Design and Implementation of a Novel Conversational Companion Robot For Older Adults

By

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Abstract

Social robots can help people with a variety of problems in everyday life. One of the issues that have been explored in the field of Human-Robot Interaction (HRI) is using social robots as companions, or to help with issues such as loneliness. Loneliness is a problem seen extensively in older adults, especially those who live alone as they have reduced social interaction. We investigate the use of a humanoid social service robot that can be used for conversation. Through iterative prototyping, we designed and developed a robotic behaviour to support individual self-reflection and wellness. We proceeded to then implement it as a stand-alone conversational social robot using Softbank's humanoid robot NAO. Our approach relies on simple interaction design to avoid high robotic expectations and achieve a robust reflective behaviour.

To learn about our behaviour's feasibility, what people thought of it, and if people wanted to use it, we conducted a study where we deployed our novel behaviour using our stand-alone offline conversational robot. We deployed our robot completely unsupervised and unmonitored for two nights into the homes of 14 older adults 65 and over. This study showed that most participants engaged with, and reported enjoying using the robot; based on participant's feedback, our simple behaviour was able to successfully aid more than half of our participants to engage in self-reflection.

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This thesis provides a first step towards robots as an in-home companion for older adults by leveraging simple conversational techniques that prompt people to self reflect by talking about their day-to-day lives and feelings. Future long-term deployment can help us learn if our robot could potentially help older adults alleviate feelings of loneliness and thus, helping decrease the related stress and anxiety that comes with it.

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Dedication

A mi familia,

por apoyarme en mi decisión de mudarme a Canadá

y poder cumplir un sueño.

Sí se pudo.

Thesis Advisor
James E. Young

Author
Adriana Lorena González De la Garza

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Publications

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

A. N. Baecker, D. Y. Geiskkovitch, A. L. González, and J. E. Young, "Emotional support domestic robots for healthy older adults: Conversational prototypes to help with loneliness," *ACM/IEEE Int. Conf. Human-Robot Interact. (HRI'20)*, pp. 122–124, 2020. ACM. https://doi.org/10.1145/3371382.3378279

A. L. González, D. Y. Geiskkovitch, and J. E. Young, "When Can I Get a Robot for my Home?: A Constrained Design Approach to Feasible , Deployable Companion Robots," *Proc. 29th Int. Conf. Robot Hum. Interact. Commun. (RO-MAN 2020) Work. Soc. HUMAN-ROBOT Interact. HUMAN-CARE Serv. Robot.,* 2020, 6 pages.

A. L. González and J. E. Young, "Please Tell Me about It: Self-Reflection Conversational Robots to Help with Loneliness," (*HAI 2020) Proc. 8th Int. Conf. Human-Agent Interact*., pp. 266–268, 2020. ACM. https://doi.org/10.1145/3406499.3418764

A. L. González and J. E. Young, "A Simple and Lightweight Algorithm for Social Robot Speech Turn Taking," *Univ. Manitoba Msp. Repos*., pp. 1–4, 2020. http://hdl.handle.net/1993/36015

1 Introduction

According to the UN, the worldwide population of people 60 and over is increasing: from the year 2000 to the year 2050, the number of older adults will likely grow from 600 million to 2 billion [1]. In developing countries, this increase will happen faster. Canada's population of people 60 and over is expected to increase from 1 in 7 people in 2012 to 1 in 4 by 2030 [2].

As people age, their social network decreases due to death of people close to them or changes in their role in society after they retire; this causes them to have fewer people around that can provide emotional support [3]. These changes can lead to an increasing problem faced by this older population: loneliness, a subjective and self-perceived factor of lacking social connection [3]. Loneliness correlates with health complications such as depression, stress, anxiety, and even premature mortality [4], [5] and affects around 10% of the older adult population in Canada [6].

Novel technological interventions have shown positive results in helping people reduce their feelings of loneliness, some of these interventions have been done using social robots. Social robots are designed to leverage people's tendencies to anthropomorphize robots, and assign these robots with a sense of agency [7]. Socially assistive robots are a category of social robots which leverage this anthropomorphism to support people [8]. For example, a robot can use movements, sounds or conversation to help decrease a user's loneliness [9], stress [10], or provide emotional support [11]. We see an opportunity to explore this further and try to use these social robots to aid people to reduce their feelings of loneliness, therefore improving their wellbeing to ultimately have healthier and happier people.

We specifically aim to leverage the positives of conversation and self-reflection and explore the use of a simple conversational social robot to decrease loneliness and improve the wellbeing of older adults. Our approach focuses on building a simple conversational robot, since research in therapy, specifically work in client centered therapy and reflective listening, demonstrates that simply reflecting on one's feelings and experiences can help one feel better [12], [13]. Self-reflection is the process of evaluating one's thoughts,

emotions, attitudes, and behaviours; it can help with introspection and flexible thinking, enabling one to better understand situations and feelings [12], [13]. Techniques in this vein, such as keeping a thought diary [14] or talking to others about one's feelings [15], [16] can improve a person's mood and wellness. If a robot can facilitate such reflection through simple conversation, perhaps it can improve a person's wellbeing.

With this aim for simplicity that will allow us to deploy our robot quicker and with less complex algorithms, we explored different robotic behaviour designs and ideas before choosing one and creating a functional prototype. We focused on designing behaviours that avoid relying on the robot interpreting or understanding what the person is saying to maintain simplicity and increase the feasibility of our conversational design.

We went through an iterative design process of robotic behaviours that instead of trying to make the robot process phrases, the robot would mostly be there to listen to the person. Some of the ideas considered included a robot that could listen, provide acknowledgment, and respond by either repeating what the person said or with simple pre-programmed (but varying) phrases relating to what the person mentioned. In these behaviour ideas, a person starting a conversation with this robot could look like the interaction shown in Figure 1. This thesis will discuss the exploration of these behaviour ideas, as well as how and why the final one that was implemented was chosen.

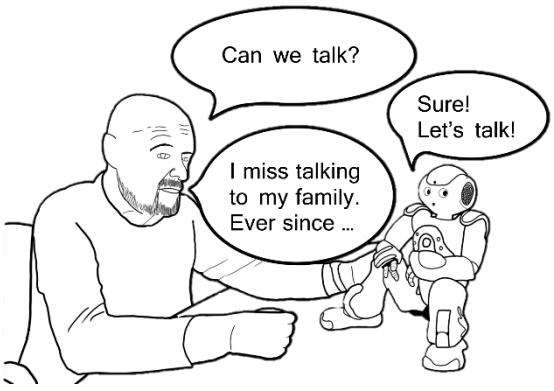


Figure 1. Person having a conversation with the robot. The robot does not need to understand what the person is saying during most of the interaction, but instead, is there to listen and encourage people to talk.

Through this design process, we developed a fully autonomous, unmonitored social conversational companion robot for the purpose of supporting people's wellness by encouraging self-reflection. This self reflection approach uses basic conversational techniques and focuses on allowing the person to talk and introspect, as well as facilitating a personal examination of how they talk about their problems and issues. We developed

this prototype to be introduced in people's homes to have simple conversations with the robot. We then deployed our chosen behaviour and prototype, unsupervised and unmonitored, for two nights each, as proof of concept for its feasibility into people's homes.

In this thesis we present a novel design, implementation, and short-term deployment of this conversational robotic prototype. We test and gather feedback on the robotic behaviour and the robot itself to understand its feasibility and usefulness: if people can use it, and if they are willing to; as well as people's opinions of the robot and the behaviour. Participants reported that they were able to use the robot to self-reflect, some liked having it and interacting with it and some reported that with some changes, people could see benefits of using this robot long term.

Although the goal for this project is to investigate the feasibility and usefulness of a conversational companion robot, we can identify issues that could be fixed and improved on the prototype to inform future design of long-term domestic robots and test its impact on loneliness.

