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A brief review of Robotics Technologies to Support Social Interventions for Older Users

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Abstract. In the last few decades, various studies demonstrated numerous robotics applications that can tackle the problem of the ageing population by supporting older people to live longer and independently at home. This article reviews the scientific literature and highlights how social robots can help the daily life of older people and be useful also as assessment tools for mild physical and mental conditions. It will underline the aspects of usability and acceptability of robotic solutions for older persons. Indeed, the design should maximise these to improve the users' attitude towards the actual use of the robots. The article discusses the advantages and concerns about the use of robotics technology in the social context with a vulnerable population. In this field, success is to assist social workers, not to replace them. We conclude recommending that care benefits should be balanced against ethical costs.

Keywords: Acceptability, Older people, Robotics, Social care.

1 Introduction

Robotics is a broad field covering different aspects of the creation and use of robots, from familiar technologies like automated vacuum cleaners and smart appliances to more advanced robots that look like humans or animals.

While there is no universally accepted definition of a robot [1] they typically comprise: *"sensors"* gather information about the robot's environment, such as monitoring temperature, *"actuators"* provide physical motion to the robot in response to input from the sensors and controllers, such as hoists, and *"controllers"* respond to data from the sensors and allow parts of one or more robots to operate together [2]. While robots are typically thought to comprise all three components, sensors and actuators can be employed on their own and can be used in social care, like sensors that detect falls and actuators in the form of stairlifts.

Robots can operate with varying levels of autonomy by making use of artificial intelligence (AI), and machine learning technologies [3]. A wide range of robotic technologies can be used in social care by providing physical, social, and cognitive assistance and several studies report positive impacts on users' education, mobility, mental health, and cognitive skills [4–10].

1.1 Social robots as support to the social care systems

The promise of artificial intelligence (AI) and Robotics in health care offers substantial opportunities to improve patients and clinical team outcomes, reduce costs, and influence population health. Robots can free up time for caregivers enabling them to focus on delivering a better service for care recipients. Meanwhile, more advanced robots can help to reduce loneliness and isolation by facilitating connectivity with friends and family and even simulating social interaction. Robots providing physical assistance have been shown to increase users' autonomy and dignity by assisting with tasks like feeding, washing, and walking, and are being developed to support physiotherapy [11]. Prototypes of robotic toilets have also been developed that can raise, tilt, recognise the user and adjust settings according to their preferences.

Novel opportunities are provided by socially assistive robots, which include robots that aid daily living activities, such as those that remind users when to take their medicine and those that detect and prevent falls [12]. It can also include robots designed to provide companionship and assist with loneliness and social engagement, monitor and improve wellbeing, and can also help educate preschool children [13, 14]. For instance, a pilot conducted by Allen [15] found that the use of Amazon Echo did result in a reduction in users' self-reported feelings of isolation and loneliness. Specifically, in a sample of participants aged 16 to 93 (60% Female, 40% male) 70% had Parkinson's Disorder, 16% showed visual impairment and 14% had Elderly frail. Results showed that: 72% was "agree Echo helps improve their life", 68% was "agree Echo helps maintain their independence, 64% was "agree Echo gives more access to information", 62% was "agree Echo helps them feel less isolated", and 48% was "agree Echo reduces their reliance on others" [15]. Also, robotic pets introduced in an UK care home were reported to bring happiness and comfort to residents.

While much has been written about the potential uses of such technology, the development and use of robotics in social care is still relatively new and, currently, there is limited evidence of robotic technology being used in social care outside of some small-scale trials. Many of the robotic services developed for social care appear to be at the conceptual or design phase, because of the technical limitations to the tasks that they can undertake. However, this might change with the increasing adoption of technology in social care and investment in robotics research.

1.2 Social robots and ethical issue

So far, most of the research studies about robots in social care were focused only on evaluating how well the technology functions, without really considering the deeper socio-economic impact. A key question is whether robots and robotic technology can integrate into existing social care environments, and with current technology, or replace them altogether [16]. Currently, there are technical limitations to the tasks that they can undertake. Crucially, increasing the use of robotics in social care will require training for existing staff to be able to work alongside the new technology. Analysts suggest that there may be more jobs in other sectors, such as for those with skills in robotics including data analysts, and programmers, but these are already in very high demand and it is unclear how the new positions can be filled.

