TECHNIUM
SOCIAL SCIENCES JOURNAL

Vol. 26, 2021

A new decade for social changes

www.techniumscience.com

ISSN 2668-7798

Technium Social Sciences Journal
Vol. 26, 514-526, December, 2021
ISSN: 2668-7798
www.techniumscience.com

Therapeutic robots as a technological intervention in residential environments for older adults: Uses, limitations and ethical concerns

Rosa Redolat[1], Mercedes Fernández-Ríos[2]

[1]Department of Psychobiology, Faculty of Psychology and Logopedy, Universitat de València, Valencia, Spain, [2]Department of Developmental and Educational Psychology, Faculty of Psychology and Logopedy, Universitat de València, Valencia, Spain

rosa.redolat@uv.es[1], merfer4@ext.uv.es[2]

Abstract. The use of Information and Communication Technologies (ICTs) is one of the innovative responses to the high prevalence of Alzheimer's Disease (AD) and other neurodegenerative disorders. A more holistic approach to the field of gerontology is being adopted, including robotics as an expanding field in the care of the elderly. Our main aim is to review how new technologies can provide opportunities for sensory stimulation and social participation for older adults. We also discuss the transformation of the models of care (from more traditional medical models to person-centered care models) reviewing the use of social robots as a valuable tool in interventions in different residential environments. Robotic technology aimed at the support and care for older adults has shown benefits in areas such as communication, social interaction and quality of life. The review of recent literature also suggests that the use of social robots presents some limitations (robots should be designed to meet the real needs of patients and we need to take into account their impact on health and environment) and ethical concerns (data protection or fear that robots will end up replacing contact among humans) that must be considered when applying these new technologies. It is concluded that social robots can be considered as promising tools for use in people with AD, both from the perspective of the patients and their caregivers, offering cost-effective solutions. New technologies should not aim to replace humans but rather could be a complementary tool for the management and provision of care.

Keywords. Aged, Alzheimer Disease, technology, caregiver, robotics, dementia

1. Introduction

The growing number of people affected by dementia demands the development of adequate screening and cost-effective monitoring tools for cognitive decline, as well as new treatment approaches. The use of Information and Communication Technologies (ICTs) is one of the innovative responses to the high prevalence of Alzheimer's Disease (AD) and other neurodegenerative disorders (Bejan, Gündogdu, Butz, Müller, Kunze, and König, 2018; König et al., 2015; Koo and Vizer, 2019).

Robotics is currently being applied in various contexts with healthy older adults and in patients with neurodegenerative disorders; among its applications are the assessment of

Technium Social Sciences Journal
Vol. 26, 514-526, December, 2021
ISSN: 2668-7798
www.techniumscience.com

cognitive deficits and cognitive activation interventions for dementia patients (Abdi, Al-Hindawi, Ng, and Vizcaychipi, 2018). Robots are also being used to provide company for people living alone, with the aim of improving their well-being and quality of life and offering physical support (Góngora et al., 2018; Pedersen et al., 2018; Riek, 2016). As suggested by the World Health Organization (WHO) in its Global Plan of Action on the Public Health Response to Dementia 2017-2025, more effective interventions and new models of care should be promoted by governments and social institutions. Cahill et al. (2019) have recently reviewed in depth the challenges and opportunities that this plan represents. Although they recognize that it may be difficult to apply the plan in some countries, the authors agree it represents an opportunity for improving research on dementia, offering technical advice and supporting national initiatives through the "Global Dementia Observatory".

Our main aim is to review different interventions based on mHealth and therapeutic robots as new approaches to the design of interventions aimed to the growing number of people affected for dementia. New technologies provide an opportunity for multisensory stimulation and social participation of older subjects in residential environments but also raise problems and ethical concerns that will be discussed taking into account experimental research with socially assisted robots in different residential environments.

2. Multisensory stimulation in therapeutic interventions aimed at patients with dementia

Various studies suggest that the absence of complex stimulation, social interactions or enriched environments may have consequences at cognitive and physical levels (Rafnsson et al., 2017; Sale, 2018; Volker and Scherder, 2011). In older adults, impoverished environments may also contribute to a faster cognitive decline (Volker and Scherder, 2011; D'Oliveira et al., 2014). Some authors have argued that manipulation of the environment, based on complex somato-sensory stimulation, physical activity or motor training, can enhance brain plasticity and neurogenesis (de Macedo et al., 2015; Sale, 2018; Sampedro-Piquero & Begega, 2017; Sansevero & Sale, 2017). It has recently been proposed that the impact of the environment on brain plasticity should be taken into account in the design of therapeutic interventions aimed at maintaining brain and cognitive health throughout life (Cattaneo et al., 2018; Sale, 2018; Sampedro-Piquero & Begega, 2017), while always bearing in mind individual differences in the response to complex stimulation (Kempermann et al., 2019).

Interventions aimed at promoting different types of environmental stimulation should be approached from a multidimensional perspective (Ballesteros, 2015, Leon and Woo, 2018, Mandolesi et al., 2017). Therefore, any strategy aimed at improving the emotional and social well-being of the older adults should include social participation and multisensory stimulation, in addition to cognitive stimulation and physical activity (Duchi et al., 2019; D'Oliveira et al., 2014). Different new technologies provide opportunities for both sensory stimulation and participation in pleasurable activities that can improve well-being in elderly people. Environments such as multisensory Snoezelen rooms are a good example of this approach and can reduce anxiety in patients with dementia (Berkheimer et al., 2017, Collier & Jakob, 2017; Jøranson et al., 2016). Furthermore, in any intervention program designed for persons with dementia, it is important to consider the characteristics, needs and resources of the users. This perspective has been adopted more recently by professionals, and echoes areas of research lacking until now in the literature, reflecting a more holistic approach to the field of gerontology (Bowes and Dawson, 2019, Fazio et al., 2018, Gravitz, 2018).

