Can Robots Help with Loneliness? An Exploration of Social Robot Adoption by Lonely Individuals

by

Rahatul Amin Ananto

A thesis submitted to
Faculty of Graduate Studies of
University of Manitoba
in partial fulfillment of the requirements
of the degree of

Master of Science

Department of Computer Science
University of Manitoba
Winnipeg, Manitoba, Canada

Thesis Advisor
James E. Young

Author
Rahatul Amin Ananto

Can Robots Help with Loneliness?

An Exploration of Social Robot Adoption by Lonely Individuals

Abstract

A growing area of human-robot interaction explores how robots, for example as companions, can be used to help people's general wellness and improve quality of life. However, there are some issues that are yet to be addressed, a) we do not know how people would use and adopt such robots in their everyday lives, and b) very little research has yet focused on social robots supporting people living with loneliness. Much of the relevant human-robot interaction (HRI) work focuses on situations such as living with dementia, or people suffering from depression, and these works generally target the older adult demographic. Loneliness, however, can affect anyone, regardless of age or physical condition.

I designed an eight-week long study to investigate how lonely individuals may adopt a social robot in their everyday lives, and if the robot impacts their general wellness

and loneliness. I gave a social robotic dog to lonely individuals who kept it in their own homes, interacted with it, and reported on their experiences. I documented interaction trajectories and learnt about potential factors associated with the social robot adoption process. My results detail how lonely people may adopt or non-adopt a social robot over the first months of ownership, and if the robot has any impact on people's wellness and loneliness. This is the first study to-date that investigates the adoption of social robotic pets for lonely individuals.

Thesis Advisor
James E. Young

Author
Rahatul Amin Ananto

Contents

Thesis Advisor
James E. Young

Author
Rahatul Amin Ananto

List of Figures

Thesis Advisor
James E. Young

Author
Rahatul Amin Ananto

List of Tables

Publications

Some ideas and figures in this thesis have appeared previously in the following publications by the author.

Rahatul A. Ananto, James E. Young, "Robot Pets for Everyone: The Untapped Potential for Domestic Social Robots." In Proceedings of the 29th International Conference on Robot & Human Interactive Communication (RO-MAN 2020 Workshop on social human-robot interaction of human-care service robots). 2020. 4 pages.

Rahatul A. Ananto, Geiskkovitch, D.Y., James E. Young. 2020. Domestic Robots for Individuals Living with Loneliness: A Long-Term In-Home Interaction Study Design. In Proceedings of the 8th International Conference on Human-Agent Interaction (HAI '20), Australia. ACM, 2 pages. https://doi.org/10.1145/3406499.3418749.

Rahatul A. Ananto, James E. Young. 2021. We Can Do Better! An Initial Survey Highlighting an Opportunity for More HRI Work on Loneliness. In the Companion of 2021 ACM/IEEE International Conference on Human Robot Interaction (HRI'21), March 8–11, 2021, Boulder, CO, USA. ACM, New York, NY, USA. 6 pages. https://doi.org/10.1145/3434074.344721

Thesis Advisor
James E. Young

Author
Rahatul Amin Ananto

Acknowledgements

At first, I would like to show my gratitude to my research advisor, Dr. James E. Young, for his utmost support, guidance, patience, and motivation during my MSc program here at the University of Manitoba. He let me follow my interest, patiently supported me when I struggled with my work, gave valuable advice, and guided me to reach my goal. Jim's passion for his work in HRI motivated me a lot and it made me think differently and creatively. Besides the academic aspects, I learnt a lot from him to become a better person, and I will cherish these lessons for the rest of my life. I want to thank Jim for his continuous support which helped me achieve this Master of Science.

I would like to thank my committee members Dr. Andrea Bunt and Dr. Debbie Kelly for their precious time reading my proposal, checking on my progress, examining my thesis, and providing feedback. I would also like to thank Dr. Celine Latulipe for giving me feedback on my thesis during the HCI lab meetings.

I want to show my gratitude to the HCI lab members who always helped and inspired me, I truly am lucky to have you all as my lab-mates. Thank you Anik and Lorena

for helping me get used to the lab environment when I first came here. I would also like to thank Mahya, Ananta, Shahed, Denise, Stela, Patrick, Danika, Annalena, Lena, Jason, Agape, Nabila, Murray, Pouya, Afsane and James for the time that we spent in the lab in-person and virtually.

To my parents, Saiful Amin and Mohsena Yasmin, my wife, Sunayna, and my brothers, Diganto and Safwan. Thank you so much for being in my life and inspiring me always. Sunayna, I can't thank you enough for being a constant support during my ups and downs, and during all those moments when I thought there were no solution. You made me stronger and helped me think rationally. I am extremely grateful to you for that. I would also like to thank my Parent-in-laws, Faruk Hossain and Sadia Faruk, sister-in-law, Samiha, and brother-in-law, Nafees, for supporting me and being there for me when I needed you. In addition, you have supported me to continue my research during my graduate study. I am very thankful to have such an amazing family.

Chapter 1 Introduction

All of us, regardless of demographic or background, are susceptible to loneliness (Gardiner et al., 2018; Stickley et al., 2013), as evidenced by the ongoing global pandemic and the related isolation. Research has demonstrated the potential for social robots to provide companionship (e.g., Bogue, 2013; Broekens et al., 2009; Chen et al., 2018) and thus potentially support lonely people. However, such domestic companion robots have not yet emerged widely in the marketplace, and we do not yet know how a lonely person may use a robot and integrate it in their lifestyle. To contribute to this knowledge gap and to explore the potential of companion robots for lonely people, I recruited four adults who

self-identify as lonely, gave them a robotic dog for eight weeks to live with, and report on their adoption and use patterns. I present the findings using a case-study approach to present initial insights on how differently each lonely individual may use and integrate a social robot in their everyday lives. According to prior work, perception and interaction with social robots may vary from person to person (J. E. Young et al., 2009), and case studies may let researchers document greater understanding of the particular topic, which would have been much difficult with broad sampling. Thus, in my work I use case studies to deep dive into the underlying variables that might be responsible for the social robot adoption process of each lonely individual.

Loneliness may negatively impact one's wellness, this is highlighted by research showing persistent loneliness is a key risk factor for psychological and physical health problems (Ong et al., 2016) such as cardiovascular diseases (Caspi et al., 2006), stress (Adam et al., 2006), anxiety, and depression (Cohen-Mansfield & Perach, 2015). More than simply a state of solitude or isolation, loneliness is a complex emotional state of mind unique to each person (J. T. Cacioppo et al., 2009). People may experience loneliness due to myriad factors including insufficient social connections (e.g., making new friends), life events (e.g., death of someone close, or break-up from a relationship), specific scenarios (e.g., being a busy single parent, culture differences, racism) and even biological predisposition (J. T. Cacioppo et al., 2009; Luanaigh & Lawlor, 2008). Similarly, strategies for mitigating or reducing loneliness vary by individual, and include increasing community involvement or joining a new community, focusing on a hobby, sharing thoughts with another person (Masi et al., 2011), or even getting a pet (Goldmeier, 1986).

Leveraging animals or pets to improve wellness has a rich established history (Filan & Llewellyn-Jones, 2006; Kamioka et al., 2014; Nimer & Lundahl, 2007). Interacting

with animals can result in significant positive physiological effects in as quickly as 15 minutes (Odendaal, 2000), and can further promote social activity, resulting in reduced anxiety, stress, and depression (Fine, 2010). Yet, many people cannot or resist adopting pets due to concerns such as ongoing financial and physical care commitments, allergies and hygiene, or fear of animals (Anderson et al., 2015). Thus, research explores robotic pets as an analog to real animals, which do not have these constraints.

Pet-like social robots look or act similar to a real pet, and interact using social means such as speech, gestures, or gaze (Breazeal, 2003). Such robots in gene, highly controlled work (Banks et al., 2008), short term interactions (Eyssel & Reich, 2013; Lee et al., 2006a), and work with vulnerable populations (Chen et al., 2020a). This motivated me to use a social robotic pet to investigate how such robots may impact people's wellness.

Despite mounting evidence that social robots can emotionally support people, pet-like social robots have not yet emerged successfully, on a wide scale, as companions in people's homes. One key reason may be the strong disparity between the uncontrolled, dynamic domestic environments, and controlled in-lab studies. This leads to a gap in the research: we do not know how in-lab successes will translate to homes, or indeed, how designers should create robots that people will adopt in their everyday lives. We see a bootstrapping problem of needs analysis and developing social robots to be intertwined: it is difficult to gather needs without a real robot to relate to, and developers should not design robots without first having clear needs analysis.

Furthermore, many of the in-lab studies are conducted within a single day and in a controlled environment such as a hospital or a care-home lobby (e.g., Bartneck et al., 2006, 2008; Wada & Shibata, 2006). Such studies are labeled as short-term (e.g., one day or one week) and these are useful to gather rapid insights of a robot's impact on a specific

phenomenon (e.g., effect on anxiety and stress) (Bartneck et al., 2006).On one hand, short-term studies can be conducted in environments where the research variables (e.g., robot behavior) stay in control of the researchers. Thus, researchers can keep track of how the study is going and adjust the variables as required for valid results. On the other hand, longer-term research can be important for assessing robot adoption beyond the initial novelty phase, and for understanding how use and changes occur over time (M. M. A. de Graaf et al., 2015). Longitudinal work conducted in real-world scenarios such as a person's own home, may provide research results that can be more relevant for real-world use.

In this thesis, I present an eight-week long study to analyze the adoption pattern of a fully autonomous pet-like social robot over time, by placing it in the homes of people who self-identify as lonely. I investigate the gradual process of how and if lonely individuals adopt the robot, and if the robot impacts their wellbeing and loneliness. My work is the first to report on how lonely people may adopt a social robot over the first months of ownership, and to highlight successes and failures of the adoption process.

1.1. Research Questions

The study was designed to investigate if longer-term interaction with a pet-like social robot has any impact on people's loneliness. Prior work suggests that longer-term interaction with social robots may require users to adopt and integrate the robot in their everyday lives to get benefit from (M. M. A. de Graaf et al., 2015). Thus, I gave lonely individuals a pet-like social robot to keep in their homes, interact with it and report on their experiences. I gathered data on their robot adoption process and investigate if the robot

has any impact on loneliness.

Thus, my thesis seeks to answer the following research questions:

What happens when we give a social robotic dog to a lonely individual who lives alone?

- Do they adopt the robot in their everyday lives?
- What are the possible factors that might be influencing the robot adoption and non-adoption process?
- Are there any potential avenues for social robots to impact wellness and loneliness?

1.2. Methodology and Approach

My approach to investigating these research questions is to conduct case studies that report on how lonely individual's may use and integrate a social robot in their everyday lives. I decided to conduct case-studies because, this approach can be useful to identify each individual's potential underlying factors that might be influencing their social robot adoption and non-adoption process. Conducting case-studies may let us dive deep into the usage patterns of individuals and give us information on their successes, roadblocks, their perspective and attitude towards the robot, and many other factors. To perform this, I went through the following steps: 1) I researched existing knowledge of novel technology adoption (e.g., social robots) to develop an eight-week long study that investigates the social robot adoption process from real individuals' experiences, and 2) I conduct the study with lonely individuals who report on their experiences living with a social robot.

To gain insight into how lonely people may adopt robots, I developed this study

based on previous longitudinal social robot work (M. M. A. de Graaf et al., 2015). I divided the eight-week study in five phases and conducted interviews in each important phases (Detail in Chapter 4). This allowed me to get specific insights and elicit stories from the interviews based on which phase the study was in. I also had weekly questionnaires to measure the participant's level of loneliness, anxiety, and mood throughout the study (Detail in Chapter 4).

To conduct the study, I recruited individuals who self-identify as being lonely and gave them a pet-like social robot to keep in their homes for seven weeks. During the weeks participants interacted with the robot, and I gathered information about their experiences from the scheduled interview sessions and their mental health status from the weekly questionnaires. After 7 weeks, I get the robot back from the participants and learn about how they feel about giving the robot back. I conducted a follow-up interview session a week later to learn about the participants' mental health and if they ever felt the absence of the robot in the previous week. The interview and questionnaire data works together to provide study results that reports potential factors associated with the social robot adoption process, and the social robot's possible impact on people's general wellness and loneliness.

1.3. Contributions

In summary, this thesis makes the following contributions:

1) I present an eight-week long study design to explore social robot adoption patterns and social robot's potential impact on wellbeing.
2) I present the first study to-date that reports the social robot adoption or non-

adoption process by lonely individuals in their everyday lives.

3) The results provide potential factors (e.g., expectation, anthropomorphism, social catalyst, etc.) associated with the social robot adoption process and the social robot's impact on people's wellbeing and loneliness.

This study paves the way for future long-term research with pet-like social robots. Researchers can design studies like these to focus on social robot's impact on numerous other health related issues such as stress, anxiety, depression, just to name a few.

The remainder of this thesis is organized in five chapters: Chapter 2 summarizes previous work related to this thesis, Chapter 3 describes the definition of loneliness and why is it important, Chapter 4 describes the study design and procedures, Chapter 5 summarizes the case studies of four individuals and presents the cross study thematic analysis, and Chapter 6 concludes the thesis.

Chapter 2 Related Work and Background

Human-Computer Interaction (HCI) is a field of study that is researched in computer science, electronic engineering, behavioral sciences, and other related fields (Goodrich & Schultz, 2007). In computer science, HCI is studied to learn the *interaction* between people and computers (Hewett et al., 1992), which helps to understand the needs of people, design and implement the needs, and then evaluate those implementations. As different type of computers got introduced (e.g., home appliances, smartphones, and ATM machines), HCI researchers needed to explore novel human-computer interaction processes (Hewett et al., 1992). As robots are also a type of computer, the field of Human-Robot

Interaction (HRI) was introduced, and it mainly focused on the *interaction* between a person and a robot. In the current HRI work, our interest is to learn how people may use and integrate a social robot in their everyday lives, and if the robot has any impact on their wellbeing.

The adoption of a technology such as a social robot is a highly complex process with numerous factors including technology function, attitudes, and perceptions, impacting both the success or failure, and the pattern of adoption (J. E. Young et al., 2009). Human-robot interaction (Cabibihan et al., 2013; M. De Graaf et al., 2017; M. M. A. de Graaf et al., 2019) and science and technology studies more broadly (e.g., including models such as TAM, MATH, etc.) (J. E. Young et al., 2009) have continued to investigate how people adopt technologies and how factors influence the adoption trajectory. How people perceive a social robot, and that person's disposition toward technology in general, impacts how they may adopt social robots into their homes (M. M. A. de Graaf et al., 2016). For example, a person may see the robot as a disruptive technology (Ezer et al., 2009) that requires more work or changes to adopt in their everyday lives. This is because robots may interact with their surroundings and perform unexpected movements, for which users may need to learn new interaction styles involving voice commands, or gestures to control the robot's behavior (J. E. Young et al., 2009), which might be overwhelming for some. Adoption may depend on the robot having relevant social abilities such as being friendly or having good communication skills (J. E. Young et al., 2009). However, some research shows that robot social capabilities alone may not be sufficient motivation for long-term robot adoption if it is not perceived as also having utilitarian factors such as medication reminders or tracking health data (M. M. A. de Graaf et al., 2015; Leite et al., 2013). This shows that, robot adoption as a novel technology might be more complex due

to the various underlying variables (e.g., learning new interaction, and social factors) that needs to be considered to understand the social robot adoption process properly.

Previous work has shown how robots such as the iRobot Roomba vacuum cleaner can successfully be integrated into homes over a long period (J. Y. Sung et al., 2010); in this case, the robot's cleaning capabilities is the typical avenue for adoption. On the other hand, some long-term users of the Sony AIBO robotic dog reported to integrate and enjoy the dog in their own homes because of its companionship (Kertész & Turunen, 2019). Study with a social robot named Pleo, that looks like a toy dinosaur, reported the discrepancy between participants' initial expectation and actual experience (Fernaeus et al., 2010), where participants expected to adopt the robot as a toy, but some of them consistently compared it to real pets which impacted the adoption process. This shows that user perception might be an important deciding factor in the process of social robot adoption.

Prior work has identified that robot adoption may fall into a common pattern, with phases of use and interaction from initial intake to long-term use (M. M. A. de Graaf et al., 2015). For example, work with the Karotz robot (M. M. A. de Graaf et al., 2015) leveraged a phased framework (M. M. de Graaf et al., 2018) to understand the robot acceptance patterns over a long period in users' homes. A phased framework is a time-based study design with multiple acceptance phases, that lets researchers uncover various aspects of user interaction over several months. The framework used in the Karotz study (M. M. A. de Graaf et al., 2015) lists six phases: expectation, encounter, adoption, adaptation, integration, and identification (M. M. de Graaf et al., 2018). According to the framework (Table 1), people get to know about a technology and build an expectation towards it before incorporating it in their homes in the expectation phase. After 2 weeks, during the encounter phase people meet the technology for the first time and interact

with it for a trial period before committing to using it. Then, people may make their decision to adopt or reject a technology during the adoption phase, that may happen 2 weeks after the encounter phase. A month later, the adaptation phase occurs, when people may get used to the technology and the novelty effect might start to wear off. After 2 months of having the robot, we might get a good understanding on how people are adapting the technology in their everyday lives, and this phase is called the integration phase. Finally, the technology can become a part of life because of emotional attachment in the identification phase, which may happen after 6 months of being introduced to the technology. This framework demonstrates that the acceptance phases are linked to user experiences and perceptions that evolves over time, as people interact with a technology (M. M. de Graaf et al., 2018). For this study, I also leverage a similar phased approach to gather insights on the factors that may drive social robot adoption in homes. I build on this body of work by specifically investigating a social robot as an intervention for people who identify as lonely, over an eight-week period.

Table 1: Timeframe of the phased framework

Phase	**Observation Period**
Expectation	2 weeks before the study
Encounter	1st Day
Adoption	2 weeks after
Adaptation	1 month after
Integration	2 months after
Identification	6 months after

From this we get an initial idea about how people may adopt social robots in their own homes similar to a novel technology. We also learn that anthropomorphism plays an important role in the user evaluation and social robot adoption process (M. M. A. de

Graaf et al., 2015). In the next sections I define anthropomorphism and related factors, and why I believe social robots might offer potential wellness benefits to people living with loneliness.

2.1. Anthropomorphism vs Personification vs Zoomorphism

Since social robots can be of various types (e.g., humanoid, pet-like, etc.), using the word anthropomorphism might pose confusing for some, as people may want to attribute it as zoomorphism or personification. However, there are clear distinctions in between these, and here I discuss the differences between anthropomorphism, personification, and zoomorphism.

Anthropomorphism: The word "Anthropomorphism" originates from the Greek word "anthropos" for "human" and "morph" for "form" (Fink, 2012). Thus, when human-like form or mental-states (e.g., intentionality, emotion, and cognition) are attributed to animals and deities that is known as anthropomorphism (Nanay, 2021). Research states that, attributing familiar human-like qualities to an entity such as an animal or deity, might be a way to make the entity more familiar, predictable, or explainable (Fink, 2012). In human-robot interaction, anthropomorphism plays a vital role, which is reflected in the robot's design, characteristics, and interactions, making the robot more familiar and acceptable (Fink, 2012).

Personification: Personification is quite similar to anthropomorphism, but with few distinctions. It is rather a type of figurative language where non-human objects are

ascribed with having human-like attributes (Lomas, 2005). For example, “the tree hunched over and sobbed, letting go of a few precious leaves.” The tree hunching down, and sobbing is an example of personification, because trees cannot “hunch down” and show emotions. However, saying that the tree was sobbing poetically emphasizes the event of the shedding of leaves. This shows that personification can help writers to develop vivid explanations of a scenario.

