderly.
[75]	Synthesizes the terminologies variations for describing barriers and facilitators affecting the application of social robots for the elderly.
[76]	Reviews the application of assistive social robots to improve support and social helps among older persons with and without cognitive impairment.
[43]	Reviews the social robots technologies such as robotic nursing, ambient assisted living and assistive robotics for elderly care.
[77]	Reviews the personal robot assistant for elderly care and scrutinizes their benefits for the elderly.
[78]	Reviews the type of assistive social robots and their functions in the daily living activities of elderly.
[79]	Reviews the use of telepresence robots. The focus was on these systems: ExCITE project [80], Telepresence Robot for Interpersonal Communication [81], TELEROBOT [82] and Flo [58] which having different methods and types of application to remotely interact with the elderly.
[83]	Reviews the use of social robotic telepresence systems – focused on mobility.

[19]	Reviews the effects of assistive social robots in healthcare for elderly, which focus on the companion function.
[84]	Reviews various assistive devices for elderly focusing on mobility and self-transfer systems.
[85]	Reviews sociodemographic factors with regards to acceptance of socially assistive robots.

2. Methodology

The authors searched relevant articles from electronic databases such as Google Scholar, Scopus and Web of Science (*n* = *246*), taking into account as date of publication from 2000 to the present. Relevant articles were also searched from Google search (*n* = *135*). The following keywords were typed throughout the search: elderly; senior citizens; assistive social robots; companion robots; personal robots; usability; user experience. Then the full texts of journal articles include original research and review article which written in English were downloaded. Additionally, the authors examined the reference lists of all articles to gather additional relevant articles.

After screening the similar or overlap articles, there were 215 articles remained. The authors then examined and comprehend the title of these articles. Next, the abstract of 162 articles were read, any article with unclear abstract was removed (*n* = *83*). Subsequent step was reading the full text of 79 articles. To justify the relevancy of studies, these articles will be included in the final review if they meet the following inclusion criteria: participants or subjects in the study were older persons aged more than 65 years old, and provide findings on usability and user experience studies. The journal name, authors, and institution were not considered as criteria to minimize bias in selection of the articles. Quality of the selected articles was assessed by fulfilling these requirements: was the method applied in the usability and user experience studies is reliable? Were the subjects participated in the studies are provided adequate time to test the usability and user experience of the assistive social robot? Finally, 54 articles were selected and reviewed to extract issues and information with regards to usability and user experience of assistive social robots in elderly care. Fig. 3 provides a flow chart of processes involved in collecting, filtering and reviewing the articles.

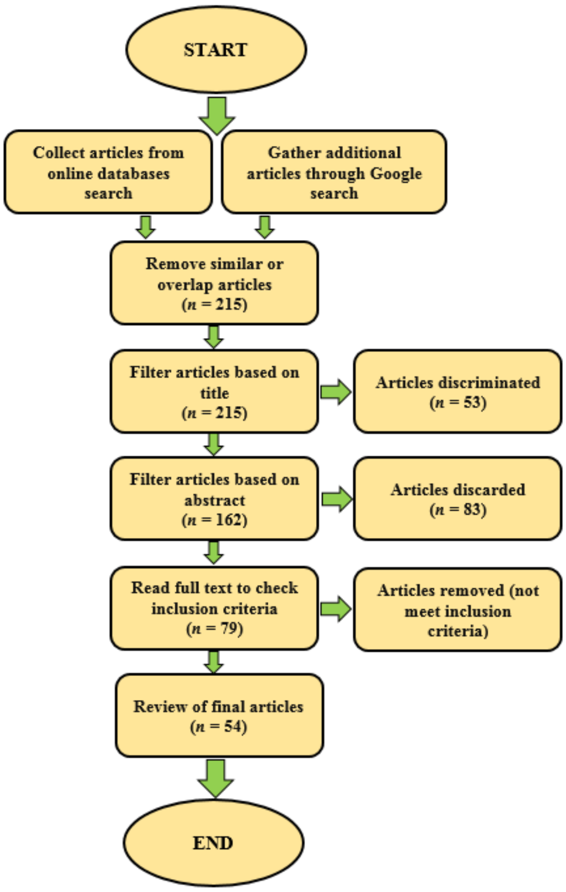

Fig. 3 - Flow of process in collecting, filtering and reviewing the articles

3. Results

The success of assistive social robot's applications in the older person community is highly rely on user experience factor. Fig. 4 illustrates the five key elements of user experience in assistive social robots. The user experience is strongly influenced by usability element that relates to the ease of using the robot. In addition to that, functionality, desirability, accessibility, and adoptability demonstrate the perceived enjoyment while interacting with the assistive social robots.

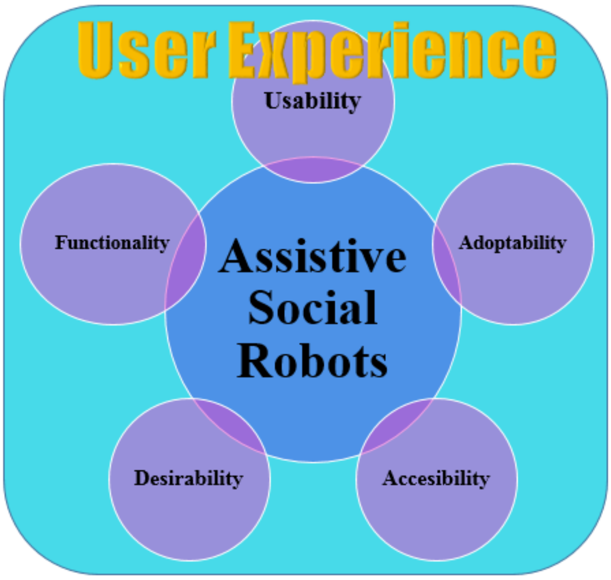

Fig. 4 - Key elements of user experience in assistive social robots

Table 3 summarizes the usability issues highlighted by older persons when using and interacting with the assistive social robots. The issues were reported by previous researchers who conduct studies on human-machine interaction among 28 assistive social robots (arranged from the most popularly robots studied).

Table 3 - Usability concerns - issues faced by older persons when interacting with assistive social robots

Robot	Participants of study	Usability feedback (functional acceptance)	Sources
Hobbit	Eighteen older persons from Austria, Greece, and Sweden. The age ranged from 75 to 89 years.	The robot has a limitation in terms of functionality because not all its functions operated constantly. This limitation was considered acceptable for a prototype but requires further improvement.	[86]
	Forty-nine older persons from Austria, Greece, and Sweden. Aged more than 70 years.	Participants preferred to have voice commands to interact with the robot. They had self-confident to use the robot and assessed a positive perceived usability rating.	[18]
	Eighteen older persons from Austria, Greece, and Sweden. Age ranged from 75 to 89 years.	Participants appreciated the functions provided by the robot. The robot was intuitive to handle, but some errors in the actions of the robot causing frustration.	[87]
	Forty nine older persons from Austria, Greece, and Sweden with age more than 70 years.	The robot was perceived as easier to use.	[88]
	Hundred and thirteen older persons in Austria, Greece and Sweden, aged over 70 years.	A majority (91.9%) of participants rated the robot as easy to use.	[89]
Kompaï	Eleven older persons with Mild Cognitive Impairment (MCI) and 11 healthy older persons from Broca Hospital.	The participants experienced problems when using some of graphical user interface elements for the first time. The problems disappeared after receiving some training.	[90]
	Eleven older persons with MCI and 11 healthy from Broca Hospital.	The participants needed more time to familiarize with the robot and task after a 1-	[91]

		week period of not using the robot.	
	Four male older persons, age ranged from 69 to 75 years.	The perception about robot's usability was very positive, especially the robot´s Skype-call feature was considered simple and intuitive.	[92]
	Twenty-two older persons with MCI, aged between 60 to 86 years living in Paris.	Participants faced difficulties when using the robot graphical user interface with regards to NumericUpDown control. The intuitiveness of the interface needs to be enhanced.	[93]
	Eight older persons, aged between 70 to 83 years.	Limitations have been identified in terms of reliability of the robot, low nonstop service, instability of Hungarian speech recognition system, navigation, and self-localization problems.	[94]
NAO	Twenty older persons, aged 70 years and older.	1) Participants' speech is too soft; thus the robot cannot hear them correctly. 2) Participants were unable to hear the robot. 3) Participants' speech could not be correctly interpreted by the robot when they replied the robot too fast, before NAO completed its speech.	[71]
Combined NAO and VGo	Nine older persons, aged more than 50 years.	1) The Wi-Fi network used was faulty, and transmitting between the programs that controlled the robots seemed to be difficult. 2) The switch to start the NAO's exercise program (tapping the head) could be problematic for certain users.	[95]
Combined KSERA and NAO	Eight Austrian older persons aged 70 to 95 years.	Participants stated that the ease of use of robot could be improved over time; especially after getting familiarized to the speed and behavior of the robot. *"If I could use him longer, I believe I could learn how to use him without help"* *"You have to get accustomed to it, to the interaction and to the (slow) speed of the system"*	[96]
Paro	Twenty-three older persons. Age is not mentioned.	1) The robot is too heavy to lift and move. 2) Participants were unable to hold the robot. 3) Participants complained the robot size and bulkiness. 4) The robot switch is hidden between its split tail fins, so it is not easy to turn on and off.	[13]
My Real Baby	Twenty-three older persons. Age is not mentioned.	The participants were comfortable with the robot because it is easy to control.	[13]
Ed	Five older persons with dementia aged 59 to 88 years, from Toronto.	Three participants rated 'easy' to use the robot because it does not require any special environment to operate.	[97]
MOPASS	Ten older persons aged 60 and above.	The robot received an overall moderate usability rating. The robot obtained a high System Usability Scale score on: *"I can well imagine to use the system regularly"* and *"I perceive the system as easy to use".* Concerns: To attach and detach the robot system was reported as time-consuming.	[98]
Robot-Era	Eighty-two Swedish older persons aged 65 years and older.	1) Majority participants assessed positively System Usability Scale (score of 4 or 5) all services provided by the robot. 2) First time user was difficult to identify the	[99 - 100]