Sensory group therapy based on social robots is also being applied in patients with dementia (Chang et al., 2013). Sensory stimulation is mainly used for psychological and

Technium Social Sciences Journal
Vol. 26, 514-526, December, 2021
ISSN: 2668-7798
www.techniumscience.com

behavioral symptoms displayed by these patients, since the appearance of this symptomatology has been related, at least in part, to sensory reduction or deprivation in older adults (Sposito et al., 2017; Strøm et al. 2016). A recent review highlights the positive effect of multisensory stimulation as a non-pharmacological treatment for agitation, improving mood and reducing behavioral and psychiatric symptoms. These results can contribute to the improvement in both the quality of life of the patients themselves and in the well-being and reduction of burden of their caregivers (Lorusso & Bosch, 2018, Silva et al., 2017). New approaches, such as cognitive activation, immersive virtual reality or neuromodulation techniques, are currently being applied as non-pharmacological interventions for Alzheimer's disease (Raggi et al., 2017).

3. mHealth in the context of a person-centered care model

In the gerontology context we are witnessing a transformation in models of care, moving from a more traditional medical model to person-centered care models (PCC), in which people are the central axis of all decisions (Diaz-Veiga et al., 2014; Fazio et al., 2018). This model takes into consideration the needs of the patients but also of their caregivers, their family members and all other actors in the caregiving situation. A systematic review suggested the possible benefits of this model of care in reducing behavioral and psychological symptoms (BPSDs) and improving the quality of life of people with dementia (Kim & Park, 2017). This shift in the caregiving model in the context of dementia seeks to promote patient autonomy and necessitates the incorporation of the ITCs in the day-to-day life of the elderly at home, and in the centers they attend (both day-care centers and nursing homes) (Diaz-Veiga et al., 2014, Mordoch et al., 2013). In the PCC model, the person and his/her individual needs, preferences and interests are the fundamental principles of any decision. Robots have been suggested as a valuable tool in interventions within this approach, in different residential environments (Bemelmans et al., 2016; Lane et al., 2016).

mHealth refers to different health-related objectives supported mainly by mobile devices (Valenzuela et al., 2018) and is becoming consolidated as an innovative response to the significant increase in the elderly population and huge costs arising from the high dependency ratios as a result (Changizi and Kaveh, 2017; Martínez-Alcal et al., 2016). There are some encouraging data, reflecting the willingness of patients and families to use ITCs and other technological solutions that can be applied to support caregiving tasks (Pilotto, 2011, Nordgren et al., 2018). Digital technologies are therefore a promising tool for use in people with Alzheimer's disease, both from the perspective of patients and their caregivers, offering more cost-effective solutions (Koumakis et al., 2018; Redolat, Fernández- Ríos, Mazza, 2019). In this context, collaboration among different disciplines to share research results in order to improve the well-being of older adults living both in the community and in nursing homes is vital (Robbins et al., 2018).

On the other hand, there is a group of digital tools designed to offer treatment and/or prevention in dementia. Based on new technologies, these interventions are mainly focused on cognitive stimulation or "serious games" as a means of maintaining the residual capacities of the subject (Manera et al., 2017). However, these types of approaches do not generally attend to the emotional and social well-being of the patients and their caregivers, factors that are clearly related to quality of life and should be taken into account when developing interventions, whether based on traditional approaches or on new technologies (Klein, Gaedt & Cook, 2013; Rodríguez-Blázquez et al., 2015).

Technium Social Sciences Journal
Vol. 26, 514-526, December, 2021
ISSN: 2668-7798
www.techniumscience.com

4. Robotic therapeutics in day-care centers

One of the therapies widely used among clinical and research communities are animal-assisted interventions (Peluso et al., 2018). This type of therapy involves impediments, especially when introduced in residential and hospital settings, for reasons related to safety, hygiene, logistical issues or allergies (Peluso, De Rosa, De Lucia *et al*. 2018). However, the positive results obtained in different studies of animal therapy has promoted a growing body of research to create companion and social robots (Bechade, Dubuisson-Duplessis, Pittaro, Garcia, & Devillers, 2019; Liang et al., 2017; Robinson, MacDonald, Kerse & Broadbent, 2013). Recently, Ambrosi et al. (2019) reported that dog-assisted therapy facilitated social interaction and helped to reduce symptoms of depression in institutionalized elderly patients. However, other studies do not support such benefits of animal-assisted therapies for people with dementia. For example, in a systematic review, Zafra-Tanaka et al. (2019) concluded that this type of intervention had limited effects in improving apathy but did not significantly influence depression, quality of life or cognitive impairment in dementia patients. In this context, more research is needed in order to confirm the effects of animal-assisted therapies in these patients.

According to some authors, the use of robots can help to overcome, at least in part, some of the ilimitations associated with animal-assisted therapies. For this reason, social robots have been proposed as an alternative tool for promoting the health and social welfare of the older adults, both in day-care centers and in nursing homes (Birks et al., 2016, Preus and Legal, 2017, Shibata, 2011). Many assistance and company robots have been developed in recent years, including AIBO, Bandit, CuDDler, Jack and Sophie, JustoCat, Mario, Mero, MIRo, NAO, NeCoRo, Nodding Kabochan, Silbot and PARO. In care for the older population, different roles or areas have been identified with regard to the application of robots. A recent systematic review identified five main roles of socially assistive robots (SAR): affective therapy, physiological therapy, cognitive training, companionship, social facilitating and physiological therapy (Abdi et al., 2017).

