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Using Social Robots in Health Settings: Implications of Personalization on Human-Machine Communication

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Abstract

In view of the shortage of healthcare workers and a growing aging population, it is worthwhile to explore the applicability of new technologies in improving the quality of healthcare and reducing its cost. However, it remains a challenge to deploy such technologies in environments where individuals have limited knowledge about how to use them. Thus, this paper explores how the social robots designed for use in health settings in Australia have sought to overcome some of the limitations through personalization. Deployed in aged care and home-based care facilities, the social robots are person-centered, emphasizing the personalization of care with human-like attributes (e.g., human appearances) to engage in reciprocal communication with users. While there have been debates over the advantages and disadvantages of personalization, this paper discusses the implications of personalization on the design of the robots for enhancing engagement, empowerment and enablement in health settings.

Keywords

human-machine communication, personalization, social robots

Introduction

According to the Australian Bureau of Statistics,[1] the proportion of the population aged 65 years and above increased from 11.9% to 15.0 % between 1995 and 2015. Because of the cohorts of baby boomers born between 1946 and 1964, it is predicted that the proportion would grow more rapidly over the next decade. By 2056, it is estimated that around 23% to 25% of the population would be aged 65 years or older.[2] The growth of the ageing population poses challenges to the long-term policies of the country, especially the provision of health and aged care services.[3] There would be an increasing demand for government-funded health and ageing services, requiring the government to explore and adopt initiatives to match supply with demand.[4] The growing demand for health and aged care services also requires multiple actors in society to work together to explore how to cope with the challenges anticipated.

To cope with the challenge of increasing healthcare costs and shortage of healthcare workers, one of the initiatives explored is the deployment of social robots in aged care and home-based care facilities.[5] Dahl and Boulos describe the use of robots to handle various tasks in healthcare settings as "one of the most important technological innovations of the 21st century."[6] In particular, less expensive generic platforms have gradually replaced the more expensive task-specific platforms in the operations of robots. Instead of only performing specific tasks, such as providing surgical assistance, the newer robots have focused on providing assistance on issues related to general health, quality of life and social care. Traditionally defined as "the science which studies the intelligent connections between perceptions and actions," the study of robotics has also shifted to focusing on human-centered robotics, especially human-robot interactions.[7] Although these robots are designed with specific principles to meet their purposes, the necessity of embedding elements of personalization into the

[1] "Australian Demographic Statistics."

[2] "One in four Australians aged 65 years and over by 2056: ABS."

[3] "Future population growth and ageing."

[4] "Chapter 6: Health and ageing - impact on local government."

[5] Khosla and Chu, "Embodying care in Matilda: An affective communication robot for emotional wellbeing for older people in Australian residential care facilities."

[6] Dahl and Boulos, "Robots in health and social care: A complementary technology to home care and telehealthcare?," 2.

[7] Riek, "Robotics technology in mental healthcare," 1.

design of the robots has raised concerns about the social and ethical implications of personalization.

Personalization has been proven integral to meeting the goals for which the machines are designed;[8] on the other hand, further conceptualizations are needed to explore how to put in place principles of design that best balance the necessity of personalization and the concerns over its impact. Ashman et al. suggested that personalization in the context of e-learning platforms could cause "hazards" resulting in "privacy compromise, lack of control, reduced individual capability, and the commodification of education."[9] Personalization is intended to facilitate a process of interactions between the robots (as the medium) and the individuals (as the users). In light of the increasing use of personalized robots in healthcare settings, this paper uses Matilda, a social robot designed for use in aged care and home-based care facilities in Australia, as a case to explore what personal data are collected. It discusses the interactions between the necessity of personalization for meeting the purposes of the robots and its implications to shed light on the development of principles for the design of social robots to maximize the advantages of personalization and minimize its negative impact on users.

