Engaging Older Adults with Depression as Co-Designers of Assistive In-Home Robots

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ABSTRACT

We used participatory design methodology to engage independently living older adults with depression and co-occurring physical illness in the design of assistive robots for their homes. Our aim was to work toward a design that can extend the amount of time they can live independently and increase their quality of life. Clinicians were also invited to contribute their ideas, as they are important advocates for using assistive technology in a clinical capacity. In this paper, we outline our strategies for engaging older adults as co-designers, noting what succeeded and what failed in our participatory design approach. We also discuss the viability of replication studies in participatory design and the need to engage other stakeholders besides older adults, such as clinicians, to provide practical robot applications.

CCS CONCEPTS

H.1.2 User/Machine Systems: Human Factors; I.2.9 Robotics: Commercial robots and applications; K.4.2: Social Issues: Assistive technologies

KEYWORDS

Participatory design; co-design; assistive robots; home robotics; depression management and therapy; mental health; older adults; human-robot interaction

1 AIMS

Participatory design (PD) treats those that will be affected by a new artifact as partners in its design. It emphasizes a design process that is varied and flexible – responsive to the needs and desires of individual populations and to the context the design is envisioned to exist in. It also empowers potential users and other stakeholders to make decisions about the purpose and design of new technologies. While participatory design was initially developed for the application of new computing technologies in the workplace, contemporary interest in developing preventative healthcare technologies may benefit from employing PD methodologies to create assistive technologies for the home [1,9]. These aids can be used as part of people's therapeutic regimen and to increase wellbeing.

Using a participatory design approach, we engaged older adults with depression in discussions of existing in-home assistive robots, and worked with them to generate and express new robot design and application ideas. Assistive robots have shown promise in the care of aging populations [3,17], with researchers suggesting they can be used to extend the amount of time older adults can live independently in their homes [4]. Researchers have done surveys [2,11], observational studies, [5,10] and quasi-experimental studies [4,20] to discover how robots are used by older adults with mental and physical health issues in this environment. However, more work is necessary to explore how these robots should be designed to increase their usefulness and acceptability among this population, and to ensure robotic technologies address concerns most relevant to them. In our study, the use of PD methodology was appropriately aligned with our goal of engaging older adults more extensively in the design of novel technology for their homes. We also hoped that it would allow us to better understand their needs, desires, and expectations for assistive robots compared with more traditional design methodologies, leading to a higher likelihood of adoption.

This paper discusses our successes and failures in implementing a PD approach to design assistive robot concepts with older adults with depression and clinicians, with lessons applicable to other fields desiring to use PD for emerging technology design. In particular, the strategies we used for building early rapport, contextualizing the design, and encouraging stakeholders to develop a designer's mentality are explained. Additionally, we comment on whether PD processes are replicable, and how to assess whether an adequate array of stakeholders have been represented in the process.

2 BACKGROUND

Assistive robots function in ways that improve the functioning or quality of life of their users. These robots can be physically or socially assistive. Research on assistive robots show they have a number of social, psychological, and physiological benefits on older adults [6,23,25]. In the home context specifically, few studies of the therapeutic use of assistive robots for older adults have occurred, but those that exist suggest they might have

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promising therapeutic benefits in this context [4].

Various design approaches have been utilized in creating assistive robots for older adults. These include ethnography [12], field studies [16], and user-centered design [7]. PD approaches to the creation of this technology are harder to find, but a few have been conducted since 2010 [14,15,18,24]. Frennert and Ostlund (2014) call for more participatory design projects to be undertaken that involve users early in the design phase [13].

Robotics is a particularly interesting area to employ PD strategies, as people have little everyday experience with this technology, but often have pre-conceptions about what they can and should do from their exposure to media and the entertainment industry. At the same time, the development of robotics applications by designers, who are often quite different from users, may lead to stereotypical notions of the users being reflected in their designs [19]. As these emerging technologies begin to meet the technical requirements that allow them to stably exist in our environments, it is important that they be co-created by roboticists and potential users to overcome preconceptions on both sides.