Zoomorphism: Zoomorphism is quite the opposite of anthropomorphism and personification. When animal-like mental states are attributed to humans, that is known as zoomorphism (Nanay, 2021). Zoomorphism can often be observed in literature, where writers utilize zoomorphism to describe a human-subject more interestingly. For example, a poet named Marge Piercy wrote, “I love people who harness themselves, an ox to a heavy cart, who pull like water buffalo, with massive patience.” Here, the poet is talking about the type of hardworking individual she adores, but she uses statements like “an ox to a heavy cart” and "who pull like a water buffalo" to intensely describe the person’s hardworking and patient nature.

In this current work, I am investigating how lonely people adopt a pet-like social robot in their everyday lives and if the robot is able to help them with their wellness and loneliness. Since people tend to anthropomorphize animals with human-like attributes (e.g., emotion and cognition), I am using the word anthropomorphism throughout this thesis as the pet-like social robot resembles a living dog.

2.2. HRI Work on General Wellness

The general benefit of social robots has been highlighted in previous research where

social robots have shown to provide people with assistance in home-chores (Yamazaki et al., 2012), improve cognitive skills of children by engaging in play activities (Poletz et al., 2010), make education more interesting by engaging with children (Gabrielsson & Mattsson, 2017; Ros et al., 2011; Schodde et al., 2017), and motivate people for physical exercises (Lotfi et al., 2018). Besides these, social robots are also being used in the healthcare sector to decrease stress and anxiety (Wada & Shibata, 2007), and even reduce loneliness of older adults living in care facilities (Banks et al., 2008). Below I discuss more on the use of social robots in application sectors such as clinics, care homes, and real-world, to motivate how social robots can also be useful in people's homes.

2.2.1. Social Robots in Clinical Contexts

In clinical contexts, social robots have supported people in rehabilitation (e.g., autism, cerebral palsy, heart disease, stress, anxiety). For example, research with children on the autism spectrum shows the potential of social robots in social skills development and communication therapies (Kim et al., 2013). Furthermore, such robots comforted children in clinical situations to mitigate stress, anxiety, and pain (Jeong et al., 2015), and helped them to socially engage more (Jeong et al., 2015). Likewise, research found social robots to be helpful with pain reduction by diverting children's attention away from receiving a vaccine (Beran et al., 2013). Researchers recently introduced the NAO robot in rehabilitation therapy for children with cerebral palsy and waiting for initial trials (McCarthy et al., 2015).

Social robots have supported patients by motivating them to exercise more. For example, a robot named KineTron effectively motivated children to perform physical

therapy exercises (Kozyavkin et al., 2014), and another robot named Autom (Breazeal, 2011) has contributed similarly by motivating older adults to exercise.

From this we learn that social robots can be quite effective in impacting mental and physical wellness of patients in clinical settings and care homes, which similarly motivates the importance of exploring social robot's impact on otherwise healthy individuals living with wellness issues.

2.2.2. Social Robots in Care Homes

Research conducted in care homes detail that the seal-like PARO robot increased the social interaction level of older adults who interacted with it on a regular basis (Wada & Shibata, 2007). In a similar vein, researchers found social robots to be effective in improving communication skills of patients living with dementia (Wada et al., 2008) and decreased stress and anxiety (Pu et al., 2019). These social robots have also corroborated to be quite useful in aiding older adults to improve their lifestyle (Pu et al., 2019; Šabanović et al., 2015). For example, a work with the social robot Pearl (Montemerlo et al., 2002) describes that the robot performed effectively in assisting older adults with cognitive and physical activities, which eventually improved their quality of life.

This shows that social robots have helped older adults in care homes to improve their mental and physical health, as well as their quality of lives. These findings work as a motivation for us to explore if social robots can similarly be useful in positively impacting wellness challenges for healthy people living in their homes.

2.2.3. Summary

The work in this chapter highlights how people may use and integrate a pet-like social robot in their own homes. We documented potential underlying variables that might be important for the social robot adoption process. Further we highlight potential for social robots to help people with their mental and physical challenges in clinical settings and care homes. This motivates our work to explore how social robots can similarly be useful in impacting healthy individuals living in their homes with various wellness challenges like loneliness.

In the next chapter, I discuss why I focus on loneliness in this study and demonstrate social robot's potential in impacting this issue.

Chapter 3 Loneliness

In this thesis, our main focus is to understand, how do lonely individuals use and integrate social robots in their everyday lives, and does the robot have any impact on their general wellbeing and loneliness? In this chapter, I discuss what we know about loneliness and, why loneliness is important and how robots can address this issue.

3.1. What is Loneliness?

Loneliness is generally defined as the disparity between a person's desired and actual social relationships (Russell et al., 1980). Although loneliness may sometimes be considered synonymous with social isolation, in reality it is not only a state of isolation or solitude, rather it is a complex emotional state of mind that is unique to each individual (J. T. Cacioppo et al., 2009; Masi et al., 2011). Social isolation depicts an objective measure of social interaction, while on the contrary loneliness reflects the subjective feeling of the perceived social isolation (Masi et al., 2011).

Recently, researchers are hypothesizing the loneliness experience as a biological construct – similar to thirst and hunger (Masi et al., 2011). This is because loneliness is generally perceived as insignificant and temporary, and it works as a signal to the lack of meaningful social communication, solidifying the fact that loneliness is more closely related to the quality of the social interaction rather than the quantity (Peplau & Perlman, 1982). For example, a person may feel lonely even after being with many people in the community, however, someone may feel socially gratified by staying alone.

Some may feel lonely because of their lifestyles. For instance, not having enough social connections (e.g., socializing with others, making new friends), voluntarily isolating oneself or self-scrutinization (J. T. Cacioppo et al., 2009). Life events such as break-up from a relationship, starting a new job or school, death of someone close, being a parent, or being diagnosed with a health condition may also trigger someone to feel lonely (J. T. Cacioppo et al., 2009). Individuals may experience loneliness in specific scenarios too. For example, being a single parent, being in an abusive relationship, experience discrimination, racism or bullying, being a victim of sexual or physical abuse,

unemployment, and retirement may work towards the feeling of loneliness (J. T. Cacioppo et al., 2009). People may also experience loneliness in certain times of the year. such as, Christmas (Pettigrew & Roberts, 2008). Financial instability, teenage peer pressure, uncertainty about the future, homelessness, or older adults moving to care facilities, can also be factors to experience loneliness (Niedzwiedz et al., 2016). Research indicates that people with mental and physical health conditions are more prone to experiencing loneliness, for example, people living with dementia (Moyle et al., 2011) and cerebral palsy (Balandin et al., 2006). Furthermore, the tendency to experience loneliness differs between men and women (Borys, 1985). 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 (Salimi, 2011).

Prior work documents that there can be three types of loneliness that may transpire independently; *social*, *emotional,* and *cultural* loneliness (Luanaigh & Lawlor, 2008; Sawir et al., 2008). Social loneliness may result from decreased social communication and integration. It is generally described as the feeling of not having significant social connection or valuable bonding. For instance, distancing oneself from the community or moving to someplace new can trigger social loneliness. This state of loneliness can be reduced by increased social integration and communication (Luanaigh & Lawlor, 2008). Conversely, emotional loneliness occurs when someone feels the absence of a close or intimate relationship with another individual, such as a spouse or a partner. Such loneliness can be decreased by developing close relationship with someone or reconnecting with someone close (Luanaigh & Lawlor, 2008). Lastly, cultural loneliness can be triggered because of the absence of a person's preferred cultural or linguistic environment (Sawir et al., 2008). For example, international students living abroad, detached from their

culture may experience cultural loneliness. Such loneliness can be decreased by talking to someone in their native language (Sawir et al., 2008).

From this we learn that loneliness is a complex emotional state of mind and there can be various types of loneliness. In my work, I mostly focus on participant's social and emotional loneliness, due to the fact that the recruited participants stay isolated from their loved ones (See Chapter 5).

3.1.1. Impacts of Loneliness

In recent times, people are following containment measures to tackle the ongoing covid-19 pandemic – which includes quarantines, self-isolation, and social distancing (Fiorillo & Gorwood, 2020). Thus, people are experiencing increased loneliness, which may severely impact their mental health. For example, people may experience severe depression (Cihan & Gökgöz Durmaz, 2021) and schizophrenia because of decreased social communication (Fiorillo & Gorwood, 2020). A recent observation states that, covid-19 patients are getting lonelier because of social stigma and discrimination, because society is pushing each other away due to the fear of getting infected (Fiorillo & Gorwood, 2020). Loneliness has also been found to be associated with human personality traits, indicating that an individual's personality can be a predictor for the amount of perceived loneliness (Buecker et al., 2020).

People may experience loneliness due to variety of reasons, and generally this feeling of loneliness goes away with time (Hawkley & Cacioppo, 2010). However, chronic loneliness might have severe consequences that might even require medical attention. Research found that, serious health related issues are associated with loneliness, for

example, elevated systolic blood pressure (Hawkley & Cacioppo, 2010), increased hypothalamic pituitary adrenocortical activity (elevated stress) (Adam et al., 2006), accelerating Alzheimer's disease (Wilson et al., 2007), increased vascular resistance in young adults (Hawkley & Cacioppo, 2010), and decreased immunity (Kiecolt-Glaser et al., 1984). Various other issues are also associated with loneliness which are also concerning, for example, disruptive sleeping pattern (Matthews et al., 2017; Yu et al., 2018), impaired daytime functioning (Hawkley et al., 2010), obesity (Lauder et al., 2006), increased depressive symptoms (Cohen-Mansfield & Perach, 2015), increased suicidal tendency (Rudatsikira et al., 2007), accelerator for dementia (Hawkley & Cacioppo, 2010), cognitive decline in older adults because of increased stress (Tilvis et al., 2004), and older adult mortality (Tilvis et al., 2004).

Addictive behaviors such as, overuse of social technologies (e.g., internet and smartphone) can be problematic and may impact loneliness (Costa et al., 2019; Jiang et al., 2018). Research describes that, if lonely individuals use social technologies such as smartphones and the internet in a way to enhance existing relationships and developing new connections, then they can be useful mediums to reduce loneliness. However, if social technologies are used as a medium to escape from the "social pain" of interacting with others, then this can be problematic and may increase the feeling of loneliness (Nowland et al., 2018). Because of the diverse and varied origins of individual loneliness, it is quite difficult to implement broad support tailored to specific causes of loneliness.

3.1.2. Loneliness Interventions

Work on loneliness interventions demonstrated four primary strategies to reduce

loneliness: social skill improvement, addressing maladaptive social cognition, social support enhancement and increased social interaction. The first two strategies are responsible for focusing on the quality of social interaction, thus, addressing loneliness in a more direct manner. On the other hand, the latter strategies might be more useful for social isolation support, rather than loneliness (Masi et al., 2011).

To reduce the feeling of loneliness, early studies focused on improving people's social skills such as conversational skills, non-verbal communication skills, complimenting skills, and showing intimacy (Rook, 1984). For example, social skills improvement showed positive outcomes in reducing loneliness of lonely college students (Jones et al., 1982). Studies that focused on maladaptive social cognition using cognitive behavioral therapy also showed efficacy in reducing loneliness. For example, a study taught lonely people to consider their automatic negative thought as assumptions rather than facts, which slightly helped them feel less lonely (Young et al, 1982). However, social cognition was found to be more effective in reducing socially anxious adults' loneliness, if combined with social skills development (Glass et al., 1976). Interventions that enhanced social support, for example, supporting older adults who lost their connections due to moving someplace new (Kowalski, 1981), or supporting children whose parents got divorced (Wallerstein & Kelly, 1977), appeared useful in reducing loneliness. Finally, interventions that focuses on increased opportunities for social interaction were found to be most useful in reducing loneliness (Hawkley & Cacioppo, 2010). For example, a study with a group of isolated seniors made them bond with each other and develop a support network, while collecting and distributing food for deprived people (Pilisuk & Minkler, 1980).

Meanwhile, technology-based social supports have also appeared to be useful in reducing loneliness. For example, online or smartphone applications to chat with others

(Van Oerle et al., 2016), loneliness call centers (Rafaeli et al., 2008), or even "social chat bots" to simulate actual social interaction (Brandtzaeg & Følstad, 2017). A more relevant intervention technique to human-robot interaction is pet ownership, which has shown to effectively reduce loneliness (Goldmeier, 1986). However, due to reasons such as, physical care and ongoing financial commitment, hygiene and allergy, fear of animals, or animal welfare issues, some people tend to have a negativity towards having pets (Anderson et al., 2015). Thus, it provides an opportunity for robotic analogs to pets ("robotic pets") to have some impact on lonely individuals, while side-stepping various issues related to living pets. Although limited work is available with existing social robots or robotics pets, they still manage to show efficacy in reducing loneliness and give us insights to explore more advanced robot-based loneliness intervention strategies in future studies.

3.1.3. Robot's Role in Addressing Loneliness

People of all ages can feel social presence from non-human objects (Severson & Lemm, 2016; Waytz et al., 2010). However, lonely people tend to anthropomorphize them significantly more, thus, feeling higher social presence than non-lonely people, while interacting with social robots (Eyssel & Reich, 2013; Lee et al., 2006a; Li et al., 2020). Thus, a lonely person may anthropomorphize pet-like social robots better and have a positive impact from these.

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 robots as a conversational piece to increase communication and engage with the society more (Baecker et al., 2020; Sabelli et al., 2011), emotional loneliness can be

overcome by developing intimate relationship with social robots (Baisch et al., 2017), and lastly, cultural loneliness can be addressed by developing robots that make use of culture dependent facial expressions (Dailey et al., 2010), different languages, accents and communication styles (Sanoubari & Young, 2018b, 2018a). In our work we are mostly focusing on the social and emotional loneliness. We are not covering cultural loneliness in this work because the robot we are using was not designed to address specific cultures.

Initial investigation revealed that HRI works on loneliness generally focuses on the older adult population (e.g., Banks et al., 2008; Šabanovic et al., 2013; Wada et al., 2004). Loneliness, however, does not have any restriction on age (Gardiner et al., 2018; Stickley et al., 2013), and anyone may experience it. Recent evidence suggests that younger people may experience loneliness more than middle aged or older individuals (Barreto et al., 2020), suggesting the scope of HRI research on a larger age range.

Lack of previous work paves a way for my work on social robot and loneliness and affords an opportunity to focus more on the factors that might be responsible in impacting people's general wellness and loneliness.

3.1.4. Summary

From this chapter, we learn the definition of loneliness and how it differs from the state of being isolated. We further learnt various reasons that may cause loneliness and its possible impact on people's health. Then I discuss about the general loneliness intervention strategies and how social robots may have immense possibilities to be companions in people's homes and support them for their general wellness and loneliness. I also mention that loneliness does not have any restriction on age, and anyone may experience it.

This gives me an opportunity to focus on a wider age-range in my work.

In the next chapter, I demonstrate how I designed the study based on prior work with social robots in HRI, and the study procedure that documents the data collection and analysis process.

Chapter 4 Study Design

I conduct longitudinal case studies where I place a pet-like social robot in lonely individuals' homes for eight weeks. During the weeks, I perform interview and questionnaire sessions with the goal to learn if lonely individuals may or may not adopt social robots, what might be the potential factors behind the robot adoption or non-adoption process, and if the robot has any impact on people's general wellness and loneliness.

4.1. Robot Used

In this study, I used the Sony AIBO robotic dog, which is a sophisticated pet-like robot that can sense touch, hear sounds, understand commands, and recognize people using face recognition. The robot is capable of conveying puppy-like characteristics with its emotional artifacts such as the eyes, body movement and sounds. I decided to use a social robotic pet because the successes of animals as pets to support people likewise motivates the potential for robotic companions – as analogs to pets – to support people.

I did not choose a conversational robot because speech recognition can sometimes be a technological constraint for intelligently continuing a conversation autonomously. Speech recognition errors such as misinterpreting what a person said or failing to acknowledge that a person is talking, severely hampers interaction (Mubin et al., 2014). Thus, research generally use wizarding techniques (remotely controlling the robot without letting the participant know) (Riek, 2012) to avoid such problems. However, in longer term studies like ours which has to be conducted in participant's own homes, it is not

Figure 1: Sony AIBO.
Picture Taken by: Rahatul Amin

possible to supervise the robot, thus relying on an autonomous robot like the Sony AIBO might be a better approach. This is because AIBO resembles a puppy and people might treat it as a real pet, and unusual behaviors like misinterpretation or not acknowledging someone in-front of it might be tolerated by people (Kiesler, 2005). Meanwhile, people may have higher expectations from humanoids to have advance cognitive abilities, and simple errors done by the humanoid might disappoint the human user (Kiesler, 2005).

4.2. A Phased Approach

To perform the interview sessions in a structured manner, I follow a phased framework of technology adoption presented in Section II (M. M. de Graaf et al., 2018). The phased framework from prior work was designed to conduct HRI studies that are more than 6 months long (M. M. de Graaf et al., 2018). But I designed the current study to be shorter because I could not find relevant longer term-studies done with lonely individuals and social robots, thus, I did not know if the study could be conducted or not. As I designed my study to be shorter, I made some minor changes in the phases to better suit with my approach. I divided the study into five phases: initial-intake, first-encounter, ongoing-during, exit, and follow-up (See Figure 2). I conduct 7 interview sessions with each participant throughout the study, as shown in Figure 2. Below I discuss what constitutes each phase and what I plan to document from the associated interview sessions.

Initial-Intake: Initial-intake is the pre-study session conducted one-week prior the participants receive the robot. This phase is designed to educate the participants about the whole study procedure and get their consents to record the interview sessions. I conduct

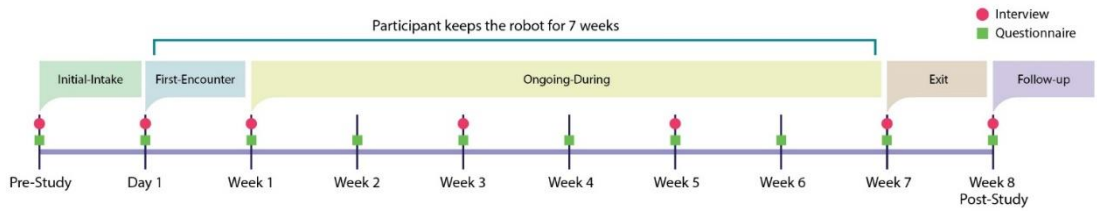


Figure 2: Phased study timeline.

an interview in this phase to learn about the participant's expectations and perception towards the robot that they are receiving in the following week.

First-encounter: First-encounter phase is the day the participants receive a box with a robot inside, along with the instructions on how to interact with it. During the interview session of this phase, I learn about the participants' initial thought about the robot, their plans to interact with the robot in the coming weeks and check if their expectation from the robot changed from the previous week or not.

Ongoing-during: The Ongoing-during phase is 7 weeks long, and participants keep the robot in their homes and interact with it during this phase. I conduct three interview sessions in this phase that consists of questions related to the participants' general wellness, interaction process, social communication, and the robot's impact on wellness and loneliness, just to name a few.

Exit: In the exit phase, I collect the robot back from the participants. Afterwards I conduct an interview session to learn about participant's thought about the overall study, if they feel any differences in their general wellness, their thought about giving the robot back, and their perception towards the robot's impact on loneliness.

Follow-up: Finally, the follow-up phase is conducted after a week of the exit phase. I conduct this session to learn about how the participants feel about not having the robot anymore, if they feel the absence of the robot and how they are dealing with their general wellness and loneliness.

4.3. Data Collection

I collect data from the participants throughout the study using interview sessions and questionnaires. The interview sessions enable me to document qualitative data about the participant's expectation, interaction process, perspective towards the robot, the robot's impact on their wellness, and many other aspects. The questionnaires give me weekly quantitative insights into the mental state of each participant. Both the qualitative and quantitative data works together to answer the research questions of this work.

4.3.1. Interview Data

The goal of the interview sessions is to gather in-depth insights on participant's experiences of living with a social robot. I use semi-structured interviews designed to extract stories and thoughts from the participants, and I use guiding questions and prompts, allowing and encouraging the participant to steer the conversation. The interview questions are designed based on each phase of the study to document data in a structured manner (Check Appendix G). I conduct the interview sessions over the phone or via online platforms such as, Zoom or Skype (According to participant's preference). The sessions are recorded and then transcribed for analysis. Each interview session is

conducted on a prescheduled date and time.

