

We Can Do Better! An Initial Survey Highlighting an Opportunity for More HRI Work on Loneliness

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ABSTRACT

Although research has demonstrated the potential for social robots to positively impact a person's mood and provide comfort, very little research has yet focused on social robots supporting people living with loneliness. Much of the relevant human-robot interaction work focuses on more serious situations such as living with dementia, or on related areas such as stress, anxiety, or depression, and these works generally target the older adult demographic. Loneliness, however, can affect anyone of any health and age. In this paper we present a summary review of the current research on loneliness and social robots, highlighting the gaps in research and the potential opportunity for more work in the area.

CCS CONCEPTS

• Human-centered computing ~ Human computer interaction (HCI)
~ HCI design and evaluation methods ~ User studies

KEYWORDS

loneliness, human-robotics interaction, social robots

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1 Introduction

While everybody feels lonely at times, ongoing loneliness is a serious problem and key risk factor for mental and physical health issues [1]. For example, living with loneliness can result in poor sleep quality [2]–[4], elevated cardiovascular diseases [5] and has been linked to stress, anxiety, and depression [6]. Loneliness can be caused by a range of factors including being socially isolated (of

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particular concern given the ongoing global pandemic [7]), losing someone close, or moving to a new location [8]. Although some people may be particularly susceptible, such as those living in care facilities, or students living away from home, it is crucial to recognize that people from all walks of life are susceptible to loneliness [9], [10]. In this paper, we highlight the untapped potential for social robots to support people living with loneliness.

Activities can be employed to reduce feelings of loneliness, such as sharing ones thoughts with another person or participating in social events [11], as well as intervention strategies such as social skill improvement (e.g., addressing maladaptive cognition or actions), social support enhancement, or increasing social contact [12]. Particularly relevant to human-robot interaction, pet ownership can reduce loneliness, enhance social support and generally improve mental health [13]. However, many people cannot keep pets due to concerns including ongoing financial and physical care commitments, allergies and hygiene, or fear of animals [14]. Thus this provides an opportunity for robotic analogs to pets (“robotic pets”) to provide some of the benefits of real animals, while side-stepping the related challenges.

Social robots that elicit a personality and engage people using life-like interaction techniques [15] have the potential to provide emotional support and reduce loneliness. Research in the community has demonstrated positive outcomes for people living with dementia [16]–[18], autism [19], stress [20], anxiety [21] and depression [22], while very little work has specifically targeted loneliness. We present a literature survey that intersects general work on loneliness with human-robot interaction, with our results highlighting opportunities for future work in this area.

2 Loneliness

Loneliness is generally defined as the disparity between a person's desired and actual social contacts and relationships [23]. However, in reality it is not only a state of solitude or isolation, rather it is a complex emotional state of mind that is unique to each person [12]. Therefore, management of loneliness varies extensively from one person to another [12].

Research suggests that there can be three types of loneliness that may occur independently; *social*, *emotional* and *cultural* loneliness [8]. Social loneliness can occur because of decreased social communication and integration. For example, being isolated from a community, or moving to another city or country. This state of loneliness can be reduced by associating with new people [8]. On the other hand, emotional loneliness develops when someone

feels the lack of a close or reliable relationship with another individual, such as a spouse or a partner. Such loneliness can be mitigated by others who also have a close relationship with the lonely person [8]. Lastly, cultural loneliness can be triggered because of the absence of a person's preferred cultural and linguistic environment [24]. For example, international students living abroad, detached from their culture may experience such loneliness [24]. Talking with someone in their own language can help reduce the feeling of cultural loneliness [24].

Loneliness can seriously impact a person's mental and physical health [12]. Research has found loneliness to be associated with obesity [25], increased hypothalamic pituitary adrenocortical activity (increased stress) [26], an accelerator for Alzheimer's disease [27], decreased immunity [28], increased consumption of alcohol [29], increased suicidal tendency [30], and older adult mortality [31]. Increased stress due to loneliness may result in cognitive decline in older adults [32].

2.1 Causes of Loneliness

People may experience loneliness due to a variety of reasons [33]. Some may experience loneliness because of their lifestyles. For example, not having social connections (e.g., making new friends or socializing with others), voluntarily social distancing or self-scrutinization [12]. Specific life events (e.g., death of someone close, break-up from a relationship, starting a new job/university/college) may also be responsible for a person's loneliness [12]. People living in specific scenarios can be vulnerable to loneliness too. For example, being a single parent, being in a minority group in the community, culture difference, shortage of money, experiencing discrimination or racism, being a victim of sexual or physical abuse [12]. People may even feel lonely at certain times of the year, such as Christmas [34]. From as little as 4% up to half of tendency of experiencing loneliness can be caused by biological predisposition because of inheriting personality traits [8], [35]–[37]. Social communication and financial instability can also influence people to experience loneliness [38].