Therapeutic robotics and technology are considered innovative responses to the gradual ageing of the population and to the search for new approaches for dementia treatment (D'Onofrio et al., 2019; Leroi et al. 2018; Moyle et al., 2017). However, technology aimed at stimulating patients and providing positive experiences in people with advanced dementia has received less attention than initiatives aimed at ameliorating the negative consequences of aging (Gordijn & Have, 2016; Klein et al., 2013). The European Strategic Research Agenda for Robotics in Europe 2014-2020 (SPARC) has included robotics among their intervention strategies in the field of ageing. The implementation of robots in the care of older people includes among its objectives the improvement of mood, quality of life and health, reduction of stress and enjoyment of patients (Klein et al., 2013; Darragh et al., 2017).

A systematic review performed by Pu et al. (2018) found that social robots could improve anxiety and agitation in dementia patients, although it had no significant effects on neuropsychiatric symptoms. Another uses of social robots with older adults are related to their potential to reduce social isolation in people living with dementia (Pu et al., 2018) or to support the performance of daily activities (Wilson et al., 2019). It has also been suggested that social robots could reduce social vulnerability in residential care facilities, thus providing support to caregivers (Khaksar et al., 2016). Joransson et al. (2015) found that a long-term intervention based on a robot-assisted activity with the robot-seal PARO reduced depression and agitation in dementia patients living in a home care center, suggesting the usefulness of these types of interventions in the management of neuropsychiatric symptoms in dementia. In a study by Jøranson and colleagues (2016), an intervention with the PARO seal-robot stimulated interaction and communication among the patients themselves, as it encouraged conversation

between the patient holding the robot and fellow patients. Social robots also seem to facilitate communication between patients and caregivers, helping the former to become more actively involved in their environment (Robinson et al., 2013; Sharkey & Wood, 2014). For example, PARO has been shown to promote conversations about patients' own real pets and those of their relatives, thus helping individuals to connect their life histories (Sabanovic et al., 2013).

These results support prior studies suggesting that social robots can improve quality of life among older people (Bemelmans et al., 2015; Kanamori et al., 2003).

5. Benefits and limitations of therapeutic robots

Interaction with robots could be an appropriate and novel way to stimulate communication and improve the mood and wellbeing of patients, and so the use of this type of instrument is becoming increasingly widespread in the care of people with dementia (Jung et al., 2017; Moyle et al., 2019; Yu et al., 2015). Robotic technology aimed at older people has shown benefits in areas such as communication, social interaction and quality of life (Abdi et al., 2018, Khaksar et al., 2016; Mordoch et al., 2013; Wada and Shibata 2007). It can also decrease levels of stress-related hormones, offering socio-emotional support to the residents (McGlynn et al., 2014). In this way, social robots imply new approaches that provide promising opportunities for the care of people with dementia (Bemelmans et al., 2016; Broadbent et al., 2018; Moyle, Bramble, Jones & Murfield, 2018).

Among the possible limitations of the use of robots in people with dementia we can highlight the following: 1) Resistance or skepticism: initially the use of these resources meets resistance or skepticism, but these sensations are usually replaced by enthusiasm on the part of professionals and users once intervention with robots begins (Bemelmans et al. 2016); 2) Possible infantilization of the elderly; 3) Deceit or lies about the nature of the robot, that negatively affects the dignity of the person (Sharkey & Wood, 2014; Vercelli et al., 2018; Zubrycki & Granosik, 2016); and 4) Interventions with robots require monitoring in order to avoid the reduction of human contact (Mordoch et al., 2013). In addition to these limitations, we must add the high cost of social robots and the necessity to safeguard the security and privacy of users and to legislate about the use of these tools in some contexts (Maalouf, Sidaoui, Elhajj & Asmar, 2018). In this respect, robot design would need to be improved, increasing acceptability and improving user safety and confidence. Fos-Villaronga and Albo-Canals (2018) have reviewed the legal and social aspects related to the use of robots in different therapeutic settings, including dementia patients, considering the possible long-term consequences of the use of robots, including the loss of social contact and their impact on health and environment.

In the future, it will be necessary to develop new robots with more finely tuned capacities for interaction by means of different sensory modalities. It is also important to adapt robots to the social and emotional needs of the patients, increasing their possibilities of communication and social interaction (Jung et al., 2017; Whelan et al., 2018). Different authors raise the need to promote research on the relationships established between people and robots, identifying possible limitations that obstruct greater acceptance by users, family members and professionals (Maalouf, Sidaoui, Elhajj & Asmar, 2018). The ultimate goal here should be to design robots that meet the real needs of patients and their caregivers (Maalouf, Sidaoui, Elhajj & Asmar, 2018), both in residential contexts and in day-care centers.

6. Ethical concerns related to the use of technology and robotics

In geriatrics, robots are used sometimes with the intention of replacing real pets and thus avoiding many of the limitations that animal-assisted therapies encounter in clinical practice.

Technium Social Sciences Journal
Vol. 26, 514-526, December, 2021
ISSN: 2668-7798
www.techniumscience.com

In no case is the use of robots intended to replace interaction between people (Banks, 2013; Tuisku et al., 2018). The results of different studies support the use of social robots for facilitating and increasing interactions among patients themselves and between them and their environment (Abdi et al., 2018). Although it is important to take into account the demographic characteristics and limitations of the older adults when designing specific robots for this population group in order to improve human-robot interaction (Beer et al., 2017).