3 METHODS

3.1 Participants

Nine older adults were recruited to take part in this study. Participants were selected on the basis of meeting the following criteria: a) aged 55 and older, b) lived alone and independently, c) had a depression diagnosis, and d) had a co-occurring physical illness. No participants had psychosis or dementia. We focused on older adults with depression because it is a condition that affects 15-20% of older adults [8], and is a significant risk factor for physical health issues and institutionalization [22]. Recruitment was performed in coordination with a local mental health clinic in the Midwest. Additionally, ten clinicians (therapists, care coordinators, etc.) were also recruited.

Older adults were recruited at two points in time (2014 and 2017) and from two different towns in the Midwestern United States. They were involved in independent but identical PD processes. Five participants (3 men and 2 women) were recruited for the first study. All lived in a rural area, were low income, and were mostly socially isolated. We replicated our study with four older adults, who met the same criteria as specified, but lived in a suburban area of the same Midwestern state. Compared to our first set of participants, these participants tended to have a slightly higher income and were more diverse in their degree of existing social ties (some had stronger social networks).

3.2 Study Design

3.2.1 Older Adults

We conducted an in-home semi-structured interview with each older adult, followed by a series of four workshops.

Figure 1: The seal robot Paro and the automatic vacuum cleaner Roomba, which were shown to participants during Workshop 1.

All nine participants were interviewed individually. In the first set of workshops (2014-2015), 3-4 participants attended each workshop. In the second set of workshops (2017), 2-3 participants attended each workshop. The participants who stopped participating did so because of their health conditions. The content of the four workshops was identical between the two sets of workshops.

Workshop 1 was an introduction to physically assistive and socially assistive robots through videos and live demos (Figure 1). Workshop 2 was focused on developing designs for desired assistive home robots collectively, while in Workshop 3 designs were developed individually by participants. Sketches were made by several research team members, as participants were generally not comfortable with doing their own drawings. Workshop 4 introduced older adults to the technical aspect of how robots work through sensor cards and demo. All workshops were approximately two hours.

The majority of content for our first set of workshops was *not* defined *a priori*. This allowed us to be responsive to the needs of the individuals we had in the session, and finalize upcoming workshops as the direct result of the experiences (of the participants and researchers) in the ones before it. The second set of workshops was conducted as a replication of the first set.

3.2.2 Staff

A separate workshop was held with four clinicians, mainly to assess their willingness to use robots in their practice and exactly how they would be the most useful to them and their patients. They were also informed of the results of the workshops on assistive robot design with older adults and consulted about the therapeutic appropriateness of the resulting design recommendations for that population. This workshop lasted approximately two hours. Prior to all workshops, these clinicians, plus one other, were also interviewed individually. Before the second set of older adult workshops, five additional staff interviews were also conducted.

3.2.3 Research Team

Our team consisted of a participatory design researcher, a health technology developer, two recreational therapy scholars, one human-computer interaction designer, and four human-robot interaction (HRI) researchers. This interdisciplinary team was created out of the desire to employ technology and interaction experts relevant to the domain, as well as scholars with the training to diffuse intense emotional states and deal with pressing mental issues, should they arise when the team was present with participants. Not all team members were present at the workshops at one time, with members participating as their expertise was needed (e.g. technologist attended one session to present the capabilities of robotic sensors).

4 IMPLEMENTATION STRATEGIES & CHALLENGES

4.1 Building Rapport

Supporting older adults to become active members of the design team requires that they feel comfortable enough to express their opinions. Therefore, rapport building must occur between both the participant and researchers, and the participant and other older adults who share the same space. It is critical to do this effectively early on, to maximize the benefits of subsequent encounters. As well, it can be difficult to undo a negative first impression [21], so it is important to manage impressions established during the first encounter. Therefore, the team discussed who would have the best chance of early relationship building with each participant. We wanted our participants' first contact to be a particularly warm and encouraging one, and include team members who could react appropriately to the sensitive information they shared. In addition, we visited them in their homes, a space in which they are familiar and typically comfortable. We also typically designated female researchers to visit their homes, as many of our participants were women who lived alone, who conceivably could have been uncomfortable with men that they had never met before visiting. It was somewhat less crucial to engineer who participants had subsequent contact with, after initial rapport and trust in the process had been established. This regard to early encounters was particularly important as this population did have some mental health issues, but we would advocate that this is an important part of the process, no matter the population.

