Advanced Assistive Technologies for Elderly People: A Psychological Perspective on Older Users' Needs and Preferences (Part B)

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Abstract: This paper provides a general overview of the literature regarding advanced assistive technologies devoted to improving elders' life. Recent studies on assistive robots and embodied conversational agents are carefully examined in order to identify main seniors' preferences regarding their general design. While providing data on seniors' preferences about the design of assistive devices, main evidence on both robots and virtual agent's appearance, abilities/functionalities, personalities, and role features are summarized and commented.

Keywords: older user; assistive technology; robot; virtual agent; design; preferences

1 Introduction

There is a general agreement that the successful incorporation of assistive social technologies (e.g., virtual agents, robots) in everyday life can positively influence the well-being of elders by affecting their psychological characteristics, e.g., mood, motivation, autonomy, self-determination, and coping abilities [1].

If a user's needs and expectations are accurately and appropriately addressed and aligned with the agent's (or robot) behaviors, physical appearance, and role, then seniors and vulnerable people may be in favor of accepting and using such every day assistive technologies [2, 3].

This paper reviews the literature on advanced assistive technologies aimed at improving older people's well-being, focusing on assistive robots and embodied conversational agents, in order to discover seniors' main preferences regarding the general design of such technologies, including appearance, functionalities, and attitudes.

2 General Designs of Assistive Devices and Seniors' Preferences

Following the premise of "customization needs" as a basis for developing assistive technologies for seniors' uses, it follows that personalization (also referred to as one-to-one marketing) is of significant concern in designing both robots/virtual agents' appearance, as well as defining the services, behaviors, and attitudes these technologies can offer to their end-users. These design-related features aim primarily at engaging and maintaining user engagement throughout interactions with the device [4-6]. The main findings regarding seniors' preferences about these design features are described below, distinguishing evidence regarding robots by those related to virtual agents.

2.1 Appearance

Seniors' preferences and opinions about the appearance of assistive devices, both robots and virtual agents, were broadly investigated with controversial findings.

2.1.1 Robot

Several reasons were identified related to a robot's physical appearance and why this is considered a significant factor for potential users' acceptance. How a robot or a virtual agent appears affects the way individuals appraise the agent/robot functions, abilities, desirability, accessibility, and expressiveness [2, 7].

To this aim, inconsistent evidence has been reported on whether a robot should have a human- or animal-like appearance.

Broadbent et al. [2] highlighted that since both soft (used in health care and designed to resemble animals, e.g., Hopis) and humanoid robots (designed for companionship) have proven to be either disliked or popular, a good match between animal-like robots and companionship seems to be suggested.

De Graaf et al. [8] has shown that seniors seem to welcome the idea of some animal-like robots so that they are comforting to hold and pet them while being able to communicate and perform other activities.

Conversely, Hutson et al. [9] and Robinson et al. [7] showed that elders negatively evaluate animal-like robots (e.g., Pleo and FurReal Cat) because they expected them to act like real pets and express dissatisfaction when their behavior is different. According to these authors, animal-like robots are characterized by a toy-like appearance and older people do not appreciate the contrast between their fluffy appearance and the seriousness of the tasks they are required to perform.

Similarly, to what extent a robot should have a human-like appearance is a hotly debated issue. Some evidence showed that older adults prefer human-like appearing robots [10], while other findings reported little preference for them [2, 11]. Based on these data, some authors concluded that seniors do not appreciate human-like robots because their anthropomorphic shape is less socially acceptable in comparison to robots that looked more like machines [2, 11, 12].

This rejection can be motivated by the user's cultural and/or religious background [13]. It has been argued that seniors are not attracted by robotic devices with human-like features and appearances because they are more religious than their younger counterparts [14].

Other investigations reported that elders prefer creative robots with human traits, humanoid robots, and mechanized human-like robots that incorporate in their design anthropomorphic facial features so that they look like familiar objects in their home setting [11, 14].