This thesis therefore aims to investigate the following research questions:

1) Technical feasibility – is it plausible to design and deploy a conversational robot for self reflection that is fully unsupervised and autonomous?
2) Domestic integration feasibility – would people accept a conversational robot into their homes: their social and physical spaces and routines?
3) Self-reflection feasibility – are people able to use a conversational robot to engage in self reflection with the potential for meaningful interaction?

1.1 Older Adults and Social Companion Robots

As the older adult population continues to increase around the world [17], Human Robot Interaction (HRI) research is focusing on exploring different ways in which robots can be developed to support the needs and desires of this population. One way to do this is through the use of social robots: robots that are made to have human- or pet-like features to assist them in interacting with people [18]. These robots can be designed to impact a person's feelings, mood, and behaviours through certain robot behaviours or through the use of anthropomorphism [10], [19].

Research with robots and older adults has predominantly focused on finding ways to help people with serious health problems including different stages of cognitive impairment [20], [21]. We propose moving beyond these health issues and complimenting the efforts of this area of research by studying interactions with healthy older adults since there is not much research targeting this group. We do this by focusing on an initial short deployment of a standalone social humanoid companion robot that supports conversation in homes of healthy older adults and investigating the feasibility, usefulness, and performance of this novel conversational behaviour as proof of concept for possible future long-term use.

Some of the studies in the field of Social Human Robot Interaction are made using animal-like robots, such as PARO [19] and AIBO [22] in supervised settings and nursery homes. With their simple and fun appearance, they have the potential to reduce behavioural and psychological symptoms, and improve the quality of life for people living with dementia [19], [23]. Studies with these animal-like robots and healthy older adults have also shown that robots can increase psychological wellbeing, improve overall mood, and reduce the anxiety levels of the participants [24]. Yet, there is not much literature researching companion social robots and healthy older adults [25]–[27].

Our goal for this project is to move beyond these animal-like robots, that have more limited interaction capabilities (e.g., being able to be petted and played with), and consider different types of social interactions, in this case, using human-like interactions

like conversation, movements, and body language. This project focuses on exploring the usefulness of our proposed behaviour, as well as older adult's perceptions and willingness to engage with this conversational companion robot.

1.2 Reflective Listening and Chatbots

Simple reflection or introspection, by oneself or with others, can help improve someone's mood. Some self-support techniques leverage technology, for example, engaging digital social networks [28] or online automated "chatbots" [29] to reduce feelings of loneliness. We continue this trend by designing and examining the use of a social companion robot for self-reflection and emotional support. Unlike passive reflective methods such as diaries or written prompts, a social robot can also leverage its human-like social communication and presence to motivate people to engage with it. We leverage ideas behind client centered therapy to try to encourage people to talk about their feelings and experiences.

The inspiration for this conversational companion robot comes from a well-known conversational agent, ELIZA [30]. This conversational agent was successful even without understanding the context of the conversation, and people who used it actually believed they were talking with a real person [30]. Using the sample program DOCTOR in the 60's, it was able to mimic a conversation people could have with a psychotherapist and induce emotions in people [30]. Although the ELIZA algorithm had issues that could affect the user, such as saying offensive or triggering phrases when trying to reply using its simple pattern matching algorithm, it helped inspire newer and more complex chatbots.

Despite these chatbots, we chose a humanoid robot since we can leverage people's tendency to anthropomorphize and give a sense of agency to the robot to increase people's involvement and comfort around it. We take inspiration from ELIZA as it was able to support people without complex programs, however we take a different, design centered approach, where we avoid trying to generate targeted phrases, and instead try to create a dialogue between the person and the robot without having to do much conversational analysis. The

goal was to have a robot mainly listening to the person while still being successful in helping people self reflect and avoiding damage to the user.

1.3 Methodology

To engage with this problem of creating a conversational robot that could help support people's wellness, our methodology consists of the following steps.

To answer our first research question and learn about the technical feasibility of an autonomous conversational robot for self reflection, we first developed guiding design goals to help us achieve a fully stand-alone, unsupervised, deployable robotic design. We wanted to create a system that is as technically simple as possible to decrease development times and be able to deploy it, and easy to use so people would not be discouraged from using it. This simplicity approach leads to additional benefits such as safety and privacy, where fully testing the behaviour reduces the chance of the robot saying something that could damage or affect the user, and there is a higher chance of people being open with the robot since they are not being observed or recorded. We also aim to maintain social engagement so people can benefit from this robot, and we want to manage user's expectations of the behaviour to avoid abandonment.

Once our goals were defined, we conducted a somewhat informal iterative process of brainstorming and refining potential solutions for our system. We explored multiple conversational design ideas on how the interaction between the robot and the person might unfold, as well as different level of conversation involvement from the robot. Our iterative process included meetings with lab members where we would present how we imagined these interactions could go, and we would discuss what might go differently and what could be improved. We also brought the robot to show and gather feedback on the robot's movements and voice. After designing and gathering feedback on multiple behaviours, we chose a behaviour that was feasible to implement and designed to prompt people to reflect on their experiences and feelings [31].

To answer our other two research questions and understand the feasibility of integrating a conversational robot into people's homes and it being used for self reflection, we needed to learn how people would feel about having a robot at home and if it could fulfill its purpose of simple conversation; as well, we had to understand people's perceptions about it, since early-stage feedback is important for design iteration before investing in longer-term studies [32]. We designed a short-term study where we deployed our social conversational robotic behaviour unsupervised in people's homes for 2 nights or approximately 48 hours, this helped elicit participants' general thoughts on having the robot, the approach, as well as their feedback on usability of the behaviour and our novel conversational robotic design. At this early stage we do not study the long-term impact on wellness or loneliness, which would require more longitudinal inquiry.

1.4 Results

Based on our results from our design process and how the robot was successfully tested by the participants of our study, we can answer our first research question and see that it is feasible to create a conversational robot that works completely autonomously. With the appropriate design constraints based on current technological capabilities, a robot can be designed and deployed completely unsupervised. Although our design is not meant to be the best design or the best implementation, we use our deployment as a proof of concept of these robots being plausible to make and deploy in unsupervised testing environments.

Our study helped us also answer our two other research questions. We wanted to understand the feasibility of domestic integration into people's homes. Participant's feedback suggested that the offline and unmonitored nature of our robot supported their comfort and encouraged natural interaction with the robot. Despite some robotic errors (e.g., the robot cutting people off while talking, misunderstanding an answer, or just exiting the behaviour while people were interacting with it) and perhaps due to it being easy to operate, no participant abandoned the robot over the two days, with some demonstrating willingness to try to find workarounds to problems that arose during the 2 nights. We note

that talking to users about the robot's actual capabilities helped with managing initial expectations and therefore could have influenced how these robots were received. Most participants liked the size of the robot since they could place it wherever they wanted without needing too much extra space; and being able to keep it static in a place helped them be able to use it whenever they needed it.

Our results indicate that most people were able to use our prototype successfully to talk and self-reflect without any incidents that caused them to stop using the robot. We received some remarks noting the lack of intelligence or the robot, and these participants indicated they would like more complex behaviours. Despite this, most participants had positive remarks, such as reporting seeing benefits in the interaction design and how it supported them to self-reflect despite the simplicity and limited robot capability.

This thesis provides data from a short-term study that highlights the feasibility of a simple unsupervised robotic design made to fit into people's homes and help them engage in self reflection. Although more research is needed to understand the long-term implications and acceptance of such a robot, this is a first step towards creating humanoid robots that can work outside supervised environments and could be an everyday companion in people's lives.

1.5 Contributions

After designing this novel conversational robotic behaviour and deploying NAO standalone for two nights in homes of older adult's living alone, our contributions are the following:

- A new robotic conversational behaviour design that could potentially help with loneliness;
- A simple robotic implementation that operates fully offline and is deployable for the real world;
- Investigation of effectiveness and performance of the behaviour through a short-term deployment that yielded qualitative and quantitative results that could inform future long-term deployment of companion social robots;

- Interview data on people's willingness and ability to engage with the robot and how they felt when using it;
- A proof of concept for long-term in-home deployment of this simple robot;
- A simple audio processing approach to find end of utterances when a person speaks to the robot that was used as part of our behaviour focused on simplicity.

