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Participatory Design of Socially Assistive Robots for Preventive Patient-Centered Healthcare*

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Abstract— **This paper presents an ongoing project using participatory design methods to develop socially assistive robots (SARs) for older adults diagnosed with depression and co-occurring physical illness. We frame SARs development in the context of preventive patient-centered healthcare, which empowers patients as the primary drivers of health and aims to the delay the onset of disease rather than focusing on treatment. We describe how SARs can be of particular benefit in this new direction in healthcare, and detail our participatory design study with older adults and therapists aimed at developing preventive SARs applications for this population.**

I. Introduction

Recent years have seen the proliferation of socially assistive robots (SARs) for the purposes of improving the functioning and quality-of-life (QOL) of people who experience chronic and age-related health issues [1, 2]. Many SARs-related studies occur in either laboratory or institutionalized care settings (e.g. nursing homes) and focus on treatment and rehabilitation. However, "health" is not something that happens once someone gets sick or diagnosed; it is the result of an accumulating cascade of daily choices and environmental factors. Impacting health in daily life – prior to the development of illness or the need for institutionalized care (i.e. preventative healthcare) – represents a novel opportunity for exploring applications of assistive robotics, and brings up the need to understand how robots may fit into peoples' everyday lives and within the growing focus on patient-centered care.

A noteworthy example is clinical depression in the elderly. Depression is the 2nd leading cause of disability in the United States [3], and a particularly prevalent problem among older adults. Mental health issues such as depression often precipitate the emergence of physical health problems and/or decline in physical functioning, resulting in the need for institutionalized care. Institutionalized care is far more expensive than in-home care [4]. Moreover, most elderly prefer to remain independently living in their own homes for as long as possible. Thus, the current paradigm neither meets the needs of individual users nor benefits society at large.

Research in laboratory and institutional settings suggests that interactive robots and sensors can support and enhance the social, cognitive, and physical functioning of older adults [1, 5, 6]. Our current project, presented here, explores how SARs could be implemented in the homes of older adults *before* they become institutionalized, with the aim of preventing or delaying the need for such institutionalization. The participants are independently living older adults diagnosed with clinical depression and co-occurring physical illness. To address the social challenges of developing and deploying assistive robotic technologies in this setting (and to fit within the paradigm of patient-centered care), we use participatory design (PD) with relevant stakeholders – older adults, therapists, and case workers. The aim is to provide a better understanding of appropriate designs, deployment methods, uses, and effects of SARs that can lead to more successful technical and social outcomes.

We describe our motivation for examining SARs for preventive healthcare applications and how we use PD to develop appropriate ways of implementing SARs in the homes of older adults. *The ultimate goal of the project is to understand 1) how socially-assistive robots can best be used for prevention of the development of health issues in real world settings, and 2) how we can better incorporate user needs and concerns into SARs design and deployment strategies.*

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II. Background and Motivation

A. *Depression Incidence and Treatment in Older Adults*

The Institute of Medicine's 2012 report on mental health in older adults estimates that currently at least 5.6-8 million, (nearly one in five) older adults in the US experience a mental illness, and that by 2030 that number will rise to between 10.1-14.4 million [7]. Clinical depression affects 15-20% of older adults in the US [8]. Depression in the elderly entails intensive treatment, which is often inconsistently provided and/or provided in clinical settings (e.g. primary care doctor's office) that may not be the most appropriate. The IOM 2012 report suggests the field leverage technology to improve care and access to care in this population.

SAR technologies hold potential to address this IOM recommendation. One particular area in which SARs stand to be beneficial is in addressing loneliness, which the literature reveals to be a key component of depression in the elderly and an independent risk factor for physical/cognitive decline in this population (see Section II.C) [9]. Research with the therapeutic robot PARO in institutionalized settings has shown that robots can be used to help alleviate feelings of loneliness in older adults [10], suggesting SARs could provide therapeutic benefits that reduce symptoms of clinical depression in older adults living independently as well.