Regarding the size, seniors seem to approve small-sized rather than human-sized robots since the former can be easily integrated into users' home environment (e.g., into the existing furnishings; the television and the system could be contained in the same device) in a non-intrusive way, and are simultaneously not cumbersome, discreet robust, and effortlessly manageable by users with reduced mobility [9, 14, 15]. Additionally, seniors seem to prefer slowly moving, and non-threatening robots, entrusted with a feminine voice. These characteristics are likely to reduce anxiety related to distrust and a lack of confidence in robots' abilities [2, 16].

2.1.2 Virtual Agent

The external appearance of the virtual agent (i.e., its representation as human-like, animal-like, or anything else like) determines the potential degree of seniors' willingness to cooperate with them [17]. Bickmore et al. [4], emphasized that the extent to which virtual agents appear is a fundamental design element to be accounted for by all developers of robotic devices for domestic use.

In the health care and well-being domains conclusive evidence exists that seniors prefer female human-like rather than animal-like or other non-human like virtual agents [3, 18-22].

Realistic human design tends to elicit a sense of trustworthiness and competence.

Therefore, increasing the human-like qualities of virtual agents increase users' trust and compliance, and this is particularly true for virtual agents involved in health care services [23-26]. As further support to the abovementioned results, several empirical studies had shown that users aspire to interact with virtual agents resembling them, aligned with their own personalities (based on introversion vs. extroversion according to displayed text messages) and their own body shape, suggesting that a human-shaped virtual agent is the most appropriate digital interface for a social collaborative behaving system [4, 27-29].

However, seniors are not strict in these preferences and are willing to accept also agents with non-human like appearances. To this aims, seniors have shown positive attitudes also for fictitious cartoon-like (Smiley) (human-like appearances were less popular), animal-like (e.g., GeriJoy), and flower-like (Flowie) characters all considered to convey cooperation and warmth, and purposely serve as supportive friends [3, 17, 30, 31].

2.1.3 Human-like Appearance and Related Issues

It should be noted that specific issues related to human-like appearances also exist, such as the "uncanny valley" effect [32]. According to this phenomenon, a robotic virtual agent device resembling a living creature too closely is expected to behave like that particular creature, and the failure in doing so elicits discomfort, potentially breaking down the success of the user–agent interaction. Furthermore, it has been found that as artificial constructs become increasingly sophisticated in their visual design, human beings' positive emotional responses to them decrease. In particular, agents/robots too similar to humans have been found to elicit distrust because their design represents something interpreted as being alive and not alive at the same time [3, 25]. This can be particularly true for seniors contending with dementia, having difficulties in distinguishing the agent/robot from a human being. Thus, a highly realistic human appearance can be potentially problematic since an extreme human-like appearance can be seen as a kind of deception and raise ethical issues, as impaired seniors (e.g., suffering from dementia) can be disoriented by interacting with these types of devices [11, 14, 25, 33].

Thereby, robotic or virtual agent devices designed to strongly resemble to human beings can be judged fraudulent and, unethical, since the proposed benefits of the relationship depend on the user's willingness to engage with an illusory representation of a human being [34].

2.2 Abilities and Functionalities – Robots

Whether and to what degree a robotic device is accepted is closely associated with its functionalities. For elderly person's these functionalities must aim to provide practical help for daily issues, promote healthy behaviors and wellness, offer health monitoring and preventive care, as well as carry out household activities.

2.2.1 Practical Help for Current Issues and Household Activities

Older people often expressed that they would like a robot to be able to carry out tasks that support their independence in the performance of their daily activities. Seniors appreciate a robot able to find objects, pick them up from the floor, manage information, manipulate items [35-37]. Also, the robot should be adept at controlling appliances, cleaning the house (especially in the case of older adults with mobility impairments), making calls, doing shopping online (especially if needed in relation to an illness or injury), planning outings, simplifying internet access, fetching and organizing objects, and doing household tasks like laundry, and trash disposal [11, 38-40].

2.2.2 Promoting Wellness

Regarding well-being, a robotic device should be capable of performing useful functions that promote wellness. These might include communicative services that allow users to remain socially active (e.g., video calls, email) and facilitate their communications with family members, friends, doctors, nurses, and caregivers, as well as allowing contacts with the world beyond the home environment, increasing and strengthening social interactions and relationships. In addition, robotic devices should be able to promote creativity through intellectual stimulation and provide assistance for new learning and engaging in hobbies reducing loneliness, bridging distances, and facilitating exchanges [9, 11, 40-42].