One of the main criticisms of robot-assisted therapy refers to ethical issues, such as a fear that robots will end up replacing contact among humans. Different authors agree that therapeutic robots should be used as tools that can be added to human contact, rather than replacing it. It is important that social robots are designed to respect the autonomy and psychological, social and emotional needs of dementia patients in order to increase acceptation of this technology (Riek, 2016, Whelan et al., 2018). A recent study in a German population found a significant relationship between certain personality factors (neuroticism and agreeableness) and the acceptance of social assistance robots (Gessl et al., 2019).

Some other ethical considerations need to be taken into account in this context; namely, the monitoring of socially assistive robots when used in the care of elderly people (Mordoch et al., 2013), expectations evoked by the robots, and how to implement care of a technical device (Misselhorn et al., 2013). In addition, we must take into account the potential conflict between the use of socially assistive robots in care and individual needs of the patients (Borenstein & Arkin, 2019; Misselhorn et al., 2018). As Calo et al. (2011) emphasize, the benefits of using robots with dementia patients are likely to outweigh any associated cost.

In light of all these considerations, a more in-depth reflection on the ethical aspects and technological functioning of robots in aged-care settings is required (Mordoch et al. 2013; Vandemeulebroucke et al., 2017). For example, Ponce (2018) endorse Robo-Ethics as an emerging field that can help to answer pending questions related to the use of robots in care settings. In this context, it is also important to consider aspects related to privacy and control (Banks, 2013), including data protection (for example, how data are stored and who can access them) (Stahl et al., 2016). Some authors have suggested the need for developing specific legislation and guidelines regarding robot development and their use in older people (Frennert and Östlund, 2014). These guidelines should always incorporate ethical issues (Oliver, 2018).

7. Conclusions

Robotics is an example of an expanding field in the care of the elderly. The study of the affective interaction between robots and humans needs to be addressed in depth given its implications for both the development and application of robotics in health care in general (Beer, Liles, Wu & Pakala, 2017). Multidisciplinary research is needed to evaluate the role of technology and social robots as tools for helping older persons to maintain their independence and aging-in-place (Beer et al., 2017; Mois and Beer, 2020). The use of robots can also be extended to healthy older adults and not only to dependent subjects (McGlynn et al., 2017). Future studies should evaluate the effectiveness of robot interventions (Abdi et al., 2017) and their impact on caregiver wellbeing and professional "burnout" (Birks et al., 2016).

There is also a need to develop instruments that facilitate a greater participation of elderly people in social and cultural issues (Pedersen et al., 2018). It is also important to overcome resistance to the use of technological tools when working with older adults. Good management of these tools should include a thorough training of personnel to improve the acceptance of robots in care environments and their adequate use, which also requires a consideration of ethical aspects (Coco, Kangasniemi & Rantanen, 2018; Rantanen, Lehto, Vuorinen & Coco, 2018). Furthermore, it is vital to take into account individual differences that

patients display in their attitudes towards robots and other types of technological interventions (McGlynn et al., 2017), as well as cultural, physical and social contexts when evaluating human-robot interactions (Zafrani et al., 2018; Kolling et al., 2016; Wu et al., 2012). In summary, there are still many challenges to the design of robots in their use for different purposes (Andtfolk, Nyholm, Eide & Fagerström; Lipson, 2019).

As several authors emphasize, new technologies should not aim to replace humans, but rather should be a complementary tool for the management and provision of care (Calo et al., 2011; Bendixen et al. 2017; Lehoux & Grimard, 2018), and a strategy to promote a more active aging (Robbins et al., 2018).

References

[1] Abdi J, Al-Hindawi A, Ng T *et al*. Scoping review on the use of socially assistive robot technology in elderly care. *BMJ open* 2018; 8: e018815. doi:10.1136/bmjopen-2017-018815

[2] Andtfolk, M., Nyholm, L., Eide, H., & Fagerström, L. Humanoid robots in the care of older persons: A scoping review. *Assistive Technology* 2021, 1-9.

[3] Ambrosi C, Zaiontz C, Peragine G *et al*. Randomized controlled study on the effectiveness of animal-assisted therapy on depression, anxiety, and illness perception in institutionalized elderly. *Psychogeriatrics* 2019; 19: 55-64. doi: 10.1111/psyg.12367

[4] Ballesteros S, Kraft E, Santana S *et al*. Maintaining older brain functionality: A targeted review. *Neurosci Biobehav Rev* 2015; 55: 453-77. doi: 10.1016/j.neubiorev.2015.06.008

[5] Banks WA. Artificial emotions: Robots caring for the elderly. *J Am Med Dir Assoc* 2013; 14: 635-636. doi:10.1016/j.jamda.2013.04.011

[6] Bechade, L, Dubuisson-Duplessis, G. Pittaro, G *et al* (2019). Towards Metrics of Evaluation of Pepper Robot as a Social Companion for the Elderly. In *Advanced Social Interaction with Agents* (pp. 89-101). Springer, Cham.

[7] Beer JM, Liles KR, Wu X *et al*. Affective Human–Robot Interaction. In *Emotions and Affect in Human Factors and Human-Computer Interaction* 2017: 359-381.

[8] Bejan A, Gündogdu R, Butz K *et al*. Using multimedia information and communication technology (ICT) to provide added value to reminiscence therapy for people with dementia: Lessons learned from three field studies. *Z Gerontol Geriatr* 2018; 51: 9-15. doi: 10.1007/s00391-017-1347-7

[9] Bemelmans R, Gelderblom GJ, Jonker P *et al*. How to use robot interventions in intramural psychogeriatric care; a feasibility study. *Appl Nurs Res* 2016; 30: 154-157. doi:10.1016/j.apnr.2015.07.003

[10] Bendixen RM, Fairman AD, Karavolis M *et al*. A User Centered Approach: Understanding Client and Caregiver Needs and Preferences in the Development of mHealth Apps for Self-Management. *JMIR Mhealth Uhealth* 2017; 5: e141. doi:10.2196/mhealth.7136

[11] Berkheimer SD, Qian C, Malmstrom TK. Snoezelen therapy as an intervention to reduce agitation in nursing home patients with dementia: A pilot study. *J Am Med Dir Assoc* 2017; 18: 1089-1091.