B. *Socially Assistive Robots in Eldercare*

Socially assistive robots (SARs) are an emerging technology envisioned as having widespread applications in the context of eldercare [1]. Assistive robots are expected not only to help people accomplish certain tasks, but also to have measurable behavioral, cognitive, or therapeutic effects. Researchers have shown that the therapeutic effects of SARs on the elderly can include positive health impacts, decreased stress and improved mood, decreased loneliness and better communication with others [2]. One projected use for socially assistive robots is to complement therapists in the course of rehabilitation (e.g. [11], as well as play both functional and affective roles in the lives of older adults. Care-O-bot, for example, supports independently living older adults by delivering meals and drinks [12]. The seal-like robot PARO [5, 6] is used as a social companion. Robots can also act as communication devices that bring older adults into contact with remote caregivers (e.g. [13]).

SARs development has so far focused on two main contexts of use: the home, where robots can provide aid to independently living individuals, and institutions such as nursing homes and hospitals, where robots assist both older adults and caregivers. The development of SARs for these environments raises significant social concerns beyond the technical issues involved. Field studies of interactions between people and robots in hospitals (e.g. [14]), nursing homes (e.g. [15], and private homes (e.g. [16]) have brought attention to the effects of emergent social factors, including workflow, individual interpretations, users' values, and the physical environment, on the success and consequences of robots in society. This suggests that developing co-robots for everyday use requires research, design, and evaluation sensitive to the social effects and interpretations of robots.

C. *Healthcare-Related Challenges & Opportunities*

Healthcare in recent years has seen a push toward *patient-centered care,* which views patients as the primary drivers of health and healthcare needs, in comparison to the more traditional view centering on diagnosis and treatment of disease after it occurs. An individual's health is now commonly seen as an amalgamation of lifestyle choices, genetics, and environmental factors that accumulate over long periods of time. Moreover, a person's health status is fundamental toward their quality-of-life (QOL) [17]. There is, accordingly, an increasing focus on wellness, activity, and participation [18]. Consequently, the question for any innovative technology geared towards health-related applications is how that technology can ameliorate an individual's QOL by affecting a person's health status over their lifespan. This is particularly true in chronic illnesses, where a cure is often not available [19]; with issues like dementia, for example, delaying onset is a key strategy [20]. A preventive approach to health can reduce costs and better aligns with patient preferences to minimize time spent in institutionalized settings [21].

SARs hold significant potential in supporting preventive healthcare, especially among the elderly. A majority of older adults (70% of the broader population from which we draw our participants) have multiple co-occurring chronic health conditions and/or are at risk of several others. Development of mental illness in older adults (e.g. clinical depression) often precipitates a significant decline in physical health, which in turn often leads to the need for institutionalized care [22]. The incidence of co-occurring disorders only increases with age [23]. SARs can be used to directly intervene in this co-occurring cycle. Research in laboratory and institutional settings suggests that interactive robots and sensors can support and enhance the social, cognitive, and physical functioning of older adults [1, 5, 6]. Similar benefits may potentially exist for older adults in their own homes before they become institutionalized and/or seriously ill. SAR-based interventions will also impact clinicians, as the introduction of in-home robots may alter how healthcare is provided within the clinic. Finally, SARs as preventative tools dovetail nicely with ongoing trends in the delivery of healthcare, particularly the focus on patient-centered care. However, bringing such potential to fruition necessitates an understanding of how SARs might fit into the broader sociotechnical ecosystem of the home.

III. Case Study: Participatory Design with Older Adults with Depression and Therapists

A. *Participatory Design for SARs Development*

Along with the increasing focus on patient-centered care and prevention, the long history of using participatory design methods to develop healthcare solutions also informs our approach. Over forty years of practice and research in participatory design (PD) for information technology has shown that negotiation of the social meanings, uses, and effects of technologies throughout the design process can lead to more successful technical and social outcomes. The basic element of PD, as implied by its name, is to involve all those with a stake in the functioning of technology to participate in decisions about its design and/or implementation. One potential benefit of such involvement is that participation of users will increase the likelihood that the eventual system fits its intended use context and works well. Another is that stakeholders involved in system development are likely to feel more positively about the system than those not so involved, and will actively scaffold its deployment and use. Such an approach aligns well with the user-centered approaches to healthcare described above (Section II.C).