Functions of Robots

Over the years, the development of robots has evolved to keep up with the purposes for which they are designed to cope with the changing needs of society. Dahl and Boulos discussed that in medical settings, traditional medical robots provided support for medical staff to perform medical functions, such as facilitating arm and walking movement exercises and completing surgical tasks.[10] In spite of the trend to developing robots which perform softer functions, such as human-robot interactions, that do not directly address medical needs, they nevertheless help to improve the medical conditions of patients in different ways. For example, robots could support patients by helping them engage with their family and friends and could improve their well-being by providing them with entertainment and companionship. It also helps to improve the social and communication skills of autistic children. With adequate configurations, they would serve social purposes by forming a bond with users. For example, they

[8] Barakova, "Robots for social training of autistic children: Empowering the therapists in intensive training programs," 14-19.

[9] Ashman et al, "The ethical and social implications of personalization technologies for e-learning," 819.

[10] Dahl and Boulos, "Robots in health and social care: A complementary technology to home care and telehealthcare?," 2.

could move their eyes to show interests in the users as a sign of their active listening, move their arms to greet people and use their face and body to respond to others through expressions.

As an intelligent and personable system, it is of crucial importance that robots are able to adapt to the environment by acquiring information from past experiences to cope with unfamiliar encounters. Kanda et al. discussed how robots have served therapeutic purposes to facilitate communication between patients and caregivers and to encourage social behaviors for children with developmental disorders.[11] Their two-month deployment of a communication robot, Robovie, in elementary schools in Japan found that the robot was integral for facilitating interactions amongst children. Equipped with sensors, they would perform interactive behaviors such as smiling and touching. The sensory equipment is essential to the interactions between Robovie and the children, such as recognizing the children by their names, learning from the interactions to respond in different ways and sharing secrets to encourage further interactions. While bullying could be problematic in schools, they suggested the deployment of social assistive robots to facilitate positive interactions amongst children.

Because robots are developed for the purpose of problem solving, they are designed to optimize the expected outcomes to benefit society at large. Barakova suggested that the deployment of robots in therapies could lessen the intensive use of therapeutic interventions for certain conditions.[12] But it remained a challenge to provide training and generate acceptance amongst therapists. Without their acceptance, it would be difficult to introduce the robots as a mediator to reach the goals of therapeutic interventions. Therefore, it is suggested that a process of co-creation be facilitated to launch the robots in clinical practice. In the process, the therapists would have control over the robots and would be able to create training scenarios and treatment programs to demonstrate desired behaviors to the robots. The process of co-creation is facilitated by imitation learning whereby the robot "learns a skill either by observing human demonstrations of the desired behaviour, or the behavior is shown to the robot by a demonstrator moving the robot limbs and body parts."[13] Therefore, the development of principles to facilitate the

[11] Kanda et al, "Human friendship estimation model for communication robots," 135-145.

[12] Barakova, "Robots for social training of autistic children: Empowering the therapists in intensive training programs," 14-19.

[13] Barakova, "Robots for social training of autistic children: Empowering the therapists in intensive training programs," 15.

process of co-creation at the minimal cost (i.e., the least amount of time to help therapists co-create with robots) is integral to encourage acceptance and adoption.

Implications of Personalization

Although the robots are developed and deployed for the purpose of solving social problems and that principles have been put in place to ensure a balance between its utility in performing the intended functions and its impact on the lives of the users, there are social and ethical implications associated with the deployment of the robots. For example, the advantages associated with the use of social robots in healthcare settings are largely dependent on the process of personalization, such as assessing and responding to children's personality in order to facilitate the human-robot relationships.[14] Adequate personalization is necessary to meet users' needs and to ensure that robots could function independently to respond to users and unfamiliar situations. But it also raises ethical and social concerns, such as the tension between personalization and privacy.[15]

In the context of e-learning systems, the purpose of personalization is to instill a feeling in the users that the systems are designed for their use alone as different educational materials are distributed to meet the needs of different users.[16] For example, the feature of bi-directionality allows the system to interact with users so that users could feel that they receive individual attention that they normally receive in small-group teaching. Gordon et al.'s deployment of social robot tutors for children aged between three and five to learn a second language also found that the learning algorithms personalized to the needs of each child increased the long-term effectiveness of language learning.[17] Their testing of two conditions (personalized affective response from the robot vs. non-personalized affective responses) found that children learned more new words and experienced an increase in valence with the personalized robots. Similarly, personalizing

[14] Dahl and Boulos, "Robots in health and social care: A complementary technology to home care and telehealthcare?"