[12] Birks M, Bodak M, Barlas J *et al*. Robotic seals as therapeutic tools in an aged care facility: a qualitative study. *J Aging Res* 2016; 2016: 8569602.

[13] Borenstein, J., Arkin, R. Robots, ethics, and intimacy: the need for scientific research. In *On the Cognitive, Ethical, and Scientific Dimensions of Artificial Intelligence*. Springer, Cham., 2019. doi: 10.1007/978-3-030-01800-9_16

[14] Bowes A, Dawson A. *Designing Environments for People with Dementia: A Systematic Literature Review*. Emerald Publishing Limited. 2019 https://doi.org/10.1108/9781787699717

[15] Broadbent E, Ahn HS, Kerse N *et al.* Can robots improve the quality of life in people with dementia? In *Proceedings of the Technology, Mind, and Society* (p. 7) ACM. 2018. doi: 10.1007/978-3-030-01800-9_16

[16] Cattaneo G, Bartrés-Faz D, Morris TP *et al*. The Barcelona Brain Health Initiative: A Cohort Study to Define and Promote Determinants of Brain Health. *Front Aging Neurosci*. 2018; 10: 321. doi: 10.3389/fnagi.2018.00321

[17] Cahill S. WHO's global action plan on the public health response to dementia: some challenges and opportunities. *Aging Ment Health*. 2019; 2: 1-3. doi:10.1080/13607863.2018.1544213

[18] Calo CJ, Hunt-Bull N, Lewis L *et al*. (2011). Ethical implications of using the Paro robot, with a focus on dementia patient care. In -Robot Interaction in Elder Care, Papers from the 2011 AAAI Workshop, San Francisco, California, USA, 2011

[19] Chang WL, Šabanovic S, Huber L. Use of seal-like robot PARO in sensory group therapy for older adults with dementia. In *Human-Robot Interaction (HRI), 2013 8th ACM/IEEE International Conference on* (pp. 101-102). IEEE. 2013

[20] Changizi M, Kaveh MH. Effectiveness of the mHealth technology in improvement of healthy behaviors in an elderly population-a systematic review. *Mhealth*. 2017; 3: 51. doi: 10.21037/mhealth.2017.08.06

[21] Coco K, Kangasniemi M, Rantanen T. Care Personnel's Attitudes and Fears Toward Care Robots in Elderly Care: A Comparison of Data from the Care Personnel in Finland and Japan. *J Nurs Scholarsh*. 2018; 50: 634-644.

[22] Collier L, Jakob A. The multisensory environment (MSE) in dementia care: examining its role and quality from a user perspective. *HERD*. 2017; 10: 39-51. doi:10.1177/1937586716683508

[23] Darragh M, Ahn HS, MacDonald B *et al*. Homecare robots to improve health and well-being in mild cognitive impairment and early stage dementia: results from a scoping study. *J Am Med Dir Assoc.* 2017; 18: 1099-e1. doi: 10.1016/j.jamda.2017.08.019

[24] Díaz-Veiga P, Sancho M, García Á *et al*. Efectos del Modelo de Atención Centrado en la Persona en la calidad de vida de personas con deterioro cognitivo de centros gerontológicos. *Rev Esp Geriatr Gerontol.* 2014; 49: 266-271. doi:10.1016/j.regg.2014.06.003

[25] de Macedo LDED, De Oliveira TCG, Soares FC *et al*. Beneficial effects of multisensory and cognitive stimulation in institutionalized elderly: 12-months follow-up. *Clin Interv Aging*. 2015; 10: 1351-1360.

[26] De Oliveira TCG, Soares FC, De Macedo LDED *et al.* (2014). Beneficial effects of multisensory and cognitive stimulation on age-related cognitive decline in long-term-care institutions. *Clin Interv Aging* 2014; 9: 309- 320. doi:10.2147/CIA.S54383

[27] D'Onofrio G, Sancarlo D, Raciti M et al. MARIO Project: Validation and Evidence of Service Robots for Older People withDementia. *J Alzheimers Dis* 2019; 68: 1587-1601. doi:10.3233/JAD-181165

[28] Duchi F, Benalcázar E, Huerta M *et al*. (2019)Design of a multisensory room for elderly people with neurodegenerative diseases. In World Congress on Medical Physics and Biomedical Engineering, Singapore; 2018. 207-210. Springer