Technical complexity has often been used as a justification for keeping users outside of the decision-making processes regarding the design and use of robotic technologies. Ethically speaking, however, the people who will interact directly with eldercare robots should have opportunities to influence their development. Applications of PD methodologies to robotics, though few to date, suggest that active participation in the design of robotic technologies can empower users with knowledge about technology, allowing them to take part in critical discussions of the potential social consequences and meanings of new technologies [24]. PD has so far been used to work with community members to build robotic sensing devices [24], in educational robotics [25]. Frennert, Eftring and Ostlund [26] recently used a participatory approach to robot design by having older adults evaluate assistive robot mock-ups in their homes to explore the potential uses and appearance of assistive robots. Ezer et al [27] found that technological experience, rather than age, was the main predictor of people's expectations from robots, suggesting that making older adults more aware of the technical possibilities of robots through PD could also increase acceptance [28].

B. A Case Study of SARs Participatory Design

Our current project focuses on the utilization of SARs for the prevention and early management of clinical depression in independently living older adults, reducing institutionalized care. The aim is two-fold: attempting to understand user needs and potential implementation strategies through PD approaches, and exploring which PD methodologies are appropriate for co-designing assistive technologies with older adults and their therapists.

The project includes older adult patients (>55) experiencing co-occurring chronic mental (major clinical depression) and physical illness (mainly hypertension, diabetes, chronic pain, and cardiovascular disease), who receive treatment services from a large outpatient healthcare provider in rural Indiana. The patients are approximately gender-balanced (i.e. 50/50 male to female ratio). The providers see over 80,000 distinct patients a year across 150 outpatient clinical sites in multiple states (e.g. Tennessee, Indiana, Kentucky, and Illinois). Informed by prior PD studies in information and robotic technologies, we are conducting initial in-home interviews with individual participants, followed by two group workshops to study how they perceive existing SARs and what design characteristics they desire to be part of future SAR technologies, as described below.

1) In-Home Interviews

Initial semi-structured interviews will be performed with participants in their homes. The interviews will involve the collection of demographic information about participants, and continue with a discussion of their current life situation and experiences, their social relationships, specific life issues they face, and current ways technology is used in their daily life. The interviews will provide information about participants' general needs and allow researchers and participants to define design goals together. The interviews will be followed by a walk-through of the participant's house, which will be documented through field notes and photos.

2) Therapist Interviews

Along with interviewing participants in their homes, we will also interview five therapists about their experiences working with independently living older adults with depression. This will allow us to better understand the practices and needs of therapists who are working with the population. We will show therapists videos and live demos of existing assistive robotic technologies and ask them to critique the robots, letting us know whether they think they would be usable in their work and what kinds of attributes assistive technologies should have to be useful for them.

3) Participatory Design Workshops

Participatory design workshops will give older adults an opportunity to be active in the development of SARs, both through critiquing existing robots and developing their own interactive prototypes.

The *first workshop* will last 2 hours. Participants will be invited in groups of 5-8 in two separate sessions. The workshop will start with a summary of the interview findings. For the first hour, participants will watch and critique videos of assistive technologies. In the second hour, we will have live demonstrations of robots, including the PARO robotic seal (see Figure 1 below). Our main aim for this workshop is to learn how participants interpret existing technologies, relate these technologies to their own experiences and concerns,) see themselves using such technologies, and what kind of characteristics assistive technologies should have in the future. We will also note what kinds of tasks and questions elicit better feedback from participants (e.g. videos or live demos), how best to inspire them to critique the artifacts, and what kinds of challenges we face in getting participation, which will help us further

develop our PD methodology for working with older adults. The workshops will be videotaped for more detailed analysis later on.