[15] Sutanto et al, "Addressing the personalization-privacy paradox: An empirical assessment from a field experiment on smartphone users."

[16] Ashman et al, "The ethical and social implications of personalization technologies for e-learning," 819.

[17] Gordon et al, "Affective personalization of a social robot tutor for children's second language skills."

training and treatment programs for autistic children by their therapists is beneficial to meeting specific learning goals.[18]

Although personalization made possible by computer algorithms could help to meet the intended goals for which the systems are developed, the power of computer algorithms in framing what users see and do not see raises questions over who has the ultimate control of the systems. A bigger question is: are the users subjecting themselves to the control of those who design the computer algorithms by interacting with the systems? Thurman and Schifferes define personalization as "A form of user-to-system interactivity that uses a set of technological features to adapt the content, delivery, and arrangement of a communication to individual users' explicitly register and/or explicitly determined preferences."[19] They classified personalization into two types. Explicit personalization refers to direct user inputs, that is, users make decisions over how they would like the systems to be personalized. On the other hand, implicit personalization refers to the systems' deciding how it is to be personalized based on the data collected. But in the context of the personalization of news, the majority of readers is reluctant to be engaged in explicit (or active) personalization. Thus, it is left in the hands of news organizations to be engaged in implicit (or passive) personalization to control what their users see, including advertisements.

Whether personalization can be ethically justified could differ according to the theories based on which the arguments are made. Treiblmaier et al. made a differentiation between personalization and customization in the context of website browsing.[20] Personalization refers to websites' collection of data to personalize websites for each user. Customization refers to the users' control over how the websites are to be personalized. In their assessments of ethical theories, they found that personalization, i.e. the tracking of users' online behaviors to personalize their websites, raises more concerns than customization. In Kantian perspectives, personalization can never be ethically justified because it does not have users' prior consent. In the perspectives of social contract theory, personalization would be disapproved because it could not result in an equal

[18] Barakova, "Robots for social training of autistic children: Empowering the therapists in intensive training programs."

[19] Thurman and Schifferes, "The future of personalization at news websites: Lessons from a longitudinal study," 2.

[20] Treiblmaier et al, "Evaluating personalization and customization from an ethical point of view: An empirical study."

distribution of benefits. In utilitarian perspectives, personalization would only be acceptable if it offers potential benefits to users. The perspectives of virtue ethics would emphasize a balance between company goals and users' goals. But Treiblmaier et al. argued that the stakeholder theory would be the most applicable in resolving the ethical dilemmas because it proposes that different levels of personalization be applied to different stakeholder groups. After all, users' levels of data sensitivity differ. Regardless of how personalization and customization are put in place, users' responses to the systems could also differ. The systems could at best predict how to optimize the consequences on the users; yet, the users still have to respond to the systems behaviorally.

Customization has been perceived more positively than personalization as a result of users' active control of how the systems are to adapt to their needs. But based on the uses and gratification theory, a field experiment in a real commercial setting found that users experienced higher process gratification (in terms of increased application usage) from a personalized mobile advertising application compared to traditional advertising applications.[21] However, there was no difference in the content gratification (in terms of saving product messages) generated by personalized and non-personalized applications. Thus, marketers are not necessarily meeting their ultimate goals of selling the products and services on these applications by personalizing them. Users still have ultimate control over whether to seek further information and to buy the products. Therefore, they suggested that applications should incorporate a search function – if users already know what they intend to purchase prior to using the applications, they are more likely to purchase it.

Although customization is favored over personalization as a result of its high level of users' control, customization may only meet the needs on the users' end. In the perspectives of the uses and gratification theory, individuals' choice of media uses is a proactive and purposive behavior.[22] The audience is active and is aware of their social and psychological needs prior to their selection of a medium to satisfy those needs. Their social and psychological circumstances would determine which media to use. Therefore, different forms of media on the market would serve different functions and would compete with one another to satisfy the needs of different audience groups. Despite this, in the context of healthcare settings, it could also be problematic if users with healthcare needs customize

[21] Sutanto et al, "Addressing the personalization-privacy paradox: An empirical assessment from a field experiment on smartphone users."