1.6 Summary

Wellness is an important factor that can affect a person's quality of life; social companion robots can be an effective tool to help improve wellness. In this thesis, we create a novel simple conversational robotic behaviour and explore its feasibility: is it technically feasible to create and deploy such a robot, can people use it, and would they accept it into their homes, and are people able to use it as a tool for self reflection? We also explore people's perceptions: what they think of the robot, the behaviour and possible long-term use of the robot. We deploy our behaviour using a humanoid in a completely unsupervised fashion in the homes of 14 older adults 65 and over as an initial proof of concept for our behaviour. Most of our participants indicated that they were able to use the robot for self-reflection, opening the door for future long-term deployment to learn if wellness or loneliness could be impacted by having an always available companion conversational robot in homes.

2 Related Work

2.1 Introduction to Human-Robot Interaction

Robots in industry, such as robotic arms, have been widely used for some time for doing specific, repetitive tasks. We see widespread adoption of these robots for automatization in assembly lines, or in factories doing welding, handling, or serving as machinery [33].

To understand how these industrial robots interact with their environment, we could analyze them using ideas from the field of Human-Computer Interaction (HCI). HCI studies how technology changes people's work and activities, as well as focuses on how people feel about the system and the usability of this technology: how efficient, effective and satisfactory it is [34]. However, the rapid rise of robots has led to the field of Human-Robot Interaction (HRI), which specifically studies the collaboration and communication between people and robots. HRI is meant to "understand and shape the interactions between one or more humans and one or more robots" [35].

Applications that are studied in the field of HRI include those that require mobility (e.g., teleoperation or supervision of remote robots), physical manipulation (e.g., robots being controlled to grasp or move things) or social interaction (e.g., where humans and robots interact as companions and robots have social abilities) [35]. Of particular interest to us is the area of social interaction, where social robots are meant for people to use and interact with, as well as to elicit feelings from them. These robots also follow social norms expected by the user [36]. These social robots are appearing more and more in different everyday places such as museums, airports, or malls.

In this thesis, we focus on assistive social robots to learn and understand how a robot could be used as a companion to support people's wellness.

2.2 Assistive Social Robots and Older Adults

Although the field of HRI studies a variety of robots that interact with people, in this thesis we focus on assistive social robots. Social robots are robots that are able to leverage behaviour to appear social and are able to communicate in some way or another with a user [24]. Assistive social robots are social robots that are meant to aid people, they can be generally separated into two categories: service type robots and companion robots. Service type robots are meant to help people in their daily activities such as eating, dressing, moving or cleaning one's house while being social and interacting with the person [24]. On the other hand, companion robots aim to improve or support users' mental health and wellbeing [21], [37], [38].

We focus on older adult's use of companion social robots. Companion robots are broadly being used to support older adult's mental health (e.g., [9], [25]). Reviews looking at older adults' use of socially assistive robots highlight that results tend to be positive: robots help reduce loneliness, anxiety, and improve quality of life [20], [21], [37], [39]. However, these reviews highlight that most of these studies are done with animal-like robots, such as the ones shown in Figure 2: Sony's AIBO dog robot [40], the seal robot Paro [41], [42] or iCat [43], to leverage people's familiarity with real animals and encourage similar interactions.



Figure 2. Animal-like robots used for studies with older adults; (a) AIBO, (b) Paro and (c) iCat.

Humanoids, on the other hand, have increased interaction capabilities and potential for more human-like companionship [44]. As well, most studies focus on older adults living with dementia or some type of cognitive impairments [20], [21]. We contribute to the ongoing

work by additionally exploring humanoid robots as conversational companions and targeting healthy people.

2.2.1 Long Term Studies with Humanoids

Since we are deploying a humanoid robot in older people's homes, it is important to look at other studies with this population in similar conditions. Of special interest to us, are studies deploying robots for long-term, since we aim to have a fully standalone and deployable robot to be able to conduct future long-term studies with it. Conducting long term studies in homes is important, because unlike short-term studies in lab environments, they can provide the necessary tools for understanding people in their natural environments, their needs, and how the robot is used in the day to day [32], [45].

However, doing these studies is challenging; the studies take longer and current robots might not be robust enough to be deployed for long term without any type of researcher supervision [32], [37], [46]. A robotic system might rely on a complex designs that include interactions that are not possible with current technology or that might be too time consuming and complex to program and test; to avoid this hurdle, some researchers use the Wizard-of-Oz technique for their systems and designs [47], where the robot capabilities are being faked by someone controlling the robot. Although this is a good approach to try to understand how robots might be able to help people in the future [48], [49], these robots are not able to be currently deployed without a researcher present.

Other researchers attempt to use more autonomous robots for their studies, but a complex interaction design meant to be autonomous, in an already complex system such as humanoid robots, adds significant implementation complexity and results in a higher probability of behaviour error [50], [51].

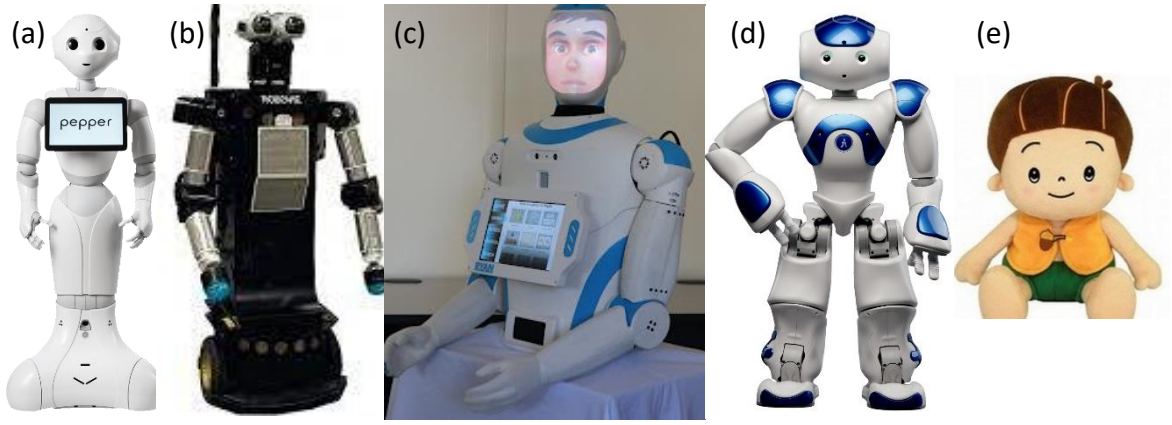


Figure 3. Humanoids used for studies with older adults; (a) Pepper, (b) Robovie2, (c) Ryan, (d) NAO and (e) Kabochan.

Humanoid robots have been used for long term studies with older adults in home environments where interactions have been supervised. Studies lasting over 2 months in care homes or care centers with Pepper [45] (Figure 3a) and Robovie2 [49] (Figure 3b) interacting with groups of people during specific time schedules use wizarding as a way to get over the complexity and challenges that come with deploying a standalone robot. These studies show positive results, they show that simple chatting [49] or playing games with people [45] increases engagement and people enjoy having the robots around. However, these robots were used in group situations and needed to be monitored and controlled by a researcher using the Wizard of Oz approach.

Other examples of long term studies include Ryan (Figure 3c), a humanoid robot able to provide cognitive behavioural therapy to people with dementia [52], the NAO robot (Figure 3d) being used as a conversational partner in hospitals [48], and the Kabochan robot (Figure 3e) used to have friendly interactions with senior woman [53]. These applications of robots have shown that people enjoy interacting with social robots [48], and that these robots can help improve cognitive function of the user [53]. However, in addition deceiving users about having thoughts and feelings, these robots, again, often require an individual to act as the Wizard [48], or when autonomous and online, cause privacy concerns [54], and are prone to speech recognition errors [55].