		shopping items because of small size and lack of labels. 3) Participants who were not used to technology experienced initial difficulties using the tablet - always failed in the first trial. 4) Some participants experienced difficulties to use the speech user interface because they did not say the right keyword to activate the robot.	
Vizzy	Seventeen older persons, age range between 55 to 90 years with and without memory impairments.	The robot was perceived as a useful, pragmatic and hedonic quality.	[73]
RAMCIP	Eighty-three older persons from Poland and Spain aged between 55 and 90 years with mild cognitive impairment or early stages of Alzheimer disease.	1) The robot was rated high priority for safety functionalities such as calling for help, and reminder for medication intake, boiling water, turning off the gas and light. 2) The robot is highly recommended to have voice-command.	[63]
SocialRobot	The number and age of the older persons who participated in the study are not mentioned.	The range sensors attached to the robot was enabling it to accurately navigate in indoor environment, even though in tight spaces.	[17]
Telepresence	Thirty older persons aged between 65 to 78 years.	Participants perceived positively about the usefulness of navigation, vital signs measurement, manipulator, reminder, calendar and video conference. They rated 3 of Likert scale for 'ease of use' with regards to these functionalities.	[102]
Giraff	One man and woman aged 86 years and 84 years, respectively.	Participants criticized that the docking operations (e.g. *"Go back to the docking station"*) as problematic.	[103]
	Not mentioned in the article.	Difficulty in docking task due to low video resolution and poor lighting which led to frustrating and time-consuming.	[80]
	Ten older persons (aged 61-82 years).	One female participant expressed that interacting with a person led to confusion when watching herself on the video.	[104]
ROBIN	Twenty five (mean age 37.4 ± 14.9 years).	The overall usability perception was good and the interface was judged appropriate.	[105]
Combined mobile remote presence system and Texai robot	Twelve older persons aged between 63 to 88 years.	The participants faced difficulty in controlling the speed and direction of robot with regards to the use of mouse and web-based user interface.	[106]
Care-O-bot 3	Thirty-four older persons (mean age 78).	The robot interface was rated well usable by the participants, however, they had difficulties to assess the capabilities of the robot (for example, the robot could not find or identify the object).	[107]
VGo	Eight older persons aged between 64 to 92 years.	1) It was easy to hear and answer calls and turn the robot on and off. ii) The picture and volume were clear and worked well. However, 2) Participants confused on how to use the remote control, for example one of them unplugged the robot because she was worried about a fire. 3) Driving hazards were not communicated clearly by the robot. 4) Robot transitions from solid floor to carpet	[108]

		were problematic.	
Brian 2.1	Firty six older persons (aged 62 to 91 years).	Participants perceived that the robot is easy to use. Training on the robot operation is meaningful to minimize anxiety. When users felt less anxious toward the robot, they perceived that the robot is easy to use.	[109]
CompanionAble (Scitos G3)	Ten older persons (aged 55 to 80 years) with cognitive impairments.	The virtual keyboard was hard to use - difficult to find some keys. Sometimes the robot overlooked participants when searching for them due to limitations of its tracking system.	[110]
Nabaztag	Three older persons (aged > 50 to 65 years).	All participants did not find the robot a very useful machine. This is due technical problems (e.g. conversation buttons) and limited conversation abilities (e.g. keep repeating same messages).	[111]
RoboPhilo	Ten older persons (age is not mentioned).	The robot was unable to detect the raised hands of one of participants because the hands were outside of the active frame. Additionally the vision-processing software of the robot requires good lighting to detect head and hand motions accurately.	[112]
Pearl	Six older persons (age is not mentioned).	All participants demonstrated ease of use of the robot. However, they experienced confusion due to poorly adjusted speech recognition system.	[113]
MYRAbot	Five older persons (aged 59 to 90 years).	The participants required: 1) Taller platform to interact with the robot (adapted in height) 2) Better interface design for increasing or decreasing the size of the rendered graphics.	[114]
Max	Nine older persons, aged 68-92 years.	The robot obtained positive ratings of usability due its technical robustness.	[115]
MOVAID	Thirteen older persons from Switzerland. Their age is not mentioned.	The robot functioned as a microwave oven equipped with Multimedial Man-Machine Interface (MMMI). The robot is simple and ergonomic, however, its size, multiple components and lack of specific user features interfere the environment of older persons.	[116]
Robovie	Fifty-five older persons, average age was 83.9 years.	The participants expected that the robot come to them to communicate and interact, not the other way around. Robot mobility is limited. The robot's voice needs to be clearer for better audibility.	[117]

Furthermore, Table 4 tabulates user experience feedback based on human-robot interaction studies of 41 assistive social robots. In general, the acceptability of older persons towards the robots is mixed positive and negative perceptions. This shows that the users' acceptance level depends on multi factors such as culture and health condition.

Table 4 - Feedback of user experience in the past studies on assistive social robots

Robot	Participants of study	User experience feedback	Sources
Hobbit	Eighteen older persons from Austria, Greece, and Sweden. Age ranged from 75 to 89 years.	The emotional bonding of participants to the robot diminished as a result of technical problems.	[86]
	Forty-nine older persons from Austria, Greece, and Sweden. Aged more than 70 years.	57.2% of the participants willing to own the robot at home. Majority participants felt the robot take care of them.	[18]

	Eighteen older persons from Austria, Greece, and Sweden. Age ranged from 75 to 89 years.	Neither did participants believe the robot could improve their own independence, nor did the robot make them feel safe at home.	[87]
	Forty-nine older persons from Austria, Greece, and Sweden with age more than 70 years.	Perception of participants was shaped by the mutual conversations between robot-human.	[88]
	Hundred and thirteen older persons in Austria, Greece and Sweden, aged over 70 years.	The robot functionalities such as helping to stand up from the floor were well accepted by the participants and they preferred keeping this robot at home for a longer period of time.	[89]
i-Cat	Forty older persons aged between 65 and 89 years.	Participants found the robot more fun, so they planned to use the robot more.	[22]
	Forty older persons from Almere and Lelystad, Netherlands. Their age is 65 years and above.	Participants were comfortable with the robot and its interface.	[101]
RoboCare	Forty older persons aged between 65 and 89 years.	Participants enjoyed the robot, and want to share it with caretakers and others.	[22]
Paro	Twenty-three older persons. The age is not mentioned.	The robot portrays itself as a baby seal (non-domesticated species). This representative will give users a greater sense of awareness when initial interaction take place. This seemed more of an issue for older users and less mentally astute ones. A few participants worried that the robot would bite them, saying, *"I think he is going to bite me [...] he scared me."*	[13]
	Twenty three older persons with average aged more than 80 years.	The findings of the study are summarized as follow: 1) Reduce stress level, improve moods. 2) Waiting and willing to interact with the robot. 3) Increase laughing. 4) Encourage to communicate. 5) Sang song to the robot thus made people to laugh. 6) Made a song and sang it to the robot.	[118]
	Twenty older persons, age range 55-100 years.	The robot contributed positive impacts such as decrease of depression and loneliness among the participants.	[119]
My Real Baby	Twenty-three older persons. Age is not mentioned.	The robot succeeded in reducing intense anxiety amongst the participants.	[13]
Kompaï	Eleven older persons from Broca Hospital, aged between 76 and 85 years.	Participants demonstrated low intention to use the robot. They found the robot is not to be useful.	[91]
	Four male older persons, age ranged from 69 to 75 years.	Participants felt it was crucial that the robot should produce audible signals before moving. They liked the robot to keep enough distance, and stopped ahead of time. These are to ensure safety for users.	[92]
	Eight older adults, aged between 70 to 83 years.	The robot's acceptance among participants was quite good, even better with those who have had no previous experience with computers.	[94]
Ed	Five older persons with dementia	Three participants had a high degree of	[97]