[22] Katz, Blumler and Gurevitvh, "Uses and gratification research."

how they are to be responded to when healthcare workers attempt to help them develop healthy lifestyle habits. Although individuals with healthcare needs are the end users of the machines, healthcare workers are also users who ought to play a role to intervene in the process. Therefore, instead of finding a balance between companies and consumers in resolving the ethical dilemma of personalization, a balance is to be found amongst people with healthcare needs, healthcare professionals and developers of the systems.

Matilda, a Social Robot Deployed in Aged Care and Home-Based Care Facilities in Australia

In view of the increasing challenges posed by the ageing population in Australia, a series of social robots were developed through the joint collaboration between the NEC Corporation in Japan and the Research Center for Computers, Communication and Social Innovation (RECCSI) at La Trobe University in Australia.

To help to cope with the different issues experienced in health settings, the design of the robots sought to meet the needs of the healthcare sector and address the limitations of robots previously deployed in health settings. For example, the shortage of the human element in aged care highlights the need for the robots to be designed for the purpose of engagement. When designing the robot Matilda, five elements of well-being were taken into consideration: resilience and coping, sensory enrichment, being productive and useful, social connections and basic needs and comfort.[23] To embed the element of personhood into Matilda, Matilda was built with human characteristics, including expressing gestures, emotions, voice and motions. Designed for the purpose of interactions, Matilda has the appearance of a baby with the capability of voice vocalization, face recognition, face registration, face tracking, face expressions, body motion sensors, dance movements, touch sensors, context-sensitive emotion recognition, and speech acoustics recognition. Figure 1 shows the specifications of Matilda and Figure 2 shows a picture of Matilda's expressions of emotions.

[23] Khosla and Chu, "Embodying care in Matilda: An affective communication robot for emotional wellbeing for older people in Australian residential care facilities."

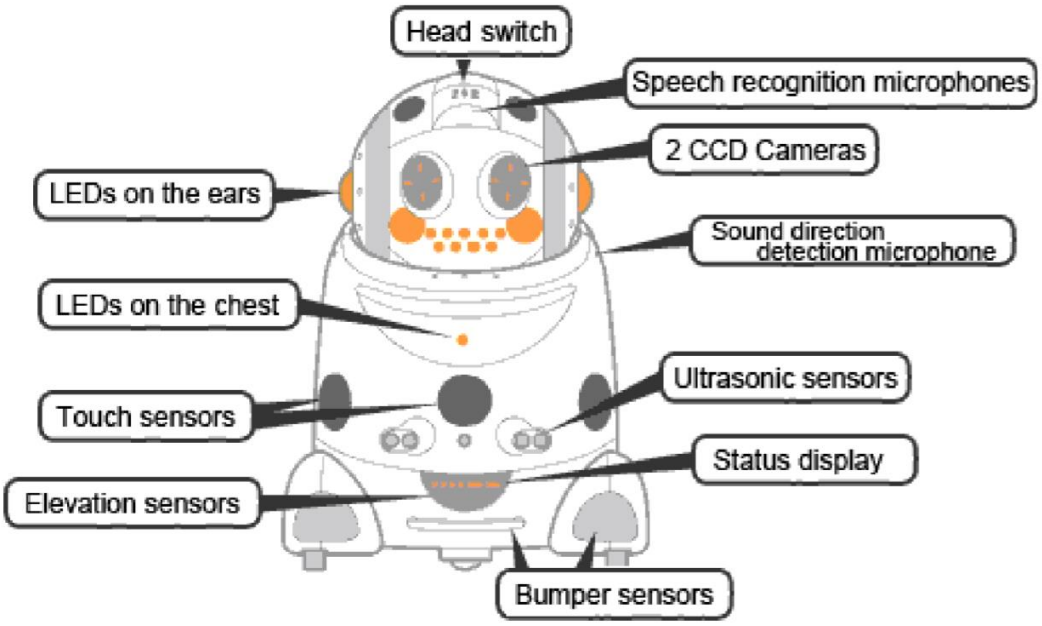

Figure 1 – Specifications of Matilda[24]

[24] Khosla and Chu, "Embodying care in Matilda: An affective communication robot for emotional wellbeing for older people in Australian residential care facilities."