[29] Ehni HJ, Kadi S, Schermer M *et al*. Toward a global geroethics–gerontology and the theory of the good human life. *Bioethics* 2018; 32: 261-268. doi:10.1111/bioe.12445
[30] Elfaki AO, Alotaibi M. The role of M-health applications in the fight against Alzheimer's: current and future directions. *Mhealth* 2018; 4: 32. doi:10.21037/mhealth.2018.07.03
[31] Fazio S, Pace D, Flinner J *et al*. The fundamentals of person-centered care for individuals with dementia. *Gerontologist* 2018. 58(suppl_1): S10-S19. doi: 10.1093/geront/gnx122
[32] Fosch-Villaronga E, Albo-Canals J. "I'll take care of you," said the robot. *Paladyn* 2019; 10: 77-93.
[33] Frennert S, Östlund B. (2014). Seven matters of concern of social robots and older people. *Int J Soc Robot* 2014; *6*: 299-310.
[34] Gessl AS, Schlögl S, Mevenkamp N. On the perceptions and acceptance of artificially intelligent robotics and the psychology of the future elderly. *Behav Inf Technol* 2019; 1-20.
[35] Gravitz L. Drawing on the brain's resilience to fight Alzheimer's disease. *Nature* 2018; *559*: S8-S9.
[36] Global Burden of Disease Study 2017 (GBD 2017). All-cause Mortality and Life Expectancy 1950-2017. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2018.
[37] Góngora Alonso S, Hamrioui S, de la Torre Díez I *et al*. Social Robots for People with Aging and Dementia: A Systematic Review of Literature. *Telemed J E Health* 2018. doi: 10.1089/tmj.2018.0051
[38] Gordijn B, Have HT. *Technology and dementia. Med Health Care Philos* 2016; 19*: 339*- 340. doi:10.1007/s11019-016-9715-4
[39] Jøranson N, Pedersen I, Rokstad AMM *et al*. Change in quality of life in older people with dementia participating in Paro-activity: A cluster-randomized controlled trial. J Adv Nurs 2016; 72: 3020-3033. doi: 10.1111/jan.13076
[40] Jøranson N, Pedersen I, Rokstad AMM *et al*. Effects on symptoms of agitation and depression in persons with dementia participating in robot-assisted activity: a cluster-randomized controlled trial. *J Am Med Dir Assoc* 16: 867-873. doi: 10.1016/j.jamda.2015.05.002
[41] Jung MM, Van der Leij L, Kelders SM. An exploration of the Benefits of an animallike robot companion with More advanced Touch interaction capabilities for Dementia care. *Frontiers in ICT* 2017; 4: 16
[42] Khaksar SMS, Khosla R, Chu MT *et al*. Service innovation using social robot to reduce social vulnerability among older people in residential care facilities. *Technol Forecast Soc Change* 2016; 113: 438-453.
[43] Kempermann G. Environmental enrichment, new neurons and the neurobiology of individuality. *Nat Rev Neurosci* 2019; 20: 235-245. doi: 10.1038/s41583-019-0120-x
[44] König A, Sacco G, Bensadoun G *et al.* The role of information and communication technologies in clinical trials with patients with Alzheimer's disease and related disorders. *Front Aging Neurosci* 2015; *7*: 110. doi: 10.3389/fnagi.2015.00110
[45] Klein B, Gaedt L, Cook G. Emotional Robots: Principles and experiences with Paro in Denmark, Germany, and the UK. *GeroPsych.* 2013; 26: 89- 99.
[46] Kim SK, Park M. Effectiveness of person-centered care on people with dementia: a systematic review and meta-analysis. *Clin Interv Aging* 2017; 12: 381-397. doi: 10.2147/CIA.S117637

[47] Kolling T, Baisch S, Schall A *et al*. (2016). What Is Emotional About Emotional Robotics?. In *Emotions, Technology, and Health*. 85-103. Academic Press.
[48] Koo BM, Vizer LM. Mobile Technology for Cognitive Assessment of Older Adults: A Scoping Review. *Innov Aging* 2019; 3: igy038. doi: 10.1093/geroni/igy038
[49] Koumakis L, Chatzaki C, Kazantzaki E *et al*. Dementia Care Frameworks and Assistive Technologies for Their Implementation: A Review. *IEEE Rev Biomed Eng* 2019; 12: 4-18. doi: 10.1109/RBME.2019.2892614
[50] Lane GW, Noronha D, Rivera A et al. Effectiveness of a social robot, "Paro", in a VA long-term care setting. *Psychol Serv* 2016; 13: 292- 299. doi:10.1037/ser0000080
[51] Leon M, Woo C. Environmental Enrichment and Successful Aging. *Front Behav Neurosci* 2018; 12:155. doi: 10.3389/fnbeh.2018.00155
[52] Leroi I, Kitagawa K, Vatter S *et al*. Dementia in 'super-aged' Japan: challenges and solutions. *Neurodegener Dis Manag.* 2018; 8: 257-266. doi: 10.2217/nmt-2018-0007
[53] Liang, A., Piroth, I., Robinson, H., MacDonald, B., Fisher, M., Nater, U. M., ... & Broadbent, E. (2017). A Pilot Randomized Trial of a Companion Robot for People With Dementia Living in the Community. *J Am Med Dir Assoc* 2017; 18: 871-878. doi:10.1016/j.jamda.2017.05.019
[54] Lipson H (2019) Robots on the run, Nature, 568: 174-75. *doi: 10.1038/d41586-019-00999-w*
[55] Lorusso LN, Bosch SJ. Impact of Multisensory Environments on Behavior for People With Dementia: A Systematic Literature Review. *Gerontologist* 2018; 58: e168-e179. doi: 10.1093/geront/gnw168
[56] Maalouf N, Sidaoui A, Elhajj IH *et al.* Robotics in Nursing: A Scoping Review. *J Nurs Scholarsh* 2018; 50: 590-600. doi: 10.1111/jnu.12424
[57] Mandolesi L, Gelfo F, Serra L *et al*. Environmental factors promoting neural plasticity: insights from animal and human studies. *Neural Plast* 2017; 2017:7219461. doi: 10.1155/2017/7219461
[58] Manera V, Ben-Sadoun G, Aalbers T *et al*. Recommendations for the use of serious games in neurodegenerative disorders: 2016 Delphi Panel. *Front Psychol* 2017; 8: 1243. doi: 10.3389/fpsyg.2017.01243
[59] Martínez-Alcalá CI, Pliego-Pastrana P, Rosales-Lagarde A *et al*. Information and communication technologies in the care of the elderly: systematic review of applications aimed at patients with dementia and caregivers. *JMIR Rehabil Assist Technol* 2016; 3:e6. doi:10.2196/rehab.5226. doi:10.2196/rehab.5226
[60] McGlynn S, Snook B, Kemple S *et al*. (2014) Therapeutic robots for older adults: investigating the potential of Paro. In *Proceedings of the 2014 ACM/IEEE international conference on Human-robot interaction* 246-247.
[61] McGlynn SA, Kemple S, Mitzner TL *et al*. (2017) Understanding the potential of PARO for healthy older adults. *Int J Hum Comput Stud* 100: 33-47. doi: 10.1016/j.ijhcs.2016.12.004
[62] Misselhorn C, Pompe U, Stapleton M. (2013). Ethical considerations regarding the use of social robots in the fourth age. *GeroPsych* 2013.
[63] Mois, G., & Beer, J. M. (2020). Robotics to support aging in place. In Living with Robots (pp. 49-74). Academic Press.
[64] Mordoch E, Osterreicher A, Guse L *et al*. Use of social commitment robots in the care of elderly people with dementia: A literature review. *Maturitas* 2013; 74: 14-20. doi:10.1016/j.maturitas.2012.10.015