In our work, we propose steering away from supervised or remote-controlled robots. Instead, we posit that an alternate approach is to design socially assistive robots with an aim for technical and interaction simplicity: if we can discover technically simple ways to realize social interaction, and therefore not rely on complex designs, we can achieve the benefits of social robots while reducing the need for real time monitoring, control, or potentially fragile complex behaviour algorithms. This will allow people to use the robot whenever and however much they want, without the user being worried about being monitored. As well, it allows one on one interaction, which can increase comfort when talking about personal things and experiences, instead of deploying the robot in a group where someone else might listen. If we see positive results, it will serve as a proof of concept for future long-term deployment of simple, offline, unsupervised, and standalone robots.

Since our goal is to create a fully standalone humanoid robot to deploy into older adult's homes, we explored research that has used autonomous humanoids that did not require someone to always control them. One of a few studies using an autonomous humanoid robot deployed a Softbank Pepper for up to 18 hours with care home residents in the span of two weeks, with results showing that interacting with the robot improved emotional wellbeing and mental health compared to not using a robot at all [50].

We build on this work by reporting on the deployment of an offline, completely autonomous (and unsupervised) companion robot into people's homes. By keeping our behaviour simple, we are able to deploy our behaviour completely unsupervised into people's homes, and by not recording any of the things the participant say, participants can feel more comfortable being themselves when interacting with it, therefore leading to what could be, more ecologically valid results.

2.3 Conversational Robots

With our goal of creating a conversational companion robot, we looked at different implementations of conversational technologies. Social conversational agents, such as virtual chatbots and robots have been used for companionship and to improve wellness of

the user [56]. One of the earliest chatbots was ELIZA, which attempted to simulate a virtual psychotherapy session, and despite being simple, people reported enjoying using it [57]. Nowadays online chatbots like Microsoft's XiaoIce are able to have more natural conversations, and provide emotional support by simulating friendship with the user [56]. However these chatbots rely on faking emotional connections [56], an ethical concern of current significance [58].

Our work avoids the need to leverage artificial relationships by instead employing self-reflection, and leverages the physical embodiment of the robot, which can elicit more engagement [59]. These conversational agents, as well as research with conversational robots highlight that both simple and complex robots have been used and are able to provide companionship. We opt for a simple, completely offline, and standalone robot using currently available technology to be able to study the effects of long-term deployment of this robot after this initial testing of the robot's feasibility.

2.4 Perception of Robots

Our implementation focuses on a simple behaviour that is still able to fulfill its goal of simple reflective conversation. However, due to NAO's physical design, people might think it will have a highly complex functionality; it is important to understand how these perceptions and expectations play a part in robot acceptance and adoption into people's lives.

Expectations of a robot play a very important role in acceptance; if people expect certain things from a robot (e.g., being reliable or competent) and the robot does not fulfill these expectations, it can lead to user's disappointment [60]. One way to help avoid this is to be transparent: to give people information to make sure people's expectations match the robot's real world capabilities [60].

When designing a robot or a robotic behaviour, researchers have to be aware that user's preconceived notions or expectations of robots have a huge impact on their perceptions of robots. A study looking into setting expectations high or low for animal-type robots Pleo and AIBO, reported that how a robot is presented, and therefore the expectations that it

sets, affects how people perceive the robot [61]. If robots are presented as simple, setting users expectations of its abilities lower, then there is lower disappointment on the robot's abilities and people have more positive perceptions on the robot's competence [61].

Another important aspect when designing these robots or behaviours is that people might not adopt a robot if it is too novel. A study with the humanoid Hobbit showed that abilities that were too novel for the user were barely used, establishing that these complex behaviours might not be a good approach [32]. The robot did not become part of their routine since participants thought it was too feature rich, they ended using only the features that their already existing devices (e.g., phones, laptops or tablets) had [32].

Following the results from these studies, we argue that simple interactions, that are introduced as such, might be easier for people to integrate into their routines and accept. Therefore, we limit the scope of our behaviour to only simple conversation. By introducing our prototype as a simple robot with no intelligence, we aim to help lower or perhaps match people's expectation to the robot's real-world capabilities.

3 Interaction Design

Work presented in this chapter has previously appeared in the following publications:

A. N. Baecker, D. Y. Geiskkovitch, A. L. González, and J. E. Young, "Emotional support domestic robots for healthy older adults: Conversational prototypes to help with loneliness," Adjunct Proceedings *ACM/IEEE Int. Conf. Human-Robot Interact. (HRI'20)*, pp. 122–124, 2020. ACM. https://doi.org/10.1145/3371382.3378279. Poster Presentation.

A. L. González, D. Y. Geiskkovitch, and J. E. Young, "When Can I Get a Robot for my Home?: A Constrained Design Approach to Feasible , Deployable Companion Robots," *Proc. 29th Int. Conf. Robot Hum. Interact. Commun. (RO-MAN 2020) Work. Soc. HUMAN-ROBOT Interact. HUMAN-CARE Serv. Robot.,* 2020, 6 pages.

A. L. González and J. E. Young, "Please Tell Me about It: Self-Reflection Conversational Robots to Help with Loneliness," (*HAI 2020) Proc. 8th Int. Conf. Human-Agent Interact*., pp. 266–268, 2020. ACM. https://doi.org/10.1145/3406499.3418764. Poster Presentation.

The main focus of this thesis is to explore the feasibility of a companion social robot that through the use of reflective listening techniques, could help people self reflect. To achieve this, we require a robot that can support basic conversation interactions with the user, and behaviours that make conversation feel natural and smooth. This will potentially be able to help users engage in meaningful self reflection. Alongside this, with our future goal of a long-term in-home study to examine changes in loneliness and wellness, we need a fully standalone robot and a behaviour that is feasible and reliable enough to use without any researcher supervision.

This section will explore the robotic behaviours we created that are focused on employing reflective conversation as a way to engage a person, drawing elements from client-centered therapy. In particular, we use reflective listening as an inspiration, where a social entity's (e.g., a person, or social robot) role is to prompt someone and listen to what they say, rather than giving advice or opinions, to encourage self-reflection [62]. Our reflective listening focus, specifically prompting people to talk about their experiences or feelings, emphasizes key elements of the client-centered therapy approach, including acceptance and being non-judgmental [63], [64].

This focus on reflective listening, where the robot's role is to prompt people instead of understanding them and giving advice or opinion, helps us avoid technical challenges that could arise from more complex behaviours if we were to try to analyze and understand what the person said. The advantage of this is that instead of trying to understand the user and reply with something that makes sense and is not harmful for them, we can instead focus on simple behaviours and just have preprogrammed phrases or questions to prompt people to talk. We can simplify our design by creating behaviours that only need to understand when a person finished talking to know when to say the next thing while still leveraging the positives of reflective listening.

With our aim to create a conversational behaviour, we first developed guiding design goals for our robotic design by considering what was necessary to be able to create our simple, robust, and deployable robot. Using these goals, we brainstormed different robotic behaviours and interaction ideas and then chose the one we were going to prototype and deploy with study participants. This section explores those goals, the behaviours that were created using the goals as a guideline, and how our final behaviour was chosen.

3.1 Interaction Design Goals and Strategy

Before starting to create our behaviours and interaction designs, we devised a set of guiding goals to help us keep our focus in developing a deployable, standalone robot. We also get inspiration from our previously published work that proposed constrained design strategies for feasible and deployable robots [65].

We aimed for as-simple-as-possible interaction and implementation design that can meet our social interaction goals relating to self-reflection while allowing us to have a fully standalone, unsupervised, deployable robot. We can achieve this by leveraging the reflective listening approach, giving us the opportunity to focus on simple and generic conversation to encourage people to talk. This generic conversation will not require the robot to fully understand the context of the conversation and instead only require the robot to know when the person finished talking before saying its next phrase. The benefits of a simple behaviour are that the fewer parts a behaviour has, the more testing can be done in each part, and it can have less issues and be less prone to failing.