Furthermore, ethical issues have been raised: for the degree to which robots could prevent people from engaging in risky behaviours, e.g. smoking; the extent that robots could persuade users to do something if they did not wish to, like take scheduled medication; and the potential that users may become dependent on robots, undermining their ability to do things for themselves and reducing independence [17]. Other challenges to the use of robotics in social care include privacy, security and legal and regulatory concerns [18]. However, these are like those we currently face when using smartphones and computers and they can be addressed by applying similar solutions [19]. For example, robots capable of processing personal data are subject to regulation under the General Data Protection Regulation (GDPR), which requires 'privacy-by-design', whereby data protection safeguards are built into technology early on.

1.3 Acceptance or Acceptability towards robots

A component of robotics research has recognized the importance of understanding general attitudes towards robots, including social acceptance and social acceptability [20].

Some conceptualizations of social acceptance imply its importance for situations in which participants are exposed to specific robots, such as when they define it "attitudes and perspectives about the socialness of the robot and...willingness to accept it as a social agent" [21] (p.547).

Social acceptance is also known to be culture-specific [21], and it is thus more frequently used to refer to relatively constant attitudes and general evaluations of robots as opposed to reactions in specific situations [22]. Busch and colleagues [23] considered acceptability divided in social acceptability that is how society views robots, and practical acceptability that is how people perceive a robot during or after interacting with it. Also, the difficulty of distinguishing between general opinions about robots and perceptions during specific encounters with robots is obvious in usage that equates acceptability with user acceptance [24]. Nam [25] suggests a clearer distinction regarding timing has been offered: "acceptability" as an evaluation before use or implementation of robots, and "acceptance" as the evaluation after the implementation.

Literature suggests that acceptance is influenced by the psychological variables of individual users [26, 27] and their social and physical environment [28]. Also, the evidence regarding how gender, education, age, and prior computer experience impacts on anxiety and attitude towards robots presents a complex picture.

Examining technology acceptance is closely related to research fields of social acceptance and attitudes in general. In detail, the deployment of new technology concerning social and human factors has been studied under the concept of technology acceptance [29] and based on the theory of reasoned action [30].

Currently, robots are starting to become a part of working life in many areas including journalism [31], agriculture [32], the military [33], medicine such as surgery [34], education [14, 35], and care [36, 37]. A factor influencing the attitude toward robots may indeed be a concern over the risk of unemployment caused by robots [38], con-

sidering certain occupations are even at risk of being replaced by robots or other technology [39].
In recent decades, many studies on the factors that can influence the acceptance by potential users and on how such acceptance can be increased have been conducted. There is a mixed attitude in the public about robots. According to a Eurobarometer survey [40], Europeans (n=26.751) generally have a positive view of robots, but they do not feel comfortable about having robots in domains such as caring for children, the elderly, and the disabled. In fact, 60% of Europeans surveyed thought robots should be banned from such care activities [40]. Specifically, they are seen as technically powerful but potentially *dangerous* machines, which are mainly useful in space exploration, in military applications and in industries where human beings are not present. For this reason, the objectives of the recent robotics research focus on the attitude, usability, and acceptability by the users, aspects which are often not correlated [41–45]. The recent Eurobarometer survey shows also the public concern about robots, a technology that *"require careful management"* (88%), and about replacing humans and stealing jobs (72%). Though, the analysis underlines how the attitude is related to the exposition to information in the last year, which makes more likely to have a positive view of artificial intelligence and robots (75% vs. 49% who have not). This negative attitude is shaped by people's previous experience and expectations and may be indicated through their attitudes to computers and related technologies more generally [46].
Taipale at al. [47] specified further that people are reluctant to use robots in the fields of childcare and elderly care, leisure, and education. Nor did they favour robots for *"jobs that require artistry, evaluation, judgement and diplomacy"* [48].
On the other side, a project by the Isle of Wight council suggested that robots were perceived more positively when they are designed to operate alongside people or with human input because they are less likely to replace human caregivers [49].

2 Social robotics for older people

The growing number of older people living alone in need of care is one of the great societal challenges of the most developed countries (e.g. Japan, USA, Europe, Australia) [50]. Indeed, high-income countries have the oldest population profiles, with more than 20% of the population predicted to be over 65 in 2050, when citizens older than 80 will be triple than today. This is likely to increase social isolation and loneliness, which can be associated with several health hazards, e.g. cognitive deterioration, and increased mortality [51].
This is a challenge for the social care systems, which, as of now, are struggling to meet the demand of assistance for vulnerable adults because of limitations in their budgets and, moreover, in the difficulty in recruiting new skilled workers.
The new technologies, in particular the social robotics, are seen as a way to address human resource and economic pressures on social care systems.
Humanoids robots are capable to provide greater support to older people, because they can pick things up, move around on their own, and have a more natural, intuitive way of interaction, e.g. include gestures with the hands and arms. Usually, the more advanced humanoid platforms embed additional sensors and devices, like

touchscreens to provide easier to use interfaces thanks to multimodality: it has been observed that older users preferred to send commands the robot using speech, because they found touchscreen difficult to use, vice-versa they like to have visual feedback on screen when the robot is speaking. The availability of multiple ways for the interaction is indispensable in the case age related hearing loss or visual impairments which can reduce the ability of the elderly to interact [52].