Entertainment functionalities are also highly appreciated by older users, such as playing music (either from their own collections or a radio), audiobooks, and fitness instructions [8, 35].

2.2.3 Health Improvement, Monitoring, and Safety Functions

Seniors require a robot be able to promote healthy behaviors, have the potential to give dietary and exercise advice, offer cognitive support by providing reminders for appointments, and taking medications, address concerns regarding side effects and dosage changes, and send information to users' health practitioners, propose directions, motivations, and cues for daily acting (i.e., suggest what to eat or which movie watch), and several types of mental stimulation including memory training, card games, music, audiobooks, and videos that could support cognitive awareness to compensate for mild cognitive impairment (e.g., finding misplaced items, offering reminders) [7, 8, 11, 36, 40, 43].

Other functionalities considered useful to prevent health problems and accidents are risk prevention and health care applications for detecting falls, managing critical events, calling for help, and monitoring locations [2, 11, 44].

2.3 Abilities and Functionalities – Virtual Agent

Seniors' attribute to virtual agents similar robotic skills and functionalities including assistance in performing daily activities that promote well-being and execute functions for health improvement and monitoring.

2.3.1 Practical Help for Current Issues and for Household Activities

Within tasks considered useful for virtual agents there are daily schedule management, support in routine activities (e.g., maintaining a personal up-to-date daily plan and providing appropriate reminders during the day); managing personal agenda, using interactive calendar creating new entries and reminders of events (e.g., a reminder about social engagements or dental or medical appointments); provide dietary advice, helping to locate recipes based on ingredients already available at home [3, 15].

In addition, virtual agents are required to be able to simplify seniors' exploitation of ambient intelligent environments, acting as simplifying interfaces. This kind of agent is seen as a virtual butler, able to answer any user request and need of exploiting a computing device, as well as, simplifying elderly uses of smartphone interfaces, for example replacing fonts, or using voice to substitute complex menus that usually characterize smartphones [45-47].

2.3.2 Promoting Wellness

Older adults enjoyed agents functioning as automated coaches that would motivate them to perform activities to promote their wellness, such as taking walks, performing relaxation exercises or playing brain-training games [30, 48].

Additionally, agents can promote seniors' physical and mental well-being, suggesting to drink more water, eat meals, and reminding them to make contact with friends and family members [3, 31].

2.3.3 Health Improvement, Monitoring, Safety Actions

Older users living alone at home were especially interested in virtual agents able to perform safety measures such as monitoring the home to identify dangerous situations (e.g., loud noises, fallen objects, fallen people) and help them to improve their health status, remembering them to take medications on time [3].

In addition, the agent should be aware of the user's location and identify inconsistencies between what the older adult was supposed to be doing at a particular time and what she/he was doing instead, in case of discrepancies. Moreover, if something was wrong, it should be able to notify medical services, the user's relatives, and caregivers, or other specified individuals via email, or phone calls [3, 47].

In this regard, specific agents (e.g., Frederick) were designed to represent a medical doctor, assisting patients with specific illnesses or health conditions that need to be daily monitored (e.g., for patients with type 2 diabetes, the agent is able to keep track of their blood sugar levels, issue reminders, check blood-sugar levels over time, and share that data with external reviewers) [17].

2.4 Assistive Devices' Personalities and Roles

The success of the deployment of an assistive device depends not only on its usefulness but also on its social intelligence, namely its capability to show personality traits, attitude, social skills, and emotional aspects of face-to-face interaction in a comfortable and socially acceptable way [3, 18].