Besides simplicity, we focused on a design that could maintain social engagement; this is important if people are going to use this robot and test its effects on loneliness in a long-term study in the future. Another important aspect was to be able to manage people's expectations to avoid disappointment due to inflated perceptions of the robot's ability [61]. We also address safety and privacy given the sensitive nature of a self-reflection robot in a home setting. This section will be an explanation of each of our goals and their importance.

Interaction simplicity – A single simple function for the robot will help prevent people getting overwhelmed by a feature rich system [32]. We focus on a simple single step to start interacting with the robot, this could be a single touch or phrase. To maintain simplicity, we also steer away from using complex speech recognition and instead have behaviours that leverage's people's own ability to self-reflect. While leveraging the robot's sociality to encourage interaction, our behaviours could allow users to be the ones steering the

conversation and deciding what they want to talk about. Allowing the user to talk freely and introspect, perhaps could help them improve their mood and reduce feelings of loneliness.

Implementation simplicity – The Wizard of Oz technique is used in studies exploring complex social robotic behaviours; the participants believe they are interacting with an autonomous robot when, in reality, there is a person controlling the robot from a different place [47]. With our goal of an always available robot in people's homes (as opposed to short term studies or the robot being only available at predefined times), it is not feasible to always control the robot. Instead, to reach a level of deployment that allows to test our robot completely unsupervised in people's homes, we opt for an implementation that is simple, and thus intrinsically more robust and technically feasible. We also want to maintain a simple linear structure that is repeatable and has minimal points where there is a choice to change what will happen in the behaviour to avoid complex systems and points of failure.

Social engagement – People tend to be more engaged with embodied robots [59]. We can leverage the humanoid nature of our NAO robot by using social interaction techniques, making it act like it is listening or noticing the user by using techniques such as face tracking to face the user, and using body language to convey emotion and empathy. We do not aim to deceive about the robot's abilities; however, these social techniques and movements will help the robot convey emotions and increase anthropomorphism and comfort around it to encourage people to have more natural interactions with the robot that can lead to self-reflection. If behaviours are not engaging and the robot is abandoned, it will not be able to fulfill its goal of supporting wellness through repeated and long-term use.

Expectation management –To avoid creating high or unrealistic expectations of the robot, and the inevitable related disappointment if the robot does not meet these expectations [61], we draw from transparent design [66] to manage expectations. We can focus on highlighting the simplistic nature of our robot and explain what it can and cannot do from the first encounter. We hope managing (or lowering) expectations can lead to increased positive perceptions of the robot.

Safety and privacy – An important safety issue is the robot potentially saying something harmful given the complex social context and the sensitive topics a person might bring up. To avoid this, we rely on safe and simple, pre-programmed utterances rather than relying on the robot trying to generate its own phrases that could be interpreted as something wrong or hurtful. Another important aspect is that monitoring people increases the potential for the Hawthorn effect (i.e., people interacting differently when they know they are being observed or recorded) [67] which can have an impact on the validity and generalizability of the results, as highlighted in various reviews and studies (e.g., [21], [37], [50]). To avoid this, in our unmonitored and stand-alone approach, the robot is completely offline to ease the participant into being open and comfortable knowing that their data is not being heard, saved, or sent to an online server, therefore increasing trust and comfort around it. However, by steering away from internet connections, we limit ourselves to simple behaviours since the complex behaviours used by many robots typically rely on cloud services to do extensive processing.

3.2 Design Iterations and Process

To create the interactions for our robotic prototype, we went through a design process to create behaviours that could potentially help people and meet our goals outlined in the section above. We leveraged ideas from client centered therapy, a branch of positive psychology, to design behaviours that could be an analogue to reflective listening. By using conversation and reflective listening, where people talk about their ideas, feelings, and experiences, it could perhaps help with feelings of loneliness.

Following our design goals and using self-reflection techniques, in an informal process we brainstormed different conversational behaviours. During in-person meetings with lab members, we gathered feedback on what worked and what did not and how to improve our conversational behaviours. We then chose the behaviour that most matched the ideas behind client centered therapy and what we thought would be more engaging. We also

focused on the technical feasibility of our approach to be able to create an unsupervised conversational behaviour that could be introduced in people's lives.

With our goals in mind, we tried to imagine what type of conversations or interactions would get people to reflect and how those might look like. This required us to think about what we wanted out of the behaviour, but also, how a person might begin to engage with the robot or how finishing interactions could look like. Some of our initial ideas for conversational behaviours are presented in [68].

Through a somewhat informal process, we iteratively prototyped different designs, and we revised these ideas and received input and feedback during informal in-person meetings with other lab members. We would present our ideas and how we could imagine the interactions would play out in real life and we would get comments on the positives and negatives, and how to improve them. For robot specific things such as the robot's voice speed or movements, we would program it on the robot and show the robot doing these actions and get feedback on what could be better. These meetings led to coming up with new and improved interactions that were explored as possible robot behaviours.

Afterwards, we chose a behaviour based on what we thought would be a better fit as a reflective listening behaviour and could be more engaging with the user. As well, our research questions regarding domestic integration and self-reflection feasibility played a role in what type of interaction we chose. After choosing a behaviour, we again gathered feedback from meetings with lab members to improve upon it.

One of the first ideas we had when looking at reflective listening, was to try to do a robot equivalent of the Eliza chatbot [57], try to do phrase spotting to be able to ask questions and follow ups that related to what the person was saying. However, due to the complex nature of speech recognition, and the possibility of saying something harmful, we recognized this did not follow our simplicity or safety approach.

That led us to try to find other solutions; mainly focusing on self-reflection; perhaps the robot did not need to understand what the person was saying, maybe it could just be there

to listen and prod people to talk things out loud. We created behaviours following this idea, the robot would not have to understand the person, instead, it would ask questions and it would only need to be able to know when the person finished talking to say the next thing while avoiding interrupting the user. If we asked generic enough questions or none at all and just ask them to talk, we give the user the ability to steer the conversation into whatever they want to talk about wile preventing saying something harmful.

Our broad exploration covered different ideas and iterations on them based on feedback. The main type of ideas we explored were short interactions where the robot would check in on the person by asking short-answer questions, longer interactions where the person could talk and hear themselves back, and prodding people to reflect with the robot providing conversational prompts. We then chose a behaviour based on what could be more engaging and helpful for people to keep our main goal of a behaviour that could help with loneliness.

3.2.1 Ideas: Daily Check-Ins

One idea we envisioned was the robot doing multiple checkups with a person throughout the day. We wanted this behaviour to remind people of things and at the same time help them think and reflect upon their day. In this behaviour, the robot would ask general questions, for example, to remind people of things, it could ask “have you eaten today?” or “do you have any plans today?”, to help them reflect, it could ask things such as “how is everything going?” or “how are you feeling today?”

The goal behind this idea was to have the robot check in on people by asking quick questions since they would likely be alone. The robot would sporadically ask general check-in questions about the person’s day that could be answered in a couple of sentences without any kind of follow-up question. Initially, we brainstormed it as the interaction being started by the robot: if it sensed a person walked in front of it, it would start and ask them if they had time to talk. However, we decided to go for interactions started with the person

touching the robot's head to avoid startling the person and to give them more control and a greater sense of privacy.