The increasing evidence from scientific research is leading the growth of the robotics market focused on services for ageing well, with robots that are increasingly available to assist and accompany the older users.

To this end, one of the most developed commercial examples is Mobile Robotic Telepresence (MRT) [53] systems that incorporate audio and video communication equipment onto mobile robot devices which can be steered from remote locations. MRT systems facilitate social interaction between people by eliminating the necessity to travel while still providing a physical presence, which has a greater positive influence in the social perception [54] of the interaction. Thanks to MRT technology, relatives can visit more often their older family members and social workers will be able to engage more clients per day, especially in sparsely populated rural areas. MRT from a simple smartphone app, meanwhile the local user is free while interacting with the pilot user who can also use the robot to inspect the home. The freedom for the local user is particularly beneficial in the case of people with disability who can have difficulties in reaching a phone.

However, MRT systems still require a human operator for the social interaction, which can be present only for a limited amount of time during the day, for the rest the current MRT systems risk to remain just a modern piece of furniture with no use.

Another solution could be robot companions, which embody advanced Artificial Intelligence (AI) functionalities to conduct social interaction in complete autonomy.

Nevertheless, such completely autonomous robots are not available on the market yet, but the underlining idea of a robot companion has been extensively investigated with pet-like shape robots, e.g. Aibo, MiRo, or humanoids robot, e.g. Pepper, Care-o-Robot, which resemble the shape of the human body. Pet robots are programmed with limited interaction abilities, but they proved to be as effective or even more than real pets in reducing loneliness [55] for elderly in care homes while overcoming the concerns about live animals.

Humanoid robots are more ambitious systems, which include support for complex functionalities such as dexterous manipulation, advanced navigation and a natural, more intuitive interface, which can overcome some of the difficulties currently experienced especially by the elderly, thanks to the multimodality of stimulation given by them [52].

Social robots can provide a solution for the ageing population challenge, in particular, to reduce social isolation and loneliness. Solutions like MTR systems or pet-like companions are already in the market and ready to be deployed soon. More sophisticated humanoid companions with human-like social capabilities are being studied and seem a promising solution for more comprehensive quality care. Nevertheless, researchers and service providers must address public anxiety and make clear that the robots are being designed to improve productivity by assisting the social workers, who will be facilitated in their work and not replaced. Moreover, robot programmed autonomy has to be limited and humans must always be in full control so that any danger or accidental situation can be avoided.

Scientific research is also exploring multi-robot systems to favor independent living, improve the quality of life and the efficiency of care for older people. For instance, this was the case of the Robot-Era project [52] where a multinational European consortium of academies and industries developed a plurality of complete advanced robotic services, integrated into intelligent environments. The project conducted one of the largest experiment ever carried out using multiple service robots, developing eleven different services to support older users individually at home, or collectively in the building and outside. In summary, the experimental results [6] showed that the robot companions can be effective at home as an instrument to help the family with their care and in case of need (e.g. illness).

Researchers are also exploring the use of multi-robot systems which would enable more independent living for seniors because they are able to coordinate with each other to better perform their tasks, also outside the home.

2.1 Acceptance and Acceptability in older people

The acceptance of robots by older people has been examined in many studies. However, usually, older users have expressed an opinion without interacting directly with a robot, showing a strong limitation in the studies [6].

In a study, a robot was used as a physical exercises coach with 33 older participants [56]. The results showed that most of the users were pleased with the robot as an exercise motivator [56]. In another recent study with 16 adults, the acceptability of robots for partner dance-based exercise was investigated. The results suggested that the robot was perceived as useful, easy to use and enjoyable [57]. In a study with 32 older participants, the authors [58] investigated how the human-likeness of the robot's face could influence the perceptions of the robots. But no real robots were used in the study and the imagination of the participants was stimulated by robot images. Finally, with interviews and questionnaires, the results showed a greater preference for the human aspect of the robots by older adults [58].

In European Robot-Era project the results of the experiments indicated that older participants were keen to accept robot companions at home as a way to help the family with their care [52]. Specifically, experiments were conducted in a domestic environment, condominium, and outdoor areas. Eleven robotic services were provided by the Robot-Era system, and each service was tested by older adults that extensively interacted directly with three robots to accomplish tasks [6].