After the opportunity to interview participants individually in their homes, they were invited to a series of four workshops to share their experiences and opinions. Anywhere from two to four older adults were concurrently present in each workshop. As participants would be talking about potentially emotionally charged events from their past, and have conflicting views on how they would use an assistive robot based on their current situation, we also needed to make sure participants were comfortable with each other. Therefore, we didn't lead participants to share relevant personal experiences to their design until the second workshop session, so they had time to become acquainted with each other. During our second run of the first workshop in our series, we noticed that one participant often looked to the other (the more dominant one) for reassurance and agreement. This dissipated in the second workshop. In this workshop, we also made more overt efforts to rapport build among participants, having them collaboratively design a robot together (which our researchers drew) and perform an experience sharing exercise. The number of sessions over which older adults collaborated (four) seemed to make them more comfortable with each other and the process, asking more questions to us and each other as the workshops progressed.

4.2 Seeing the Space

As mentioned above, we interviewed participants individually in their homes. In addition to rapport building, this allowed us to see the layout of their homes. This made it feasible to answer several questions concerning the practicality of using robots in this context. Could robots actually work in their space, and if so, which might work best? How did they use and incorporate other technologies in their environment? Were there any likely constraints, despite what older adults might later indicate to be among the most useful or interesting ideas? One thing we observed quickly was that many spaces were small and cluttered, making it difficult for mobile robots to traverse the area with ease. As well, most of the older adults had and regularly used computers, as well as other technologies, in their daily life. The visit also highlighted that despite all our participants living alone, some participants had frequent visitors in their home, which even occurred while we were there. This allowed us to gauge the range of living conditions, as this could have conceivably had an effect on participants' favored robots. Later on, we used our knowledge of the living space of participants as the foundation for our design activities in Workshop 3, where participants specifically talked about how robots would fit into their living space.

4.3 Co-Designing Emerging Technologies

An aspect of assistive robotics that is particularly challenging for design in general, and participatory design in particular, is that the technologies that are being constructed with participants do not yet exist in daily life. This means that participants do not have experience with the technologies, or anything quite like them. In the case of robots, the expectations and design ideas are therefore often based on fictional notions of what robots should be able to do, or on projections of capabilities of people, animals, computers, or other more familiar agents and artifacts to the new technologies.

Our initial idea was to deal with this issue of the participatory design process by giving our participants hands-on experience with robotics technology – working with them to design some simple robots using Arduinos and other hobbyist electronics. The inappropriateness of this plan quickly became clear, as participants reacted very negatively to a robot we presented to them that was programmable using a Scratch interface – they did not want to have anything to do with programming the robot or telling it how to do tasks. This caused us to change our tactics and start with more inclusive activities of developing different robot use scenarios and related robot designs first, which we followed

with a discussion of robotic sensors and their capabilities and how they could be part of participants' robot designs.

4.4 Encouraging a Designer's Mentality

Based on our experience, it can be difficult for participants to see themselves as designers rather than mere consumers or users. Certainly, the length of the process and the number of diverse activities in which they engaged facilitated this shift. Older adults began, in workshop 1, by viewing four videos of existing robots, followed by live demonstrations of four robots (all different than those shown in the videos except for the robot Paro) (Figure 1). They were then asked to comment about what they liked and what they might change, and to select three product reaction cards that described how they felt about the robot and explain their choices. This exercise of showing videos and demos of finished, existing robots only seemed to reinforce older adults' role as consumers. They had a hard time thinking about modifications, instead generally wholly accepting or rejecting the product. Statements such as "Yea, I'd buy one of those" and "it's not for me" were common, and conversations often did not go much deeper than this, even after probing. When one participant did allude to wanting a robot that was significantly different than those shown, it was met with another participant stating, "But that's nothing like what we've seen. That would be changing it completely." While the benefit of seeing robots was revealed in subsequent workshops, as this gave participants inspiration from which to draw, older adults might have been better able to engage in design thinking if they were shown a larger diversity of robots at the onset or unfinished robots. It is possible that showing adults more robots, and robots that weren't specifically targeted at the aging population, would have led to better idea generation. As well, people may be more likely to comment on unfinished products Having a visual and tangible source to comment was vital however. As one participant put it, "I don't have an imagination strong enough". This was a reflection of participants not being well acquainted with this novel technology and not being accustomed to design thinking.