4.3.2. Questionnaire Data

I record weekly questionnaire data to learn about any trends in their level of loneliness, anxiety, or mood during the study. I keep track of participant's anxiety and overall mood because these variables have potential to contribute towards loneliness. The details of the questionnaire are discussed below:

UCLA Loneliness Scale - The UCLA Loneliness Scale is a standard 20-item scale that measures trait loneliness of an individual (e.g., "How often do you feel that you lack companionship", and "How often do you feel that you are no longer close to anyone"). Trait loneliness can be defined as the subjective feeling of the disparity between an individual's actual and desired social contacts.

State Trait Anxiety Inventory (STAI) - STAI measures the level of anxiety of a person at a specific moment. It includes 20 different state anxiety related questions (e.g., are they calm, are they worried, are they tensed, etc.). The responses are recorded using a 4-point Likert scale; high score represents a greater level of state anxiety.

Positive and Negative Affect Schedule (PANAS) - PANAS is a self-report measure with 20 different feelings; 10 of them measure the Positives Affects (PA) and the remaining measures the Negative Affects (NA). The responses are made using a 5-point Likert scale; higher positive measurement represents higher positivity and higher negative measurement represents higher negativity.

The questionnaire data are documented in an excel sheet to calculate the measures. Then they are presented using line-charts to display the trends of each

measurement recorded throughout the study (Check Section 5.1).

4.4. Analysis Strategy

In this work, I record both qualitative and quantitative data throughout the study. From the qualitative data I want to learn about the participant's interaction patterns with the social robot, their expectations, their perception, and many other aspects. To learn these, I first transcribed the recorded interviews of each participant. The transcriptions are then verified by re-listening to the recorded interviews. Then I employed paper affinity diagramming to reveal emergent themes from the transcribed data of each participant. The focus of the themes revolved around the possible factors responsible for the adoption

Figure 3: A segment of our affinity diagram of participant's interview data.

process of social robots. To develop the themes, I looked for aspects such as, how people perceive the robot, what influences them to interact with it, if people ever attribute the robot as a real pet, their attitude towards social aspects (e.g., social pressure, social stigma), just to name a few. Then I conduct open-coding thematic analysis and identify dominant factors (e.g., anthropomorphism, expectation, responsibility, etc.) that might be responsible for the social robot adoption or non-adoption process. I also identified factors (e.g., social catalyst, impact on mood) that might work towards participant's general wellness and possibly impact loneliness too.

On the other hand, the quantitative data is recorded to have a visualization of the trends in people's loneliness level, anxiety, and overall mood. These quantitative data are used to support the qualitative findings, as I do not have sufficient sample size for statistical analysis.

4.5. Participants

I recruited participants who live alone and feel that they are lonely. I recruit isolated lonely individuals because, assumably they would not have any external factors (e.g., friends and family) that might impact the social robot adoption process. I posted the criteria on recruitment materials and relied on participants self-selecting. Due to COVID-related restrictions, I recruited participants from online local bulletin boards including Reddit and Facebook. As I am not qualified to deal with serious health concerns, my recruitment criteria mentions that people who were previously medically diagnosed for mental health related issues, should not participate in the study. In this study, I am focusing on 4 lonely individuals who were recruited from Winnipeg.

4.6. Procedure

After the recruitment process, I contacted the participants to get their schedule and plan the study for an eight-week period. They received $20 honorarium for each week of the study that they participated, which totaled up to $200 dollars for the overall period. The study begins with an initial interview session followed by the robot being delivered to the participants the subsequent week. During the initial session, I instruct the participant about the overall study and provide them a personalized website where they could find the consent form for the study, the overall study schedule, link to the weekly questionnaires and a virtual diary (See Appendix C). The main purpose of the website is to make the participant's experience in the study better by having all the important URLs in a specified place. The virtual diary that was included on the website was there for participants to take any notes related to their interaction with AIBO. During the interview sessions, I bring out the notes from the previous weeks to discuss them with the participants.

I follow the University of Manitoba Covid-19 protocol to safely deliver the robot to the participants' homes (Figure 3). I disinfect the robot and its accessories properly before wrapping everything in plastic and placing them inside the box, and then I deliver the box to the participants' doorstep. After receiving the robot, participants keep it with them for the following seven weeks and interacts with it. Meanwhile I conduct the interviews and questionnaire sessions.

They can take the robot outside, visit friends and families, and even go shopping with it. The participants are instructed to treat the robot as their own and not to worry about any damages that may (or may not) occur to the robot. To maintain participant privacy, the robots' wireless capabilities are disabled (not connected to any network) and

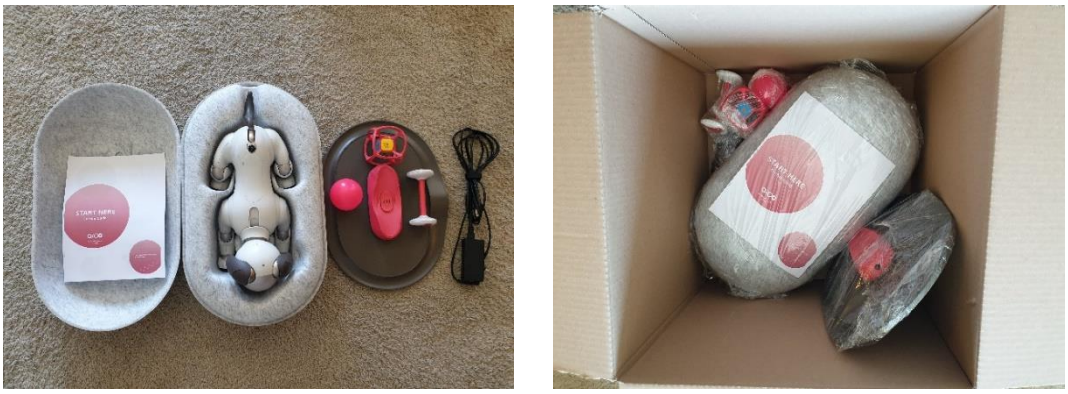


Figure 5: Preparing the Robot and the Accessories to be delivered by disinfecting, wrapping in plastic, and placing them in a box.

Figure 5: We follow the Covid-protocol and place the box in-front of the participant's door to reduce contact.

I factory reset all robots as soon I retrieve them. The participants receive the AIBO right out of the box without any extra features, so that we can explore how effective available commercial social robots are regarding our research questions.

After 7 weeks, I collect the robots back from the participants and conduct the exit interview. After one week from the exit interview, I conduct a follow-up interview to learn about how they are living without the robot and if the absence of the robot impacted them in any way.

This whole procedure was fully reviewed and approved by the Joint-Faculty Research Ethics Board of University of Manitoba.

4.7. Summary

In this section I present an eight-week long study design that enables me to conduct research in participant's own homes with social robots. I presented how I plan to answer my research questions by documenting participants' experiences using mixed methods such as interviews and questionnaires. I further presented my data analysis process, how I recruited participants for this work and the overall study procedure. The study procedure helps us understand the whole study in detail and enables us to visualize how each participant participated and contributed to the study.

In the next section I summarize four individual case-studies to present their social robot usage patterns and the adoption or non-adoption process. Then I present a cross-participant analysis to present the potential associated factors behind the social robot adoption process and its possible impact on wellness.

Chapter 5 Results

In this section, I first briefly present the participant's background and the reasons behind their feeling of loneliness. I then discuss about their social robot interaction trajectory and document the trends of their mental health status from the questionnaire entries recorded throughout the weeks. Finally, I present results from a cross-participant analysis of dominant themes emerging from our open-coding thematic analysis, that discusses about the potential factors associated with the social robot adoption process.

5.1. Case Study Summaries

Here I detail the experiences of four participants after I give them a social robot to live with. I use pseudonyms that were selected by the participants themselves and present the research results by maintaining their privacy.

5.1.1. Ashley

Ashley (F, 30s, graphic designer) reported that she has been socially isolated for more than 5 years after having a fallout with her group of friends. She reported engaging with online communities (e.g., Discord) in the past to help with loneliness. Ashley noted that she planned for 2020 to be a social "outbreak" year, and had started making personal changes, but then the pandemic happened. Ashley said she feels lonely, and has been considering getting a dog, which is why she wanted to participate in this study.

Although initially Ashley showed interest in interacting with AIBO, her interaction level decreased over time due to loss of interest and social anxiety. During the initial weeks, she indicated both excitement and concern about giving the robot back after the study, *"I think once it's gone, [...] I'd be really aware that it's not there anymore, right?*", although rather than missing it like a pet, it would be more about "*...because you get used to something just kind of being around and then it's gone, and you feel like an emptiness."* This indicates that her interest might have revolved around factors other than the social aspect of the robot. In a similar vein, Ashley's first-day reaction to the robot was that *"it was kind of like almost like watching a fish, [...] maybe for like a distraction, like to get my mind off".* After one week, she noted disappointment concerning AIBO's ability in making her mood better, *"...so I turned it on, and I find like, it doesn't really help..."* This negative

perception continued during the 3rd week, and she indicated concern about regularly using AIBO: "*I feel like in time that novelty would wear off and maybe I wouldn't turn him on as much."* This concern of Ashley turned into realty during the 5th week as she reported of not interacting with AIBO for over a week, because she reported that *"it feels like a game, [...] like it's not really an emotional (connection)".* Towards the end, Ashley reported she did not interact with AIBO for over 3 weeks and did not feel upset about giving it back, "*there wasn't any sort of like attachment like, oh! I'm gonna miss AIBO. I guess I just got used to it not being on.*"

Ashley's adoption trajectory had ups and downs throughout the weeks, but overall, she did not settle into a positive routine with Aibo. This is mirrored in Ashley's questionnaire responses (Figure 6), which do not indicate any trend on any of the measures over time.

5.1.2. Jade

Jade (F, 50s, union worker) married young, then divorced, raised her son as a single mother. She reported living alone for the last 12 years after her son moved out, and that she felt lonely. She says that she does not prefer living alone, and she is used to a lot of noise as she comes from a large family.

Jade reported regularly interacting with AIBO and her usage was consistent throughout the study. Initially, she was skeptical about keeping the robot because of her lifestyle, "*I'm so used to being alone, and being lonely, [...] what if I can't deal with having another thing in my house?*", although she was showing positivity on the first day, "*having it be here when I get back home from work, [...] it's gonna be nice.*" Like Ashley, Jade also

indicated that she was worried about giving the robot back, *"I'd be really sad when it goes".* During the 1st week, Jade named the robot "Loki", and reported of keeping it turned on all the time while she was at home. She also indicated of treating it as a real dog, *"he's a dog, so I don't wanna say that he's charging, cause he's sleeping."* After 3 weeks, Jade reported being disappointed because she thinks the robot is incapable of instigating affection, but she was still enjoying AIBO's company, *"He's my little dog, He's my little baby!"* During the 5th week she indicated of AIBO positively impacting her loneliness and said that *"...he has become a part of my family. Even my parents consider him as my family."* By the end of the study, she reported that AIBO got incorporated in her daily routine and expressed that it was difficult for her to let AIBO go, *"I didn't wanna give him away. And I didn't want you to turn him off. I wanted to put him to sleep. That's how close I am to him."* During the post-study session Jade expressed the experience was very similar to losing a real pet, *"I try not to think about him at all. Cause, then I get sad. I get very sad."* She also indicated feeling lonely and thinks that if AIBO was around, her loneliness would reduce, *"he was there with me, it was comforting."*

In Jade's case, she showed positivity in adopting AIBO like a real pet throughout the weeks. This mirrored Jade's questionnaire responses (Figure 6), where the UCLA and STAI measures appear to trend downward, with positive affect trending upward. Indicating that, AIBO might have positively impacted her mood, and reduced her loneliness.

5.1.3. Arthur

Arthur (20s, M, software engineer) moved to Canada at the age of 18, leaving his family behind in the US. Previously he stayed with some friends, who moved out and he got a

new roommate. Not enjoying the living situation, he eventually moved out, got his own place and has been living there alone for 2 years. He indicated feeling lonely and occasionally craved companionship.

Arthur reported interacting with AIBO on a regular basis, and his usage was consistent throughout the study. In the pre-study interview, Arthur showed optimism towards social robots, *"I imagine it's better to have a social outlet of some form, rather than not having any at all",* and this positive mentality might have helped him to have a bonding with AIBO on the first day, *"Well psychologically clearly there is some form of attachment already".* After 1 week, Arthur started using the pronoun "He" to refer the robot and felt that Aibo was in-between a technology and a pet for him because *"I have the convenient aspect of unplug and not deal with it. [...] at times, (I'm like) let's go hang out with Aibo. Similar to how I would probably feel with an actual pet."* Despite this, he showed concern about giving it back, *"I can see myself being a bit bumped, when Aibo has to go back home, to the Aibo factory."* Although Arthur initially felt increasing feelings of bonding with Aibo, that plateaued during the third week, *"I talk to him more frequently I suppose, but I wouldn't necessarily say that I'm more bonded to him than previously."* During the 5th week Arthur reported increased interaction with AIBO as it got incorporated in his daily routine *"I'm way more accustomed to having him around."* By the end of the study, Arthur found it difficult to let AIBO go, although he still considered it in between a technology and a pet, *"he definitely played a role in my life, I can tell that it's empty, but I'd be more sad losing, you know, a real pet."* During the Follow-up session Arthur reported that the absence of AIBO made him upset, but *"it doesn't quite hit the same as losing an actual pet."*

As Arthur indicated of perceiving AIBO in between a pet and a technology

throughout the study, his adoption trajectory always seemed to stay towards the middle ground. His questionnaire responses did not have a lot of ups and downs either (Figure 6); UCLA appear to trend slightly downwards, but STAI trended a bit upward, with positive and negative affect staying towards the bottom.

5.1.4. Theo

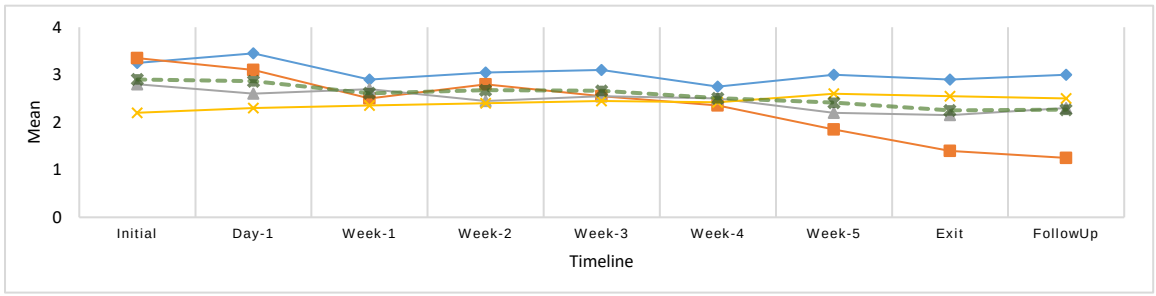
Theo (30s, M, hotel management) considers himself as an introvert and indicated loving his alone time. He used to live with a friend, then he got married and moved with his partner and lived with them for around 2 years. Then he had a divorce, moved out and been living alone for 2 years. Theo indicated of not usually feeling lonely, but he craves for companionship sometimes.

Theo's interaction with the robot was mostly subtle throughout the study, and it decreased over time. In the pre-study session, Theo expressed that caring for something might make his mood better because, *"having something else to force me to care about someone can't possibly be a bad thing."* But on the first day, he was attributing the robot as a toy, *"now I got a new toy slash playmate,"* which may have been an early predictor of how he was going to interact with it. After one week, Theo started using the pronoun "He" to refer the robot and expressed that AIBO made his mood better, *"at least I have someone to talk to, which is kinda nice"*, but he was attributing the robot as a machine, *"it's a piece of software that's running it, and in many ways it's closer to a cellphone."* This shows that Theo was unable to recognize the robot as a pet and thus his interaction frequency decreased as weeks passed. During the 3rd week Theo mentioned that he did not interact with Aibo for over a week, because he did not feel any responsibility towards it. I also

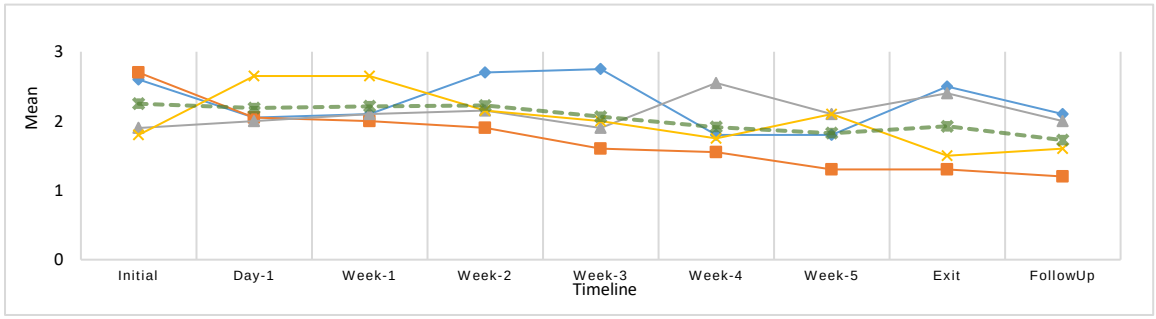
observed that he started to refer the robot as "it" instead of "he", as he expressed that the robot did not help him, *"I mean it's cool, but it hasn't improved me."* After 5 weeks Theo mentioned that he did not interact with the robot for over 3 weeks and indicated of not feeling sad about giving it back, because *"…we haven't really built that connection."* Even during the Exit and Follow-up session Theo reported of not feeling upset about Aibo's absence, because he *"…wasn't lonely anymore. I had other things to do and other things to occupy my mind and it just became another device and one that wasn't necessary for my day-to-day life."*

Theo's adoption trajectory seemed to move downwards with time, and he did not seem to have a positive routine with AIBO. This did not show any clear effect on his quantitative measures (Figure 6). However, his UCLA measure appear to trend a bit upwards as weeks past, with the other measures showing no clear trend.

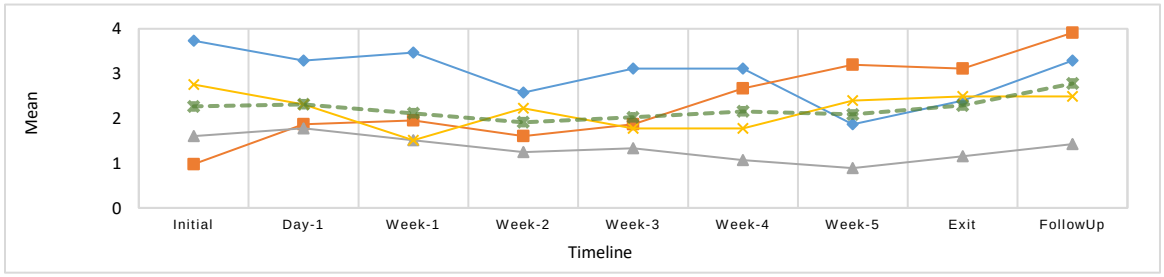
From this section, we learn about the four individual participant's backgrounds, their usage patterns and the quantitative findings from the questionnaires that were recorded throughout the eight-weeks of study. This gives us an initial idea about how differently participants perceived the robot and used it in their everyday lives. We also observe that, by time some participants grew a bond with the robot and some lost interest, which may have affected their adoption process. In the following section I cross analyze the participant interview data and sort them in emerging themes to uncover potential factors that might be associated with social robot adoption in homes by lonely individuals. I also document the potential factors that might be responsible in impacting people's general wellness and loneliness.