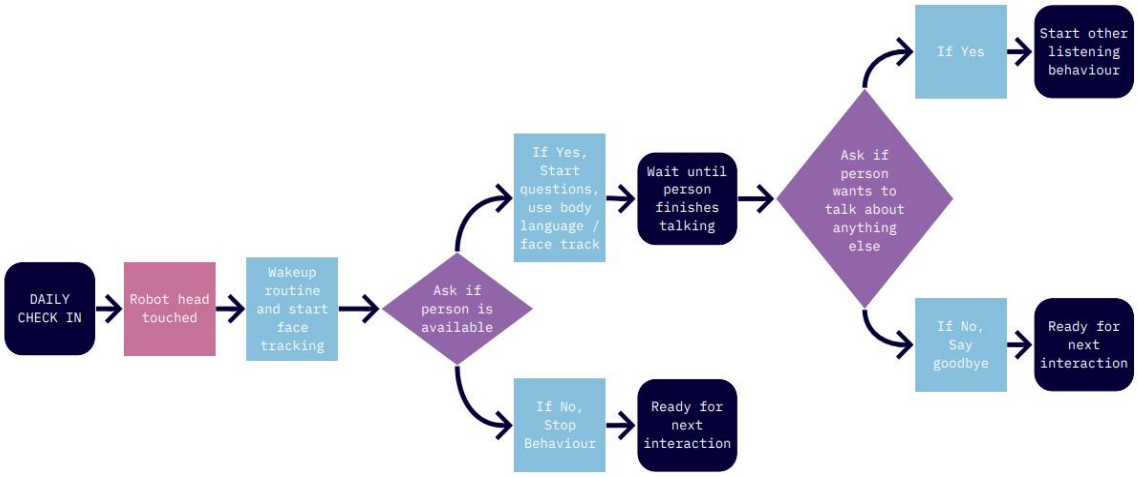


Figure 4. Daily check in. Robot will ask one generic question to check up on the person. Meant to be used multiple times throughout the day.

The process of the interaction is showed in Figure 4. The person would touch the robot's head to initiate interaction and then the robot would do a wakeup routine. To avoid scaring the person with sudden quick movements, the robot would do movements that match stretching when waking up, looking around the room slowly, and it would start face tracking the user. The robot would then ask the person if they were available to confirm the touch was not accidental, if they were available, the robot would ask a general question about their day such as "How are you?", "How are you feeling today?", "How is everything going?", "Are you seeing someone today?", and more questions that were equally generic and broad. The robot would then wait for the person to finish talking and once they did, it would ask if the person wanted to talk more. If they did not, the interaction would end, on the other hand, if they did want to continue talking, it would trigger the start of another behaviour. We expected this to be something that could be used 3 to 4 times a day due to the quick nature of the interactions.

Some of the benefits of this behaviour would be that since interactions are short, people would be able to use it when passing by it without having to commit or plan time for it. It would also have both reminder and reflective questions, which would make each interaction different. For example, if the robot asked, "have you taken your pills today?", a

person might remember their medicines in case they forgotten, which would be a benefit for them. On the reflective questions, the robot asking, “how are you feeling today?” might make people reflect on their feelings and their experiences instead of answering with a generic “good” when another person asks. Using the robot multiple times a day would also allow people to talk and hear themselves, which is something that might not happen often if they live alone and have to wait to make or receive a call to talk out loud.

This idea was the shortest one from the ones we brainstormed. Some of the concerns we had over this behaviour design were that it may not be engaging enough or that people might think it is too simplistic for such a complex looking robot. Since we know robotic expectations that are not met can lead to abandonment [38], [69], to avoid something that is “too simplistic” we considered starting any of the other ideas after finishing if the person said they wanted to keep talking. However, since we wanted the robot to only do one thing, we ended up not further developing this idea.

3.2.2 Ideas: Record and Playback

In this design, we leverage the positives of reflective listening and audio dairying where a person gets to hear themselves talk about their experiences. Audio diaries [70] allow people to express their thoughts, in a quicker way than traditional written diaries while still allowing people to self reflect by hearing themselves talk. We thought the robot would be an engaging way to introduce people to audio dairying and we explored the idea of using the robot as a companion recorder for it. In this design, the robot would not prompt a conversation topic, instead, it would record what the person was saying. It would then play the recording back to them after they finished talking, as people hearing how they express their own thoughts is beneficial. This idea does not require much conversation from the robot, but we expected it to still be able to help people self-reflect and possibly have decreased feelings of loneliness.

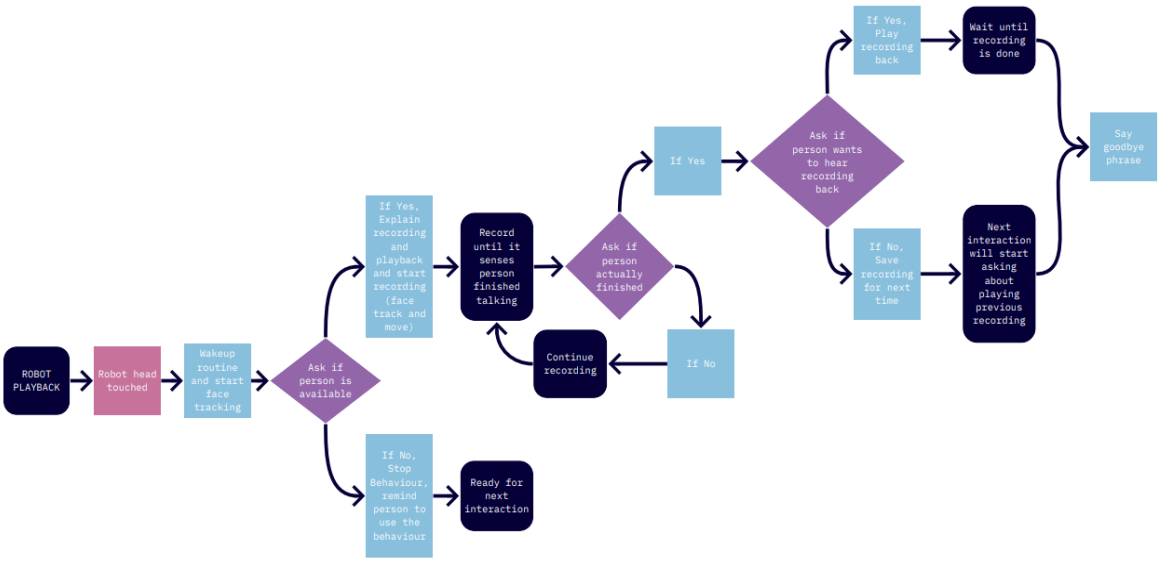


Figure 5. Record and playback. The robot will prompt the person to talk without a specific topic and will play it back once the person finishes talking.

The interaction order for this behaviour can be seen in Figure 5. The behaviour would start the same way as the daily check-ins, the person initiating interaction with a touch, the robot doing some wake up movements and asking if the person is available. From there, it is different, once the person confirms they are available, the robot would explain what it was going to do, that it was going to listen and record what the person is saying and encourage them to talk about whatever is on their mind. The robot would acknowledge the person speaking by following the person with its head to maintain eye contact, it would also nod in acknowledgement as well as slightly move its arms to show that it was listening.

After the robot processes a signal that the person was done, it would confirm if they were done talking and once they finished, it would ask the person if they wanted to hear the recording back, if so, it would play it. If not, the robot would save the recording and ask on the next interaction if they want to hear their last saved voice recording. However, if users did not want to hear the recording back in this next interaction, the recording would be discarded.

Research shows that simple things such as a person talking out loud and hearing themselves can help improve people's overall mood; we expect that by leveraging techniques from therapy in this behaviour and having people talk and hear themselves back, it may help

them feel better by encouraging them to self reflect about their experiences and the way they talk [38]. This behaviour would be simple to create since this one would not require creating any type of question bank, we would not provide any type of guidance into what the person could talk about.

Although promising, we did not use this behaviour, since its main focus on relying heavily on the person overlooks the fact that some people might not know what to talk about, and if not prompted, they would likely not use it. So instead, we took some ideas from this, the benefits of listening to oneself, and created another behaviour where the robot would prod the person, therefore taking out the problem of thinking what they wanted to talk about beforehand.

3.2.3 Ideas: Reflective Listening with Prods

As explained, this idea leverages the positives of a person listening to themselves talk out loud and takes out the stress that can come from trying to figure out what they want to talk about. Instead, here, the robot is meant to act as a sort of diary prompt, where it would ask broad questions about a person's life, relationships or experiences and would let the person answer. After the person answers, it would ask a generic follow up question to keep the conversation going and helping people have a more in depth understanding of their own situation. By designing a behaviour that will only require knowing when a person finished talking, it will help increase technical feasibility. This interaction can be seen in Figure 6.