	from Toronto aged 59 to 88 years.	adherence to robot prompts which is a clear indication of the robot's acceptance as a helper during the job.	
NAO	Twenty older persons, aged 70 years and older.	Participants liked using the robot for monitoring or training their health. They mentioned however that health monitoring and training using the robot is difficult for users with hearing impairment.	[71]
	Six older persons (aged 70 to 80 years).	The participants are regular attendees of exercise sessions. The participants did not prefer and not enjoy the robot as an exercise partner over the actual human coach because the robot had poor social skills and the participants.	[120]
MOPASS	Ten older persons aged 60 and above.	The robot was perceived as senior-friendly. Example of feedback*: "I was in harmony with the robot"*.	[98]
Robot-Era	Fifteen older persons, aged between 70 and 89 years.	The robot was equipped with Multi-Modal User Interfaces (graphic user interface and speech user interface). The participants enjoyed the experience with the robot and its interface.	[121]
	Eighty-two older persons, aged between 63 and 97 years.	More than 90% of the participants and all the stakeholders contacted viewed positively the deployment of the Robot-Era services for taking care of the older persons in the near future.	[99]
	Thirty five older persons, aged 65 years and older.	Participants had a positive impression about the robot.	[122]
Vizzy	Seventeen older persons (with and without memory impairments). Age range between 55 to 90 years.	The robot was perceived as liked and easy to get familiar with, stimulating and controllable device. Participants demonstrated a high level of acceptance.	[73]
RAMCIP	Eighty three older persons with mild cognitive impairment from Poland and Spain aged between 55 and 90 years.	More than 60 percent of participants considered the robot as friends, meaning they want to personalize it and show the robot to their family and friends.	[63]
SocialRobot	Number and age of older persons participated in the study are not mentioned.	Participants gave positive feedback on the robot. They found the robot to be amiable and fun to interact with.	[17]
Combined NAO and VGo	Nine older persons, aged more than 50 years.	The participants have enjoyed their robot training, and the features of the robot are beneficial for participants. They were able to exercise again with the robot, and showed their willingness to recommend the robot to others.	[95]
ROBADOM	Fifteen older people with mild cognitive impairment, aged 64 to 87 years old.	Most participants did not consider the robot was advantageous for them. They were not excited about the functionalities of the robot.	[123]
Combined ROCARE and NAO	Eleven older persons aged between 66 to 94 years.	The perceptions of the participants on robotic systems including performance, effort and attitude were optimistic.	[23]
PR2	Seventeen older persons aged 61 to 84 years.	Participants enjoyed interacting with the robot, and did not show any sign of nervous.	[124]
Combined KSERA and NAO	Eight older persons aged between 70 to 95 years from Austria.	The participants were not anxious while interacting with the robot because of its small dimension product. They enjoyed with the robot during the study/ trials, however,	[96]

		feeling doubtful whether its performance can be maintained after prolonged usage.	
Giraff	One man (86 years old) and one woman (84 years old).	The participants had reported anxiety due to the docking operation which was identified as a problem.	[103]
	One older person couple (age is not mentioned).	The couple is very interested to have the robot.	[125]
Combined mobile remote presence system and Texai robot	Twelve older persons aged between 63 to 88 years.	All participants shared their desire to use the robot, as it provides simulation, travel reduction, and socialization.	[106]
ROBIN	Twenty-five older persons (mean age 37.4 ± 14.9).	Because of its multimodal interaction, the participants had positive emotions about the robot.	[105]
VGo	Eight older persons aged between 64 to 92 years.	Participants reported that their experience using the robot was positive and enjoyable. They would be willing to use the robot with friends, family members, and healthcare providers.	[108]
Telenoid R1	Ten older persons. Women with dementia (mean age, 86.6 years).	Most participants had positive impressions on the robot. They were willing to have conversations with the robot. However, one participant reacted negatively because the robot is naked, mechanical looks, and its facial appearance.	[126]
ROBOCARE Home and PEIS Home	Forty Italian older persons (mean age of 70.3 years), 43 Swedish older persons (average age of 69.9 years).	Both the Swedish and the Italian groups favored the robot with less human-like characteristics. However, Swedish users thought the robot can threaten their own memory and worried of becoming dependent on the robot.	[127]
Telenoid R1	Ten older persons. Women with dementia (mean age of 86.6 years).	Telenoid can be a meaningful robot to study the needs and desires of older persons with dementia.	[126]
AIBO	Thirteen older persons (average age 84 years) with severe dementia.	AIBO was able to improve socialization and social activity of the participants.	[128]
Bandit	Thirty-three older persons aged between 68 to 88 years.	Participants felt interaction with the robot is enjoyable/entertaining, valuable and socially attractive.	[129]
Brian 2.1	Forty-six older persons aged between 62 to 91 years.	Participants had positive attitudes and less anxiety toward the robot. They enjoyed the robot's facial expressions and different voice tones.	[109]
CompanionAble (Scitos G3)	Ten older persons with cognitive impairments aged between 55 to 80 years.	The participants enjoyed with the robot. Some of them expressed: *"The more initiative the robot takes, the more enjoyable it is."*	[110]
iRo	Twelve older persons aged between 62 and 79 years.	Majority participants mentioned that iRo was not a robot for them. One of the participants said: *'I still lead too much of an active life; I've always been amongst people. I don't need an iRo, not yet anyway'.*	[130]
Matilda	Hundred and fifteen older persons with dementia aged between 65 to 90 years.	The participants showed very positive attitude toward the robot, they feel comfortable and relaxed talking with the robot. However, 16% of them expressed contrary feelings.	[131]
Nabaztag	Ten older persons aged more than 50	All participants did not enjoy using the robot	[111]

	years old.	due to technical problems and limited conversation abilities.	
Pepper	Eight older persons aged between 73 to 92 years.	Some participants did not show a sense of fear and walked near to the robot and touching it without fear.	[132]
Vizzy	Thirty-six older persons (aged 65 to 94 years).	During the initial experiment, the participants were feeling anxious to interact with the robot. However, after some trials they did enjoy and started to interact more with the robot. Some participant showed a desire to have the robot.	[133]
Phyno	A couple aged 60 and 64 years.	The participants demonstrated strong interests and get familiar with the robot.	[134]
HealthBot	Sixty seven older persons aged 65 years and above.	Majority participants enjoyed interacting with the robot.	[135] [136]
SAR- Robot Exercise Trainer	Seventeen older persons aged between 50 to 70 years.	Participants demonstrated high satisfaction and willingness to recommend the robot to others.	[55]
Florence	Twenty-four older persons aged between 60 to 85 years.	Almost all participants enjoyed with the robot. They expressed an increased feeling of presence of the remote party as opposed to traditional means of telecommunication such as phone calls.	[137]
Max	Nine older persons, aged between 68 to 92 years.	Participants felt safe and enjoyed with the robot. The positive ratings of usability were the result of the technical robustness of the robot.	[115]
Robovie	Twenty-four older persons, average age is 67 years.	Robovie is a conversational and human-like robot which can provide positive feeling and sense of *“together with someone”*.	[138]
	Fifty-five older persons, average age is 83.9 years.	The participants accepted the robot positively. Their day became cheerful. One of the participants expressed: *“Talking to Robovie opened my mind. Even when I felt sad, I could feel brighter by talking with Robovie-kun. I always thought at home, ‘Robovie-kun will be at the center today. I am going to talk to it.”*	[117]
I-SUPPORT	Twenty-five older persons with bathing disability from rehabilitation wards of German geriatric hospital, average age is 77.9 years.	The participants expressed higher satisfaction when the robot performs bathing tasks in autonomous operation mode than the user-controlled operation mode.	[12]

4. Discussion

It is certain that robotics technology can play a significant role to support older persons to perform their activities of daily living independently. Application of assistive social robots to facilitate the needs of older persons becoming widespread and extensively studied [139-147]. However, introducing robotics technology to older persons and requesting them to deploy the solution can be challenging. Acceptance level of older persons towards the assistive social robots can be categorized into positive and negative attitudes. Positive attitudes are associated with technology supporting living activities, enhanced convenience, and contained useful features. In contrary, negative attitudes are related to technology created inconveniences and unhelpful features [148]. Both positive and negative attitudes are influenced by usability and user experience of older persons while they interacting with the robots. For example, usability issue can be observed when the older persons interact with the user graphic interface of the technology [149]. Size and sharpness of the interface need to be designed by taking into account their vision limitation.

Based on numerous assistive social robots tabulated in Table 3 and Table 4, it shows that positive concerns for helping older persons in their activities physically and socially have growing enormously. This is evidently apparent by many manufacturers producing various kinds of assistive social robots that may help older persons in performing their jobs or responding to their requests. As the users of these robots, older persons respond to how do they feel from the services offered by the robots – do the robot really helps the older persons? Did the robots affect their emotion? These questions have motivated many researchers to perform assessment on usability and psychological impacts of the robots from point of view of older persons. Not all robots in the market were able to satisfy usability and user experience of older persons. For instance, a study among 58 older persons with average age of 78 years pointed that the Vizzy robot requires further improvement in terms of usability and user experience. In the study, some older persons reported a usability issue - they were unable to hear robot voice as the pace and pitch remained the same, and the volume in one fixed level (not adjustable). Additionally, the older persons were slightly higher levels of anxiety. When interacting with the robot at the first time, nervousness was observed among the older persons [150].

There are three main factors mostly been considered and evaluated by researchers concerning assistive social robots: 1) Functionality - involves robot speed, maximum load etc. 2) Usability - when interacting with the robots how older persons feel easiness, or usefulness, ease of use. The functionality and usability drive the user satisfaction on the robot usage. 3) User experience - personal experience such as feeling when they interacting with the robots. This study believed that the three factors interact each other in satisfying the elderly users. The relationship of these three factors can be represented by Fig. 5. When the robots work as the older persons wants, for example to walk approaching to users at the speed as they expected not too slow not too fast, or able to lift and grab objects and do some other physical tasks requested by users; these are considered as functional ability. In short, usability is related to the ease of doing something. In usability, there are two elements must work together. The first is, users should be able to give a right signal to robots on what they want the robots to do. Secondly, the robots should receive and interpret the signal, then respond to what the user wants. If this communication breaks, then the users would not get the right feedback that can lead to dissatisfaction.