2.4.1 Robot

Studies have indicated that whether users will take the robotic device seriously can depend on the personality they perceive it to have [7]. For example, some evidence suggested that certain character traits like a sense of humor and being curious, in addition to having a serious side, can make a difference with regard to the robot's acceptance [2, 9]. Some studies also had shown that seniors are more likely to follow exercise routine instructions delivered by a serious robot's character rather than a playful one, although the playful robot is more positively rated, suggesting that seniors are less likely to take advice from robots that are not perceived as serious devices (e.g., Ifbot and Hopis) [7, 49]. Regarding preferred roles, seniors are more likely to accept a companion a robot able to communicate by voice and touch. Additionally, it should respond to the user and the environment (audio or visual recognition), recognize and respond to a user's feelings and mood (possibly from their tone of voice) and alter its own "mood" in response [9]. Results from studies using social robots (e.g., Paro, a soft "seal" robot; AIBO, a "dog" robot) demonstrated that interacting with the device as a social entity decreases users' loneliness, reduces depressive disorders, and improves seniors' quality of life, as evidenced data showing a marked improvement in seniors' speech, attitude, outlook, and behavior [7]. This was shown to be true also for seniors living in rural locations that felt the robot like a companion making them less alone at home [50], and for mild cognitive impaired individuals who perceived the robotic companion as a pleasant distraction and a friendly company for lonely people [11].

Regarding robot's conversation ability, seniors expressed the desire for robots to be able to collect stories from them and send them to their grandchildren or keep them as memories of themselves. Additionally, they required robots to be enabled with comprehensive conversation abilities (such as weather forecast and recommendations for local events), be socially responsive, not repetitive in the interaction, and able to interact through the user's native natural language [8, 9].

Further evidence described older rural patients enjoying when they heard the robot spontaneously speaking, for example, wishing the user a happy birthday [50].

2.4.2 Virtual Agent

Conveyed by its voice, words, and facial gestures, a virtual agent's personality is important in the user acceptance process [17].

Older users stressed that it was important to them interact with an agent characterized by a friendly face and voice, and able to show a discrete range of pleasant emotions such as happiness and contentment. Seniors required the virtual companion to be characterized by emotional understanding, to communicate in a human-like way with natural language and non-verbal conversational behavior (i.e., facial expressions) and to show a supportive, joyful, and practical personality, accompanied by a professional attitude [3, 18, 51].

Regarding a virtual companion's behavior, the evidence described older adults as identifying two preferred personalities, depending on the tasks the agent has to perform. They wanted a less formal, friendly companion to remind them of appointments and a professional one reminding them about medications to take [3].

Regarding preferred roles, older people preferred the virtual partner act as a companion or friend; others thought its role should be as a family member and the personal assistant in the home [18]. Seniors strongly appreciate a virtual agent assisting them in deciding daily activities, giving advice rather than directives (i.e., the virtual agent offers suggestions), and showing a passive (i.e., only the user can initiate a conversation) rather than a proactive behavior [18]. Seniors also appreciate agents able to operate as preventive caregivers, supporting free conversation (responding to the user giving comfort, warnings or advice) on everyday life topics, and able to detect users' emotions or moods along the conversation [52, 53].

Main topics discussed by older users with their conversational agents were family, weather, and storytelling [54]. Other conversational topics include discussing plans, asking agents questions about their functioning and future development, statements regarding agents' supportive role, agents' position in the user's social network, users' personal feelings of being connected with the agent, past events, new activities, attitudes about aging, and social ties [54, 55].

Seniors' negative reactions are observed when the agents' lack realism, deploy trivial interactions, and are entrusted with insignificant functionalities [54]. An agent that actively engaged users, especially by spoken-language interaction, seemed to reduce the acceptability barriers [56]. Users were displeased if they perceived the agent's topics to be irrelevant or repetitious; this was similar to how they would react to a companion who failed to listen to them or talked about themselves too much [55].

Similarly, a lack of variability in the agent's dialogue had a negative effect (e.g., the agent uses the same language in every situation). When the agent exhibited a variety of behaviors and demeanors over time, older adults were more likely to continue the interaction [4, 57]. In addition, when the agent presented the narrative as autobiographical stories (i.e., its own life story rather than presenting the narrative as stories about a friend), especially when "cliffhanger" techniques were used, older users reported greater enjoyment and increasing long-term engagement in their relationship with the agent [4].

Finally, within crucial factors affecting the quality of interaction with a virtual agent, the importance of latency (i.e., potential delays between system input and expected and desired output) should be mentioned. It was found that older users may perceive the quality of interaction and the natural flow of dialogue according to this factor and that a high degree of latency can confuse the user and be interpreted as the agent's inability to understand the user [17].