The perception of usability, measured using the *System Usability Scale* [59] was very high (the median score for 67 users was 82 out of 100, over the cutoff score of 68), and significantly correlated (.32; $p<.05$) with acceptability, measured using the *Unified Theory of Acceptability and Use of Technology (UTAUT)* questionnaire [60]. More specifically, the *Perceived ease of use* correlated with usability .50 ($p<.001$), more than the *intention to use* (.31; $p<.05$) [52].

Moreover, the actual usability of the system influences the perception of the ease of use only when the user has no or low experience, while expert users' perception is related to their attitude towards the robot [6]. This finding should be more deeply analysed, because it may have a strong influence on the design of the future interfaces for elderly-robot interaction since it is expected that the number of elderly that possess and use technological devices is growing. Finally, the authors suggest that the positive perception of the robots' aesthetics could play a role in increasing the acceptance of robotic services by older users [6, 61].

2.2 Social robots as assessment tools

Considered that often the diagnosis is affected by the bias of the subjectivity of the evaluator, some recent studies have investigated how social robots could support the clinician during psychological diagnosis. Studies indicated that the support of robots could lead to a more objective assessment, guarantee standardized administration and assessor neutrality, especially for gender and ethnicity, and allow micro-longitudinal evaluations [44, 62]. Indeed, robots can be a useful tool for large-scale screening of cognitive functions. This condition requires further examinations by clinical psychologists, who must always be responsible for the final diagnosis. This can occur if the robotic administration of a cognitive test is supervised by a professional expert [63, 64].

In a recent study, 21 elderly Italian participants were involved [44]. The aim was to compare the prototype of a robotic cognitive test with a traditional psychometric paper and pencil tool and investigated personality factors and acceptance of technology on tests. The authors tested the validity of the robotic assessment conducted under professional supervision. Some factors such as Anxiety (.47; $p<.05$), Trust (-.49; $p<.05$), and Intention to use (.47; $p<.05$) were related to performance in psychometric tests. Finally, the results show the positive influence of Openness to experience on the interaction with the robot's interfaces (.58; $p<.01$) [44].

3 Conclusion

Though research into social robots is just beginning, we know so far that they can provide some solutions to society's ageing population challenge - and might also help in reducing social isolation and loneliness - if society is willing to adopt them. MRT systems and "pet" companions are already on the market. Humanoid companions are still being studied, but seem like a promising solution for more comprehensive quality care [65].

In a recent review, Savela and colleagues [22] found that social acceptance of robots is still a relatively new but an incremental field of research as most of the 42 selected studies were published in the 2010s and were focused on the fields of social and health care.

The literature suggests that young people are more in favor than older people to use robots in caring [66]. Also, differences with males, between countries, and those who live in cities, and more educated are more favorable have been found. Besides the importance of psychosocial variables for user acceptance of social robots and technology in the context of everyday functioning, because the level of psychosocial functioning could either hinders or promotes robot acceptance [67].

The observation of an "uncanny valley", that is a phenomenon in which highly humanlike entities provoke aversion in human observers, has had an important role for the recent researches [68]. To understand the uncanny valley, and the visual factors that contribute to an agent's uncanniness, the relationship between human similarity and people's aversion toward humanlike robots via manipulation of the agents' appearances were been studied [69]. The authors showed a clear and consistent "uncanny valley", and the category ambiguity and atypicality provoke aversive responding, thus shedding light on the visual factors that drive people's uneasiness [69]. Also, the time and/or exposure to robots is unlikely to mitigate the "uncanny valley" effect, because no relationship exists between people's aversion and any pre-existing attitudes toward robots [69].

The robots' acceptance in intervention and diagnostic evaluation will be essential for employing robots in social purposes, particularly for older users. However, it is evident that the research still in progress and, as usual in the diffusion of innovation, the success is mostly shown with early adopters. For this reason, future studies should focus on managing and acting upon adverse user responses to maximize the effectiveness of robots also with the general population. Furthermore, longitudinal studies would be needed to assess the long-term effects - positive and negative - of how older people perceive social robots.

In conclusion, academics and service providers must address public anxiety and clarify that robots are designed to assist social workers, not to replace them. Indeed, before social robots can be fully integrated on a wider scale into practices and care homes, most robotics researchers sensibly recommend that care benefits should be balanced against ethical costs. As long as humans remain in full control to avoid any negative outcome, robots might well be the future of care.

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