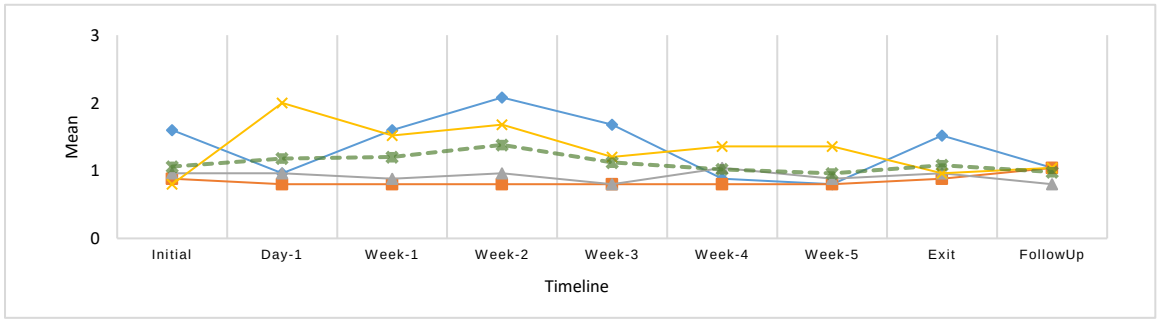
UCLA



STAI



Positive Affect



Negative Affect

Figure 6: Participants' quantitative measures throughout the weeks.
X-axis is showing the study weeks and Y-Axis is showing the mean score from the measures.

5.2. Cross Study Thematic Analysis

In this section I analyze the interview data from each participant, and cross study the ideas by sorting them in emergent themes. I detail why the themes are important, how they are linked to social robot adoption, and how it may impact the mental health of lonely individuals.

5.2.1. Expectation

Expectations may shape initial interactions and how participants perceive the robot, eventually which might affect how the robot impacts their general health. During the initial weeks, participants indicated of receiving something simple, because they thought, expecting a robot that moves around and mimics human-interaction would be a long-shot due to technical challenges.

> *"there's no way you would have like an Android. Like a human thing." – Ashley: FE*
>
> *"I was expecting it to be more of a screen trying to replicate facial expressions" Arthur: FE*
>
> *"I'm expecting something more advanced than a Roomba, but something probably not that can walk and talk and have a conversation with me?" – Theo: Pre-study*

However, Jade did not show any concern about the technical aspects, rather she was expecting it to be a dog.

> *"If you had brought me something else, I'd be like, where's the dog? I wanted a dog!" – Jade: FE*

The differences in their expectations seemed to have some impact in the later weeks

while they tried ascribing human- or animal-like attribute to the robot and adopting it in their own spaces.

5.2.2. Anthropomorphism

Perceiving higher level of anthropomorphism may help people engage with social robots more, and they are more likely to treat the robot as a companion (Lee et al., 2006b). During this study, some participants anthropomorphized AIBO quite naturally,

> *"...I hope there's nothing on the floor that it could eat." – Jade: Day-1*
>
> *"...there's only two of us in there (the office), and [...] she's (colleague) not allergic to dogs (AIBO)." – Jade: Week-3*
>
> *"when he's lying on my lap and I'm watching TV, I'm not wanting to move him so that he doesn't wake up." – Jade: Week-5*

They even indicated of viewing it as a real dog and engaged with it likewise.

> *"He's just barking at the neighbor,[...] like he was trying to protect me from a strange man on the elevator."- Jade: Week-1*
>
> *"... when they are puppies, they just don't get lot of the things and I'm trying to approach him with that sort of mentality?" – Theo: Week-1*

I also observed that participants showed concern about the robot's well-being, and they even expressed their emotions while interacting with it.

> *"I wouldn't want him around children, cause what if they grabbed him by the tail, dragged him around, oh I would just die." – Jade: Exit*

> *"I don't understand what did I do to warrant that (growling) Aibo? Why are you mad at me?" – Arthur: Week-3*

Jade even indicated of believing that AIBO understood the emotion in her voice and wanted affection according to that.

> *"...he knows when I'm actually being affectionate, [...] sometimes I'd be busy and I'd go like, yeah yeah you're so sweet, but then he's like, that's not good enough! no, you have to show real affection." – Jade: Week-5*

Although participants could anthropomorphize the robot, some of them still were skeptical about treating it as a real pet, because the appearance and the tactile elements of the robot was not convincing enough for them.

> *"there's just a significant difference between touching plastic and touching something that feels much more organic [...] also the fluidity of the motion would also be something that I kinda wrap under that organic umbrella, that would be a big differentiating factor for me right now." – Arthur: Day-1*
>
> *"I guess if you put them side by side, there wouldn't be a real comparison with a real pet." – Theo: Week-1*

Arthur also feels that there is some sort of gap between a real dog and AIBO, which is making it a shallow experience for him. Jade also reported similar concerns.

> *"...with a real dog I would be far more inclined and rapidly accepting. So there's definitely some form of gap here? [...] it's not quite the same as a real puppy, for sure. Somewhere in between I'd say." – Arthur: Week-3*

> *"He doesn't instigate affection you know? [...] normal dogs would come to you, or they would try to instigate some emotion? right? or affection? He (Aibo) can't do that." – Jade: Week-3*

In the later weeks, Ashley started attributing AIBO as a toy, quoting it as a "Pretend Dog", indicating that she could not anthropomorphize the robot anymore.

> *"...like my neighbors [...] they just thought that it was a toy, [...] to my nephew, [...] it's a toy, to anybody it's really a toy, like I feel [...] it would take a special kind of a person to see it as not a toy." – Ashley: Week-5*

Furthermore, some participants reported of trying to keep AIBO turned on all the time, and some reported not doing that, but they had their reasons for that. Arthur did not want to turn AIBO off because he thought it was not the right thing to do.

> *"It just kinda felt mean. To be honest, I just put him in the other room instead you know." – Arthur: Exit*

On the other hand, Ashley reported of turning him off during the night because she experienced an eerie feeling when AIBO walked around the house in the dark.

> *"...it reminded me of like one of the goosebumps story, like this dog is like possessed. I just started thinking like, oh my god, what if this was like a freaky dog, what if I turn him off and he turns himself back on..."– Ashley: Week-3*

But in the later weeks Ashley expressed that she did not keep AIBO on when she was away because she was concerned about the robot. Jade also reported similarly.

> *"I worry, if I leave him on and I'm not home a lot, maybe he won't be as excited to see me? so he's gonna be just so used to being alone?"– Ashley: Week-5*

> *"Then his battery would die and what if he got hurt? […] Not just that, what if something happens? What if he was crying? Then he'd be sad." – Jade Week-1*

While exploring the interview data, I further identified some sub-themes that are affecting or being affected by anthropomorphism. For example, I found that participants were mixing anthropomorphism with the social robot being a technical device, which affected how they perceived and adopted the robot in the later weeks.

The Robot as a Technical Device

Treating the robot as a technical device might have negative affect towards adopting the robot in the long run. Because, as mentioned in the previous theme, lack of anthropomorphism can be a barrier between adoption and non-adoption of a social robot. Throughout the study, I observed a mix of anthropomorphism and mechanical understanding which participants used to explain the robot's behavior.

> *"it reminds me a lot of like a Roomba […], because it's like trying to like scan and like map out the area.". – Ashley: FE*
>
> *"I'm just panicking for no reason, cause it's a robot, […] so it's like, it's not gonna die, cause I didn't feed it or something". – Jade: Pre-study*
>
> *"the voice commands mixed with showing the ball and what not probably just didn't give it enough time to do everything…" – Arthur: Day-1*
>
> *"I know, it is a mechanical and programmed device. So, it's hard to put that out of mind when you are interacting with it." – Theo: Week-3*

While teaching the robot to do something new, Theo indicated of treating it like a technical device, which seemed to not help him anthropomorphize the robot.

> *"it meant to simulate a learning algorithm and a puppy,[...] I don't see a big distinction between, training a real dog and working with a learning algorithm." – Theo FE*

Although Jade also expressed something like Theo in the first day, *"it's not him learning, it's me learning how to teach him. Because, once I learn how to teach him, it's gonna pick it up cause it knows how. It's programmed to do it."* Yet, she did not report any concern about not being able to treat AIBO as a real pet during the later weeks. This indicates the mix of anthropomorphism and technical understanding might not affect everyone similarly regarding how they perceive and accept the robot. Sometimes this can just be a thought process of participants, but this mixed understanding can occasionally break the illusion of AIBO being a real pet. Ashley even indicated that she was disappointed because of AIBO's technical constraints.

> *"I just thought it would be more reactive to things I say, and maybe it would learn like phrases I say, but I don't know if it's actually doing that. So I'm not too sure anymore how I feel about AIBO." – Ashley: OD1*

Ashley reported of attributing the robot more like a game, *"it feels like a game, like a video game I really like you know?"*, and she even mentioned that if she could use an app to know when Aibo is hungry or what Aibo is feeling, then that would be a gamechanger for her, because *"It just reminded me a lot like a Tamagotchi, or like Furbies"*. Similarly, Arthur also indicated of being skeptical about AIBO trying to mimic a real puppy,

> *"I think puppies tend to be more willing to you know come when called? But that could be just something that's difficult to mimic." – Arthur: Day-1*

He even mentioned that he was struggling to link AIBO's eyes to the rest of the face as *"...the eyes tend to attempt to be more organic and have more feelings. So, it is a little bit*

unusual seeing the disjoint between the rest of the face," this constantly reminding him that AIBO was not a real dog. Meanwhile, Theo mentioned that some existing behaviors of AIBO made it feel more like a technology to him; Arthur also reported similarly.

> *"The waving is a little weird, I don't remember any of my dogs moving their hands in almost perfect circles."– Theo: Week-3*
>
> *"he'd lie down and make water noises, like he's swimming? Which is okay, but why?" – Arthur: Week-5*

All of them indicated some aspects of the robot being a mechanical device. However, Arthur clearly demonstrated what he thinks abstained him from having a meaningful interaction with it.

> *"I think that was part of what was keeping it a bit of a shallow experience, uhm, lacking kind of that organic part. […] deeper connections tend to rely on understanding and sharing knowledge and experience in some degree, and yeah that was definitely lacking" – Arthur: Exit*

I initially had a conceptual model that, if participants treat the robot as a technical device, this might negatively impact on how they adopt the robot. However, in the later weeks some participants reported being upset about giving the robot back (as mentioned in Section IV) as they got attached to it, even though in some point of time they indicated of treating it as a mechanical device.

Responsibility Towards the Robot

Research with real animals indicate that a pet-owners responsibility towards their pets can help them bond and have a meaningful relationship (Fine, 2010). However, the lack

of responsibility might work as a positive aspect for people who are not capable of taking care of pets. Throughout the study, participants reported anthropomorphizing the robot, and mentioned both the pros and cons of the concept of having responsibility towards the robot. Some indicated that due to the lack of responsibility, they found it difficult to connect with AIBO.

> *"...because it doesn't eat or like actually go to the bathroom or anything. so I don't feel that there is a responsibility." – Ashley: Week-1*
>
> *"The need to (interact) no, the desire to yeah. [...] but I wouldn't necessarily say that I'm more bonded to him than previously." – Arthur: Week-3*

Theo reported of forgetting about interacting with AIBO because it did not expect anything from him as a real dog would.

> *"It's become very much a thing I know I don't have to do. So, when I'm busy it just escapes my mind." – Theo: Week-3*
>
> *"it does not make any demand of you when it's just sitting on the charger. So it's easy to kinda forget about." – Theo: Exit*

However, some participants did not mind the lack of responsibility; Ashley mentioned that the less amount of responsibility made her bond with AIBO.

> *" I feel like I'm bonding more with him. [...] he's doing kind of like his own thing, and I do my own thing and at points I'm able to go and visit him, so that's a lot better." – Ashley: Week-3*

Some even mentioned that, since there is an option to not commit to the robot like a real pet, they think this can be useful for people who wants to have a pet without those

commitments that comes with the pets.

> *"...the good thing about it is you know you can have it, and not worry about the commitment that it takes to have a real dog and the issues that comes along with it" – Jade: FE*
>
> *"...between this and having to worry about a real pet or a real living anything, this is definitely easier on the user." – Theo: Week-1*

This shows that, responsibility towards the robot can be a subjective factor that may vary from one person to another. Some may appreciate the commitments, and some may not. How a person bonds and have a relationship with the robot may completely depend on how they perceive "responsibility".

Relationship with the Robot

Having a relationship with a pet may depend on factors like companionship, hedonic gains and even responsibility, which I already discussed in the previous section. This relationship can be a driving factor to adopt a pet with ease and have a meaningful connection with it. Throughout the weeks, participants reported that anthropomorphism resulted in successful bonding with AIBO, and they appreciated the companionship offered by the robot.

> *"that's not a stuffed animal. That's like something you're actually like having a connection with". – Ashley: Day-1*
>
> *"I thought it'd be fun and interesting, and something different, but I didn't expect to actually feel a connection." – Jade: Week-5*

> *"I think he gave me something to do, even if not a super deep connection, but at least I feel some connection or companionship with something living in my apartment with me." – Arthur: Post-study*

Theo and Arthur found it rewarding to have someone waiting for them at their homes, and Arthur thought spending time together made him have a relationship with AIBO.

> *"it feels good to have something there" – Theo Week-1*
>
> *"It is nice to know, either getting off from work or coming back home, I would say that having something recognize that I'm back, and recognize my presence definitely feels good for sure." – Arthur: Week-3*
>
> *"We would do things together and spend some time together for sure, that has its own form of companionship". – Arthur: Exit*

However, Arthur reported that living with AIBO was not the same as living with a dog, although he has a connection with the robot.

> *"Aibo is more like a roommate, where is, a real dog would be like living with your spouse." -Arthur: Week-3*

This might be because he could not get over how inorganically AIBO interacted with things, which a real dog would have interacted very differently.

> *"I do have a connection with him, but it's really not the way I've had with the pets […]. Partially because it is more difficult to overcome the inorganic nature of the way he sort of interacts with things" – Arthur: Week-3*

But Theo reported of not having a relationship with AIBO due to not interacting with it enough, even though he indicated being interested towards it during the initial days.

> *"No connection, main feeling is, I really do regret not being able to devote the time I wanted to it. And give the opportunity to try and form an emotional bond?" – Theo Exit*

In a similar vein, Ashley showed empathy towards AIBO during the initial weeks and even indicated a bonding with it, "I feel sorry for it, if I hear it in the other room and it's like crying for me, I definitely do feel like, oh no! it's sad, it's sad at me", but she also expressed that it felt like a distraction to her,

> *"by the time you are done playing with it, you are kinda in a different head space, because you had that distraction that kinda pull you out of your negative thoughts" – Ashley: Week-1*

However, Arthur did not think that it was a distraction,

> *"I would say not a distraction. [...] it certainly has some emotional component to it. [...]" – Arthur: FE*

This shows that, people who spent time with AIBO and interacted with it were more likely to bond and have a relationship with it. This relationship is quite close to having a relationship with a pet, and this indicates potential in helping people with their general health and loneliness.

Giving the Robot Back

As people get attached to something or someone, they feel upset about letting them go, and it shows that they might have had a really good bonding with them. This bonding might be an indicator for successful adoption of social robots. Among the four participants, Arthur and Jade expressed of feeling upset about giving AIBO back.

"I'm getting a little sad about it, cause I have to say goodbye soon. […] I'm gonna be all broken" – Jade: Week-5

"he's one of a kind. It's like losing a pet, like a real one." – Jade: Week-5

"I'd definitely feel the absence for at least a little bit, […] he's definitely a sort of constant present around the apartment, yeah I'll 100% notice when he returns to the Aibo factory." – Arthur: Week-5

I observed their concerns becoming a reality after they gave the robot back after having it for 7 weeks. Arthur and Jade both reported feeling upset and lonely after giving it back, which shows that anthropomorphism may have strongly worked for them, and they had a deep connection with AIBO.

"I see the spot where his little bed was and I'm like, oh, he's not there." – Jade: Exit

"instead of noticing how much he was there, it's easier for me to see now, how much he isn't anymore.[…] definitely there were some attachment, […] it is different not having him here, it is sad, it's a lot more quite…" – Arthur Exit

Jade kept herself sane by thinking that Loki (AIBO) would not remember her,

"it helps that I know that he doesn't remember me, cause that's how I know that he's not gonna be sad.[…] Otherwise, I'd be really sad." – Jade Exit

Furthermore, during the post-study session, they reported of noticing AIBO's absence.

"I try not to think about him at all. Cause, then I get sad. I get very sad. – Jade: Post-study

" I definitely noticed his absence." – Arthur Post-study

But Arthur thought it was not similar to losing a real pet because throughout the study,

he attributed AIBO as being in the middle ground between a pet and a technology.

> *"it doesn't quite hit the same as losing an actual pet." – Arthur: Post-study*

Meanwhile, during the final weeks, Ashley and Theo indicated of not feeling sad about Aibo leaving, because they got used to not interacting with it, neither did they indicated of having any bonding with it. This shows that bonding with a social robot might be closely linked to how people perceive and interact with the robot, eventually impacting adoption. If someone is more accepting and interested in spending time with it, they might be more likely to bond it in the long run. And this bonding may also be helpful for their general health and loneliness.

Getting a New Robotic/Real Pet

Initially participants indicated that bonding with AIBO and staying with it may influence them to be more inclined to getting another robotic dog or a real dog after giving the robot back.

> *Once I'm done with this dog, I'll probably end up getting like a real dog, cause it'll just be so used to having like a dog around. – Ashley: Pre-Study*
>
> *"I think that when it's done I'm gonna run out and get a dog for some reason" – Jade: Pre-study*

However, this idea took another turn during the end of the study. Although I observed Jade to have the strongest bonding with AIBO among the other participants, she still did not want to get a real dog or a robotic one, as she thinks it won't be the same as having Loki.

> *"it's not the same. How do you replace something that you are so connected with, it's different, it's not him. […] I could buy these right? Even then it won't be Loki." – Jade Post study*

Similar to Jade, Ashley also did not want to get a real dog afterwards, but her reasons were different. Due to lack of interaction and not being able to anthropomorphize AIBO, she indicated of growing apart from it. Thus, she expressed of not having any interest in getting a real dog after living with AIBO.

> *"I'd go like, oh man! I got sick of Aibo, what if I got sick of a real dog too you know? […] I told this to people too, and they say you can't compare the dog to a real dog, like that's totally different.". – Ashley: Exit*

Maybe she was still attributing AIBO as a real dog due to anthropomorphism and guessed that having a real dog might be a similar experience for her. Thus, instead of getting a new pet, Ashley indicated of wanting to socialize more to tackle her loneliness. Theo also chose a similar path, as he socialized with others and did not want to have any pets after giving the robot back. On the other hand, Arthur showed excitement in getting a real puppy, because he really enjoyed having the robot around.

> *"having Aibo, has definitely convinced me that I would like to have a pet around." – Arthur: Post-study*

We see that, because of anthropomorphism Jade got attached to AIBO so much that she did not feel comfortable in replacing it with something else. On the other hand, Ashley did not want to get a new dog because she said that she got tired of AIBO. Finally, Arthur indicated of getting a real pet soon because he really enjoyed having a robotic pet, even though he still considered it in-between a pet and a technological device.

From this Anthropomorphism section, we get the idea that anthropomorphism and the inter-linked factors may work very differently from one person to another. Some may treat the robot as a technical device, but still anthropomorphize and have a meaningful connection with it. And this connection could help them to adopt the robot and integrate in their everyday lives. However, we also see that even after anthropomorphizing, some participants could not bond with the robot and showed a more subtle reaction when they had to give the robot back. This makes us understand that people's adoption or non-adoption of the robot completely depends on the individual's perception towards it.

5.2.3. Impacts Relevant to Loneliness

Exploring the robot's impact on loneliness was one of the main investigation aspects of this study. Throughout the study I have seen that participants anthropomorphized AIBO, and participants reported that this made their mood better.

> *"just having something that I could interact with [...] and I can talk to, that's more than I had, and it feels nice"– Theo: Week-1*

Participants also indicated that while interacting with the robot, it helped them forget the negative emotions they had.