3 Gender Preferences

The considerations noted here as interacting with acceptance by older users of assistive robots and virtual agents have occasionally been noted as dichotomous, with some individuals having a strong opinion in favor of one alternative and others feeling equally stronger in favor of the other. Clearly, other variables, possibly demographic variables, explain these differences. In relation to these assistive technologies, it is also important to address differences associated with gender, at the very least addressing binary gender preferences. In at least one study, males have been found to be more accepting of robots deployed in healthcare settings than females [58], but other studies have shown no gender effect among elderly (or other age groups) on preferences for the degree of human qualities in assistive robots [59].

In some cases, both user genders have a preference for seemingly gendered assistive technology. For example, it has been shown that both males and females prefer virtual agents to have a female voice [21]. In other work, there was a significant preference for female users (representative of both a general population of users or elderly users) for female agents, but no significant difference in preference of agent gender for males [60]. In another study, older users did not show particular preference, but caregivers preferred a female agent [18].

Further, given that gender is a socially conditioned construct, one may anticipate that gender effects among the elderly may vary over time. This means that the study of gender preferences must be resumed periodically.

Conclusions

The evidence that older users' preferences varied across assistive devices' functionalities, appearance, and roles suggest that any generalization regarding the preferences of older users, even when tasks are related, should be carefully considered in the design of assistive robotic technologies [40] and that the accurate evaluation of older users' needs and opinions is critical.

Conversely, several criticisms were that professionals who design these forms of assistance often do not take into account the end-users' individual backgrounds, needs, and opinions, exploiting stereotypes of older users' behaviors (i.e., as ill, dependent, or reluctant to try new technologies) that negatively influence the system's design process [13, 61]. These design-related aspects should be carefully taken into account in order to maintain user long-lasting engagement with the device [4-6].

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References

[1] Gallego-Perez, J., Lohse, M., and Evers, V. (2013) Robots to motivate elderly people: Present and future challenges. Proceedings of IEEE International Workshop on Robot and Human Interactive Communication, Gyeongju, South Korea, 2013, pp. 685-690

[2] Broadbent, E., Stafford, R., and MacDonald, B. (2009) Acceptance of healthcare robots for the older population: Review and future directions. International Journal of Social Robotics, 1(4), 319-330

[3] Tsiourti, C., Joly, E., Wings, C., Moussa, M. B., and Wac, K. (2014) Virtual assistive companions for older adults: qualitative field study and design implications. In Proceedings of the 8th International Conference on Pervasive Computing Technologies for Healthcare, Oldenburg. Brussels (Belgium): ICST, 2014, pp. 57-64

[4] Bickmore, T., Schulman, D., and Yin, L. (2010) Maintaining engagement in long-term interventions with relational agents. Applied Artificial Intelligence, 24(6), 648-666

[5] Fasola, J., and Mataric, M. J. (2012) Using socially assistive human–robot interaction to motivate physical exercise for older adults. Proceedings of the IEEE, 100(8), pp. 2512-2526

[6] Young, J. E., Hawkins, R., Sharlin, E., and Igarashi, T. (2009) Toward acceptable domestic robots: Applying insights from social psychology. International Journal of Social Robotics, 1(1), 95-108

[7] Robinson, H., MacDonald, B., and Broadbent, E. (2014) The role of healthcare robots for older people at home: A review. International Journal of Social Robotics, 6(4), 575-591

[8] De Graaf, M. M., Allouch, S. B., and Klamer, T. (2015) Sharing a life with Harvey: Exploring the acceptance of and relationship-building with a social robot. Computers in Human Behavior, 43, 1-14

[9] Hutson, S., Lim, S. L., Bentley, P. J., Bianchi-Berthouze, N., and Bowling, A. (2011 October) Investigating the suitability of social robots for the wellbeing of the elderly. In International Conference on Affective Computing and Intelligent Interaction, Berlin, Heidelberg: Springer, pp. 578-587

[10] Prakash, A., and Roger, W. A. (2015) Why some humanoid faces are perceived more positively than others: Effects of human-likeness and task. International Journal of Social Robotics, 7(2), 309-331

[11] Pino, M., Boulay, M., Jouen, F., & Rigaud, A. S. (2015) "Are we ready for robots that care for us?" Attitudes and opinions of older adults toward socially assistive robots. Frontiers in aging neuroscience, 7, 141