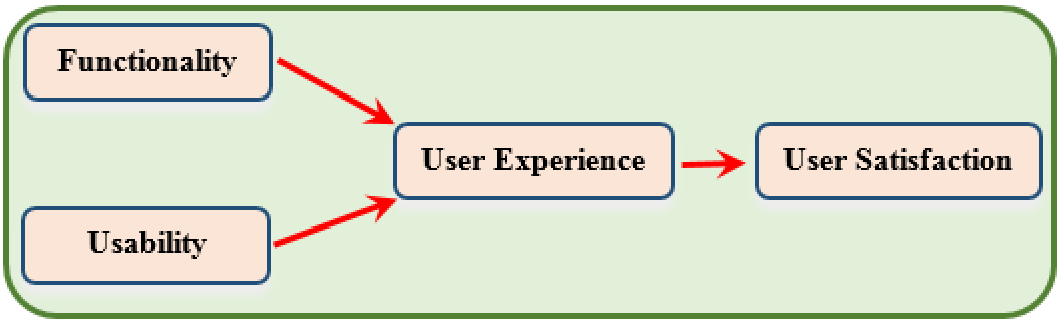

Fig. 5 - Theoretical framework of user satisfaction on assistive social robots

Several researchers in Table 3 [80] [93-95], [99-100], [103], [106-108], [110-113], [117] revealed some technical issues on robots' performance which lead to dissatisfaction among the older persons. In any situation, when the communication breaks, there are ergonomics factors appeared between the users and the robots. The possible factors that play a significant role in unsuccessful communication can be classified into display, cognition, information processing or decision making, and human computer interaction. According to Wickens [151], in any variety of task, the process of signal detection as explain in Signal Detection Theory there are four possibilities can happen. The first one, the right signals given by the users and the robots detect the signals correctly and responding accordingly. Secondly the wrong signals (e.g. caused by noise) are given and the robots responded incorrectly. Thirdly, the users sent right signals, but the robots respond wrongly. The fourth possibility occurs when the users give no signal and the robots do not respond. In this case, the signal is referred to instructions or commands sent to robots, which may in form of voice or using devices such as remote control, joy stick, tablet, etc. Based on this theory, the second and the third cases are the two possibilities can happen when the communication breakdown between the older persons and the robots.

Another theory that may provide explanations on the communication breakdown between the robot and users is the bottom-up versus top-down processing [151]. The knowledge and experience possessed by someone are useful to assist them to figure out information come from their senses. If the information from the senses is not complete or unclear, the person still can figure out the message or meaning because they had knowledge and experience. This principle expects the users to perceive on the basis of their past experience. For example, assistive social robots rely on battery power for their operations. The green, yellow and red battery level indicators represent full, empty and no power. It is always like that on any robot, so the user can guess the next color that indicates the battery power level. This mental process is called as top-down processing. Another mental process is bottom-up processing. This process is merely based on senses capability of hearing or seeing. The message captured by the senses, then transferred to the brain, and someone may get the perception of the message. In reality, the processing of perceptual information depends on the interplay between these two processing as illustrated in Fig. 6.

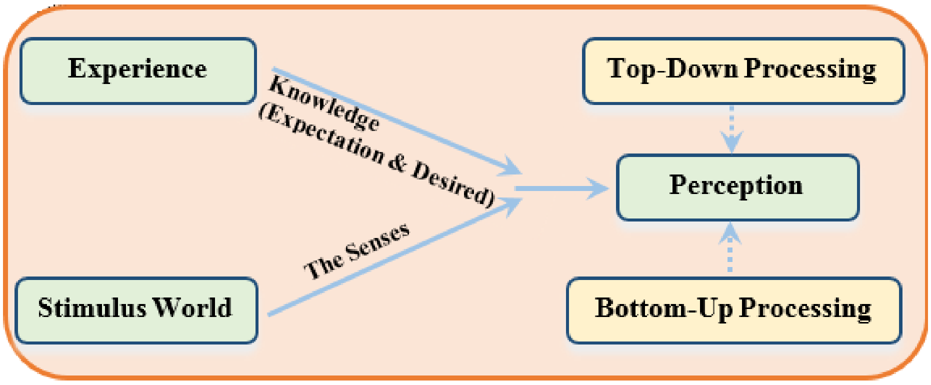

Fig. 6 - Top down and bottom up processing model

Success in handling the robots also depends on the users' knowledge and experience. It would be hard for the users to figure out message from the robots if no experience or knowledge. The robots are designed and developed based on computer hardware and software. Furthermore, users send commands or instructions to robots through interfaces such as tablets and remote controls. Older persons, especially those who were born before 1950 or at age 70 years and above might not be familiar and have no experience in operating these computer accessories and gadgets. Therefore, they have difficulties in figuring out on how to operate these tools. This constraint may be one of reasons why some of older persons were not satisfied with the usability of the robots. Hands-on training on the use of computer accessories and gadgets for those who are unfamiliar with these tools would help in the usability of robots and interfaces.

Another factor that may contribute to the low acceptance or usability of the assistive social robots is the display of the tools or interfaces. Display is defined as a human-made device designed to support the perception and facilitate further action of information [151]. Even though there is no specific complaint related to usability of the display, it plays a major role in the communication process between the robots and users. For example, users instruct the robots through apparatus or media such as remote control. In the application of assistive social robots, the display should be readable to older persons which most of them possibly has degraded in vision capability. If the display is improperly designed or having technical problems, then the older persons would experience difficulties to read and understand the message which can lead to faulty action. There are some principles of display design need to fulfill. The display principles that interconnect to robots among others are make the displays legible (or audible). The older persons should easily read the display or can hear the sound from the display. This principle should be integrated with a good contrast, visual angle and illumination. In designing a display, designers should consider to replace the users' memorizing effort by the visual information. For example, an older person user might like to retrieve information from the robot's interfaces through direct commands (knowledge in the head), rather than stepping in through a menu (knowledge in the world). Another principle is predictive aiding. This principle provides a simple perceptual, for example, arrows indicate movements to left and right directions. Deploying these display design principles may help the older persons to use the robot's interfaces or other accessories with minimum error, thus improved robot usability.

Application of assistive social robots in elderly care does not depends solely on the functionality and usability, but also have to fulfill users' acceptance and willingness to deploy this robotics technology [89]. This paper reveals some factors need to be considered to improve user experience when interacting with assistive social robots. At first, older persons love to stay at their own home. Lammer et al. [88] assumed that an assistive social robot could gain a great acceptance from the older persons if the robot can help them to live independently at their own home. In order to increase acceptability of older persons, the robots should be wisely designed and developed based on their requirements and physical limitations [99]. Ferreti [152] performed a study on acceptability among 202 Italian older persons aged over 65 years. The study showed that a strong preference for robots similar to small animals. The worst preference is baby-like and human-like appearance robots. The older persons showed a low interest if the robots are large sizes, superfluous of human similarity, low level of controllability, and overly mechanical aspect [153]. A study proved that new assistive products that consider emotional factor in their design could acquire high desirability and acceptability among older persons [154]. For example, Care-O-bot 4 robot was equipped with facial expressions and a multi-modal user interface to evoke positive emotions for enhancing human-robot interaction [155].

5. Conclusion

In this paper, the authors have reviewed a substantial volume of research work on usability and user experience of assistive social robots to provide physical and cognitive supports among the older persons. One of major issues in the usability of assistive social robots includes communication breakdown between the users and the robots. In this two ways communication, an older person is an active actor. He or she is the one who initiated the communication. To improve communication between the users and the robots, understanding the physical and psychological limitations of older persons such as their senses, visualization and hearing in capturing the message or information, require more attention from the researchers or manufacturers of assistive social robots. Older persons might have physical deficiency in visualization such as nearsighted or farsighted. Consequently, the design of display interface should consider these limitations. Furthermore, knowledge and experience of older persons which are stored in the long term memory and their capability for memorizing information should be considered as well. Most of older persons have minimum knowledge in robotics and the interfaces. They might be unfamiliar with the common codes or terms used in the robot applications. Hence, the older persons faced multiple cognitive workload such as memorizing the new things about the robots is one effort; figuring out instruction and operational procedures of the robots are another challenge.

In relation to user experience, the interface design, geometry and aesthetics of the assistive social robots play an important role in gaining the acceptance of older persons. Based on the reviewed articles, the authors concluded that older persons prefer to interact with a friendly interface design, small sized and animal-like robots. The older persons dislike assistive social robots which are bulky size and human-like shape. Taking into account the interface design, geometry and aesthetics factors, can increase the acceptance level and reduce the communication breakdown of the older persons towards assistive social robots. Further key point should be considered in designing assistive social robots is fulfilling users' needs and expectations (user-centered approach) to achieve high user experience. Involvement of older persons in the early stage of robot's development may help designers to distinguish wanted or unwanted features in structure of the assistive social robots. Additionally, repeated trial sessions of robot prototype among the older persons might be helpful to determine their requirements, insights and feedback such as colour, shape and materials to attain the optimum design of assistive social robots.

The findings reported by this paper will certainly provide a new insight to robot designers and manufacturers to develop usable and well-accepted assistive social robots for older persons who are known to have physical and psychological limitations compared to young adults.

Acknowledgement

The authors would like to thank the Faculty of Manufacturing Engineering and the Centre for Research and Innovation Management of Universiti Teknikal Malaysia Melaka funding this study under High Impact Short Term Research Grant entitled "A Cost Effective Passive Exoskeleton for Prolonged Standing Jobs" (PJP/2020/FKP/HI20/S01718).