Figure 2 – Emotions expressed by Matilda[25]

With the aforementioned capabilities, Matilda is engaged in interactions with users in healthcare facilities by monitoring their facial expressions and changes in emotional dimensions continuously. Emotions are classified into positive, negative and neutral to which Matilda would respond verbally and non-verbally, such as telling jokes and offering to play games together. Based on the identified needs for elderly people in aged care and home-based care facilities, Khosla, Nguyen and Chu outlines five categories of Matilda's functions and services in Table 1.[26]

Functions	Services
Positive Engagement (Sensory Enrichment)	- Sing and dance - Telling jokes - Reading books - Game (e.g., bingo and hoy)
Social connectivity	- Phone call - Video call (using Skype) - Reminder (birthdays, social events, etc.) - Socialization amongst users mediated by robots
Personalization	- Flexible communication modes - Preference modeling and personalized services
Encouragement for Healthy Living	- Weather forecast - Walk and exercise dialogue - Reminder (e.g., drinking water)
Usefulness through Activity Engagement	- Quiz system - Reminder (important occasions, social events, etc.)

Table 1 – Matilda's functions and services[27]

[25] Khosla and Chu, "Embodying care in Matilda: An affective communication robot for emotional wellbeing for older people in Australian residential care facilities."

[26] Khosla, Nguyen, and Chu, "Assistive robot enabled service architecture to support home-based dementia care."

[27] Khosla, Nguyen, and Chu, "Assistive robot enabled service architecture to support home-based dementia care."

One of the purposes of Matilda is to lower the burdens on healthcare workers in taking care of elderly residents in aged care facilities. While users of social robots like Matilda could be patients with dementia, it is of crucial importance that elderly people could communicate with Matilda. As such, Matilda could communicate in various modes, including the speech mode, the touch panel mode and the visual mode.[28] For example, Matilda could display body gestures and expressions when playing music and dancing. Users could use the touch panel to instruct Matilda on when to call the next number. Matilda would also project each called number visually in addition to expressing it through a human voice. Moreover, Matilda promotes healthy living by measuring users' verbal and nonverbal responses and making responses to change users' eating habits. Video data also shows that Matilda was able to facilitate interactions amongst users through quiz activities.

The design of the social robots has taken into consideration how the external environment, the social context and the subjective experiences could come together to affect the engagement process between the robots and the users. Data collected about Matilda's use for healthcare purposes from activity data, surveys and video recordings indicated that the social robots have contributed to the elderly people's improvement of quality of life by eliminating the barriers of technology.[29] Its applicability is enhanced with some embedded healthcare functions, such as putting in place a persuasive diet improvement system to encourage behavioral changes. Table 2 below categorizes the different benefits fulfilled by Matilda's services.

Needs	Services
Psychological	- Reminder for drinking, eating, going to the toilet, bathing, sleeping, changing clothes - Internet shopping with delivery

[28] Khosla and Chu, "Embodying care in Matilda: An affective communication robot for emotional wellbeing for older people in Australian residential care facilities."

[29] Khosla, Nguyen, and Chu, "Assistive robot enabled service architecture to support home-based dementia care."