Figure 1. Participants will view live demos of the Roomba, a modified iCreate, our break management robot prototype, PARO, and Keepon.

During the *second workshop*, which will also last up to 2 hours, participants will design their own assistive technology prototypes with the help of the researchers. The aim of this workshop is to allow participants to actively develop the functions they want to see in a future SAR while balancing their desires with technical capabilities. We will also explore PD methods to help participants engage in creative thinking regarding assistive technologies. Participants will first be given a variety of familiar craft materials (e.g., cardboard, colored paper, pens) and asked to construct a low-fidelity prototype of an assistive technology they would like to have. Participants will work in groups of 2-3, and investigators will be there to help with the design process. Following this initial activity, we will give participants Hummingbird robotics kits (http://www.hummingbirdkit.com/) [25]. Investigators will work with the participants to see how different sensors work, i.e. how a machine might sense the world. They will then use the kits to design some interactive capabilities for their assistive technology (e.g. when it hears a voice, a part of the prototypes moves). Participants will present their designs to each other, and discuss their experiences of working with the technology and possibilities for further design of the artifact. We will end the workshop with a general discussion of the potential uses of assistive technologies, how they can be used to address the issues related to aging and depression, and any comments they have on the workshops they participated in.

IV. Conclusion

Socially assistive robots are a promising technology for preventive, patient-centered care. The ongoing project described here uses participatory design to explore the appropriate ways of implementing SARs to aid older adults with co-occurring depression and chronic physical illness in order to delay the need for institutionalized care. The confluence of user-centered approaches in both robotics and healthcare offers significant opportunities to explore how SARs can synergistically integrate and support ongoing changes in the healthcare landscape.

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References

[1] A. Tapus, M.J. Matarić, B. Scassellati. "The grand challenges in socially assistive robotics," *IEEE RAM,* vol. 14. 2007, pp. 35-42.

[2] J. Broekens, M. Heerink, Rosendal H, Assistive social robots in elderly care: A review. *Gerontech.* vol 8 no 2, pp. 94-103, 2009

[3] González HM, Tarraf W, Whitfield KE, Vega WA (2010) The epidemiology of major depression and ethnicity in the United States. *Journal of Psychiatric Research* 44(15):1043-1051.

[4] Woolhandler S, Campbell T, Himmelstein DU (2013) Costs of health care administration in the United States and Canada. *New England Journal of Medicine*, 349:768-775.Shibata 2012

[5] Šabanović S, Bennett CC, Chang WL, Huber L (2013) PARO robot affects diverse interaction modalities in group sensory therapy for older adults with dementia. *IEEE International Conference on Rehabilitation Robotics (ICORR)*, pp 1–6.

[6] Shibata T, Wada K (2011) Robot therapy: a new approach for mental healthcare of the elderly - a mini-review. *Gerontology* 57(4):378–386.

[7] Institute of Medicine, *The Mental Health and Substance Use Workforce for Older Adults: In Whose Hands?* Washington DC: The National Academies Press, 2012.

[8] Ciechanowski P, Wagner E, Schmaling K, Schwartz S, Williams B, Diehr P, Kulzer J, Gray S, Collier C, and J LoGerfo (2004) "Community-Integrated Home-Based Depression Treatment in Older Adults." *JAMA*. 291(13), pp. 1569-1577.

[9] Adams KB, Sanders S, and EA Auth (2004) "Loneliness and Depression in Independent Living Retirement Communities: Risk and Resilience Factors." *Aging & Mental Health*. 8(6): 475-485.

[10] Robinson H, MacDonald B, Kerse N, and E Broadbent. (2013). "The Psychosocial Effects of a Companion Robot: A Randomized Controlled Trial." *Journal of the American Medical Directors Association.* In PressKang et al, 2005

[11] Kang KI, Freedman S, Matarić M, Cunningham MJ, Lopez B (2005) A hands-off physical therapy assistance robot for cardiac patients. *Proceedings of the International Conference on Rehabilitation Robotics (ICORR)*, pp 337-340.