[65] Moyle W, Arnautovska U, Ownsworth T *et al*. Potential of telepresence robots to enhance social connectedness in older adults with dementia: an integrative review of feasibility. *Int Psychogeriatr* 2017; 29: 1951-1964. doi: 10.1017/S1041610217001776
[66] Moyle W, Bramble M, Jones C *et al*. Care staff perceptions of a social robot called Paro and a look-alike Plush Toy: a descriptive qualitative approach. *Aging Ment Health* 2018; 22: 330-335. doi:10.1080/13607863.2016.1262820
[67] Moyle W, Bramble M, Jones CJ *et al*. "She Had a Smile on Her Face as Wide as the Great Australian Bite": A Qualitative Examination of Family Perceptions of a Therapeutic Robot and a Plush Toy. *Gerontologist* 2019; 9;59(1):177-185. doi: 10.1093/geront/gnx180
[68] Nordgren A. How to respond to resistiveness towards assistive technologies among persons with dementia. Med Health *Care Philos* 2018; 21: 411-421. doi: 10.1007/s11019-017-9816-8
[69] Oliver D. David Oliver: Will robotic automation solve social care? *BMJ* 2018; 21;363:k4854. doi: 10.1136/bmj.k4854
[70] Peluso S, De Rosa A, De Lucia N *et al*. Animal-Assisted Therapy in Elderly Patients: Evidence and Controversies in Dementia and Psychiatric Disorders and Future Perspectives in Other Neurological Diseases. *J Geriatr Psychiatry Neurol* 2018; 31: 149-157. doi:10.1177/0891988718774634
[71] Pedersen I, Reid S, Aspevig K. Developing social robots for aging populations: A literature review of recent academic sources. *Sociology Compass* 2018; 12: e12585.
[72] Pilotto A, D'Onofrio G, Benelli E et al. Information and communication technology systems to improve quality of life and safety of Alzheimer's disease patients: a multicenter international survey. *J Alzheimers Dis* 2011 23: 131-141. doi: 10.3233/JAD-2010-101164
[73] Ponce, M. F. (2018). Robots and Public Health in the 21st. Century: A Robo-Ethics Object of Inquiry [Robots y Salud Pública en el Siglo XXI: Un Objeto de Indagación en Robo-Ética].
[74] Preuß D, Legal F. Living with the animals: animal or robotic companions for the elderly in smart homes?. *J Med Ethics* 2017; 43: 407-410. doi: 10.1136/medethics-2016-103603
[75] Pu L, Moyle W, Jones C *et al*. The Effectiveness of Social Robots for Older Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Studies. *Gerontologist* 2019; 59: e37-e51. doi: 10.1093/geront/gny046
[76] Rafnsson SB, Orrell M, d'Orsi E *et a*l. Loneliness, Social Integration, and Incident Dementia Over 6 Years: Prospective Findings From the English Longitudinal Study of Ageing. *J Gerontol B Psychol Sci Soc* Sci 2017; doi: 10.1093/geronb/gbx087
[77] Redolat R, Fernández- Ríos M, Mazza G. A double look at the application of information and communication technologies in patients with Alzheimer's Disease. *J Community Med* 2019; 1: 1012. Available from: https://meddocsonline.org/journal-of-community-medicine-archive.html
[78] Raggi A, Tasca D, Ferri R. A brief essay on non-pharmacological treatment of Alzheimer's disease. *Rev Neurosci* 2017; 28: 587-597.
[79] Rantanen T, Lehto P, Vuorinen P *et al*. Attitudes towards care robots among Finnish home care personnel–a comparison of two approaches. *Scand J Caring Sci* 2018; 32: 772-782. doi: 10.1111/scs.12508