Given the diverse and varied roots of loneliness, broad supports cannot be tailored to such specific causes of loneliness if they are expected to help many people. More general social support strategies, such as owning a (possibly robotic) pet, are perhaps better suited to more generally supporting social, emotional and cultural loneliness.

2.2 Interventions to Reduce Loneliness

Loneliness can be mitigated by keeping oneself busy, participating more in one's community, finding someone to share thoughts with [29], or having a pet [39]. Technology-based social supports have also been shown to help people manage their loneliness, for example, online spaces or smartphone applications to chat with others [40], call centers [41], or even on-line artificial intelligent "chat bots" to simulate social interaction [42]. Recently, researchers introduced social robots to manage loneliness [33].

3 Initial Survey

Although limited in number, existing research with available social robots have shown to be quite effective in supporting loneliness [33]. We conducted this survey to understand how loneliness is framed and understood in the mental health community, and to intersect this with the current human-robot interaction works on loneliness, how technology and social robots are being used to support this problem, and which instruments are people relying on to measure loneliness.

We carried out an extensive literature review process to select the most relevant papers for this survey. We looked for papers generally on loneliness (e.g., causes, impacts and interventions [1]), social robot works on loneliness (e.g., Aibo [33], [43] and Paro's [44] impact) and loneliness works with other technologies (e.g., internet use and loneliness [12], effect of smartphone [45]). We searched for papers in digital libraries including Google Scholar, the ACM Digital Library, and IEEE Xplore using keywords that included "loneliness", "social robots" and "study". We additionally surveyed the following specific venues: the ACM Human-Robot Interaction Conference, ACM Transactions on Human-Robot Interaction Journal, Springer International Journal of Social Robotics, Springer International Conference on Social Robotics, and Human-Agent Interaction Conference. We performed backward and forward search within citations from the relevant papers and collected 72 papers on robots relating to loneliness. Some papers are excluded from this number based on focuses on more general mental wellness and not targeting loneliness. Our in-depth analysis is ongoing; here we present initial survey findings from the selected papers.

3.1 Robots can support loneliness

Research investigated the impact of social robots (e.g., Aibo [33], Paro [44], Vector [46]) on loneliness, and initial results suggest that these robots were quite effective in reducing the feeling of loneliness. For example, use of the Aibo successfully managed to improve the quality of life as well as reduce loneliness among older adults in a seven week long study [47]. The study was conducted in a long term care facility, and older adults could pet, play and speak to Aibo during the interaction sessions. In a similar study, researchers compared the impact of the robotic dog with a living dog [33]. Research outcome showed statistically significant drop in loneliness among older adults who interacted with both the robot and the living dog [33]. These results suggest that, Aibo can be used in scenarios where having living pets may not be suitable (e.g., hospital, allergy, fear of living animals).

Work with Paro investigated the psychological effects of the companion robot in a care home and a hospital setting [44]. Results highlight that older adults were increasingly communicating with each other after interacting with Paro. Researchers observed similar outcomes from other studies with Paro [22], and they suggests that this robot has the ability to improve the mental health of older adult's [22].

Recent work with Vector demonstrated how effectively it accompanied people during the ongoing pandemic. Outcomes from

the work indicate that Vector has the capability to reduce the feeling of loneliness [48]. Commercially available animatronic pets also performed well in reducing loneliness and improving quality of life among older adults [49].

The mentioned works mostly target lonely older adults living in care homes and provide convincing research outcomes on improving their quality of life as well as reducing loneliness. However, these works do not generally address the questions of whether these interventions work for people of all ages, for people living independently in their homes, or how social robot appearance or features have a role in reducing loneliness. This illuminates a needed area of inquiry.

3.2 Robot's Role in Addressing Loneliness

People of all ages can feel social presence from non-human objects [50], [51]. However, lonely people tend to anthropomorphize them significantly more, thus, feeling higher social presence than non-lonely people, while interacting with social robots [52]–[54]. On the contrary, recent evidence suggests chronic loneliness may decrease attribution of positive human traits (i.e., Humble, Thorough, Organized, Broadminded, and Polite), which may discourage people from developing anthropomorphic inferences (e.g., social response, warmth, competence) [55]. Thus, a lonely person may anthropomorphize social robots better and have a positive impact from these, if their level of loneliness is not critical [55].

Evidence suggests social robots to be useful regarding the three different types of loneliness (social, emotional and cultural). Social loneliness can be mitigated by introducing conversational robots to increase communication [56], [57], emotional loneliness can be overcome by developing intimate relationship with social robots [58], and lastly, cultural loneliness can be addressed by developing robots that make use of culture dependent facial expressions [59], different languages, accents and communication styles [60], [61]. Lack of previous work paves a way for future human robotics interaction (HRI) research to focus more on the variety of loneliness individually and explore novel ways of interventions to reduce loneliness.