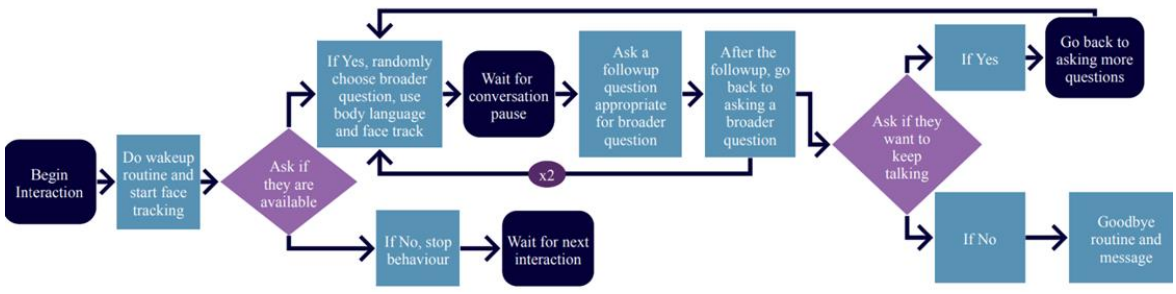


Figure 6. Reflective listening with prods interaction flow. The robot will ask questions and generic follow-ups to create a more fluid conversation between the robot and the person.

This again, starts as the previous interactions, a person touching the robot's head, the robot moving and asking if people are available. In this case, the robot would ask questions, but after people's replies, it would ask a generic follow-up to keep people talking. The idea is that after a broader question the robot will wait until the person finished talking and ask 2 follow-ups to encourage the person to keep talking. After that, it would repeat the whole process 2 or 3 times with different meaningful questions to engage in longer conversation. The questions would be very open so that the person could choose what to talk about. Follow up questions can be general enough that they could match what the person was saying after every main question, encouraging them to keep talking to help with feelings of loneliness.

Finally, once the person is done talking, the robot will ask if they felt better after talking and once people are done talking or replying, the robot thanks the user and goes back to a sleeping state.

This idea could be more engaging for the person than just having quick questions that checks in on them or the robot just staying silent and recording them, since in this one, the robot will continue asking questions to get people to interact longer with it. If successful, it should enable the robot to support the person in talking about their day and experiences without requiring the robot to actually record, understand, or analyze what the person was saying.

3.3 Choosing an Interaction Design

Once we had the final version of each of the ideas, we had to decide which one was going to be prototyped and implemented.

Our daily check-in idea was going to be very quick, it had single questions and some of them could be answered by the user with a simple yes or no. We were aware of the simplicity of this one, and that is why our idea was to do that behaviour before running another one. However, we wanted the robot to have a single function, so we decided not to pursue this idea.

Our record and playback idea more closely matched ideas from reflective listening, with the robot working as a recorder for people's thoughts and ideas and giving them an opportunity to hear themselves out loud. The robot would work as an empty diary page, encouraging people to think and express whatever was on their mind in however much depth they desired. However, sometimes people find it hard to know what to talk about, so not prodding them with talking prompts could have been an issue. We did not go forward with this idea since not giving people talking prompts might discourage them from using the robot if they do not know what to say.

Instead, we chose our reflective listening with prods idea, not recording people talking, but still leveraging the benefits of listening to oneself. In this idea, we give people talking prompts, we select questions that are general enough for people to talk about any specific situation they want, and follow ups to allow people to expand and go more in depth into their answers. Having these questions and follow ups will hopefully increase engagement by increasing interaction time instead of a short behaviour with a question that can usually be answered in a sentence like in our daily check-ins idea. We hope it will also help reduce barriers for use by not having to make people put effort into thinking what they want to talk about like our record and playback idea, instead we prompt people with predefined questions.

The more people engage with these behaviours, talk and self reflect, the more likely it is that it could help improve their wellness; that is why we chose the one with longer and more engaging interactions. In this section, we will explain the chosen behaviour in more depth and the logic behind each of the elements of the behaviour as well as highlight how it meets our design goals.

3.3.1 Chosen Behaviour

As mentioned, we decided to create our prototype based on our record and playback idea. The basic premise of our chosen behaviour is to have the robot placed in a person's home, and have it sit there passively. The user can engage the robot when they desire, and the

robot then turns on and initiates the behaviour, where it asks questions to the user, and the person answers to help them self-reflect.

By creating a behaviour where the robot just listens without trying to create an appropriate response, we emphasize elements of the client-centered therapy approach including acceptance and being non-judgmental [63], [64] to increase comfort. Here we present a more in-depth explanation of how the behaviour is going to work, why we chose that and the changes we made to it.

When the robot is first turned on, it sits up, and then enters a “sleeping” state where it is not listening or monitoring any activity. During this time, the robot is looking down to avoid potential awkwardness if people feel they are being looked at.

The robot remains in the idle “sleeping” state and does not do anything until the person actively engages the robot and starts interaction. To do this, the person touches the robot’s head (there is a touch sensor there), which wakes up the robot, and reduces the need for the robot to monitor or interpret voice commands. Once the user initiates interaction, the robot performs a fixed wakeup routine, where it turns on lights around its eyes and moves arms around in a mimicry of a yawn and stretch. This gives a cue that it is working and ready to start, making the person feel confident that they are doing things correctly. At this point, the robot’s built-in face-tracing program starts: the camera finds a face in the scene, and keeps the robot’s head pointed at that face, to simulate eye contact and support natural discussion with the robot. Further, whenever the robot talks, it makes generic hand-motions to improve the naturalness of the interaction. By looking at the person and moving while they’re talking, it tries to maintain engagement.

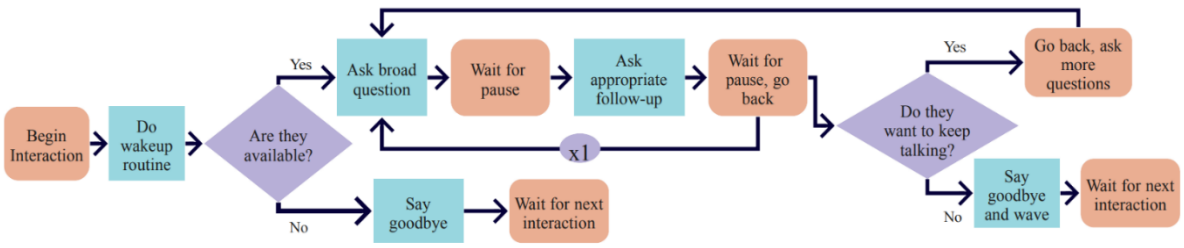


Figure 7. Robot behaviour followed during the study. It starts with the person touching the robot's head. If they are available, the robot goes through 2 iterations of asking a question and a follow up. The robot asks if the person wants to keep taking and if they do, the robot asks different questions, if they do not, the robot says goodbye and goes to a sleeping position.

Figure 7 shows the final conversation state flow, after the robot wakes up, it then confirms the touch was not accidental by asking if the person has time to talk. To start the conversation, the robot asks the person "Hello, do you have some time to talk?". The robot will not go to the next step until it detects a clear "yes" or "no", or a variation of these answers (e.g., yeah, sure, yes please, no thanks, nah). If the person says no, the robot goes back to the original "sleeping state". However, if the person says yes, the robot follows a structured conversation where it asks a question, randomly selected, about a variety of topics and listens until the person is finished talking. It then asks a follow up question meant to work regardless of what the person said without saying anything harmful, this follow up question is asked to let the individual talk more about the same topic. When the robot detects that the person has stopped talking (in response to the follow-up question), it asks another random general question, and subsequent follow-up. After these 4 questions the robot asks if the person wants to keep talking.