[12] Graf B, Reiser U, Hagele M, Mauz K, Klein P (2009) Robotic home assistant Care-O-bot 3 - Product vision and innovation platform. *Proceedings of IEEE Workshop on Advanced Robotics and its Social Impacts (ARSO)*, pp 139–144.

[13] Ogawa K, Nishio S, Koda K, Balistreri G, Watanabe T, Ishiguro H (2011) Exploring the natural reaction of young and aged person with Telenoid in a real world. *Journal of Advanced Computational Intelligence and Intelligent Informatics*, 15(5):592-597.

[14] Mutlu B, Forlizzi J (2008) Robots in organizations: The role of workflow, social, and environmental factors in human-robot interaction. *Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, pp 287-294.

[15] Chang W, Šabanović S and Huber L (2013) Situated analysis of interactions between cognitively impaired older adults and the therapeutic robot PARO. *Proceedings of the International Conference on Social Robotics (ICSR)*, pp 371-381.

[16] Forlizzi J (2007) How robotic products become social products: An ethnographic study of cleaning in the home. *Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, pp 129-136.

[17] Wilson IB, Cleary PD (1995) Linking clinical variables with health-related quality of life: a conceptual model of patient outcomes. *JAMA* 273(1):59-65.

[18] World Health Organization (2006) *Constitution of the World Health Organization Basic Documents, Forty-fifth edition, Supplement*. Accessed on June 26, 2014 from: http://www.who.int/governance/eb/who_constitution_en.pdf

[19] Bennett CC, Doub TW (2014) Expert systems in mental healthcare: AI applications in decision making and consultation. In: Luxton D (ed) *Artificial Intelligence in Mental Healthcare*. Elsevier Press. In Press.

[20] Fratiglioni L, Qiu C (2011) Prevention of cognitive decline in ageing: dementia as the target, delayed onset as the goal. *The Lancet Neurology* 10(9):778-779.

[21] Kane RL, Kane RA (2001) What older people want from long-term care, and how they can get it. *Health Affairs* 20(6):114-127.

[22] Lee Y (2000) The predictive value of self assessed general, physical, and mental health on functional decline and mortality in older adults. *Journal of Epidemiology and Community Health*, 54(2):123-129.

[23] van Oostrom SH, Picavet HSJ, van Gelder BM, et al. (2012) Multimorbidity and comorbidity in the Dutch population–data from general practices. *BMC Public Health* 12(1):715.

[24] DiSalvo C, Nourbakhsh I, Holstius D, Akin A, Louw M (2008) The Neighborhood Networks project: a case study of critical engagement and creative expression through participatory design. *Proceedings of the 10th Anniversary Conference on Participatory Design*, pp 41-50.

[25] Hamner E, Lauwers T, Bernstein D, Nourbakhsh, IR, DiSalvo CF (2008) Robot diaries: Broadening participation in the computer science pipeline through social technical exploration. *AAAI Spring Symposium: Using AI to Motivate Greater Participation in Computer Science*, pp 38-43.

[26] Frennert S, Elftring H, Ostlund B (2013) What older people expect of robots: A mixed methods approach. *Proceedings of International Conference on Social Robotics (ICSR)*, pp 19-29.

[27] Ezer N, Fisk AD, Roger, WA (2009) Attitudinal and intentional acceptance of domestic robots by younger and older adults. In: *Universal Access in Human-Computer Interaction. Intelligent and Ubiquitous Interaction Environments*. Berlin: Springer, pp 39-48.

[28] Priska Flandorfer, "Population Ageing and Socially Assistive Robots for Elderly Persons: The Importance of Sociodemographic Factors for User Acceptance," International Journal of Population Research, vol. 2012, Article ID 829835, 13 pages, 2012. doi:10.1155/2012/829835