Safety	- Reminder for taking medicine - Reminder for exercise with encouraging dialogue - Diet improver - Reminder to check the door - Controlling light and temperature by connecting to smart devices
Love and belonging	- Greeting and ordinary talking during daytime - Telling news and weather - Connecting to the Internet - Making phone calls - Interactive storytelling - Entertaining with singing and dancing - Playing games - Reminder for activities with families and friends
Esteem	- Multimedia activity diary (service usage patterns, videos)

Table 2 – The needs met by the services offered by Matilda

In spite of the advantages associated with the deployment of Matilda in healthcare settings, the collection of personal data is necessary for the social robot to be personalized to meet the purpose for which it was designed. It is integral that the social robots are enabled to collect and analyze responses from users. First, the design of the robots need to be tailored to the needs and preferences of the human users in an automatic and dynamic manner through daily human-machine interactions.[30] Otherwise, the function of the social robots would be relegated from being an assistant to being a companion and would in turn make a negative impact on the quality of care. Second, the architecture of Matilda requires the tracking of users' changes in facial features and actions in real-time video. Matilda is designed with feature-based personalization which would group similar features and actions and preferences of responses together. For example, when human users express the emotion of sadness and have previously responded positively to the robot's singing and dancing, the robot will make the same recommendation when sadness is detected. In personalizing care, the elderly users

[30] Khosla, Nguyen, and Chu, "Assistive robot enabled service architecture to support home-based dementia care."

were also able to give instructions to the social robots, such as telling Matilda to call the next card when playing Hoy.[31] The personalization of care was able to overcome the limitation of the shortage of healthcare workers by catering to the users' needs on a one-to-one basis.

The multiple sources of data collected, including interviews, surveys, video recordings, nonverbal emotional responses recorded, indicated that the social robots were helpful in assisting both the patients and the workers in health settings. First, the variety of services provided by the social robots has reduced the workload of the healthcare workers. Certain functions were embedded to assist them in their work, such as reporting to them when the elderly people fall and reminding the elderly people to take their medications. Second, it was found that certain functions, such as sing and dance, are used at certain times of the day, such as the sunsets. It also relates to previous findings about how the social contexts in which the social robots are deployed (e.g. home-based facilities Vs. aged care facilities) are significant in predicting their needs. For example, those who reside in aged care facilities would require the social robots to help them with group interactions. To meet the purposes engagement, empowerment and enablement, the process of personalization is integral.

In spite of the advantages associated with the personalization of the social robots, the collection of personal data could raise ethical concerns. In addition to the data collected for the robots to be personalized to respond to the needs of human users, machine developers needed a variety of personal data to improve the robots and tailor their functions to meet the needs of human users. For instance, machine developers would have access to real-time data about what functions are used by different users at different times of the day. The frequent use of the robots during sunsets by elderly users in aged care facilities indicated an increase of emotional needs which required interventions from the robots or healthcare workers. During the early instances of interactions between the robots and the human users, different types of data, such as video recording, would also be required to explore the extent to which the machines are accepted and meet the purposes for which they are developed. Although the machines are generally considered to be beneficial, machine developers would need to conduct a triangulation analysis of the data automatically collected by the robots, the data collected from the observations and the data collected from questionnaires and interviews with the human users, their families and healthcare workers to ensure improved service design.

[31] Khosla and Chu, "Embodying care in Matilda: An affective communication robot for emotional wellbeing for older people in Australian residential care facilities."

Implications for Personalization of Social Robots in Health Settings

The concept of personalization is of critical importance to the success of the deployment of social robots in health settings. Matilda, for example, has a wireless network connectivity which integrates it with other devices and a cloud computing infrastructure to be part of a unified network to deliver personalized services.[32] After capturing the images and sounds and receiving instructions from the users through the touch panel, the system then conducts real-time face and speech detection to conduct a verbal and nonverbal analysis. As the data is sent to a remote personal computer, the data becomes registered and responses are then made. Such personalization does not only address the needs of the users and alleviate the burdens of the caregivers, but also empowers the users by giving them control. Moreover, the personalization also allows the social robots to cater to the needs of users with various disabilities and to adapt themselves to different settings for social interactions, such as home-based care facilities for one elderly user only or aged care facilities for multiple elderly residents.