3.3 Robot Support for Everyone

Initial investigation revealed that HRI works tend to have a narrow targeted participant pool of older adults (e.g., [33], [62], [63]). Since loneliness does not have any restriction on age [9], [10], HRI research should focus towards a wider age range to provide evidence on robot support for everyone. Recent evidence suggests that, younger people may experience loneliness more than middle aged or older individuals [64], suggesting the scope of HRI research on a larger age range.

The tendency to experience loneliness differs between men and women [65]. Although men are more vulnerable towards experiencing loneliness, they often hesitate to self-identify their loneliness because of the fear of receiving a more negative response from society [66]. Since, gender differences can influence research outcomes [65], this factor should be given importance in HRI works on loneliness.

Individual's cultural preferences should also be taken into account in HRI research. Designing social robots based on cultural specifications (e.g., language, outlook, facial expressions [59]–[61]) can be an interesting step towards having more compatible social robots, which can help with cultural loneliness more effectively.

3.4 Measuring Loneliness

Research on loneliness with robots is conducted both in lab and external environments (e.g., care homes, hospitals, individuals' homes), and such works tend to be both short-term (e.g., ranging from 1 day to 4 weeks [52], [54]) and long-term (e.g., more than a month [33], [44]). In these works, researchers commonly chose from two standardized instruments to measure loneliness that relates to their studies; the UCLA Loneliness Scale [67] and the de Jong Gierveld Loneliness Scale [68].

The UCLA Loneliness Scale is a standard 20-item scale that measures a person's subjective feelings of loneliness (e.g., 'How often do you feel close to people?') [69]–[72]. On the other hand, the de Jong Gierveld Loneliness Scale is a 11-item scale that focuses on both the emotional dimensions (e.g., 'I experience a general sense of emptiness') as well as the social dimensions of loneliness (e.g., 'I miss having people around me') [73]–[76]. Participants need to rate each item on both the scales, and high value from the results means that the level of loneliness is high.

3.5 Non-Loneliness Works related to Loneliness

Besides the HRI works that focuses precisely on loneliness, there is a range of non-loneliness social robot work [18], [77], [86]–[89], [78]–[85], that shows evidence on social robot's efficacy regarding various mental health problems. As loneliness is also a complex emotional state of mind [12], these robots can also be helpful for loneliness [90]. Previous works mostly used Paro and Aibo for such studies [33], [44], however, modern research introduced variety of social robots with diverse capabilities that can be useful for loneliness.

A social robot named Fribo can increase social connectedness by sharing auditory information (e.g., sound from microwave, door closing, refrigerator opening, etc.) to friends or roommates [91]. Receiving such auditory information from peers can help people communicate better and reduce the feeling of loneliness. Another social robot called Petbe uses a smartphone display to portray the sense of a living puppy [92]. As living pets tend to have a good impact on loneliness [33], Petbe can also be effective regarding this issue [92]. Further, pet-like social robot Miro can learn new behaviors autonomously [93], which can be leveraged towards developing novel loneliness reduction techniques in future studies.

The abovementioned social robots are not particularly designed to be helpful for loneliness. However, since lonely individuals feel higher social presence from non-human objects, these robots can still be useful for this specific mental health problem.

3.6 Discussion and Conclusion

Social robotics is an active research area that aims to develop social robots to support and co-exist with humans in the real-world [94]. However, to accept and use a novel technology, people need a sense of usefulness or purpose from the technology [95]. Given that mental health issues are on the rise and social robots have shown efficacy on reducing associated challenges, people may start using such robots more in the near future to support mental wellness.

These initial results from our survey highlights the limited focus on demographics such as age, gender and culture in HRI works on loneliness. It also details the broad range of causes and the serious impacts of loneliness on people's mental and physical health. Further, drawing from the findings from the initial survey, in addition to moving beyond a somewhat narrow participant pool of older adults, and specifically older adults living with serious health conditions, future work should also focus on otherwise-healthy people and consider the various types of loneliness - emotional, social, and cultural. Work also demonstrated that, a person's level of loneliness effects how they attribute social presence from non-human objects and people may even struggle to anthropomorphize a robot if the appearance or features of the robot is not convincing enough [96].

Another important factor to consider is where and how the study is taking place. Current HRI studies on loneliness are often heavily controlled (e.g., Wizard-of-oz technique [97]), and they are generally conducted in care homes, hospitals or laboratory settings. This approach is useful for targeted inquiry but limits application and development for use in real-world scenarios and deployment. Therefore, such studies may not provide precise research result which can be used for real-world social robot applications to reduce loneliness.

In this work, we make a call for further focus on loneliness work in HRI. Our initial survey results highlight the need for more HRI work that considers a broader demographic and the broad range of factors associated with loneliness.

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