References

[1] Department of Economic and Social Affairs of United Nations in the World Population Prospects 2019 Report. https://population.un.org/wpp/

[2] Fiorini, L., De Mul, M., Fabbricotti, I., Limosani, R., Vitanza, A., D'Onofrio, G., ... & Cavallo, F. (2021). Assistive robots to improve the independent living of older persons: results from a needs study. Disability and Rehabilitation: Assistive Technology, 16(1), 92-102.

[3] Rambaldini-Gooding, D., Molloy, L., Parrish, A. M., Strahilevitz, M., Clarke, R., Dubrau, J. M. L., & Perez, P. (2021). Exploring the impact of public transport including free and subsidised on the physical, mental and social well-being of older adults: a literature review. Transport Reviews, 1-17.

[4] Mulat, N., Gutema, H., & Wassie, G. T. (2021). Prevalence of depression and associated factors among elderly people in Womberma District, north-west, Ethiopia. BMC psychiatry, 21(1), 1-9.

[5] Yildirim, H., Işik, K., & Aylaz, R. (2021). The effect of anxiety levels of elderly people in quarantine on depression during covid-19 pandemic. Social Work in Public Health, 1-11.

[6] Niu, L., Jia, C., Ma, Z., Wang, G., Sun, B., Zhang, D., & Zhou, L. (2020). Loneliness, hopelessness and suicide in later life: a case–control psychological autopsy study in rural China. Epidemiology and Psychiatric Sciences, 29.

[7] Chen, S. C., Moyle, W., Jones, C., & Petsky, H. (2020). A social robot intervention on depression, loneliness, and quality of life for Taiwanese older adults in long-term care. International Psychogeriatrics, 32(8), 981-991.

[8] Whelan, S., Murphy, K., Barrett, E., Krusche, C., Santorelli, A., & Casey, D. (2018). Factors affecting the acceptability of social robots by older adults including people with dementia or cognitive impairment: a literature review. International Journal of Social Robotics, 10(5), 643-668.

[9] Dautenhahn, K. (2007). Socially intelligent robots: dimensions of human–robot interaction. Philosophical Transactions of the Royal Society B: Biological sciences, 362(1480), 679-704.

[10] Calderita, L. V., Vega, A., Barroso-Ramírez, S., Bustos, P., & Núñez, P. (2020). Designing a Cyber-Physical System for Ambient Assisted Living: A Use-Case Analysis for Social Robot Navigation in Caregiving Centers. Sensors, 20(14), 4005.

[11] Conti, D., Di Nuovo, S., & Di Nuovo, A. (2020). A brief review of robotics technologies to support social interventions for older users. In Human Centred Intelligent Systems (pp. 221-232). Springer, Singapore.

[12] Werner, C., Dometios, A. C., Tzafestas, C. S., Maragos, P., Bauer, J. M., & Hauer, K. (2020). Evaluating the task effectiveness and user satisfaction with different operation modes of an assistive bathing robot in older adults. Assistive Technology, 1-10.
[13] Kidd, C. D., Taggart, W., & Turkle, S. (2006). A sociable robot to encourage social interaction among the elderly. In Proceedings 2006 IEEE International Conference on Robotics and Automation, 2006. ICRA 2006. (pp. 3972-3976). IEEE.
[14] Feil-Seifer, D., & Matarić, M. J. (2011). Socially assistive robotics. IEEE Robotics & Automation Magazine, 18(1), 24-31.
[15] Libin, E., & Libin, A. (2003). New diagnostic tool for robotic psychology and robotherapy studies. CyberPsychology & Behavior, 6(4), 369-374.
[16] Tapus, A., Maja, M., & Scassellatti, B. (2007). The grand challenges in socially assistive robotics. IEEE Robot Autom Mag 14(1):35–42.
[17] Portugal, D., Santos, L., Alvito, P., Dias, J., Samaras, G., & Christodoulou, E. (2015, December). SocialRobot: An interactive mobile robot for elderly home care. In 2015 IEEE/SICE International Symposium on System Integration (SII) (pp. 811-816). IEEE.
[18] Fischinger, D., Einramhof, P., Papoutsakis, K., Wohlkinger, W., Mayer, P., Panek, P., ... & Vincze, M. (2016). Hobbit, a care robot supporting independent living at home: First prototype and lessons learned. Robotics and Autonomous Systems, 75, 60-78.
[19] Broekens, J., Heerink, M., & Rosendal, H. (2009). Assistive social robots in elderly care: a review. Gerontechnology, 8(2), 94-103.
[20] Buchan, J., & Aiken, L. (2008). Solving nursing shortages: a common priority. Journal of clinical nursing, 17(24), 3262-3268.
[21] Goh, Z. Y., Lai, M. M., Lau, S. H., & Ahmad, N. (2013). The formal and informal long-term caregiving for the elderly: The Malaysian experience. Asian Social Science, 9(4), 174.
[22] Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2010). Assessing acceptance of assistive social agent technology by older adults: the Almere model. International Journal of Social Robotics, 2(4), 361-375.
[23] Fan, J., Bian, D., Zheng, Z., Beuscher, L., Newhouse, P. A., Mion, L. C., & Sarkar, N. (2017). A Robotic Coach Architecture for Elder Care (ROCARE) based on multi-user engagement models. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 25(8), 1153-1163.
[24] Stiehl, W. D., Breazeal, C., Han, K. H., Lieberman, J., Lalla, L., Maymin, A., ... & Kishore, A. (2006). The huggable: a therapeutic robotic companion for relational, affective touch. In ACM SIGGRAPH 2006 emerging technologies (p. 15). ACM.
[25] Chen, K., Lou, V. W. Q., Tan, K. C. K., Wai, M. Y., & Chan, L. L. (2020). Effects of a humanoid companion robot on dementia symptoms and caregiver distress for residents in long-term care. Journal of the American Medical Directors Association.
[26] Salichs, M. A., Castro-González, Á., Salichs, E., Fernández-Rodicio, E., Maroto-Gómez, M., Gamboa-Montero, J. J., ... & Malfaz, M. (2020). Mini: A new social robot for the elderly. International Journal of Social Robotics, 1-19.
[27] Coşar, S., Fernandez-Carmona, M., Agrigoroaie, R., Pages, J., Ferland, F., Zhao, F., ... & Tapus, A. (2020). ENRICHME: Perception and interaction of an assistive robot for the elderly at home. International Journal of Social Robotics, 1-27.
[28] Fitter, N. T., Mohan, M., Kuchenbecker, K. J., & Johnson, M. J. (2020). Exercising with Baxter: preliminary support for assistive social-physical human-robot interaction. Journal of Neuroengineering and Rehabilitation, 17(1), 1-22.
[29] Ofgaa, G., & Umar, S. Social Robo to control symptoms in elderly institutional patients with dementia. Journal of Shanghai Jiaotong University, 16(7), 1158-1164.
[30] Winkle, K., Caleb-Solly, P., Turton, A., & Bremner, P. (2020). Mutual shaping in the design of socially assistive robots: A case study on social robots for therapy. International Journal of Social Robotics, 12, 847-866.
[31] Nunez, E., Hirokawa, M., & Suzuki, K. (2018). Design of a Huggable Social Robot with Affective Expressions Using Projected Images. Applied Sciences, 8(11), 2298.
[32] Shibata, T., Wada, K., & Tanie, K. (2003). Statistical analysis and comparison of questionnaire results of subjective evaluations of seal robot in Japan and UK. In 2003 IEEE International Conference on Robotics and Automation (Cat. No. 03CH37422) (Vol. 3, pp. 3152-3157). IEEE.
[33] Liang, A., Piroth, I., Robinson, H., MacDonald, B., Fisher, M., Nater, U. M., ... & Broadbent, E. (2017). A pilot randomized trial of a companion robot for people with dementia living in the community. Journal of the American Medical Directors Association, 18(10), 871-878.
[34] Hung, L., Liu, C., Woldum, E., Au-Yeung, A., Berndt, A., Wallsworth, C., ... & Chaudhury, H. (2019). The benefits of and barriers to using a social robot PARO in care settings: a scoping review. BMC geriatrics, 19(1), 232.