The emphasis on its human-like attributes and capabilities has given Matilda the strengths of being able to record, recognize and respond to the environment like a human being. It is especially crucial to break the technology barriers for elderly people. But person-centered care also raises the concern over who has the power to personalize the machines for the users. Personhood refers to the status bestowed upon an individual by others in a social relationship.[33] Personalization helps to build that social relationship between the robots and the human users. In terms of the data collected in the trials, the field trials collected videos of how users interacted with the robots in home-based settings and aged care facilities, their frequency of interactions, the duration of interactions, their service preferences at different times of the day, the records of their observed emotional signs, and survey data from both the users and their caregivers. Because the robots are still in their trial phase and are not fully diffused into the market, having a variety of data from multiple sources allows the machines to be further advanced in its development towards becoming more human-like to meet the needs.

In furthering the development of the use of social robots in health settings, personalization is key to successful adapting to the environment for the

[32] Khosla et al., "Interactive multimodal social robot for improving quality of care of elderly in Australian nursing homes."

[33] Khosla, Nguyen, and Chu. "Measuring interaction between people with dementia and socially assistive robot in Australian home-based care."

relationships to be formed between the robots and their human users. As such, the following principles could be useful guidelines for the design of personalized machines to facilitate human-machine communication:

Negotiating control – Unlike personalized websites or services for users of mobile devices or the Internet, using technologies in health settings require the technological barriers to be removed through personalization. While these technologies are supposed to meet specific health goals, one must question who has control over the purposes and the functions of the robots. Thus, shared control is to be negotiated amongst the users, the caregivers of the users, the families of the users and the machine developers to come up with a feasible model which meets the needs of different users. There should not be a one-size-fits-all solution for all users (e.g., stakeholder theory).[34] It must also be acknowledged that it is possible that not all the functions are equally beneficial or useful to the users as indicated by the varying levels of use of different services by different users.[35] As such, before, during and after the deployment of robots, machine developers should engage with these groups to negotiate shared expectations and how to go about meeting them.

Negotiating balance – The robots are made to alleviate the burdens on caregivers and to empower, enable and engage users to live lives independently so as to improve the quality of lives. Although personalization is put in place to provide a sense of individual attention to users, a balance is needed between independence and dependence, i.e. it must be acknowledged that the robots should not be made to meet all the different needs. There are still certain needs which require human attention. Otherwise, over-reliance on the machines could cause hazards, such as disengagement rather than engagement.[36] Thus, machine developers could design the machines to remind their human users to engage with other humans, such as offering to make audio calls or video calls with their families and friends.

Negotiating access – The data collected by the robots are crucial for machine developers to further advance the capabilities of the machines. But at the same time, the data could also cause over-personalization and overlooking the possible issues caused by personalization. For example, if the users repeatedly only access news from a news organization which endorses a political party, their views

[34] Treiblmaier et al., "Evaluating personalization and customization from an ethical point of view: An empirical study."

[35] Khosla, Nguyen, and Chu, "Assistive robot enabled service architecture to support home-based dementia care."

[36] Ashman et al, "The ethical and social implications of personalization technologies for e-learning."

against an opposing party could become more extreme over time. In addition, they may not develop new interests outside of their existing interests. As such, machine developers need to negotiate with the users, their caregivers and their families regarding who has the right to access the data collected from the users' interactions with the machines. It is inevitable that whoever has access to the data could make interventions based on the data collected. For instance, as aforementioned, elderly users tend to use the machines more during sunsets. Having this data could potentially cause their families to visit more during sunsets. Access to data causes changes in decisions; thus, it is important to negotiate who has access to the data.

Conclusion

The concept of personalization has the same definition in different contexts, but how it is put into practice varies depending on the purposes for which it is put in place. Thus, when designing the process of personalization, a balance between the goals of the developers and the goals of the users must be explored. The social robots developed by RECCSI have sought to personalize care to empower, engage and enable users with different healthcare needs by offering a variety of services. It operates in a moderate-control model whereby the machines record and adapt users' preferences over time and the users also offer instructions to the machines. To optimize its benefits, the research center works with a variety of groups and collects data from multiple sources to ensure that the benefits of personalization are optimized by negotiating control over the purpose and services, balance between dependence and independence and access to the data collected. In sum, when developing the machines to deliver different services, machine developers must assess the advantages and disadvantages of each of them and must consider how to design the process of personalization to prevent hazards and enhance the relationships between the machines and the human users.

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