[80] Riek LD. Robotics technology in mental health care. In *Artificial intelligence in behavioral and mental health care.* Academic Press, 2016; 185-203.
[81] Robinson H, Macdonald B, Kerse N *et al*. The psychosocial effects of a companion robot: a randomized controlled trial. *J Am Med Dir Assoc* 2013; 14: 661-667. doi:10.1016/j.jamda.2013.02.007
[82] Robbins TD, Lim Choi Keung SN, Arvanitis TN. E-health for active ageing; A systematic review. *Maturitas* 2018; 114: 34-40. doi:10.1016/j.maturitas.2018.05.008
[83] Rodríguez-Blázquez C, Martín-García S, Frades-Payo B *et al*. Calidad de vida y estado de salud en personas mayores de 60 años con demencia institucionalizadas. *Rev Esp Salud Publica* 2015; *89*: 51-60.
[84] Šabanović S, Bennett CC, Chang WL *et al*. PARO robot affects diverse interaction modalities in group sensory therapy for older adults with dementia. *IEEE Int Conf Rehabil* Robot 2013; 013:6650427. doi:10.1109/ICORR.2013.6650427
[85] Sale, A. A Systematic Look at Environmental Modulation and Its Impact in Brain Development. *Trends Neurosci 2018 41*(1), 4-17. doi:10.1016/j.tins.2017.10.004
[86] Sampedro-Piquero P, Begega A. Environmental enrichment as a positive behavioral intervention across the lifespan. . *Curr Neuropharmacol* 2017; 15: 459-470. doi:10.2174/1570159X14666160325115909
[87] Sansevero G, Sale A. Environment as therapy: neuroatscience for intellectual disability and dementia. *Oncotarget* 2017 8: 5682 –5683. doi:10.18632/oncotarget.14602
[88] Sekhon, H., Cray, H. V., & Vahia, I. V. (2021). Robots in Geriatric Mental Health: Pipe Dream or Viable Solution?. *The American Journal of Geriatric Psychiatry: Official Journal of the American Association for Geriatric Psychiatry*.
[89] Sharkey A, Wood N. The paro seal robot: Demeaning or enabling? AISB 2014 - 50th Annual Convention of the AISB. 2014. London: United Kingdom.
[90] Shibata, T., & Wada, K. Robot therapy: a new approach for mental healthcare of the elderly–a mini-review. *Gerontology* 2011, 57(4), 378-386. doi:10.1159/000319015
[91] Silva R, Abrunheiro S, Cardoso D *et al*. Effectiveness of multisensory stimulation in managing neuropsychiatric symptoms in older adults with major neurocognitive disorder: a systematic review. *JBI Database System Rev Implement Rep* 2018; 16: 1663-1708. doi: 10.11124/JBISRIR-2017-003483
[92] Sposito G, Barbosa A, Figueiredo D *et al*. Effects of multisensory and motor stimulation on the behavior of people with dementia. *Dementia* 2017; 16: 344-359. doi: 10.1177/1471301215592080
[93] Stahl BC, Coeckelbergh M. Ethics of healthcare robotics: Towards responsible research and innovation. *Rob Auton Syst* 2016; 86: 152-161.
[94] Strøm BS, Ytrehus S, Grov EK. Sensory stimulation for persons with dementia: a review of the literature. *Journal of clinical nursing* 2016; 25: 1805-1834. doi:10.1111/jocn
[95] Tuisku O, Pekkarinen S, Hennala L *et al*. "Robots do not replace a nurse with a beating heart" The publicity around a robotic innovation in elderly care. *Information Technology & People* 2018; 32:46-47. https://doi.org/10.1108/ITP-06-2018-0277
[96] Valenzuela PL, Morales JS, Santos-Lozano A *et al.* mHealth and Aging. *J Am Med Dir Assoc* 2018; 19: 810-811. doi: 10.1016/j.jamda.2018.06.002
[97] Vandemeulebroucke T, de Casterle BD, Gastmans C. The use of care robots in aged care: A systematic review of argument-based ethics literature. *Arch Gerontol Geriatr* 2018; 74: 15-25.

[98] Vercelli A, Rainero I, Ciferri L *et al*. Robots in Elderly Care. *DigitCult-Scientific Journal on Digital Cultures* 2018; 2: 37-50.
[99] Volkers KM, Scherder EJ. Impoverished environment, cognition, aging and dementia. *Rev Neurosci* 2011; 22: 259-66. doi: 10.1515/RNS.2011.026
[100] Wada K, Shibata T. Living with seal robots – Its sociopsychological and physiological influences on the elderly at a care house. *IEE Transactions on Robotics* 2007; 23: 972-980
[101] Wilson, G, Pereyda, C, Raghunath, N, et al. Robot-enabled support of daily activities in smart home environments. *Cognitive Systems Research 2019, 54*, 258-272.
[102] Whelan S, Murphy K, Barrett E *et al*. Factors affecting the acceptability of social robots by older adults including people with dementia or cognitive impairment: A literature review. *Int J Soc Robot* 2018; 10: 643-668.
[103] World Health Organization. Global action plan on the public health response to dementia 2017–2025. 2017. Available from: http://apps.who.int/iris/bitstream/handle/10665/259615/?sequence=1
[104] Wu Y, Fassert C, Rigaud A. Designing robots for the elderly: Appearance issue and beyond. *Arch Gerontol Geriatr*. 2012; 54: 121-126. doi:10.1016/j.archger.2011.02.003
[105] Yu R, Hui E, Lee J *et al*. Use of a therapeutic, socially assistive pet robot (PARO) in improving mood and stimulating social interaction and communication for people with dementia: Study protocol for a randomized controlled trial. *JMIR Res Protoc* 2015; 4: e45. doi: 10.2196/resprot.4189
[106] Zubrycki I, Granosik G. Understanding therapists' needs and attitudes towards robotic support. the roboterapia project. *Int J Soc Robot* 2016; *8*: 553-563.
[107] Zafra-Tanaka JH, Pacheco-Barrios K, Tellez WA *et al*. Effects of dog-assisted therapy in adults with dementia: a systematic review and meta-analysis. *BMC Psychiatry* 2019; 19: 41. doi: 10.1186/s12888-018-2009-z
[108] Zafrani O, Nimrod G. Towards a holistic approach to studying human–robot interaction in later life. *Gerontologist 2018*, 59: e26-e36. . doi:10.1093/geront/gny077