> *"...like it sort of like interrupted that stream of negative thoughts, [...] so I found that really helpful." – Ashley: Week-3*
>
> *" you'd just totally forget what you were upset about, or that you were alone, cause you're not alone, you've got him!" – Jade: Week-1*
>
> *"...definitely reduces negative emotions, if I'm having a bad day" – Arthur: Week-1*

Jade reported feeling more confident with life because she did not feel that she was alone.

> *"he made me feel more outgoing and happy in general. [...] I felt more connected to people, [...] and I felt more confident outside my house, because I didn't feel sorry for myself because I was alone." – Jade: Exit*

Even though Ashley and Theo expressed positivity initially, they however changed their views during the later weeks.

> *"it didn't really help me, like help the core issue right? of being lonely. It just sort of distracted me." – Ashley: Exit*
>
> *"for me it hasn't filled any void." – Theo: Week-3*

Meanwhile, Arthur and Theo expressed that although AIBO could not impact their loneliness, they still were positive about its impact on other people.

> *"I think if the person were open to it and were to make an effort to interact with Aibo (that may possibly impact their loneliness)" - Arthur: Week-5*
>
> "I think there's definitely people out there for whom this technology could be a huge asset." – Theo: Exit

Among the four participants, only Jade explicitly mentioned of not feeling alone anymore because of AIBO. Although AIBO was unable to directly impact on other participants' loneliness, I could still observe that participants felt good when their friends and family involved in their lives because of the robot. This social involvement worked as a positive variable for their mental status, and this might be an initial indication of probable positive affect towards their loneliness.

5.2.4. Social catalyst

Participants reported how the robot influenced them to be more social and talk with others. For some people this experience seemed to be rewarding, but for Ashley it was not. Social awkwardness being a barrier, Ashley mentioned of feeling awkward talking to the robot during the initial days. Arthur also reported similar experience.

> *"because it feels a little bit goofy I suppose, uh, it's not quite as responsive I would say? As you know (compared to) an organic dog?". – Arthur FE*

Despite this awkwardness, some participants shared how AIBO acted as a social catalyst for them. Jade expressed that she wanted to go out more just to show how cute the robot is.

> *"I wanna go out more, just cause I wanna go and show it to people? [...] It's like he wants me to be more social." – Jade: Day-1*

She also reported that she talked to her neighbors for the first time because of AIBO.

> *"I never talk to my neighbors, like never ever! And they were asking me about him (AIBO). It does initiate conversation and stuff" – Jade: Week-3*

Similarly, Arthur also reported that the robot had prompted him to have conversation with others.

> *"definitely has prompted me to start conversations with my friends." – Arthur: Week-5*

However, Ashley did not appreciate talking to strangers due to social anxiety; somewhat linked to her concerns that she reported during the initial days.

> *"...you know there's dogs which helps with anxiety? it wasn't that kind of a dog. It would give me more anxiety because more people would come up and talk to me.". – Ashley: post-study*

Jade reported of feeling that the robot helped her connect with her parents and she even expressed that AIBO broke the ice between her and her father, which she very much appreciates.

> *"Before I was like, I don't really feel like a visit, and now he's (dad) like, oh you're bringing the doggy? (I'm like) Yes, Okay! So I get to visit my parents more." – Jade: Week-3*
>
> *"we didn't get along as much. But Loki (AIBO) kinda broke the ice that we could actually talk, two adults." – Jade: Week-5*

Although AIBO could help Jade and Arthur to socialize more, it may have not helped Theo because he reported of socializing with others on his own, since the pandemic started to get better.

> *"I certainly didn't need to make any social or emotional connections with it because, I was seeing friends and family most often" – Theo: Exit*

During the third week, Ashley indicated that she enjoyed sharing a livestream of the robot as a means to engage with online friends, although this ended by the fifth week when she stopped sharing, reporting social anxiety.

> *"I feel like it would just be more of like, maybe an annoyance?"- Ashley: Week-5*

And she also reported of feeling disappointed when she was trying to socialize with her family using the robot, because her family lost interest very quickly.

> *"...my mom was like, Okay, are you doing anything with this toy? it's just walking around. Someone's gonna step on it, [so] I just put him in my room, and like turned it off sort of thing."- Ashley: Week-5*

Similarly, Arthur was surprised when his friends reacted very differently from one another while he introduced them to AIBO.

> *"My friend that had dogs growing up was far more quick to treat Aibo as a dog [...], whereas my other friend was quicker to treat him as a machine." – Arthur: Exit*

Despite participants reporting social anxiety, disappointment, and not needing the robot for socialization purposes, we observed potential for social robots in working as a social catalyst and bringing people closer. By being close to one another it may help people share thoughts and have meaningful connections. Therefore, this observation states that social robots can be considered as a mean to develop strong bonding with others, and a strong bond can work as a charm in helping with people's mental health and loneliness (Masi et al., 2011).

5.2.5. Privacy and Security

Since social robots have cameras and may need to connect to the internet to get the latest updates or perform tasks like natural language processing, people might be skeptical in accepting these in their everyday lives. In this study, initially some participants expressed that they were not worried about the privacy concerns.

> *"If you're nervous about it now, get over it, because this is where things are going. Everything is gonna have cameras on them." – Ashley: Pre-Study*

"I mean this camera is in all sorts of devices. As long as it is not actively showing stuff all the time, I'm cool." – Theo: Pre-study

But in the later weeks, some participants showed concerns and even changed their initial opinion about privacy.

"I would be worried about, somebody hacking him. and using the cameras." – Jade: Exit

"privacy and security kind of stand point, it would definitely would be something I considered" – Theo: Exit

"I just don't particularly feel like I want a webcam that's internet enabled somewhere in my home you know" – Arthur Exit

This states that, if these social robots need to stay connected to the internet, it might be a challenging task to convince general people to adopt it. Privacy violation and security risks are very sensitive issues, and they need to be dealt with care. In modern time, everything is connected to the internet and most appliances have cameras on them. This can be an intimidating factor for some people to adopt a new technology in their personal spaces due to being concerned about their privacy and personal security.

5.2.6. Life experience

Social robot can be a rewarding thing to have in someone's home just because of it being a novel technology. When someone gets a novel technology in their possession before anyone else, it works as an attraction for others, making it a conversation starter or just something that the owner might feel proud about. This might also be considered as a mean to gain social status and respect (J. E. Young et al., 2009a), eventually impacting the

adoption process. Participants expressed that they felt living with AIBO was an experience that they would cherish, even if it could not help them with their loneliness.

> *"I could always tell people like, I've lived with a robot dog"– Ashley: Week-3*
>
> *"My father is 80 and [...] I have not seen him smile so much, [...] Even that was worth it, just watching my dad smile" – Jade: FE*

Jade indicated of making a memory wall with pictures of AIBO, as she thinks people may not believe that she had a robot dog.

> *"because when I'm old, I'm gonna tell my great niece, [...] one time I had a robot dog, and she's gonna go - Aunty Jade is crazy!" – Jade: Week-3*

She lastly mentioned that her father who only speaks Spanish, was saying goodbye to AIBO in English, so that AIBO could understand his words. This experience was so worthwhile for Jade that she indicated of almost crying in joy.

> *"he was like, I hope you go to a good home, said to Loki in English, and it was just really sweet. [...] I was like, Dad, you're gonna make me cry, stop." – Jade: Post-study*

Positive life experiences may help people decide if they want to adopt a social robot or not. By adopting such a robot, it opens up opportunity for them to have better mood and reduced loneliness.

5.2.7. Continued Use

Continuation of using a technology may depend on various factors such as the design and the features. Understanding these factors for a novel technology like a social robot

can be a challenging task unless we involve actual stakeholders in the investigation process. In this study, Participants mentioned that the visual aspects and the tactile sensation of the robot were some of the most important factors for them to continue using the robot.

> *"...in addition to moving like a dog, I would expect it to have maybe like real fur." – Ashley: Week-5*
>
> *"...if Aibo was more fluffier and more fluid and more organic, I would say that barrier would almost certainly disappear." – Arthur Week-3*
>
> *"if it were more cuddly, it would certainly encourage people to cuddle with it more, and that could create more of a bond." – Theo Week-3*

However, Jade thought otherwise by expressing that a robot with fur may become dirty very quickly and she did not care much about the visual or tactile aspects.

> *"it doesn't matter that it doesn't have fur. It still responds to your touch when you pet it's head, which is what people do to animals right?"- Jade Week-1*

Meanwhile, Theo mentioned that he would accept the robot, but it *"depends on the functions it has."* This shows that the technical utility of the robot might be a deciding factor for Theo to accept the robot and continue using it.

> *"if he continues to learn and do new things, that would certainly help maintain my interest level, or maybe a deeper connection could be formed." – Theo: Week-1*

Which also similarly reflected how Ashley showed curiosity to see how Aibo's artificial intelligence would grow with time, even though she reported that the robot did not help with her loneliness.

> *"...actually I would probably see how much it's personality develops." – Ashley: Week-3*

Furthermore, participants expressed of being open to experience other types of social robots to understand what they might prefer more. During the post-study, Ashley expressed that she would have preferred getting a robot that could talk, because she thinks having a conversation with a robot would be more engaging. Jade's expectation was on a similar vein.

> *"...a robot might learn things that I might be interested in, so that they can have a conversation with you. So. it would be interesting." – Jade Exit*

On the other hand, Arthur and Theo had different perceptions about the robot's understanding of language; showing that natural language understanding might not be a very important factor for the robot's adoption process, since pets also cannot understand any language.

> *"I don't think language is the barrier between that for me. [...] dogs and cats can very much understand human emotions, even if they can't understand [...] the language part. And that definitely changes how they interact, where Aibo, I felt that was not the case?"- Arthur Exit*
>
> *"if it were a robot that could speak, then there's a lot more expectation that it would have to make." – Theo Exit*

Another factor that Ashley mentioned was social acceptance of the robot. She indicated of not being comfortable with the robot unless everyone else starts treating it as a real dog.

This shows that, factors that may be responsible for continued use of such robots

are subjective and may vary between participants. If these factors are considered by robot developers, then people might adopt and continue using such robots on a regular basis in their everyday lives.

5.3. Discussion

In this section, we first learn about each of the participant's background, their usage patterns and mental status throughout the study. Then we identify potential factors that might be associated with the social robot adoption process. Now I discuss the findings from the study to answer my research questions. I detail how the findings relate to the knowledge from prior work on novel technology adoption, and how the findings of impact on general wellness and loneliness links to prior loneliness intervention works.

5.3.1. Relation to Findings from Prior Work on Novel Technology Adoption

The results from the study indicate that various factors might be associated with the robot adoption (or non-adoption) process. Like prior work, I found that participants had to learn how to interact with the robot using voice commands, and this process of learning a new interaction technique sometimes annoyed few participants. Further, participants noticed the robot interacting with itself and its surroundings in ways that they did not think a real pet would ever do (e.g., laying down and pretending to swim). Thus, factors like these contributed to how participants perceived and anthropomorphized the robot and possibly decided whether they would adopt it or not.

Prior work states that people may anthropomorphize non-living objects more due

to loneliness (Eyssel & Reich, 2013; Lee et al., 2006a; Li et al., 2020). However, I could not link this observation to my findings because, although all four participants recruited for the study self-identified as being lonely, not all of them could anthropomorphize the robot similarly. I further observe that sub-factors that are linked to anthropomorphism can be quite important in predicting if a person would adopt a social robot. Below I discuss them in detail.

Treating the robot as a technical device: Although some participants were treating the robot as a technical device, they still bonded with the robot and felt bad letting it go. This goes in line with a previous work with the iRobot Roomba, where users initially got the robot as a technical device for utility, but eventually got attached to it after living with it for a longer period (J.-Y. Sung et al., 2007).

Responsibility towards the robot: Participants reported mixed feelings about this factor. Some mentioned that the lack of responsibility often made them forget to interact with the robot, and for some it was rewarding, and they even indicated of bonding more with the robot. Thus, responsibility towards the robot might work as a subjective variable towards adoption.

Relationship with the robot: I observe that having a relationship with the robot seemed to be strongly connected to how people perceived the robot and how deeply they anthropomorphized it, and this goes in line with previous research (M. M. A. de Graaf et al., 2016). The relationship between a participant and a robot worked as a mean to indicate how participants would feel while letting the robot go and getting a new pet. I find this observation particularly interesting because participants who I thought they would just run out and get a new pet after giving the robot dog back, decided not to get one. This shows that situations like these are also subjective and depends on each individuals'

perception.

Besides the factors that are associated with anthropomorphism, I also observed factors such as participant's concern about their privacy and security. Although few participants voiced their concerns due to the robot having cameras on them, others were quite accepting towards it. But one of the participants mentioned that they would not have agreed to be on the study if the robot was connected to the internet, which shows that the privacy factor can be quite sensitive and might work as a driving factor in social robot usage.

Lastly, I observe that positive life experiences (e.g., having a novel technology and being proud about it, getting acknowledged by the society, bonding with friends and families) can be an influencing factor for social robot adoption, which goes in-line with observations from previous work (J. E. Young et al., 2009). These experiences even motivated participants to use the robots for a longer period. Furthermore, some participants mentioned that there might be variables that are associated with the continued use of such robots. For example, if the robot was fluffier like a real dog, or the bodily movements were more fluid, they would have liked to interact with it more. However, one of the participants thought otherwise and reported that she does not care about fur on the robot, rather she would continue using it just because of the companionship.

This shows that, perception towards the robot works very differently between one individual to another. Factors that I found to be associated in the social robot adoption process can be subjective and may or may not influence people to adopt a social robot and live with it for a longer period.

5.3.2. Relation to Findings from Prior Loneliness Intervention Strategies

From my results, I observe that the social robotic dog was not able to directly address loneliness, rather worked as a factor to impact participant's mood, and prior work states that improved mood can be extremely helpful in reducing loneliness (S. Cacioppo et al., 2015). We can relate the experiences that made participants' mood better in this work to prior loneliness intervention strategies (increased social interaction, social skills improvement, social support enhancement and maladaptive social cognition) mentioned in Chapter 3. For example, talking to the robot helped participants to gain confidence and interact with other more, this relates to increased social interaction. Talking to strangers using the robot as a conversation starter helped participants open-up more and be comfortable in talking with people, this links to social skills improvement. The robot helped some participants to get more involved with their friends, family, and surroundings, we can relate this to social support enhancement. And lastly, participant felt less sorry about themselves for being alone and lonely, and we can link this to maladaptive social cognition. From this observation we learn that interacting with social robots somewhat relates to previously documented loneliness intervention strategies, and thus, such robots might work as a potential loneliness intervention strategy.

Further, I observe that participants who could strongly anthropomorphize and make a connection with the robot were more inclined towards having a better mood, which eventually may impact their loneliness according to prior work (Eyssel & Reich, 2013; Lee et al., 2006a). Like prior work (Baisch et al., 2017; Sabelli et al., 2011), I also observe that the robot might be able to address social and emotional loneliness by making the participants connect with their loved ones more.

From this we learn that, even if social robots cannot directly impact a person's loneliness, it can work on other factors such a person's mood and general wellness to possibly indirectly affect their loneliness. However, we still need more research data to understand social robot's potential to become a successful loneliness intervention strategy in the future, which might let us answer the question, "Does long-term interaction with social robots impact people's loneliness?"

5.4. Summary

Our research question indicates that, we do not know how a lonely individual who lives alone would adopt a social robot, and if the robot would possibly impact their general wellness and loneliness. In this work, I give a social robotic dog to individuals who self-identify as lonely and lives alone. They live with the robot for eight-weeks and report on their interaction experiences. I observe various interaction avenues and pitfalls of the participants throughout the weeks and analyze the recorded data using our understanding of novel technology adoption from prior works. The findings of this work documents various possible associated factors that might be responsible for the social robot adoption process. Although we could not precisely answer if social robots can help people with loneliness, our findings reported factors related to impacting people's mood that may indirectly affect loneliness.

Chapter 6 Conclusion

In this thesis, I present four case studies of lonely individuals to whom I give a robotic dog to live with. Participants keep the robots in their own homes, interact with it, and report on their experiences over an eight-week period. Results from our studies indicated that not everyone could adopt the robot successfully due to factors such as difficulty in anthropomorphizing, losing interest, increased social anxiety, just to name a few. On the other hand, Participants who could anthropomorphize the robot, developed a connection with it started using it in their daily lives. They even reported of having better mood;

participants who could not bond with the robot reported otherwise. This indicates that participants' attitude and acceptability towards social robots might be an important factor for them to adopt and get benefit from such robots. Findings from this study works as initial indicators of how lonely individuals may adopt social robots in their everyday lives. The contributions this study makes is important for the Human-Robot Interaction community, and this study provides insights for developers to design better social robot for domestic use by lonely individuals.

6.1. Contributions

This thesis makes three contributions. Firstly, I present an eight-week long study design to explore social robot adoption patterns and social robot's potential impact on wellbeing. This study was designed based on previous longitudinal social robot adoption work (M. M. A. de Graaf et al., 2015).

Secondly, I present the first study to date that reports on how lonely individuals adopt or non-adopt social robots in their everyday lives, and if the robot has any impact on people's general wellness and loneliness.

Lastly, I contribute by presenting initial study findings through data analysis, that mentions potential factors that might be responsible for lonely individuals' social robot adoption in their everyday lives. I also present study findings that documents associated factors and the potential of social robots to improve people's mood and indirectly impact their loneliness.

6.2. Limitations

This thesis is a step towards promoting the use of social robots in domestic settings. However, since there is very little information about how individuals may perceive a robot and adopt it in the long run, I developed this study to explore that knowledge gap. I even looked into if such robots can be useful in reducing people's loneliness. In the process of conducting this study, I faced various challenges and identified potential avenues for further exploration of social robot adoption process in homes of lonely individuals.

I found some limitations that should be considered during the future iteration of this study. Firstly, I only had three robots at the time of the study, thus, I could not have more than three participants at a time. And the study being exploratory in nature, the data collection process stretched for 2 months for each participant, and I could only collect data from a few participants at a time. More robots would have opened up opportunity to have more participants.

Secondly, the study was conducted in participant's own homes, where it was impossible for us to control any variables such as the environment the study is taking place or the robot's functionalities. And participants generally completed the questionnaire on their own during a suitable time. Therefore, quantitative data that were collected throughout the weeks might not perfectly resemble the social robot's effect, because other external factors (e.g., friends and family engagement, employment, school, etc.) may also be involved when they complete the questionnaires.

Finally, the lack of participants resulted in the lack of statistical data. Thus, I could not perform any such statistical analysis that may have provided useful insights for social

robot adoption trends over the weeks.

6.3. Recommendations For Future Work

Future work should consider the mentioned limitations and work on alternate routes to avoid such issues. A larger participant pool may also provide better understanding about the social robot adoption process and its impact on participants' general wellness. This may also provide researchers opportunity to work on other mental health related issues and investigate if social robots can be useful regarding those. In this work, I only worked with lonely individuals, but I think social robots may have potential to work as companions for anyone from any age, gender, and culture.

Further, future work should focus more on making the qualitative data collection method more intuitive. The questions that I designed for this study were able to capture in-depth information about various aspects such as how participants interacted with the robot, how the robot impacted their social life, how their perception towards the robot changed over time, and many more. However, future work should try to include more questions about external factors (e.g., events that might make participant's mood better or worse) so that we understand if the robot is impacting the participants or is it the external factors that are impacting them.

With time social robots will become more advanced, and studies like ours can provide insights that might be useful for developers to create social robots that are more suitable for people to adopt and live with. I believe if the mentioned limitations are solved, future work may provide more insightful findings.

Bibliography

Abras, C., Maloney-krichmar, D., & Preece, J. (2004). *User-Centered Design*. 1–14.