[12] Arras K. O., and Cerqui, D. (2005) Do we want to share our lives and bodies with robots? A 2000 people survey. Technical Report, 0605-001, 1-41

[13] 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. 2012, 1-13

[14] Wu, Y. H., Fassert, C., and Rigaud, A. S. (2012) Designing robots for the elderly: appearance issue and beyond. Archives of Gerontology and Geriatrics, 54(1), 121-126

[15] Kramer, M., Yaghoubzadeh, R., Kopp, S., & Pitsch, K. (2013) A conversational virtual human as autonomous assistant for elderly and cognitively impaired users? Social acceptability and design considerations. Lecture Notes in Informatics (LNI), P-220, 1119

[16] Scopelliti, M., Giuliani, M. V., and Fornara, F. (2005) Robots in a domestic setting: a psychological approach. Universal Access in the Information Society, 4(2), 2146–155

[17] Shaked, N. A. (2017) Avatars and virtual agents – relationship interfaces for the elderly. Healthcare Technology Letters, 4(3), 83-87

[18] Cereghetti, D. M., Kleanthous, S., Christophorou, C., Tsiourti, C., Wings, C., and Christodoulou, E. (2015) Virtual partners for seniors: Analysis of the users' preferences and expectations on personality and appearance. In Proceedings of the European Conference on Ambient Intelligence, Athens, 2015, Vol. 1528, pp. 7-10

[19] Straßmann, C., and Krämer, N. C. (2017) A categorization of virtual agent appearances and a qualitative study on age-related user preferences. Proceedings of International Conference on Intelligent Virtual Agents (IVA 2017), LNCS, 10498, Springer International Publishing, Cham, 2017, pp. 413-422

[20] Esposito, A., Amorese, T., Cuciniello, M. Riviello MT, Esposito AM, Troncone A, Torres MI, Schlögl S, Cordasco G (2019a) Elder user's attitude toward assistive virtual agents: the role of voice and gender. J Ambient Intell Human Comput (2019), ISSN 1868-5137, https://doi.org/10.1007/s12652-019-01423-x

[21] Esposito, A., Amorese, T., Cuciniello, M., Riviello, M. T., Esposito, A. M., Troncone, A., Cordasco, G. (2019b) The Dependability of Voice on Elders' Acceptance of Humanoid Agents. Proc. Interspeech 2019, 31-35, DOI: 10.21437/Interspeech.2019-1734, https://www.iscaspeech.org/archive/Interspeech_2019/abstracts/1734.html

[22] Cordasco, G., Esposito, M., Masucci, F., Riviello, M. T., Esposito, A., Chollet, G., Schlögl, S., Milhorat, P., and Pelosi, G. (2014) Assessing voice user interfaces: The vAssist system prototype. Proceedings of 5th IEEE international Conference on Cognitive InfoCommunications, Vietri sul Mare, Italy, 5-7 Nov, 2014, pp. 91-96

[23] Chattaraman, V., Kwon, W. S., E. Gilbert, J., and Li, Y. (2014) Virtual shopping agents: Persona effects for older users. Journal of Research in Interactive Marketing, 8(2), 144-162

[24] De Visser, E. J., Krueger, F., McKnight, P., Scheid, S., Smith, M., Chalk, S., and Parasuraman, R. (2012, September) The world is not enough: Trust in cognitive agents. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting, Los Angeles, CA: Sage Publications, 2012, Vol. 56, No. 1, pp. 263-267

[25] Garner, T. A., Powell, W. A., and Carr, V. (2016) DIGITAL Virtual carers for the elderly : A case study review of ethical responsibilities. Digital Health, 2, 1-14

[26] Powell, W., Garner, T., Tonks, D., and Lee, T. (2014) Shaping the face of Rita: Building an interactive advocate for older adults, ICDVRAT Proceedings, Gothenburg, Sweden

[27] Reeves, B., and Nass C. (1996) The Media Equation. Cambridge: Cambridge University Press