[35] Aminuddin, R., Sharkey, A., & Levita, L. (2016). Interaction with the Paro robot may reduce psychophysiological stress responses. In 2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 593-594). IEEE.
[36] Jensen, E. A., Smith, J., & Kovach, C. R. (2019). Social robots, robotic assistants, and home health monitoring devices: a gerontological research perspective. Research in Gerontological Nursing, 12(4), 163-166.
[37] Trovato, G., Kishi, T., Kawai, M., Zhong, T., Lin, J. Y., Gu, Z., ... & Takanishi, A. (2019, July). The creation of DarumaTO: a social companion robot for Buddhist/Shinto elderlies. In 2019 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM) (pp. 606-611). IEEE.
[38] Saint-Aimé, S., Le-Pevedic, B., Duhaut, D., & Shibata, T. (2007). EmotiRob: companion robot project. In RO-MAN 2007-The 16th IEEE International Symposium on Robot and Human Interactive Communication (pp. 919-924). IEEE.
[39] Nakashima, T., Fukutome, G., & Ishii, N. (2010, August). Healing effects of pet robots at an elderly-care facility. In 2010 IEEE/ACIS 9th International Conference on Computer and Information Science (pp. 407-412). IEEE.
[40] Wang, R., Zhang, H., & Leung, C. (2015). Follow me: A personal robotic companion system for the elderly. International Journal of Information Technology, 21(1).
[41] Vasavi, K. P., Kumar, N. U., & Prasad, N. S. (2017). Development of Mitthar-The Companion Robot for Lonely Elderly People. Technology, 8(3), 84-94.
[42] Do, H. M., Pham, M., Sheng, W., Yang, D., & Liu, M. (2018). RiSH: A robot-integrated smart home for elderly care. Robotics and Autonomous Systems, 101, 74-92.
[43] Christoforou, E. G., Panayides, A. S., Avgousti, S., Masouras, P., & Pattichis, C. S. (2019). An overview of assistive robotics and technologies for elderly care. In Mediterranean Conference on Medical and Biological Engineering and Computing (pp. 971-976). Springer, Cham.
[44] Bajones, M., Fischinger, D., Weiss, A., Wolf, D., Vincze, M., de la Puente, P., ... & Qammaz, A. (2018). Hobbit: Providing fall detection and prevention for the elderly in the real world. Journal of Robotics, 2018, 1-20.
[45] Koceska, N., Koceski, S., Beomonte Zobel, P., Trajkovik, V., & Garcia, N. (2019). A telemedicine robot system for assisted and independent living. Sensors, 19(4), 834.
[46] Schaeffer, C., & May, T. (1999). Care-o-bot-a system for assisting elderly or disabled persons in home environments. Assistive technology on the threshold of the new millenium, 3.
[47] Srinivasa, S. S., Berenson, D., Cakmak, M., Collet, A., Dogar, M. R., Dragan, A. D., ... & Ziegler, J. (2012). Herb 2.0: Lessons learned from developing a mobile manipulator for the home. Proceedings of the IEEE, 100(8), 2410-2428.
[48] Mukai, T., Hirano, S., Nakashima, H., Kato, Y., Sakaida, Y., Guo, S., & Hosoe, S. (2010, October). Development of a nursing-care assistant robot RIBA that can lift a human in its arms. In 2010 IEEE/RSJ International Conference on Intelligent Robots and Systems (pp. 5996-6001). IEEE.
[49] Bahrmann, F., Vogt, S., Wasic, C., Graessel, E., & Boehme, H. J. (2020). Towards an all-day assignment of a mobile service robot for elderly care homes. American Journal of Nursing, 9(5), 329-337.
[50] Huisman, C., & Kort, H. (2019). Two-year use of care robot Zora in Dutch nursing homes: An evaluation study. Healthcare, 7(31), 1-15.
[51] Nani, M., Caleb-Solly, P., Dogramadzi, S., Fear, T., & van den Heuvel, H. (2010). MOBISERV: an integrated intelligent home environment for the provision of health, nutrition and mobility services to the elderly. In Proc of the 4th Companion Robotics Workshop, Brussels, September 30, 2010.
[52] Yu, H., Spenko, M., & Dubowsky, S. (2003). An adaptive shared control system for an intelligent mobility aid for the elderly. Autonomous Robots, 15(1), 53-66.
[53] Spenko, M., Yu, H., & Dubowsky, S. (2006). Robotic personal aids for mobility and monitoring for the elderly. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 14(3), 344-351.
[54] Rehrl, T., Geiger, J., Golcar, M., Gentsch, S., Knobloch, J., Rigoll, G., ... & Wallhoff, F. (2014). The robot ALIAS as a database for health monitoring for elderly people. In Ambient Assisted Living (pp. 225-245). Springer, Berlin, Heidelberg.
[55] Lotfi, A., Langensiepen, C., & Yahaya, S. W. (2018). Socially assistive robotics: Robot exercise trainer for older adults. Technologies, 6(1), 32.
[56] van de Ven, A. A., Sponselee, A. M. A., & Schouten, B. A. (2010, August). Robo MD: a home care robot for monitoring and detection of critical situations. In Proceedings of the 28th Annual European Conference on Cognitive Ergonomics (pp. 375-376).
[57] Meyer, J., Brell, M., Hein, A., Gessler, S. (2009): Personal Assistive Robots for AAL at Home - The Florence Point of View.
[58] Roy, N., Baltus, G., Fox, D., Gemperle, F., Goetz, J., Hirsch, T., ... & Thrun, S. (2000). Towards personal service robots for the elderly. In Workshop on Interactive Robots and Entertainment (WIRE 2000) (Vol. 25, p. 184).

[59] Coradeschi, S., Cesta, A., Cortellessa, G., Coraci, L., Gonzalez, J., Karlsson, L., ... & Pecora, F. (2013, June). Giraffplus: Combining social interaction and long term monitoring for promoting independent living. In 2013 6th international conference on Human System Interactions (HSI) (pp. 578-585). IEEE.
[60] Pavón-Pulido, N., López-Riquelme, J. A., Pinuaga-Cascales, J. J., Ferruz-Melero, J., & dos Santos, R. M. (2015, April). Cybi: A smart companion robot for elderly people: Improving teleoperation and telepresence skills by combining cloud computing technologies and fuzzy logic. In 2015 IEEE International Conference on Autonomous Robot Systems and Competitions (pp. 198-203). IEEE.
[61] Pollack, M. E., Brown, L., Colbry, D., Orosz, C., Peintner, B., Ramakrishnan, S., ... & Thrun, S. (2002, August). Pearl: A mobile robotic assistant for the elderly. In AAAI workshop on automation as eldercare (Vol. 2002).
[62] Pigini, L., Facal, D., Blasi, L., & Andrich, R. (2012). Service robots in elderly care at home: Users' needs and perceptions as a basis for concept development. Technology and Disability, 24(4), 303-311.
[63] Korchut, A., Szklener, S., Abdelnour, C., Tantinya, N., Hernández-Farigola, J., Ribes, J. C., ... & Rejdak, K. (2017), Challenges for service robots - requirements of elderly adults with cognitive impairments. Frontiers in Neurology, 8, 228.
[64] Ke, C., Lou, V. W. Q., Tan, K. C. K., Wai, M. Y., & Chan, L. L. (2020). Changes in technology acceptance among older people with dementia: the role of social robot engagement. International Journal of Medical Informatics, 141, 104241.
[65] Kulviwat, S., Bruner II, G. C., Kumar, A., Nasco, S. A., & Clark, T. (2007). Toward a unified theory of consumer acceptance technology. Psychology & Marketing, 24(12), 1059-1084.
[66] Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS quarterly, 425-478.
[67] ISO DIS 9241-11: Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts (2015).
[68] Lund, A. M. (2001). Measuring usability with the use questionnaire12. Usability Interface, 8(2), 3-6.
[69] ISO 9241-210:2019. Ergonomics of Human-System Interaction - Part 210: Human-Centred Design for Interactive Systems; International Standardization Organization (ISO): Geneva, Switzerland, 2019.
[70] Filippi, S. (2020). PERSEL, a Ready-to-Use PERsonality-Based User SELection tool to maximize user experience redesign effectiveness. Multimodal Technologies and Interaction, 4(13), 1-20.
[71] Keizer, R. A. O., Van Velsen, L., Moncharmont, M., Riche, B., Ammour, N., Del Signore, S., ... & N'Dja, A. (2019). Using socially assistive robots for monitoring and preventing frailty among older adults: a study on usability and user experience challenges. Health and Technology, 9(4), 595-605.
[72] Oh, Y. H., & Ju, D. Y. (2020). Age-related differences in fixation pattern on a companion robot. Sensors, 20(13), 3807.
[73] Gerlowska, J., Skrobas, U., Grabowska-Aleksandrowicz, K., Korchut, A., Szklener, S., Szczęśniak-Stańczyk, D., ... & Rejdak, K. (2018). Assessment of perceived attractiveness, usability, and societal impact of a multimodal robotic assistant for aging patients with memory impairments. Frontiers in Neurology, 9, 392.
[74] Anghel, I., Cioara, T., Moldovan, D., Antal, M., Pop, C. D., Salomie, I., ... & Chifu, V. R. (2020). Smart environments and social robots for age-friendly integrated care services. International Journal of Environmental Research and Public Health, 17(11), 3801.
[75] Koh, W. Q., Felding, S. A., & Casey, D. (2020). Barriers and facilitators to the implementation of social robots for older adults: a scoping review protocol.
[76] Góngora Alonso, S., Hamrioui, S., de la Torre Díez, I., Motta Cruz, E., López-Coronado, M., & Franco, M. (2019). Social robots for people with aging and dementia: a systematic review of literature. Telemedicine and e-Health, 25(7), 533-540.
[77] Martinez-Martin, E., & del Pobil, A. P. (2018). Personal robot assistants for elderly care: an overview. In Personal Assistants: Emerging Computational Technologies (pp. 77-91). Springer, Cham.
[78] Hosseini, S. E., & Goher, K. (2017). Personal care robots for older adults: An overview. Asian Social Science, 13(1), 11-19.
[79] Reis, A., Xavier, R., Barroso, I., Monteiro, M. J., Paredes, H., & Barroso, J. (2018, June). The usage of telepresence robots to support the elderly. In 2018 2nd International Conference on Technology and Innovation in Sports, Health and Wellbeing (TISHW) (pp. 1-6). IEEE.
[80] Kristoffersson, A., Almquist, L., Björkman, P., Cesta, A., Cortellessa, G., ... & Loutfi, A. (2016). Excite project: A review of forty-two months of robotic telepresence technology evolution. Presence: Teleoperators and Virtual Environments, 25(3), 204-221.
[81] Tsai, T. C., Hsu, Y. L., Ma, A. I., King, T., & Wu, C. H. (2007). Developing a telepresence robot for interpersonal communication with the elderly in a home environment. Telemedicine and e-Health, 13(4), 407-424.
[82] Michaud, F., Boissy, P., Labonté, D., Corriveau, H., Grant, A., Lauria, M., ... & Royer, M. P. (2007). Remote assistance in caregiving using telerobot. In Proceedings of the International Conference on Technology & Aging.