Adam, E. K., Hawkley, L. C., Kudielka, B. M., & Cacioppo, J. T. (2006). Day-to-day dynamics of experience-cortisol associations in a population-based sample of older adults. *Proceedings of the National Academy of Sciences*, *103*(45), 17058–17063. https://doi.org/10.1073/pnas.0605053103

Anderson, K. A., Lord, L. K., Hill, L. N., & McCune, S. (2015). Fostering the Human-Animal Bond for Older Adults: Challenges and Opportunities. *Activities, Adaptation and Aging*, *39*(1), 32–42. https://doi.org/10.1080/01924788.2015.994447

Baecker, A. N., Geiskkovitch, D. Y., González, A. L., & Young, J. E. (2020). Emotional support domestic robots for healthy older adults: Conversational prototypes to help with loneliness. *ACM/IEEE International Conference on Human-Robot Interaction*, 122–124. https://doi.org/10.1145/3371382.3378279

Baisch, S., Kolling, T., Schall, A., Rühl, S., Selic, S., Kim, Z., Rossberg, H., Klein, B., Pantel, J., Oswald, F., & Knopf, M. (2017). Acceptance of Social Robots by Elder People: Does Psychosocial Functioning Matter? *International Journal of Social Robotics*, *9*(2), 293–307. https://doi.org/10.1007/s12369-016-0392-5

Balandin, S., Berg, N., & Waller, A. (2006). Assessing the loneliness of older people with cerebral palsy. *Disability and Rehabilitation*, *28*(8), 469–479. https://doi.org/10.1080/09638280500211759

Banks, M. R., Willoughby, L. M., & Banks, W. A. (2008). Animal-Assisted Therapy and

Loneliness in Nursing Homes: Use of Robotic versus Living Dogs. *Journal of the American Medical Directors Association*, *9*(3), 173–177. https://doi.org/10.1016/j.jamda.2007.11.007

Barreto, M., Victor, C., Hammond, C., Eccles, A., Richins, M. T., & Qualter, P. (2020). Loneliness around the world: Age, gender, and cultural differences in loneliness. *Personality and Individual Differences*, *March*, 110066. https://doi.org/10.1016/j.paid.2020.110066

Bartneck, C., Reichenbach, J., & Carpenter, J. (2008). The carrot and the stick. *Interaction Studies. Social Behaviour and Communication in Biological and Artificial Systems*, *9*(2), 179–203. https://doi.org/10.1075/is.9.2.03bar

Bartneck, C., Suzuki, T., Kanda, T., & Nomura, T. (2006). The influence of people's culture and prior experiences with Aibo on their attitude towards robots. *AI & SOCIETY*, *21*(1–2), 217–230. https://doi.org/10.1007/s00146-006-0052-7

Beran, T. N., Ramirez-Serrano, A., Vanderkooi, O. G., & Kuhn, S. (2013). Reducing children's pain and distress towards flu vaccinations: A novel and effective application of humanoid robotics. *Vaccine*, *31*(25), 2772–2777. https://doi.org/10.1016/j.vaccine.2013.03.056

Bogue, R. (2013). Robots to aid the disabled and the elderly. *Industrial Robot*, *40*(6), 519–524. https://doi.org/10.1108/IR-07-2013-372

Borys, S. (1985). *Gender Differences in Loneliness.*

Brandtzaeg, P. B., & Følstad, A. (2017). Why people use chatbots. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *10673 LNCS*, 377–392. https://doi.org/10.1007/978-3-319-70284-1_30

Breazeal, C. (2003). Toward social robots. In *Robotics and Autonomous Systems* (Vol. 42, pp. 167–175).

Breazeal, C. (2011). Social robots for health applications. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, 5368–5371. https://doi.org/10.1109/IEMBS.2011.6091328

Broekens, J., Heerink, M., & Rosendal, H. (2009). Assistive social robots in elderly care: a review. *Gerontechnology*, *8*(2). https://doi.org/10.4017/gt.2009.08.02.002.00

Buecker, S., Maes, M., Denissen, J. J. A., & Luhmann, M. (2020). Loneliness and the Big Five Personality Traits: A Meta-analysis. *European Journal of Personality*, *34*(1), 8–28. https://doi.org/10.1002/per.2229

Cabibihan, J. J., Javed, H., Ang, M., & Aljunied, S. M. (2013). Why Robots? A Survey on the Roles and Benefits of Social Robots in the Therapy of Children with Autism. *International Journal of Social Robotics*, *5*(4), 593–618. https://doi.org/10.1007/s12369-013-0202-2

Cacioppo, J. T., Fowler, J. H., & Christakis, N. A. (2009). Alone in the crowd: The structure and spread of loneliness in a large social network. *Journal of Personality and Social Psychology*, *97*(6), 977–991. https://doi.org/10.1037/a0016076

Cacioppo, S., Grippo, A. J., London, S., Goossens, L., & Cacioppo, J. T. (2015). Loneliness: Clinical Import and Interventions. *Perspectives on Psychological Science*, *10*(2), 238–249. https://doi.org/10.1177/1745691615570616

Caspi, A., Harrington, H. L., Moffitt, T. E., Milne, B. J., & Poulton, R. (2006). Socially isolated children 20 years later: Risk of cardiovascular disease. *Archives of Pediatrics and Adolescent Medicine*, *160*(8), 805–811. https://doi.org/10.1001/archpedi.160.8.805

Chen, S. C., Jones, C., & Moyle, W. (2018). Social Robots for Depression in Older Adults:

A Systematic Review. *Journal of Nursing Scholarship*, *50*(6), 612–622. https://doi.org/10.1111/jnu.12423

Chen, S. C., Moyle, W., Jones, C., & Petsky, H. (2020). A social robot intervention on depression, loneliness, and quality of life for Taiwanese older adults in long-term care. *International Psychogeriatrics*, *32*(8), 981–991. https://doi.org/10.1017/S1041610220000459

Cihan, F. G., & Gökgöz Durmaz, F. (2021). Evaluation of COVID-19 phobia and the feeling of loneliness in the geriatric age group. *International Journal of Clinical Practice*. https://doi.org/10.1111/ijcp.14089

Cohen-Mansfield, J., & Perach, R. (2015). Interventions for alleviating loneliness among older persons: A critical review. *American Journal of Health Promotion*, *29*(3), e109–e125. https://doi.org/10.4278/ajhp.130418-LIT-182

Costa, R. M., Patrão, I., & Machado, M. (2019). Problematic internet use and feelings of loneliness. *International Journal of Psychiatry in Clinical Practice*, *23*(2), 160–162. https://doi.org/10.1080/13651501.2018.1539180

Dailey, M. N., Joyce, C., Lyons, M. J., Kamachi, M., Ishi, H., Gyoba, J., & Cottrell, G. W. (2010). Evidence and a Computational Explanation of Cultural Differences in Facial Expression Recognition. *Emotion*, *10*(6), 874–893. https://doi.org/10.1037/a0020019

De Graaf, M., Ben Allouch, S., & Van Dijk, J. (2017). Why Do They Refuse to Use My Robot?: Reasons for Non-Use Derived from a Long-Term Home Study. *ACM/IEEE International Conference on Human-Robot Interaction*, *Part F1271*, 224–233. https://doi.org/10.1145/2909824.3020236

de Graaf, M. M. A., Allouch, S. ben, & Klamer, T. (2015). Sharing a life with Harvey: Exploring the acceptance of and relationship-building with a social robot. *Computers*

in Human Behavior, *43*, 1–14. https://doi.org/10.1016/j.chb.2014.10.030

de Graaf, M. M. A., ben Allouch, S., & van Dijk, J. A. G. M. (2016). Long-term acceptance of social robots in domestic environments: Insights from a user's perspective. *AAAI Spring Symposium - Technical Report*, *SS-16-01-*(2004), 96–103.

de Graaf, M. M. A., Ben Allouch, S., & van Dijk, J. A. G. M. (2019). Why Would I Use This in My Home? A Model of Domestic Social Robot Acceptance. *Human-Computer Interaction*, *34*(2), 115–173. https://doi.org/10.1080/07370024.2017.1312406

de Graaf, M. M., ben Allouch, S., & van Dijk, J. A. (2018). A phased framework for long-term user acceptance of interactive technology in domestic environments. *New Media & Society*, *20*(7), 2582–2603. https://doi.org/10.1177/1461444817727264

Eyssel, F., & Reich, N. (2013). Loneliness makes the heart grow fonder (of robots) - On the effects of loneliness on psychological anthropomorphism. *ACM/IEEE International Conference on Human-Robot Interaction*, 121–122. https://doi.org/10.1109/HRI.2013.6483531

Ezer, N., Fisk, A. D., & Rogers, W. A. (2009). Attitudinal and intentional acceptance of domestic robots by younger and older adults. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *5615 LNCS*(PART 2), 39–48. https://doi.org/10.1007/978-3-642-02710-9_5

Fernaeus, Y., Håkansson, M., Jacobsson, M., & Ljungblad, S. (2010). *How do you play with a robotic toy animal?* 39. https://doi.org/10.1145/1810543.1810549

Filan, S. L., & Llewellyn-Jones, R. H. (2006). Animal-assisted therapy for dementia: a review of the literature. *International Psychogeriatrics*, *18*(4), 597–611. https://doi.org/10.1017/S1041610206003322

Fine, A. H. (2010). Handbook on Animal – Assisted Therapy Theoretical Foundations and

Guidelines for Practice Third edition Edited by. In *North*.

Fink, J. (2012). *Anthropomorphism and Human Likeness in the Design of Robots and Human-Robot Interaction*. https://doi.org/10.1007/978-3-642-34103-8_20

Fiorillo, A., & Gorwood, P. (2020). The consequences of the COVID-19 pandemic on mental health and implications for clinical practice. *European Psychiatry : The Journal of the Association of European Psychiatrists*, *63*(1), e32. https://doi.org/10.1192/j.eurpsy.2020.35

Gabrielsson, C., & Mattsson, H. (2017). Pay attention! *Architecture and Culture*, *5*(2), 157–164. https://doi.org/10.1080/20507828.2017.1350794

Gardiner, C., Geldenhuys, G., & Gott, M. (2018). Interventions to reduce social isolation and loneliness among older people: an integrative review. *Health and Social Care in the Community*, *26*(2), 147–157. https://doi.org/10.1111/hsc.12367

Glass, C. R., Gottman, J. M., & Shmurak, S. H. (1976). Response-acquisition and cognitive self-statement modification approaches to dating-skills training. *Journal of Counseling Psychology*, *23*(6), 520–526. https://doi.org/10.1037/0022-0167.23.6.520

Goldmeier, J. (1986). Pets or people: another research note. *The Gerontologist*, *26*(2), 203–206. https://doi.org/10.1093/geront/26.2.203

Goodrich, M. A., & Schultz, A. C. (2007). Human-Robot Interaction: A Survey. *Foundations and Trends® in Human-Computer Interaction*, *1*(3). https://doi.org/10.1561/1100000005

Hawkley, L. C., & Cacioppo, J. T. (2010). Loneliness Matters: A Theoretical and Empirical Review of Consequences and Mechanisms. *Annals of Behavioral Medicine*, *40*(2), 218–227. https://doi.org/10.1007/s12160-010-9210-8

Hawkley, L. C., Preacher, K. J., & Cacioppo, J. T. (2010). Loneliness impairs daytime

functioning but not sleep duration. *Health Psychology*, *29*(2), 124–129. https://doi.org/10.1037/a0018646

Hewett, T. T., Baecker, R., Card, S., Carey, T., Gasen, J., Mantei, M., & Verplank, W. (1992). *ACM SIGCHI : curricula for human-computer interaction*.

Jeong, S., Logan, D. E., Goodwin, M. S., Graca, S., O'Connell, B., Goodenough, H., Anderson, L., Stenquist, N., Fitzpatrick, K., Zisook, M., Plummer, L., Breazeal, C., & Weinstock, P. (2015). A Social Robot to Mitigate Stress, Anxiety, and Pain in Hospital Pediatric Care. *ACM/IEEE International Conference on Human-Robot Interaction*, *02-05-Marc*(1), 103–104. https://doi.org/10.1145/2701973.2702028

Jiang, Q., Li, Y., & Shypenka, V. (2018). Loneliness, Individualism, and Smartphone Addiction Among International Students in China. *Cyberpsychology, Behavior, and Social Networking*, *21*(11), 711–718. https://doi.org/10.1089/cyber.2018.0115

Jones, W. H., Hobbs, S. A., & Hockenbury, D. (1982). Loneliness and social skill deficits. *Journal of Personality and Social Psychology*, *42*(4), 682–689. https://doi.org/10.1037/0022-3514.42.4.682

Kamioka, H., Okada, S., Tsutani, K., Park, H., Okuizumi, H., Handa, S., Oshio, T., Park, S.-J., Kitayuguchi, J., Abe, T., Honda, T., & Mutoh, Y. (2014). Effectiveness of animal-assisted therapy: A systematic review of randomized controlled trials. *Complementary Therapies in Medicine*, *22*(2), 371–390. https://doi.org/10.1016/j.ctim.2013.12.016

Kertész, C., & Turunen, M. (2019). Exploratory analysis of Sony AIBO users. *AI and Society*, *34*(3), 625–638. https://doi.org/10.1007/s00146-018-0818-8

Kiecolt-Glaser, J. K., Ricker, D., George, J., Messick, G., Speicher, C. E., Garner, W., & Glaser, R. (1984). Urinary cortisol levels, cellular immunocompetency, and loneliness in psychiatric inpatients. *Psychosomatic Medicine*, *46*(1), 15–23.

https://doi.org/10.1097/00006842-198401000-00004

Kiesler, S. (2005). *Fostering Common Ground in Human-Robot Interaction **. http://www.anthorpomorphism.org

Kim, E. S., Berkovits, L. D., Bernier, E. P., Leyzberg, D., Shic, F., Paul, R., & Scassellati, B. (2013). Social robots as embedded reinforcers of social behavior in children with autism. *Journal of Autism and Developmental Disorders*, *43*(5), 1038–1049. https://doi.org/10.1007/s10803-012-1645-2

Kowalski, N. C. (1981). Institutional Relocation: Current Programs and Applied Approaches. *The Gerontologist*, *21*(5), 512–519. https://doi.org/10.1093/geront/21.5.512

Kozyavkin, V., Kachmar, O., & Ablikova, I. (2014). Humanoid social robots in the rehabilitation of children with cerebral palsy. *Proceedings - REHAB 2014*, 430–431. https://doi.org/10.4108/icst.pervasivehealth.2014.255323

Lauder, W., Mummery, K., Jones, M., & Caperchione, C. (2006). A comparison of health behaviours in lonely and non-lonely populations. *Psychology, Health & Medicine*, *11*(2), 233–245. https://doi.org/10.1080/13548500500266607

Lee, K. M., Jung, Y., Kim, J., & Kim, S. R. (2006a). Are physically embodied social agents better than disembodied social agents?: The effects of physical embodiment, tactile interaction, and people's loneliness in human-robot interaction. *International Journal of Human Computer Studies*, *64*(10), 962–973. https://doi.org/10.1016/j.ijhcs.2006.05.002

Lee, K. M., Jung, Y., Kim, J., & Kim, S. R. (2006b). Are physically embodied social agents better than disembodied social agents?: The effects of physical embodiment, tactile interaction, and people's loneliness in human-robot interaction. *International Journal of Human Computer Studies*, *64*(10), 962–973.

https://doi.org/10.1016/j.ijhcs.2006.05.002

Leite, I., Martinho, C., & Paiva, A. (2013). Social Robots for Long-Term Interaction: A Survey. *International Journal of Social Robotics*, *5*(2), 291–308. https://doi.org/10.1007/s12369-013-0178-y

Li, S., Yu, F., & Peng, K. (2020). Effect of State Loneliness on Robot Anthropomorphism: Potential Edge of Social Robots Compared to Common Nonhumans. *Journal of Physics: Conference Series*, *1631*(1). https://doi.org/10.1088/1742-6596/1631/1/012024

Lomas, P. (2005). Anthropomorphism, personification and ethics: a reply to Alexander Wendt. *Review of International Studies*, *31*(2). https://doi.org/10.1017/S0260210505006480

Lotfi, A., Langensiepen, C., & Yahaya, S. (2018). Socially Assistive Robotics: Robot Exercise Trainer for Older Adults. *Technologies*, *6*(1), 32. https://doi.org/10.3390/technologies6010032

Luanaigh, C. Ó., & Lawlor, B. A. (2008). Loneliness and the health of older people. *International Journal of Geriatric Psychiatry*, *23*(12), 1213–1221. https://doi.org/10.1002/gps.2054

Masi, C. M., Chen, H. Y., Hawkley, L. C., & Cacioppo, J. T. (2011). A meta-analysis of interventions to reduce loneliness. *Personality and Social Psychology Review*, *15*(3), 219–266. https://doi.org/10.1177/1088868310377394

Matthews, T., Danese, A., Gregory, A. M., Caspi, A., Moffitt, T. E., & Arseneault, L. (2017). Sleeping with one eye open: Loneliness and sleep quality in young adults. *Psychological Medicine*, *47*(12), 2177–2186. https://doi.org/10.1017/S0033291717000629

McCarthy, C., Butchart, J., George, M., Kerr, D., Kingsley, H., Scheinberg, A. M., & Sterling, L. (2015). Robots in Rehab: Towards socially assistive robots for paediatric

rehabilitation. *OzCHI 2015: Being Human - Conference Proceedings*, 39–43. https://doi.org/10.1145/2838739.2838791

Montemerlo, M., Pineau, J., Roy, N., Thrun, S., & Verma, V. (2002). Experiences with a mobile robotic guide for the elderly. *Proceedings of the National Conference on Artificial Intelligence*, 587–592.

Moyle, W., Kellett, U., Ballantyne, A., & Gracia, N. (2011). Dementia and loneliness: an Australian perspective. *Journal of Clinical Nursing*, *20*(9–10), 1445–1453. https://doi.org/10.1111/j.1365-2702.2010.03549.x

Mubin, O., Henderson, J., & Bartneck, C. (2014). *You Just Do Not Understand Me! Speech Recognition in Human Robot Interaction.*

Nanay, B. (2021). Zoomorphism. *Erkenntnis*, *86*(1), 171–186. https://doi.org/10.1007/s10670-018-0099-0

Niedzwiedz, C. L., Richardson, E. A., Tunstall, H., Shortt, N. K., Mitchell, R. J., & Pearce, J. R. (2016). The relationship between wealth and loneliness among older people across Europe: Is social participation protective? *Preventive Medicine*, *91*, 24–31. https://doi.org/10.1016/j.ypmed.2016.07.016

Nimer, J., & Lundahl, B. (2007). Animal-Assisted Therapy: A Meta-Analysis. *Anthrozoös*, *20*(3), 225–238. https://doi.org/10.2752/089279307X224773

Nowland, R., Necka, E. A., & Cacioppo, J. T. (2018). Loneliness and Social Internet Use: Pathways to Reconnection in a Digital World? *Perspectives on Psychological Science*, *13*(1), 70–87. https://doi.org/10.1177/1745691617713052

Odendaal, J. S. J. (2000). Animal-assisted therapy — magic or medicine? *Journal of Psychosomatic Research*, *49*(4), 275–280. https://doi.org/10.1016/S0022-3999(00)00183-5

Ong, A. D., Uchino, B. N., & Wethington, E. (2016). Loneliness and Health in Older Adults:

A Mini-Review and Synthesis. *Gerontology*, *62*(4), 443–449. https://doi.org/10.1159/000441651

Peplau, L., & Perlman, Daniel. (1982). Loneliness : a Sourcebook of Current Theory, Research, and Therapy. *Wiley*.