Figure 2: An example sketch showing a participant's desired in-home robot, which was drawn by one of our researchers in Workshop 3.

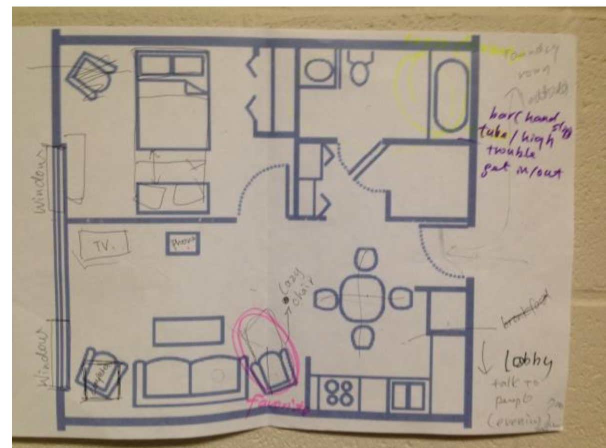

Figure 3: Floor plan. Participants used sketches and images that researches created during their in-home visit in order to ground their design to the envisioned context of use.

The second workshop had the participants experience sharing and collaboratively designing a robot. Beginning the workshop by having participants share experiences of feeling sad or lonely in the past allowed them to make connections between these moments and later design ideas. For instance, participants realized they had different strategies for coping with depressive states (self-isolating vs seeking companionship) and those that self-isolated tended to see how having a robot who could be a friend during their down times might be especially helpful for them. Furthermore, having them collaboratively design a robot(s), which two members of our research team sketched, allowed us to see overlapping areas of interest (reminders, cleaning, locating items, companionship). This activity also required that participants think about the form(s) of a robot(s) that might be well suited to engage in these activities and how it might go about executing these functions.

The third workshop, where they designed robots individually, continued to engage them deeper in the process. In this session, we showed them the layouts of their homes we had sketched in the first visit, and they walked us through how they might interact (or not interact) with the robot in each room in their home (Figure 2). This also allowed us to explore how the robot could work *in context*. For instance, one participant discussed how he would like his robot to wake him up in the morning in the bedroom, then move to the living room later in the day, where it would rest again his favorite chair and watch tv with him (Figure 3). Repeatedly articulating that designing a robot required careful consideration of how each part of every interaction might work seemed to engage them further in the process.

The final workshop was meant to give older adults more of the technological aspects of building a robot. However, as some older

adults lacked the desire and/or confidence to work with sensors directly, we chose a low-tech way to transfer this knowledge. We began by showing them a series of sensor cards and having them pick the three that would be most relevant to them. Two of these were to be for sensory input (e.g., flex sensor for pressure, ultrasonic sensor for distance, voice recognition sensor, etc.) and one for output (motors for movement, MP3 module for sound, etc.). Participants then explained why these would be useful to their lives. For instance, one participant chose a fingerprint sensor due to concerns over information security and privacy, which had been expressed by multiple participants through the workshop series. This also brought up some new concerns, such as the desire to have a humidity sensor to help keep their gardens healthy or to help their breathing. This activity actually allowed for the discussion of intelligent technology more generally, such as interactive objects and smart homes. Additionally, we had a team member introduced as a "technologist" show them sensor demos and how they might be used in real projects. Interestingly, when he showed them a camera attached to a metal base, which could detect and follow their movements, some were uneasy. However, when this same technology was shown on an embodied robot (one with a face), some of their attitudes shifted quite dramatically and positively. This was a lesson for us; the way technology is presented can vastly affect participant's interpretation of it. Their interpretation hinges on this technology being connected to a need or desire that they have.

The end of this process still failed to show older adults fully integrated as "co-designers". In the last session, they still wanted us to tell them what the sensors were for before they could interpret their meaning, even though our goal was for them to tell us how they could be used. However, these older adults also saw the tangible benefits assistive robots could provide to their lives and were able to immerse themselves somewhat in the process of design. Having varied activities meant to engage older adults in this process was important, and no single activity was as important as having them collectively experienced.