[28] Van Vugt, H. C., Konijn, E. A., Hoorn, J. F., and Veldhuis, J. (2006 August) Why fat interface characters are better e-health advisors. In International Workshop on Intelligent Virtual Agents, Berlin, Heidelberg: Springer, 2006, pp. 1-13

[29] Cassell J. (2001) Embodied conversational agents: representation and intelligence in user interfaces. AI, 22(4), 67

[30] Albaina, I. M., Visser, T., Van der Mast, C. A. P. G., and Vastenburg, M. H. (2009) Flowie: A persuasive virtual coach to motivate elderly individuals to walk. International ICST Conference on Pervasive Computing Technologies for Healthcare, London, UK, 2009, pp. 1-7

[31] Machesney, D., Wexler, S. S., Chen, T., and Coppola, J. F. (2014 May) Gerontechnology Companion: Virtual pets for dementia patients. In Systems, Applications and Technology Conference (LISAT), IEEE, Long Island, 2014, pp. 1-3

[32] Mori, M. (1970) The uncanny valley. Energy 7(4), 33-35

[33] Sharkey, A., and Sharkey, N. (2012) Granny and the robots: ethical issues in robot care for the elderly. Ethics and Information Technology, 14(1), 27-40

[34] Sparrow, R. (2002) The march of the robot dogs. Ethics and Information Technology, 4(4), 305-318

[35] Fischinger, D., Einramhof, P., Papoutsakis, K., Wohlkinger, W., Mayer, P., Panek, P., Hofmann, S., Koertner, T., Weiss, A., Argyros, A., and Vincze, M. (2016) Hobbit, a care robot supporting independent living at home: First prototype and lessons learned. Robotics and Autonomous System, 75, 60-78

[36] Wu, Y. H., Cristancho-Lacroix, V., Fassert, C., Faucounau, V., De Rotrou, J., and Rigaud, A. S. (2016) The attitudes and perceptions of older adults with mild cognitive impairment toward an assistive robot. Journal of Applied Gerontology, 35(1), 3-17

[37] Smarr, C. A., Mitzner, T. L., Beer, J. M., Prakash, A., Chen, T. L., Kemp, C. C., and Rogers, W. A. (2014) Domestic Robots for Older Adults: Attitudes, Preferences, and Potential. International Journal of Social Robotics, 6(2), 229-247

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

[39] Broadbent, E., Tamagawa, R., Kerse, N., Knock, B., Patience, A., and MacDonald, B. (2009 September) Retirement home staff and residents' preferences for healthcare robots. In the 18th IEEE international symposium on Robot and human interactive communication, RO-MAN, Toyama, Japan, 2009, pp. 645-650

[40] Smarr, C. A., Prakash, A., Beer, J. M., Mitzner, T. L., Kemp, C. C., and Rogers, W. A. (2012 September). Older adults' preferences for and acceptance of robot assistance for everyday living tasks. In Proceedings of the human factors and ergonomics society annual meeting, Los Angeles, CA: SAGE Publications, Vol. 56, No. 1, pp. 153-157

[41] Koceski, S., & Koceska, N. (2016) Evaluation of an assistive telepresence robot for elderly healthcare. Journal of Medical Systems, 40(5), 1-7

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

[43] Louie, W. Y., McColl, D., and Nejat, G. (2014) Acceptance and attitudes toward a human-like socially assistive robot by older adults. Assistive Technology 26(3), 140-50

[44] Broadbent, E., Tamagawa, R., Patience, A., Knock, B., Kerse, N., Day, K., and MacDonald, B. A. (2012) Attitudes towards health‐care robots in a retirement village. Australasian Journal on Ageing, 31(2), 115-120

[45] Demiris, G., Rantz, M. J., Skubic, M., Aud, M. A., and Jr, H. W. T. (2005) Home-based assistive technologies for elderly: Attitudes and perceptions. In AMIA Annual Symposium Proceedings (Vol. 2005, p. 935) American Medical Informatics Association

[46] Noh, S., Han, J., Jo, J., and Choi, A. (2017) Virtual companion based mobile user interface: An intelligent and simplified mobile user interface for elderly users. Proceedings of International Symposium on Ubiquitous Virtual Reality, ISUVR, Nara, Japan, 2017, pp. 8-9