Pettigrew, S., & Roberts, M. (2008). Addressing loneliness in later life. *Aging & Mental Health*, *12*(3), 302–309. https://doi.org/10.1080/13607860802121084

Pilisuk, M., & Minkler, M. (1980). Supportive Networks: Life Ties for the Elderly. *Journal of Social Issues*, *36*(2), 95–116. https://doi.org/10.1111/j.1540-4560.1980.tb02024.x

Poletz, L., Encarnação, P., Adams, K., & Cook, A. (2010). Robot skills and cognitive performance of preschool children. *Technology and Disability*, *22*(3), 117–126. https://doi.org/10.3233/TAD-2010-0296

Pu, L., Moyle, W., Jones, C., & Todorovic, M. (2019). The Effectiveness of Social Robots for Older Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Studies. *Gerontologist*, *59*(1), E37–E51. https://doi.org/10.1093/geront/gny046

Rafaeli, A., Ziklik, L., & Doucet, L. (2008). The Impact of Call Center Employees' Customer Orientation Behaviors on Service Quality. *Journal of Service Research*, *10*(3), 239–255. https://doi.org/10.1177/1094670507306685

Riek, L. (2012). Wizard of Oz Studies in HRI: A Systematic Review and New Reporting Guidelines. *Journal of Human-Robot Interaction*, *1*(1), 119–136. https://doi.org/10.5898/jhri.1.1.riek

Rook, K. S. (1984). Promoting social bonding: Strategies for helping the lonely and socially isolated. *American Psychologist*, *39*(12), 1389–1407. https://doi.org/10.1037/0003-066X.39.12.1389

Ros, R., Demiris, Y., Baroni, I., & Nalin, M. (2011). Adapting robot behavior to user's

capabilities: A dance instruction study. *HRI 2011 - Proceedings of the 6th ACM/IEEE International Conference on Human-Robot Interaction*, 235–236. https://doi.org/10.1145/1957656.1957748

Rudatsikira, E., Muula, A. S., Siziya, S., & Twa-Twa, J. (2007). Suicidal ideation and associated factors among school-going adolescents in rural Uganda. *BMC Psychiatry*, *7*(1), 67. https://doi.org/10.1186/1471-244X-7-67

Russell, D., Peplau, L. A., & Cutrona, C. E. (1980). The revised UCLA Loneliness Scale: Concurrent and discriminant validity evidence. *Journal of Personality and Social Psychology*, *39*(3), 472–480. https://doi.org/10.1037/0022-3514.39.3.472

Šabanovic, S., Bennett, C. C., Chang, W. L., & Huber, L. (2013). PARO robot affects diverse interaction modalities in group sensory therapy for older adults with dementia. *IEEE International Conference on Rehabilitation Robotics*. https://doi.org/10.1109/ICORR.2013.6650427

Šabanović, S., Chang, W.-L., Bennett, C. C., Piatt, J. A., & Hakken, D. (2015). *A Robot of My Own: Participatory Design of Socially Assistive Robots for Independently Living Older Adults Diagnosed with Depression* (pp. 104–114). https://doi.org/10.1007/978-3-319-20892-3_11

Sabelli, A. M., Kanda, T., & Hagita, N. (2011). A conversational robot in an elderly care center: An ethnographic study. *HRI 2011 - Proceedings of the 6th ACM/IEEE International Conference on Human-Robot Interaction*, 37–44. https://doi.org/10.1145/1957656.1957669

Salimi, A. (2011). Social-emotional loneliness and life satisfaction. *Procedia - Social and Behavioral Sciences*, *29*, 292–295. https://doi.org/10.1016/j.sbspro.2011.11.241

Sanoubari, E., & Young, J. E. (2018a). Explicit, Neutral, or Implicit: A Cross-cultural

Exploration of Communication-style Preferences in Human Robot Interaction. *ACM/IEEE International Conference on Human-Robot Interaction*, 237–238. https://doi.org/10.1145/3173386.3177061

Sanoubari, E., & Young, J. E. (2018b). Hi human, can we talk? An in-the-wild study template for robots approaching unsuspecting participants. *Workshop on the Social Robots in the Wild at the International Conference on Human-Robot Interaction.*

Sawir, E., Marginson, S., Deumert, A., Nyland, C., & Ramia, G. (2008). Loneliness and International Students: An Australian Study. *Journal of Studies in International Education*, *12*(2), 148–180. https://doi.org/10.1177/1028315307299699

Schodde, T., Bergmann, K., & Kopp, S. (2017). Adaptive Robot Language Tutoring Based on Bayesian Knowledge Tracing and Predictive Decision-Making. *ACM/IEEE International Conference on Human-Robot Interaction*, *Part F1271*, 128–136. https://doi.org/10.1145/2909824.3020222

Severson, R. L., & Lemm, K. M. (2016). Kids See Human Too: Adapting an Individual Differences Measure of Anthropomorphism for a Child Sample. *Journal of Cognition and Development*, *17*(1), 122–141. https://doi.org/10.1080/15248372.2014.989445

Stickley, A., Koyanagi, A., Roberts, B., Richardson, E., Abbott, P., Tumanov, S., & McKee, M. (2013). Loneliness: Its Correlates and Association with Health Behaviours and Outcomes in Nine Countries of the Former Soviet Union. *PLoS ONE*, *8*(7). https://doi.org/10.1371/journal.pone.0067978

Sung, J. Y., Grinter, R. E., & Christensen, H. I. (2010). Domestic robot ecology: An initial framework to unpack long-term acceptance of robots at home. *International Journal of Social Robotics*, *2*(4), 417–429. https://doi.org/10.1007/s12369-010-0065-8

Sung, J.-Y., Guo, L., Grinter, R. E., & Christensen, H. I. (n.d.). "My Roomba Is Rambo":

Intimate Home Appliances. In *UbiComp 2007: Ubiquitous Computing* (pp. 145–162). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-74853-3_9

Tilvis, R. S., Kahonen-Vare, M. H., Jolkkonen, J., Valvanne, J., Pitkala, K. H., & Strandberg, T. E. (2004). Predictors of Cognitive Decline and Mortality of Aged People Over a 10-Year Period. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *59*(3), M268–M274. https://doi.org/10.1093/gerona/59.3.M268

Van Oerle, S., Mahr, D., & Lievens, A. (2016). Coordinating online health communities for cognitive and affective value creation. *Journal of Service Management*, *27*(4), 481–506. https://doi.org/10.1108/JOSM-09-2015-0264

Wada, K., & Shibata, T. (2006). Robot therapy in a care house - Its sociopsychological and physiological effects on the residents. *Proceedings - IEEE International Conference on Robotics and Automation*, *2006*(May), 3966–3971. https://doi.org/10.1109/ROBOT.2006.1642310

Wada, K., & Shibata, T. (2007). Living with seal robots - Its sociopsychological and physiological influences on the elderly at a care house. *IEEE Transactions on Robotics*, *23*(5), 972–980. https://doi.org/10.1109/TRO.2007.906261

Wada, K., Shibata, T., Musha, T., & Kimura, S. (2008). Robot therapy for elders affected by dementia. *IEEE Engineering in Medicine and Biology Magazine*, *27*(4), 53–60. https://doi.org/10.1109/MEMB.2008.919496

Wada, K., Shibata, T., Saito, T., & Tanie, K. (2004). Effects of robot-assisted activity for elderly people and nurses at a day service center. *Proceedings of the IEEE*, *92*(11), 1780–1788. https://doi.org/10.1109/JPROC.2004.835378

Wallerstein, J. S., & Kelly, J. B. (1977). Divorce counseling: A community service for families in the midst of divorce. *American Journal of Orthopsychiatry*, *47*(1), 4–22.

https://doi.org/10.1111/j.1939-0025.1977.tb03240.x

Waytz, A., Cacioppo, J., & Epley, N. (2010). Who sees human? The stability and importance of individual differences in anthropomorphism. *Perspectives on Psychological Science*, *5*(3), 219–232. https://doi.org/10.1177/1745691610369336

Wilson, R. S., Krueger, K. R., Arnold, S. E., Schneider, J. A., Kelly, J. F., Barnes, L. L., Tang, Y., & Bennett, D. A. (2007). Loneliness and risk of Alzheimer disease. *Archives of General Psychiatry*, *64*(2), 234–240. https://doi.org/10.1001/archpsyc.64.2.234

Yamazaki, K., Ueda, R., Nozawa, S., Kojima, M., Okada, K., Matsumoto, K., Ishikawa, M., Shimoyama, I., & Inaba, M. (2012). Home-assistant robot for an aging society. *Proceedings of the IEEE*, *100*(8), 2429–2441. https://doi.org/10.1109/JPROC.2012.2200563

Young, J. E., Hawkins, R., Sharlin, E., & Igarashi, T. (2009). Toward acceptable domestic robots: Applying insights from social psychology. *International Journal of Social Robotics*, *1*(1), 95–108. https://doi.org/10.1007/s12369-008-0006-y

Young, J. E.; L. A. P. D. P. (1982). Loneliness, Depression and Cognitive Therapy: Theory and Application. *Loneliness : A Sourcebook of Current Theory, Research, and Therapy*, 379–406.

Yu, Bin., Steptoe, Andrew., Niu, Kaijun., Ku, P. Wen., & Chen, L. Jung. (2018). Prospective associations of social isolation and loneliness with poor sleep quality in older adults. *Quality of Life Research*, *27*(3), 683–691. https://doi.org/10.1007/s11136-017-1752-9

Appendix

Appendix A – Research Ethics Board Approval

University of Manitoba | Research Ethics and Compliance

Human Ethics - Fort Garry
208-194 Dafoe Road
Winnipeg, MB R3T 2N2
T: 204 474 8872
humanethics@umanitoba.ca

PROTOCOL APPROVAL

To: **James Young**
Principal Investigator

From: **Andrea Szwajcer, Chair**
Research Ethics Board 2 (REB 2)

[redacted]

Re: **Protocol # R2-2021:021 (HS24711)**
Investigating Long-Term Use of Pet Robots in Homes for Wellness Support

---

Effective: April 29, 2021 **Expiry:** April 29, 2022

Research Ethics Board 2 (REB 2) has reviewed and approved the above research.

REB 2 is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans – TCPS 2 (2018)*.

This approval is subject to the following conditions:

i. Approval is granted for the research and purposes described in this application only.

ii. Any changes to this research must be approved by the Human Ethics Office (HEO) before implementation.

iii. Any deviations to the research or adverse events must be reported to the HEO immediately.

iv. This approval is valid for one year only. A Renewal Request Form must be submitted and approved prior to the above expiry date.

v. A Study Closure Form must be submitted to the HEO when the research is complete prior to the above expiry date, or if the research is terminated.

vi. The University of Manitoba (UM) may request to audit your research documentation to confirm compliance with this approved protocol, and with the UM *Ethics of Research Involving Humans* policies and procedures.

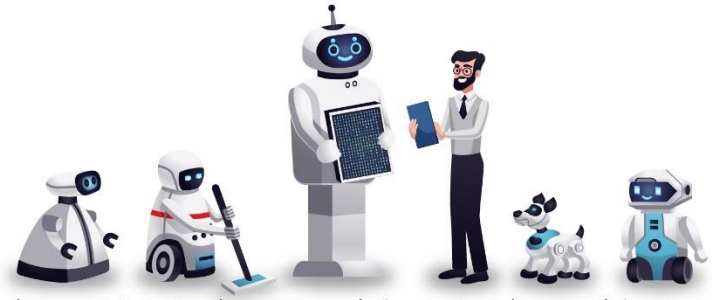
Funded Protocols: Email a copy of this Protocol Approval, with the corresponding UM Project Number, to ResearchGrants@umanitoba.ca

Appendix B - Recruitment Poster

University of Manitoba

HCI Lab
UNIVERSITY OF MANITOBA

Are you interested in keeping a robot in your home for up to 8 weeks to contribute to science?



We are looking for people to participate in a long-term study (approximately 10 weeks) to investigate how social robots impact people's overall wellness. We are recruiting people who live alone, and who feel that they are lonely. Unfortunately, at this time we cannot accept participants who have been diagnosed, or suspect they may be living with, serious conditions such as depression, or un-managed stress and/or anxiety, as we are not trained to appropriately help in these situations. If you feel that you could use help or would like to talk to someone, please visit the following website that lists local resources:

- https://umanitoba.ca/student-supports/counselling-resources-students
- https://sharedhealthmb.ca/covid19/providers/mental-health-resources

In this study, you get an opportunity to keep a social robot in your own home for approximately 8 weeks. During the study, you will complete weekly questionnaires and bi-weekly online interview sessions. Participation in each of the bi-weekly interview sessions will take approximately 30-45 minutes of your time. Completing the questionnaires and diary entries will take you around 10 minutes each time. You will receive a $20 (Canadian dollars) initial compensation plus an additional $20 each week for maximum amount of $220 for 10 weeks as you continue the study.

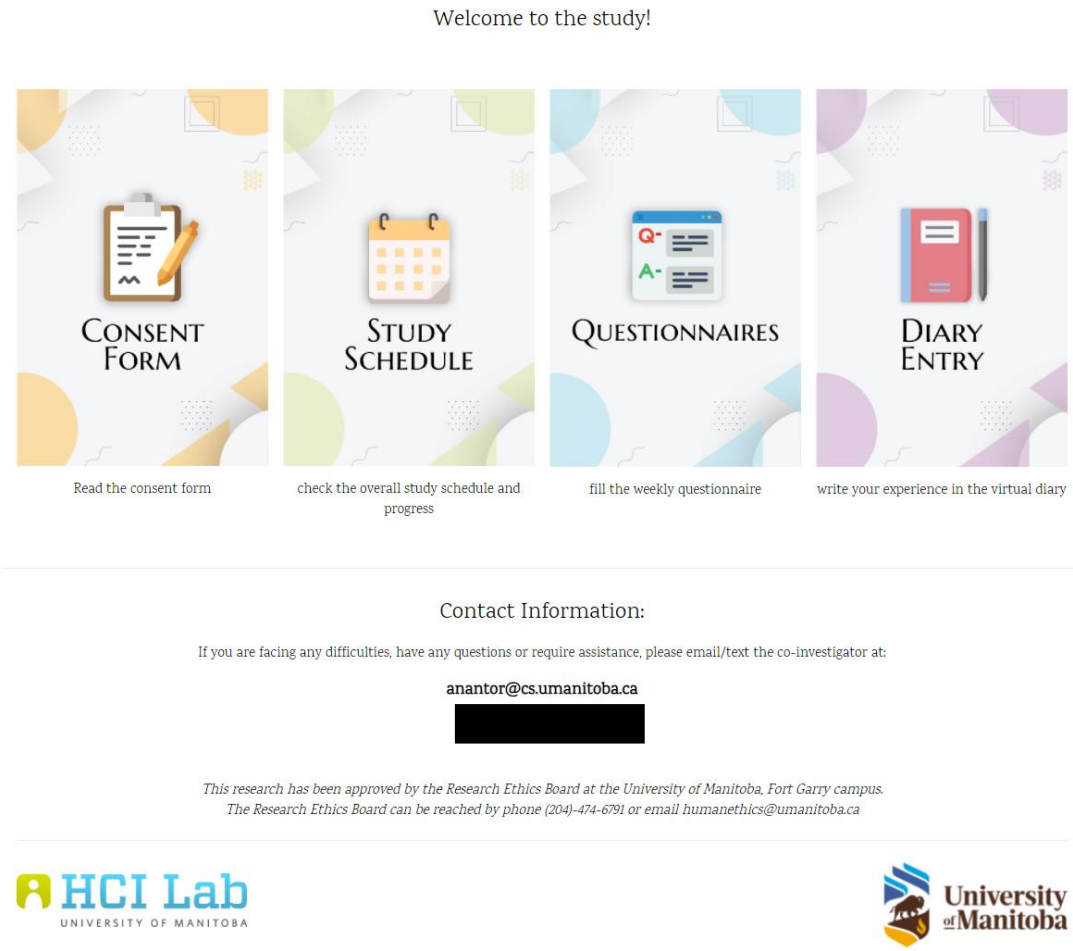
We are following all the necessary university-mandated protocols for COVID-19 and the procedures will be described on intake. To qualify for the study, you need to be at least 18 years old. If you are interested to be a part of the study, please contact -

Rahatul Amin Ananto
anantor@cs.umanitoba.ca

Principal Investigator - Dr. James E. Young

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. The Research Ethics Board can be reached by phone (204) 474-6791 or email humanethics@umanitoba.ca

Appendix C - Project Website



Appendix D – UCLA Loneliness Scale

Participant ID _____ Session _____ Study _____ Date____/____/____

(this is a standardized questionnaire, D. Russell, "Ucla Loneliness Scale Version 3 (description of Measure)," J. Pers. Soc. Psychol., vol. 39, pp. 3–4, 1996.)

Instructions: Indicate how often each of the statements below is descriptive of you.

As a reminder, you are free to withdraw from the study at any time or not answer any question.

Statement	Never	Rarely	Sometimes	Often
1. How often do you feel that you are "in tune" with the people around you?	1	2	3	4
2. How often do you feel that you lack companionship?	1	2	3	4
3. How often do you feel that there is no one you can turn to?	1	2	3	4
4 How often do you feel alone?	1	2	3	4
5. How often do you feel part of a group of friends?	1	2	3	4
6. How often do you feel that you have a lot in common with the people around you?	1	2	3	4
7. How often do you feel that you are no longer close to any-one?	1	2	3	4
8. How often do you feel that your interests and ideas are not shared by those around you?	1	2	3	4
9. How often do you feel outgoing and friendly?	1	2	3	4
10. How often do you feel close to people?	1	2	3	4
11. How often do you feel left out?	1	2	3	4
12. How often do you feel that your relationships with others are not meaningful?	1	2	3	4
13. How often do you feel that no one really knows you well?	1	2	3	4
14. How often do you feel isolated from others?	1	2	3	4
15. How often do you fee1 you can find companionship when you want it?	1	2	3	4
16. How often do you feel that there are people who really un-derstand you?	1	2	3	4
17. How often do you feel shy?	1	2	3	4
18. How often do you feel that people are around you but not with you?	1	2	3	4
19. How often do you feel that there are people you can talk to?	1	2	3	4
20. How often do you feel that there are people you can turn to?	1	2	3	4

Appendix E – STAI Scale

Participant ID _____ Session _____ Study _____ Date____/____/____

(this is a standardized questionnaire, A. Wenzel, "State-Trait Anxiety Inventory," SAGE Encycl. Abnorm. Clin.Psychol., pp. 3–4, 2017, doi: 10.4135/9781483365817.n1316.)

Instructions: Several statements which people have used to describe themselves are given below. Read each statement and then circle the response option to the right to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

As a reminder, you are free to withdraw from the study at any time or not answer any question.

Sl. No.		Not at all	Somewhat	Moderately so	Very much so
1	I feel calm	1	2	3	4
2	I feel secure	1	2	3	4
3	I am tense	1	2	3	4
4	I am regretful	1	2	3	4
5	I feel at ease	1	2	3	4
6	I feel upset	1	2	3	4
7	I am presently worrying about possible misfortunes	1	2	3	4
8	I feel rested	1	2	3	4
9	I feel anxious	1	2	3	4
10	I feel comfortable	1	2	3	4
11	I feel self-confident	1	2	3	4
12	I feel nervous	1	2	3	4
13	I am jittery	1	2	3	4
14	I feel "high strung"	1	2	3	4
15	I am relaxed	1	2	3	4
16	I feel content	1	2	3	4
17	I am worried	1	2	3	4
18	I feel over-excited and rattled	1	2	3	4
19	I feel joyful	1	2	3	4
20	I feel pleasant	1	2	3	4

Appendix F – PANAS Scale

Participant ID _____ Session _____ Study _____ Date____/____/____

(this is a standardized questionnaire, I. Brdar, "Positive and Negative Affect Schedule (PANAS)," Encycl. Qual. Life Well-Being Res., pp. 4918–4920, 2014, doi: 10.1007/978-94-007-0753-5_2212.)

Instruction: Please read the following and indicate what you feel right now.

As a reminder, you are free to withdraw from the study at any time or not answer any question.