[83] Kristoffersson, A., Coradeschi, S., & Loutfi, A. (2013). A review of mobile robotic telepresence. Advances in Human-Computer Interaction, 2013.
[84] Krishnan, R. H., & Pugazhenthi, S. (2014). Mobility assistive devices and self-transfer robotic systems for elderly, a review. Intelligent Service Robotics, 7(1), 37-49.
[85] Flandorfer, P. (2012). Population ageing and socially assistive robots for elderly persons: the importance of sociodemographic factors for user acceptance. International Journal of Population Research, 1-13.
[86] Vincze, M., Bajones, M., Suchi, M., Wolf, D., Lammer, L., Weiss, A., & Fischinger, D. (2017). User Experience Results of Setting Free a Service Robot for Older Adults at Home. In Service Robots. IntechOpen.
[87] Pripfl, J., Körtner, T., Batko-Klein, D., Hebesberger, D., Weninger, M., Gisinger, C., ... & Weiss, A. (2016). Results of a real world trial with a mobile social service robot for older adults. In 2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (497-498). IEEE.
[88] Lammer, L., Huber, A., Weiss, A., & Vincze, M. (2014, April). Mutual care: How older adults react when they should help their care robot. In AISB2014: Proceedings of the 3rd international symposium on new frontiers in human–robot interaction (pp. 1-4). London, UK: Routledge.
[89] Körtner, T., Schmid, A., Batko-Klein, D., & Gisinger, C. (2014, June). Meeting requirements of older users? Robot prototype trials in a home-like environment. In International Conference on Universal Access in Human-Computer Interaction (pp. 660-671). Springer, Cham.
[90] Pino, M., Granata, C., Legouverneur, G., & Rigaud, A. S. (2012). Assessing design features of a graphical user interface for a social assistive robot for older adults with cognitive impairment. In ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction (Vol. 29, p. 1). IAARC Publications.
[91] Wu, Y. H., Wrobel, J., Cornuet, M., Kerhervé, H., Damnée, S., & Rigaud, A. S. (2014). Acceptance of an assistive robot in older adults: a mixed-method study of human–robot interaction over a 1-month period in the Living Lab setting. Clinical interventions in aging, 9, 801.
[92] Sääskilahti, K., Kangaskorte, R., Pieskä, S., Jauhiainen, J., & Luimula, M. (2012, September). Needs and user acceptance of older adults for mobile service robot. In 2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication (pp. 559-564). IEEE.
[93] Granata, C., Pino, M., Legouverneur, G., Vidal, J. S., Bidaud, P., & Rigaud, A. S. (2013). Robot services for elderly with cognitive impairment: testing usability of graphical user interfaces. Technology and Health Care, 21(3), 217-231.
[94] Zsiga, K., Tóth, A., Pilissy, T., Péter, O., Dénes, Z., & Fazekas, G. (2017). Evaluation of a companion robot based on field tests with single older adults in their homes. Assistive Technology, 30(5), 259-266.
[95] Wilk, R., & Johnson, M. J. (2014, August). Usability feedback of patients and therapists on a conceptual mobile service robot for inpatient and home-based stroke rehabilitation. In 5th IEEE RAS/EMBS international conference on biomedical robotics and biomechatronics (pp. 438-443). IEEE.
[96] Torta, E., Werner, F., Johnson, D. O., Juola, J. F., Cuijpers, R. H., Bazzani, M., ... & Bregman, J. (2014). Evaluation of a small socially-assistive humanoid robot in intelligent homes for the care of the elderly. Journal of Intelligent & Robotic Systems, 76(1), 57-71.
[97] Begum, M., Wang, R., Huq, R., & Mihailidis, A. (2013, June). Performance of daily activities by older adults with dementia: The role of an assistive robot. In 2013 IEEE 13th International Conference on Rehabilitation Robotics (ICORR) (pp. 1-8). IEEE.
[98] Eicher, C., Haesner, M., Spranger, M., Kuzmicheva, O., Gräser, A., & Steinhagen-Thiessen, E. (2019). Usability and acceptability by a younger and older user group regarding a mobile robot-supported gait rehabilitation system. Assistive technology, 31(1), 25-33.
[99] Di Nuovo, A., Broz, F., Wang, N., Belpaeme, T., Cangelosi, A., Jones, R., ... & Dario, P. (2018). The multi-modal interface of Robot-Era multi-robot services tailored for the elderly. Intelligent Service Robotics, 11(1), 109-126.
[100] Di Nuovo, A., Broz, F., Belpaeme, T., Cangelosi, A., Cavallo, F., Esposito, R., & Dario, P. (2014, October). A web based multi-modal interface for elderly users of the robot-era multi-robot services. In 2014 IEEE international conference on Systems, Man, and Cybernetics (SMC) (pp. 2186-2191). IEEE.
[101] Heerink, M., Kröse, B., Wielinga, B. J., & Evers, V. (2006). Studying the acceptance of a robotic agent by elderly users. International Journal of Assistive Robotics and Mechatronics, 7(3), 33-43.
[102] Koceski, S., & Koceska, N. (2016). Evaluation of an assistive telepresence robot for elderly healthcare. Journal of Medical Systems, 40(5), 121.
[103] Cesta, A., Cortellessa, G., Orlandini, A., & Tiberio, L. (2016). Long-term evaluation of a telepresence robot for the elderly: methodology and ecological case study. International Journal of Social Robotics, 8(3), 421-441.
[104] Kristoffersson, A., Coradeschi, S., Loutfi, A., & Severinson-Eklundh, K. (2014). Assessment of interaction quality in mobile robotic telepresence: An elderly perspective. Interaction Studies, 15(2), 343-357.
[105] Cortellessa, G., Fracasso, F., Sorrentino, A., Orlandini, A., Bernardi, G., Coraci, L., ... & Cesta, A. (2018). ROBIN, a telepresence robot to support older users monitoring and social inclusion: development and evaluation. Telemedicine and e-Health, 24(2), 145-154.

[106] Beer, J. M., & Takayama, L. (2011, March). Mobile remote presence systems for older adults: acceptance, benefits, and concerns. In Proceedings of the 6th international conference on Human-robot interaction (pp. 19-26).

[107] Mast, M., Burmester, M., Graf, B., Weisshardt, F., Arbeiter, G., Španěl, M., ... & Kronreif, G. (2015). Design of the human-robot interaction for a semi-autonomous service robot to assist elderly people. In Ambient assisted living (pp. 15-29). Springer, Cham.

[108] Seelye, A. M., Wild, K. V., Larimer, N., Maxwell, S., Kearns, P., & Kaye, J. A. (2012). Reactions to a remote-controlled video-communication robot in seniors' homes: a pilot study of feasibility and acceptance. Telemedicine and e-Health, 18(10), 755-759.

[109] Louie, W. Y. G., McColl, D., & Nejat, G. (2014). Acceptance and attitudes toward a human-like socially assistive robot by older adults. Assistive Technology, 26(3), 140-150.

[110] Schroeter, C., Mueller, S., Volkhardt, M., Einhorn, E., Huijnen, C., van den Heuvel, H., ... & Gross, H. M. (2013, May). Realization and user evaluation of a companion robot for people with mild cognitive impairments. In 2013 IEEE International Conference on robotics and automation (pp. 1153-1159). IEEE.

[111] Klamer, Tineke, and Somaya Ben Allouch. "Acceptance and use of a social robot by elderly users in a domestic environment." In 2010 4th International Conference on Pervasive Computing Technologies for Healthcare, pp. 1-8. IEEE, 2010.

[112] Gadde, P., Kharrazi, H., Patel, H., & MacDorman, K. F. (2011). Toward monitoring and increasing exercise adherence in older adults by robotic intervention: a proof of concept study. Journal of Robotics, 1-11.

[113] Montemerlo, M., Pineau, J., Roy, N., Thrun, S., & Verma, V. (2002). Experiences with a mobile robotic guide for the elderly. AAAI/IAAI, 587-592.

[114] Lera, F. J., Rodríguez, V., Rodríguez, C., & Matellán, V. (2014). Augmented reality in robotic assistance for the elderly. In International Technology Robotics Applications (pp. 3-11). Springer, Cham.

[115] Gross, H. M., Mueller, S., Schroeter, C., Volkhardt, M., Scheidig, A., Debes, K., ... & Doering, N. (2015, September). Robot companion for domestic health assistance: Implementation, test and case study under everyday conditions in private apartments. In 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 5992-5999). IEEE.

[116] Dario, P., Guglielmelli, E., Laschi, C., & Teti, G. (1999). MOVAID: a personal robot in everyday life of disabled and elderly people. Technology and Disability, 10(2), 77-93.

[117] Sabelli, A. M., Kanda, T., & Hagita, N. (2011, March). A conversational robot in an elderly care center: an ethnographic study. In 2011 6th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 37-44). IEEE.