[47] Costa, N., Domingues, P., Fdez-Riverola, F., and Pereira, A. (2014) A mobile virtual butler to bridge the gap between users and ambient assisted living: A smart home case study. Sensors (Switzerland), 14(8), 14302-14329

[48] Bickmore, T. W., Silliman, R. A., Nelson, K., Cheng, D. M., Winter, M., Henault, L., and Paasche‐Orlow, M. K. (2013) A randomized controlled trial of an automated exercise coach for older adults. Journal of the American Geriatrics Society, 61(10), 1676-1683

[49] Goetz, J., and Kiesler, S. (2002) Cooperation with a robotic assistant. In Terveen L., Wixon D., editors, *CHI'02 extended abstracts on human factors in computing systems*. ACM Press, Minneapolis, 2002, pp. 578-579

[50] Orejana, J. R., MacDonald, B. A., Ahn, H. S., Peri, K., and Broadbent, E. (2015, October) Healthcare robots in homes of rural older adults. In International Conference on Social Robotics, Springer, Cham, 2015, pp. 512-521

[51] Esposito A., Amorese T., Cuciniello M., Esposito A. M., Troncone A., Torres M. I., Schlögl S., and Cordasco G. (2018) Seniors' acceptance of virtual humanoid agents. In Italian Forum of Ambient Assisted Living, Springer, Cham, 2018, pp. 429-443

[52] Cavazza, M., De La Camara, R. S., and Turunen, M. (2010 May) How was your day?: a companion ECA. In Proceedings of the 9th International Conference on Autonomous Agents and Multiagent Systems, Toronto, Canada, 2010, Vol. 1, pp. 1629-1630

[53] Reeves, J., Powell, W. A., Dickson, B., and Garner, T. (2014) Project RITA: Developing a digital advocate & care service with an empathetic heart and inquiring mind. International Journal of Integrated Care, 14. 157-158

[54] Vardoulakis, L. P., Ring, L., Barry, B., Sidner, C. L., & Bickmore, T. (2012 September) Designing relational agents as long term social companions for older adults. In International Conference on Intelligent Virtual Agents, Berlin, Heidelberg: Springer, pp. 289-302

[55] Ring, L., Barry, B., Totzke, K., and Bickmore, T. (2013 September) Addressing loneliness and isolation in older adults: Proactive affective agents provide better support. In Humaine Association Conference on Affective Computing and Intelligent Interaction (ACII), Geneva, Switzerland, 2013, pp. 61-66

[56] Yaghoubzadeh, R., Kramer, M., Pitsch, K., and Kopp, S. (2013) Virtual agents as daily assistants for elderly or cognitively impaired people. In Aylett R., Krenn B., Pelachaud C., Shimodaira H., editors, *Intelligent Virtual Agents. IVA* Lecture Notes in Computer Science, Springer, Berlin, Heidelberg, Vol. 8108, pp. 79-91

[57] Bickmore, T., and Schulman, D. (2009 May) A virtual laboratory for studying long-term relationships between humans and virtual agents. In Proceedings of the 8th International Conference on Autonomous Agents and Multiagent Systems, Budapest, Hungary, 2009, Vol. 1, pp. 297-304

[58] Kuo, I. H., Rabindran, J. M., Broadbent, E, Lee. Y. I., Stafford, R. M. Q., MacDonald, B. A. (2009) Age and gender factors in user acceptance of healthcare robots. RO-MAN 2009 - The 18th IEEE International Symposium on Robot and Human Interactive Communication. Toyama, Japan, 214-213

[59] Dinet, J. and Vivian, R. (2014) Exploratory Investigation of Attitudes towards Assistive Robots for Future Users. Revue le Travail Humain 77(2) 105-125

[60] ter Stal, S., Tabak, M., op den Akker, H., Beinema, T., Hermens, H. (2019) Who Do Your Prefer? The Effect of Age, Gender and Role on Users' First Impressions of Embodied Conversational Agents in eHealth. International Journal of Human-Computer Interaction. DOI: 10.1080/10447318.2019.1699744

[61] Neven, L. (2010) "But obviously not for me": Robots, laboratories and the defiant identity of elder test users. Sociology of Health and Illness, 32(2), 335-347