4.5 Replicating the Process

As mentioned, this workshop series was run with older adults at two distinct times, once from 2014-2015 and once in 2017. During our first series, we defined workshop activities as we went, letting our and the participant's experience and comfort guide subsequent content. For example, we had originally thought to introduce participants to building their robots using cardboard and Hummingbird robotics kits, but due to their expressed aversion to hands-on building activities with technology, we decided that the following workshop would involve designers sketching their designs. This flexibility and letting participants have some say in agenda setting likely helped shift their self-identification further from consumer and closer to co-designer. It certainly allowed a more fruitful workshop series.

In 2017, we replicated this established process with older adults. These were the same stakeholders – older adults with depression and co-occurring physical illness – though as mentioned, they were from a slightly different demographic. This provided us with valuable insight into how replication might work within the PD framework, particularly leading us to the realization that exact replication may not work well within the context of PD. We believe it is important to keep methods flexible and finalize upcoming workshops as the direct results of the experience of the participants and researchers. Participants may appear similar on the surface, but they bring their own interests, capabilities, and group dynamics into the process, making replication problematic from the perspective of truly engaging participants in a process of co-design. For instance, during the first workshop of our replication, participants specifically requested the ability to learn more about the technical aspects of robotics, and noted they might be better equipped to have discussions if they learned about sensors sooner than workshop 4. This was in stark contrast to our previous participants, so these participants might have benefitted from seeing the sensor workshop earlier. Group dynamics were also different, as this group was smaller, but there was more of a concern of power dynamics between participants in workshop 1, and participants tended to have more divergent opinions than in the first workshop series. Of course, insights garnered from past experience can be incorporated into later processes, but it is important to still remain flexible and reactive to the demands of the current participants. Allowing participants to guide the process will only further empower them to take on the role of designer. When replicating a design process in PD, it is likely that it should be understood as more akin to a conceptual replication than an exact one, possibly by using a common set of materials and starting with similar goals, but developing the process to address the needs and desires of diverse participants.

4.6 Engaging Other Stakeholders

We held a separate workshop with clinicians (therapists, care coordinators, etc.) following our workshops with older adults. All felt as those assistive robots could positively impact their patients and felt that if certain information was gathered, it could have a positive impact on their ability to provide treatment. Sleep tracking and anomaly detection were two of the features they mentioned that hadn't been discussed among older adults. They informed us that psychiatric units might particularly benefit from in-home assistive robots if it could be demonstrated that they would reduce hospitalizations and had a positive clinical effect. "Most of [our patients] don't have a huge problem with a ton of hospitalizations, but the ones that do definitely end up costing a lot of money." This type of knowledge would not be accessible to our participants and shows the benefit of involving many stakeholders in the design process. Concretely, we would need to design a system that could not only help older adults with depression and physical illness, but that could also demonstrate its efficacy to clinical care members. For its successful implementation, it would best be framed as a money saving tool as well as a social agent with real effects on patients' everyday lives.

Still, clinicians are patient advocates, not policy makers. Social robots are too expensive a resource for this population to afford for personal use, as many lack the income to meet basic needs. In order for them to become a reality, insights from stakeholders that have the power to approve their use in clinical applications are also necessary. For healthcare, this means engaging insurance providers and representatives of state or local government, who make funding and policy decisions.

5 CONCLUSION

Our work brings to the forefront the utility of bringing PD methodologies into novel technology design, particularly in the field of assistive robotics. It also speaks to its ability to engage individuals who are typically not technologically inclined, such as older adults, into the design process more deeply, by employing varied and low-tech methods. Although our participants did not fully assume the role of co-designer at the conclusion of our study, they did become more engaged with the process as time progressed. Our successes (e.g., rapport building, contextualizing the design) and challenges (e.g., shifting their mentality, replicating the process) in facilitating this change were discussed. It is possible that with more time and mutual learning with the research team, older adults may have been able to identify more as designers. Although we included both independently living older adults with depression and co-occurring physical illness, our target population, and clinicians in this study, we also discussed the need to include more stakeholders if this technology is to be employed as a clinical tool covered by health insurance.

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