[118] Wada, K., Shibata, T., Saito, T., & Tanie, K. (2003, October). Effects of robot assisted activity to elderly people who stay at a health service facility for the aged. In Proceedings 2003 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2003) (Cat. No. 03CH37453) (Vol. 3, pp. 2847-2852). IEEE.

[119] Robinson, H., MacDonald, B., Kerse, N., & Broadbent, E. (2013). The psychosocial effects of a companion robot: a randomized controlled trial. Journal of the American Medical Directors Association, 14(9), 661-667.

[120] Görer, B., Salah, A. A., & Akın, H. L. (2016). An autonomous robotic exercise tutor for elderly people. Autonomous Robots, 41(3), 657-678.

[121] Di Nuovo, A., Wang, N., Broz, F., Belpaeme, T., Jones, R., & Cangelosi, A. (2016, June). Experimental evaluation of a multi-modal user interface for a robotic service. In Annual Conference Towards Autonomous Robotic Systems (pp. 87-98). Springer, Cham.

[122] Cavallo, F., Esposito, R., Limosani, R., Manzi, A., Bevilacqua, R., Felici, E., ... & Dario, P. (2018). Acceptance of Robot-Era system: results of robotic services in smart environments with older adults. Journal of Medical Internet Research, 20 (9).

[123] Wu, Y. H., Chetouani, M., Cristancho-Lacroix, V., Matre, J., Jost, C., Pevedic, B., ... & Rigaud, A. S. (2011). ROBADOM: an assistive robot for the elderly with mild cognitive impairment: System design and users' perspective. In 5th Companion Robotics Institute Workshop AAL User-Centric Companion Robotics, France.

[124] Mollaret, C., Mekonnen, A. A., Lerasle, F., Ferrané, I., Pinquier, J., Boudet, B., & Rumeau, P. (2016). A multi-modal perception based assistive robotic system for the elderly. Computer Vision and Image Understanding, 149, 78-97.

[125] Cesta, A., Cortellessa, G., Orlandini, A., & Tiberio, L. (2012). Into the wild: Pushing a telepresence robot outside the lab. In Proceedings of SRT 2012—Workshop on Social Robotic Telepresence (pp. 7-14).

[126] Yamazaki, R., Nishio, S., Ogawa, K., & Ishigur, H. (2012, September). Teleoperated android as an embodied communication medium: A case study with demented elderlies in a care facility. In 2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication (pp. 1066-1071). IEEE.

[127] Cortellessa, G., Scopelliti, M., Tiberio, L., Svedberg, G. K., Loutfi, A., & Pecora, F. (2008, November). A Cross-Cultural Evaluation of Domestic Assistive Robots. In AAAI Fall Symposium: AI in Eldercare: New Solutions to Old Problems (pp. 24-31).

[128] Tamura, T., Yonemitsu, S., Itoh, A., Oikawa, D., Kawakami, A., Higashi, Y., ... & Nakajima, K. (2004). Is an entertainment robot useful in the care of elderly people with severe dementia? The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 59(1), M83-M85.
[129] Fasola, J., & Mataric, M. (2011). Comparing physical and virtual embodiment in a socially assistive robot exercise coach for the elderly. Center for Robotics and Embedded Systems, Los Angeles, CA.
[130] Neven, L. (2010). 'But obviously not for me': robots, laboratories and the defiant identity of elder test users. Sociology of Health & Illness, 32(2), 335-347.
[131] Khosla, R., Nguyen, K., & Chu, M. T. (2017). Human robot engagement and acceptability in residential aged care. International Journal of Human - Computer Interaction, 33(6), 510-522.
[132] Piezzo, C., & Suzuki, K. (2017). Feasibility study of a socially assistive humanoid robot for guiding elderly individuals during walking. Future Internet, 9(3), 30.
[133] Avelino, J., Simão, H., Ribeiro, R., Moreno, P., Figueiredo, R., Duarte, N., ... & Odekerken-Schröde, G. (2018, March). Experiments with vizzy as a coach for elderly exercise. In Proc. Workshop Pers. Robots Exercising Coaching-HRI Conf. (PREC) (pp. 1-6).
[134] Nakagawa, Y., Park, K., Ueda, H., & Ono, H. (2014, June). Driving assistance with conversation robot for elderly drivers. In International Conference on Universal Access in Human-Computer Interaction (pp. 750-761). Springer, Cham.
[135] Jayawardena, C., Kuo, I., Datta, C., Stafford, R. Q., Broadbent, E., & MacDonald, B. A. (2012, June). Design, implementation and field tests of a socially assistive robot for the elderly: HealthBot Version 2. In 2012 4th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob) (pp. 1837-1842). IEEE.
[136] Jayawardena, C., Kuo, I. H., Broadbent, E., & MacDonald, B. A. (2016). Socially assistive robot healthbot: Design, implementation, and field trials. IEEE Systems Journal, 10(3), 1056-1067.
[137] Lowet, D., Isken, M., Lee, W. P., Van Heesch, F., & Eertink, E. H. (2012). Robotic telepresence for 24/07 remote assistance to elderly at home. Social Robotic Telepresence, 17.
[138] Iwamura, Y., Shiomi, M., Kanda, T., Ishiguro, H., & Hagita, N. (2011, March). Do elderly people prefer a conversational humanoid as a shopping assistant partner in supermarkets? In Proceedings of the 6th international conference on Human-robot interaction (pp. 449-456).
[139] Reppou, S. E., Tsardoulias, E. G., Kintsakis, A. M., Symeonidis, A. L., Mitkas, P. A., Psomopoulos, F. E., ... & Iturburu, M. (2016). Rapp: a robotic-oriented ecosystem for delivering smart user empowering applications for older people. International Journal of Social Robotics, 8(4), 539-552.
[140] Manti, M., Pratesi, A., Falotico, E., Cianchetti, M., & Laschi, C. (2016, June). Soft assistive robot for personal care of elderly people. In 2016 6th IEEE International Conference on Biomedical Robotics and Biomechatronics (BioRob) (pp. 833-838). IEEE.
[141] Rızvanoğlu, K., Öztürk, Ö., & Adiyaman, Ö. (2014, June). The impact of human likeness on the older adults' perceptions and preferences of humanoid robot appearance. In International Conference of Design, User Experience, and Usability (pp. 164-172). Springer, Cham.
[142] Kachouie, R., Sedighadeli, S., Khosla, R., & Chu, M. T. (2014). Socially assistive robots in elderly care: a mixed-method systematic literature review. International Journal of Human-Computer Interaction, 30(5), 369-393.
[143] Bogue, R. (2013), Robots to aid the disabled and the elderly, Industrial Robot, Vol. 40 No. 6, pp. 519-524. https://doi.org/10.1108/IR-07-2013-372
[144] Hoefinghoff, J., Rosenthal-von Der Pütten, A., Pauli, J., & Krämer, N. (2015, October). "Yes dear, that belongs into the shelf! - Exploratory studies with elderly people who learn to train an adaptive robot Companion. In International Conference on Social Robotics (pp. 235-244). Springer, Cham.
[145] Miehle, J., Bagci, I., Minker, W., & Ultes, S. (2019). A social companion and conversational partner for the elderly. In Advanced Social Interaction with Agents (pp. 103-109). Springer, Cham.
[146] Niemelä, M., & Melkas, H. (2019). Robots as social and physical assistants in elderly care. In Human-centered digitalization and services (pp. 177-197). Springer, Singapore.
[147] Vercelli, A., Rainero, I., Ciferri, L., Boido, M., & Pirri, F. (2018). Robots in elderly care. DigitCult-Scientific Journal on Digital Cultures, 2(2), 37-50.
[148] Mitzner, T. L., Boron, J. B., Fausset, C. B., Adams, A. E., Charness, N., Czaja, S. J., ... & Sharit, J. (2010). Older adults talk technology: Technology usage and attitudes. Computers in Human Behavior, 26(6), 1710-1721.
[149] Paez, L. E., & Del Río, C. Z. (2019, July). Elderly users and their main challenges usability with mobile applications: A systematic review. In International Conference on Human-Computer Interaction (pp. 423-438). Springer, Cham.
[150] Čaić, M., Avelino, J., Mahr, D., Odekerken-Schröder, G., & Bernardino, A. (2019). Robotic versus human coaches for active aging: an automated social presence perspective. International Journal of Social Robotics, 1-16.

[151] Wickens, C. D., Gordon, S. E., & Liu, Y. (2004). An introduction to human factors engineering. Upper Saddle River, N.J: Pearson Prentice Hall.
[152] Ferretti, M., Morgavi, G., & Veruggio, G. (2018). The acceptability of caregiver robots in elderly people. In ICT4AWE (pp. 111-118).
[153] Ferretti, M., Morgavi, G., & Veruggio, G. (2018). How should a robot caregiver for elderly people be? International Journal of Control Systems and Robotics, 3, 26-33.
[154] Hirsch, T., Forlizzi, J., Hyder, E., Goetz, J., Kurtz, C., & Stroback, J. (2000, November). The ELDer project: social, emotional, and environmental factors in the design of eldercare technologies. In Proceedings on the 2000 conference on Universal Usability (pp. 72-79).
[155] Kittmann, R., Fröhlich, T., Schäfer, J., Reiser, U., Weißhardt, F., & Haug, A. (2015). Let me introduce myself: I am Care-O-bot 4, a gentleman robot. Mensch und Computer, 223-232.