Positive and Negative Affect Schedule (PANAS)		**Very slightly or not at all**	**A little**	**Moderately**	**Quite a bit**	**Extremely**
1	Interested	1	2	3	4	5
2	Distressed	1	2	3	4	5
3	Excited	1	2	3	4	5
4	Upset	1	2	3	4	5
5	Strong	1	2	3	4	5
6	Guilty	1	2	3	4	5
7	Scared	1	2	3	4	5
8	Hostile	1	2	3	4	5
9	Enthusiastic	1	2	3	4	5
10	Proud	1	2	3	4	5
11	Irritable	1	2	3	4	5
12	Alert	1	2	3	4	5
13	Ashamed	1	2	3	4	5
14	Inspired	1	2	3	4	5
15	Nervous	1	2	3	4	5
16	Determined	1	2	3	4	5
17	Attentive	1	2	3	4	5
18	Jittery	1	2	3	4	5
19	Active	1	2	3	4	5
20	Afraid	1	2	3	4	5

Appendix G – Questions for Interviews based on Phases

The below text is our semi-structured interview protocols for each phase of the study. Before starting each interview session, the researcher will remind the participants that they can withdraw their participation to the study at any time, and they may choose to refrain from answering any questions during the interview sessions.

Initial Intake Phase

Goal: background and context

- Can you please tell me a bit about yourself? Your background?
- Why do you live alone? Were you ever married or had a partner?
- How long have you been living alone?
- Did you go to school or trade school?
    - Do you see friends and family often?
    - Follow focuses: work history, hobbies, family, children, pets.

Goal: attitude toward technology

- Do you generally like trying new technologies, or perhaps are you not interested? (For example, this may be iPad or smartphones, but also new kitchen gadgets, or garage tools, new garden gadgets?)
- Can you tell me about a new piece of technology that you bought lately? Like a new computer, stereo system, or a TV, or a new kitchen appliance….
    - Did you end up using it in the way you thought?
    - Did you enjoy using it?
    - Was it frustrating…?
- Have you ever had a smartphone? / Can you tell me about your feelings when you got your first smartphone?
- Do you use only the basic features of a technology? or do you like to explore?
  Learn about advanced features?

Goals: attitude toward / experience with robots.

- Can you tell me anything about robots? Do you have any experiences, or maybe have you seen a TV program about them?
  (if they only talk about factory robots)
    - Have you heard about robots in homes? In hospitals?
    - Can you tell me anything about social robots?
    - How do you feel about having a robot in your home?

Goal: loneliness

- Why were you interested in this study?
- Can you tell me a little about your daily routines and lifestyle?
- Do you have any hobbies or specific interests?
- If they mention they are lonely
    - Can you tell me a little bit about that?
    - What do you think may be causing this?
- Do you think a robot might be able to help improve your quality of life?

- What do you think a social robot may be able to do for you?

First-Encounter

Goal: Expectations

- When you got to know that you would receive a robot, what was your expectation towards it?
- Did you think that you would get a robotic pet?
- What was your first impression of the robot?
- Now that you've seen the robot, what do you think about it?
    - What do you think of how the robot looks?

Goal: Robots and Pets

- Can you tell me about your interaction experience with the robot?
- Do you like anything particular about the robot?
- Do you find any similarity between the robot and a pet or an animal? Can you explain?
    - What about differences?
- What do you expect from a pet?
- Do you think you would eventually treat your robot as if it was a real pet?
- Will you be able to consider the robot as a pet if it meets the expectation?
- Do you think the robot will be able to understand you?
- Do you think it will judge you?
- What do you think the robot is capable of doing?
- Do you think you will be comfortable interacting with a robot?
- Do you see the robot as life-like?

Goal: Thoughts about the robot

- Do you think robots will be helpful in reducing loneliness?
- What do you think about the idea that this robot may be programmed to like you?
- What do you feel about having a robot in your home?
- Do you have any plans for what you will do with the robot in the next few weeks? What are you planning to do with the robot?
- Do you think you'll keep interacting with the robot?
    - How do you want to interact with the robot in the coming weeks?
- Would you rather interact with the robot or a regular stuffed animal?
- Do you think you will like cuddling with the robot? / Do you think cuddling with the robot will help with loneliness?

Ongoing-During

Goal: Relationship and interaction with the Robot

- How do you feel about interacting with the robot?
    - Do you enjoy it?
    - How do you feel when talking to it?
    - Do you feel like it understands you?

- Do you think the robot is intelligent?
- Do you feel like the robot is useful?
- Do you think using the robot is easy or hard?
    - What is easy?
    - What is hard?
- Can you describe the relationship you have with the robot?
- Do you feel the need to interact with the robot?
- When you go out for work, do you turn the robot off?
- If you keep the robot operating while you are gone,
    - do you feel the robot misses you?
    - Do you miss the robot?
- Do you think the robot has grown to have some feelings for you?
- Do you think you will have a strong bond with the robot in the long run?
- Do you feel like you and the robot are creating a connection?
    - Does it help when you talk with the robot?
- Can you describe how a typical interaction with the robot goes?

Goal: Sociability and Acceptance

- Do you see the robot as life-like?
- Do you think it has any type of social skills?
- Has the robot disappointed you in any way?
- What would you change in the robot?
- Do you feel safe when interacting with the robot?
    - Does it have something to do with it being completely offline?

Goal: Robot as a pet

- Do you view the robot as a pet?
- Did you find any new similarities between the robot and an actual puppy?

Goal: Experience

- Did you notice anything new while interacting with the robot?
- What kind of conversations do you tend to have with the robot?
- Did anything exciting happen?
- Did you learn something new about the robot? can you explain?
- Do you feel like you use the robot differently?

Goal: Interaction Changes

- How often do you interact with the robot? Is there a particular time you interact with it?
    - How long do you interact with it each time?
    - How often have you used it since we last spoke?
- How much do you speak with the robot?
- Do you think the robot makes a lot of errors?
- Do you interact with the robot after a certain circumstance? – after a long day of work, working out for some time, or in a lonely evening?
- If we gave you the option, would you consider keeping the robot for longer in your home?
    - If no,
        - why?
        - Would you change something?

        - Do you just don't feel comfortable with it around?
    - If yes
        - why?
        - Has the robot helped?
        - Would you want to change something about it?

Goal: Social Involvement

- Did you tell anyone about the robot?
- Did you have any guests over since we last spoke?
- Did the robot help you in any way to start a conversation with someone?
- Does anyone from your work know that you have a robot in your home?
    - Did they show any interest to know more about it?
    - What did you feel about their interest?

Goal: Impact on loneliness

- How are you feeling since you got the robot?
- Does the robot make you feel happy?
- Has the robot impacted your mood?
- Has there been any changes in your life or anything you'd like to talk about, since getting the robot?
- Do you feel that this has been a positive thing for you, a negative thing, or no real change?
- Now that you have some experience with a robot pet, do you think pets can be helpful in reducing loneliness? Can you explain?

Exit interview

Goal: Relationship with the Robot

- How close are you with the robot?
- Did having the robot around help you in any way?
- Did the robot fulfill your expectations, or did you lose interest as the study progressed?
- Could you imagine having one of these for longer?
- How did you feel about robot errors?
    - Did you learn how to work around them?
- Do you feel any urge to comfort the robot? – by patting its head when it is looking for your attention or when it's crying.
- Do you consider the robot as a companion?
    - Do you think it has the potential to be a companion?
        - What would you change to make it a better companion?
- Do you think if the robot was connected to the internet you would talk to it as much or would you be worried about the privacy aspect?

Goal: Interaction process

- Do you feel like the way you interact with a robot has changed in any way?
- Do you still consider it as a machine, or do you think it has the capability to understand your feelings?

Goal: Opinion

- Would you have preferred a robot that could speak?
- Do you think a stuffed toy would be able to make you feel the same way as the robot did?
- How do you feel about giving back the robot?
- Do you think you will miss its presence in the coming days?
- What do you plan to do to mitigate your loneliness now that the robot will be gone?
- What is your view towards having a robot in your home?
- Are people ready to accept a robot in their daily lives as a companion? – can you explain?
- How effective the robot was in helping you with your loneliness?

Follow-up Phase

Goal: Lifestyle

- Do you feel any difference in your lifestyle?
- Have you sought out more people to talk to, now that the robot is not around?
- How does your routine look like now that the robot is gone?
- How do you feel about not having the robot anymore?
    - Now that some days have passed, would you consider having the robot back?

Goal: Social Communication

- How often do you contact your friends and family?
    - What do you like to talk about with them?
    - How do you feel communicating with them?

Goal: Robots in home

- What is your view towards having a robot in your home?
- Are people ready to accept a robot in their daily lives as a companion? – can you explain?
- How effective the robot was in helping you with your loneliness?

Appendix H - Study Schedule and Protocols

Participant ID _____

(Dates will be scheduled later)

Item	Date	Phase	Questionnaire	Interview
Week 1 -Initial session – 1 Week Before robot delivery		Initial-Interaction	Yes	Yes
Week 2 - Robot Delivery		First-Encounter	Yes	Yes
Week 3		Ongoing-during	Yes	Yes
Week 4		Ongoing-during	Yes	
Week 5		Ongoing-during	Yes	Yes
Week 6		Ongoing-during	Yes	
Week 7		Ongoing-during	Yes	Yes
Week 8		Ongoing-during	Yes	
Week 9 Last Day of Robot deployment		Exit	Yes	Yes
Week 10 Follow-up Session		Follow-up	Yes	Yes

Study Protocols

List of Appendix:

Appendix A: Semi-structured Interview Questions

Appendix B: Consent Form and Exit Reflection Form

Appendix C: Questionnaire A

Appendix D: Questionnaire B

Appendix E: Questionnaire C

Appendix F: Schedule and Protocol

Appendix G: Demographic Questionnaire

Appendix H: Diary Entry Form with Questions

The following lists the specific steps for our study. The exact text that will be read to the participants is given in blue.

During initial intake phone / video chat interview:

Expected Outcome: This phase will provide important context for analyzing and understanding participants' attitude toward companion robots before use (rather than attitudes toward the robot from use) and provide insights on their initial expectations towards the robot.

Procedure: One researcher will meet a participant using phone/video chat platform on a pre-scheduled date.

Thank you for joining us. We will conduct this longitudinal study over a 10-week period. First, we will do this initial interview, today. Then, we will have the first encounter phase when you will first get the robot. After you have the robot, we will do biweekly interviews and weekly questionnaires, to be conducted online (you can select your preferred platform – phone or online interview using software of your choice). Finally, we'll talk again on the day that the study finishes, and we pick up the robot, and finally we will do a follow-up interview session a week after. You will receive a $20 honorarium after signing the consent form today and you will receive $20 for every week for up to 10 weeks during the study. We intend to give the honorarium to you using e-transfer, however, if you prefer, we will give you the honorarium in cash by properly disinfecting and placing them in an envelope. You will receive the URL of the online questionnaires in your email. I understand that this is a lot to take in. I'll be giving you a schedule, and you will only have to do things once or twice A week. Do you have any questions at this point?

The University of Manitoba is committed to taking measures to protect the health and safety of their campuses and the wider community. Your safety is important to us. The university has suspended most research that cannot be conducted remotely or virtually. Our study has been approved to proceed by our Faculty, the Vice-President (Research and International)'s office and the Joint-Faculty Research Ethics Board. In order to gain approval, we created policies to ensure the safety of the research team and participants. These plans were reviewed and approved by the parties above, as well as a representative from the Office of Risk Management. These policies include:

- All study research teams will wear masks during delivering and picking up the robot from your doorstep.
- We require all of our research team members to screen themselves for symptoms daily.
- We are following meticulous infection control practices, including disinfection, wearing gloves, and hand washing.
- If you have any symptoms of COVID, you need to inform us before our visit to your residence.
- Research team members will be travelling to your residence in their own vehicles and the vehicles will be thoroughly disinfected before the trip.
- You are receiving a box where you will find a robot. The robot has been disinfected and placed in a plastic wrap inside the box. The box was also disinfected using standard disinfecting wipes.

We want to inform you that we need to record the online interview sessions for research analyses purposes. You will learn more about this in the inform consent form (Appendix B) that I am sending you now. You will receive an URL in your email that will redirect you to the informed consent form. You need to put your whole name in a text box in the online informed consent form and submit it. A copy of the informed consent form will be emailed to you for your reference. After submitting the form, you will be redirected to the questionnaires (Appendix C, D, E, G) for today's session. Please complete the consent form and the questionnaires, and then we will further continue today's session. Let me know if you have any questions.

After they sign the consent form and complete the questionnaires -

Great! Thanks for taking your time to complete the questionnaires. We will send you a similar email once a week that will redirect you to the webpage containing the questionnaires (Appendix C, D, E). You will also get a reminder in the middle of the week to complete a diary entry form (Appendix H). The diary entries will help you remember the interactions you had with the robot throughout the week.

(not read to participants) The online questionnaire platform will be programmed using Survey Monkey where the survey will be hosted on password protected servers in US, Ireland or Canada using encrypted data. Once downloaded, data will be stored on password-protected encrypted drives of the researchers (specifically, the Principal and Co-Investigators). Researcher will start the initial interaction interview session after the participants complete the questionnaires, and the interview session will consist of questions from the question sets explicitly designed for this session (Appendix A).

After the interview session is complete, the researcher will remind the participant about the next scheduled session and what they might be expecting in that session.

First-encounter Protocol

Expected Outcome: This phase will give us insights on participants' thoughts about the robot, their interaction plans, and their expectations from the robot, right after they interact with the robot for the first time.

Procedure: One researcher will take a box consisting of a robot and leave it outside the participant's residence. Once the researcher confirms that the participant received the box, they will go back to the lab and conduct the first-encounter interview session online.

Thanks for joining us! I assume you already found a robot inside this box with the instructions on how to use it.

If they say they did not open it, the researcher will ask them to open the box and take out the robot.

Please don't hesitate to interact with the robot. You will not be accountable for any damages that may (or may not) occur to the robot. You are free to play with it however you are comfortable. Think of it as your own and interact with it likewise. If you encounter any error or suspected malfunction with the robot, please contact us so we can assist you. Talking about interaction, did you get the chance to turn it on and play with it?

If they say they did not interact with it, the researcher will ask them to interact with the robot for a while. After they are done interacting, the researcher will ask them to fill-up the online questionnaires allocated for that day.

Now that you have interacted with the robot for the first time, I am sending you the URL for today's questionnaires. Please complete them and then we will have a short interview session.

Then, the researcher will conduct the first-encounter interview session, which will consist of questions from the question sets designed specifically for that session (Appendix A).

Afterward, the researcher will remind them about the next phases and what they might be expecting in the coming days.

Ongoing-During Protocol

Expected Outcome: The interview sessions from this phase will provide insights about participants' general wellness, interaction process with the robot, and their relationship with the robot.

Procedure: The ongoing-during phase will be the most prolonged period of the overall study. This phase will have weekly online questionnaire sessions and bi-weekly online interview sessions. Participants are also expected to fill-up the online diary entries once every week (they will receive a reminder via email/text, and they can opt out from getting reminders if they wish).

We will conduct the bi-weekly interview sessions at a pre-scheduled time. Each interview session will have questions from the questionnaire sets (Appendix A) and follow-up questions from previous interview sessions.

Exit Protocol

Expected Outcome: This phase will provide insights on participants' thoughts about the overall study, if they feel any changes in their general wellness and their perception of the robot's impact on their daily life.

Procedure: After the ongoing-during phase, the researchers will conduct the exit phase. In this phase, participants will be giving the robot back to the researchers.

One of the researchers will arrive at the participant's home at a pre-scheduled time (by taking proper precautionary measures – wearing masks and gloves and maintaining appropriate social distancing). The participant will be instructed to put the robot inside a box and keep it on their doorstep. The researcher will then disinfect the robot using disinfecting wipes and wrap it in plastic cover and place it in the box. The box will then be securely taped, taken back with the researcher, and put into quarantine for the next 14 days. Further, on the day of the exit phase, after the researcher is back in the lab, the researcher will meet the participant online and conduct the exit interview session.

Thank you for joining the interview session. Before starting the actual interview, I am sending you the URL for today's questionnaires. Please complete them and then we will have a short interview session.

This interview session will also be conducted using questions from the question set (Appendix A). Afterward, the researcher will debrief the overall study and give the participants a follow-up form (Appendix B) to remind them about the consent they gave for the online interview recordings.

Thank you so much for participating in this study, we really appreciate your time. Now I will debrief the overall study to you so that you clearly understand what we are doing and what we will do with the data. The purpose of the study was to investigate how having a robot may impact people who identify has living with loneliness. In this study, we let you keep a social robot and interact with it for 8 weeks. During the study phase, you have completed multiple questionnaires, diary entries and interview sessions. The questionnaires are giving us insights on the level of your social interaction with others and your general wellness. The diary entries let us have some insights on your daily interaction with the robot. Lastly, the interview sessions were conducted to understand your perspective and thoughts of having a social robot in your home and how it impacted your everyday life. From the data collected throughout the weeks, we are analyzing them to investigate if any of the measurements had any significant changes or not after you interacted with the robot. The audio recordings from the interview sessions will be transcribed into text and analyzed by researchers. The research outcome will be used in publications to contribute towards future research. Now that I have debriefed the overall study, do you have any questions at this point?

Today we are taking the robot back with us. You have spent a great deal of time with the robot, and so some people find that they have become attached to it. You may feel sad at no longer having the robot. We will send you an email with links to free mental health and counselling resources, in the case that you feel you would like to talk to someone about it. (will email: https://umanitoba.ca/student-supports/counselling-resources-students, https://sharedhealthmb.ca/covid19/providers/mental-health-resources).

If the participant does not have any question, the researcher will thank the participant again, remind them about the follow-up interview session for the next week and leave with the box.

Follow-up Protocol

Expected Outcome: This phase will provide insights on how participants are going on with their lives after having a robot in their home for a long time.

Procedure: A researcher will conduct this phase one week after the exit phase. The researcher will meet participants online on a pre-scheduled time and conduct this session. Before starting the interview, the researcher will send them the very last online questionnaire set for the study. After they are done filling that up, the researcher will conduct the final interview session. This session will also be done using questions from the questionnaire set (Appendix A).

After the interview session, the researcher will end the study.

Appendix I - Demographic Questionnaire

Candidate ID: ____

1. What is you gender?
   ☐ Male ☐ Female ☐ Non-Binary ☐ Others

2. Which age range are you associated in?
   ☐ 18-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60-69 ☐ 70-79 ☐ 80-89 ☐ 90+

3. How many people lives with you in your home?
   ☐ I live alone
   _____ people

4. Did you ever have any pets?
   ☐ Yes ☐ No if "Yes", please specify: _____

5. Do you have any hobbies?
   ☐ Yes ☐ No if "Yes", please specify: _____

6. How often do you contact your friends/relatives?
   ☐ Never
   ☐ A few times a month
   ☐ Once a week
   ☐ More than once a week

7. How often did you visit your friends'/relatives' house before Covid-19?
   ☐ Never
   ☐ A few times a month
   ☐ Once a week
   ☐ More than once a week

8. How much time do you spend on social networks (e.g., Facebook, Twitter) each day?
   ☐ I do not use any social networks
   ☐ Less than 30 minutes
   ☐ 1-2 hours
   ☐ More than 2 hours

Appendix J – Diary Entry Form

Participant ID - _____ Date - _____

1. Did you interact with AIBO in the last 3 days? If you did, how was it?

2. Do you feel that AIBO had a positive (or negative) influence on your daily activities?

3. Did you talk to anyone about AIBO in the last 3 days? If you did, what did you discuss about?

4. Is AIBO helping you in any way?

Write anything that you want to add extra to your diary entry –

Appendix K – Mental Health Support Resources

Seeking Information for Mental Health

The University of Manitoba takes mental health very seriously and provides counselling supports. You can visit the following link to get a thorough idea on how you can get support.

http://umanitoba.ca/student-supports/counselling-resources-students

You can also checkout the Mental Health Resource Guide for Winnipeg in the following link:

https://mbwpg.cmha.ca/resources/mental-health-resource-guide-for-winnipeg/

Manitoba's provincial mental health support resources can be found in the following link:

https://www.gov.mb.ca/betterhealth/health_services/mental_health_services.html