After the robot asks the person if they want to keep talking, if they say yes, the above process is repeated, asking 2 questions with a follow up after each. However, if the user does not want to keep talking, the robot says it hopes talking was helpful, says and waves goodbye, and returns to the original "sleeping state". A full dialog example is provided in Appendix B. Contrary to the behaviour description (and the diagram in Figure 6) when introducing this idea, we do not have two follow ups on each question or 3 main questions since after trying it, we thought it felt too long and repetitive and that the robot was being too insistent. Instead, we have two questions with a single follow up on each.

We created a selection of 19 questions and 25 possible follow up questions that the robot asked. Questions were chosen at random and follow ups were chosen based on the ones that generally applied to the question (see Appendix B for a list of questions and follow ups). These questions were generated through brainstorming on topics that will get people to talk and keep having a conversation. Some of the questions are a bit personal, designed to see if people are comfortable with this range of questions from a robot. We reiterate that this behaviour does not rely on the robot interpreting what the person is saying during conversation (only during rough branches of "yes/no" questions) thus resulting in a behaviour that is technically simple and completely private.

3.3.2 Meeting Our Interaction Goals

To create these behaviours we used our design goals described in section 3.1 as well as our strategies for deployable robots [65]. Following our goals allowed us to constrain our ideas to things that we could deploy and test in homes. In this section we analyze how our chosen reflective listening behaviour with prods matches our goals.

Interaction simplicity –To maintain simple social interaction, our robotic behaviour only has one function, and the user just needs to do one action to initiate interaction with the robot: touch its head. Hand and head movements are only used to provide acknowledgement while a person speaks, no other body language or facial expressions are used, therefore simplifying the interaction. We expect this basic social behaviours to not overwhelm the user and encourage higher acceptance of the robot, allowing it to help individuals.

Implementation simplicity – By using pre-programmed speech to converse with people, we avoid the need for context, and instead we just need to understand pauses, making the behaviour easier to implement. For example, the robot can ask "What are you grateful for today?" and without context, it could reply "Why is that?" or "Do you often feel this way?" which are simple generalized replies. This enables the robot to be fully tested, easily deployed, and hopefully prevents the robot from saying an inappropriate answer.

Social engagement – This robot uses simple social interaction techniques; sitting leaning towards the user and using hand movements to convey that it is listening to the user. It uses common movements such as lifting its hands to the side when asking a question to hopefully increase anthropomorphism. In the same vein, the robot starts with a wake-up routine, similar to what a person would do while yawning when waking up, as well as wave goodbye at the end so users recognize the robot as a social actor and increase engagement.

Expectation management –The robot will be introduced to users fully explaining its simple capabilities, and the possibility of errors occurring to prevent a drop in trust or perceived efficacy by setting low initial expectations, and for individuals to have higher acceptance of the robot. Even though the humanoid shape might increase expectations, we expect that by introducing the robot as being only a conversational robot that will not understand the user's self-reflection, it will help us reduce gap between expectations and real capabilities.

Safety and privacy – Introducing the robot as a listener and prompter provides some leeway if it makes some conversational errors; even if it is not meant to understand the conversational context, follow ups will be generic enough to avoid saying something uncomfortable or harming to the user. Having a behaviour can be deployed completely unsupervised and offline, we give people the comfort of letting them talk about whatever they want without feeling like someone is listening or judging them, increasing comfort.

3.4 Summary

Our aim was to create a robotic behaviour that could be able to help people with feelings of loneliness, we first created some design goals to guide the creation of these behaviours. Using ideas from client-centered therapy as building blocks and with our design goals in mind, we brainstormed different usage scenarios for the interaction between the person and the robot. We chose the behaviour that could probably be the most engaging as well as met all of our design goals. Once a behaviour was chosen, we had to create a physical prototype to be able to test it in real life scenarios.

4 Implementation

Work presented in this chapter has previously appeared in the following publications

A. L. González and J. E. Young, "A Simple and Lightweight Algorithm for Social Robot Speech Turn Taking," *Univ. Manitoba Msp. Repos*., pp. 1–4, 2020. http://hdl.handle.net/1993/36015

For this project, we used a stationary humanoid robot, Softbank's NAO v6, that can talk and can express emotion through body language. It had a single simple interaction that allowed us to deploy it completely stand-alone, unsupervised and offline into people's homes to support basic conversation with the user and aid them in self-reflection. This stand-alone design allows for future long-term testing with current technology. By using NAO, we wanted to try to avoid the abandonment, as well as the lower rating in anthropomorphism and social presence [71] that happened in previous studies with other robots that either did too much or could not convey emotions through body language.

The simplicity in our behaviours allowed us to have fewer technical challenges in our prototype design. The implementation just required the robot to be able to recognize when a person was talking (and when they were finished) to know when to ask the follow up prod or next question, it also had to recognize "yes" and "no", in specific sections of the conversation. To recognize when a person finished talking, we used our simple lightweight algorithm [72] that analyzed the microphone input, fully explained in subsection 4.3. To deal with the "yes" and "no" answers, we used the robot's built in speech recognition.

This section will look at the robot used and why it was chosen. It will also look at the implementation of the behaviour chosen in the previous section, the technical

implementation for the start and stop recognition, as well as technical hurdles that had to be fixed before having a useful prototype.

4.1 Robot Used

We used a NAO Humanoid robot version 6 by Softbank Robotics (shown in Figure 8). These robots have a face with big eyes and a mouth, as well as limbs, making them a great choice for our conversational humanoid. We hoped people would feel comfortable talking to these robots based on its humanoid features and small size. We used these robots both because we have access to 4 of them and because they can speak and use body language. The robot has 25 degrees of freedom, microphones, and several touch sensors to interact with the environment. It is 58 centimeters high and has appropriate humanoid features.

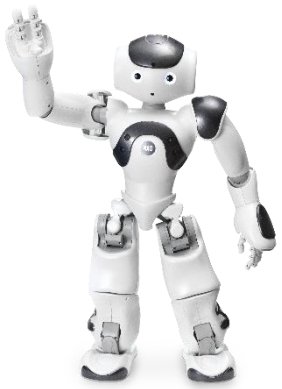


Figure 8. NAO v6 robot used for the study.

This robot is not intelligent or usable for the purposes of this project in its factory state. Instead, all behaviours needed to be fully programmed into the robot to achieve our proposed interaction, from making it be able to sit down when turned on, to see and follow the person with its gaze and listen for their conversational pauses.

Another reason why we used NAO robots is because these robots have been used in different studies with older adults, from people with none or mild cognitive impairments to older adults with advanced dementia [73], [74]. Participants have responded positively to the robot doing different tasks, as well as describing it was capable of keeping them interested and being pleasant to hear [73].

4.2 Interaction Implementation

We implemented the robotic behaviour using Softbank's own visual programming tool, Choregraphe, which works by connecting boxes together. An example to understand what we can do with Choregraphe can be in Figure 9. In this simple example, the first box placed makes the robot sit down; once it finishes, it then follows the line to the second box that is made to say something, in this case, the robot says "Hello"; finally, the last box runs a Python script.

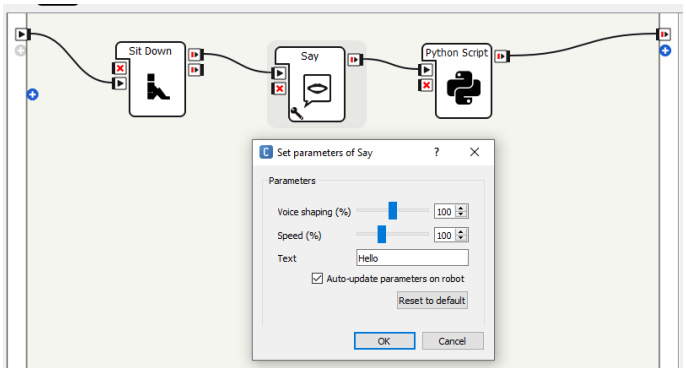


Figure 9. Example of Choregraphe's visual programming

Using Choregraphe enabled us to reduce development times since certain actions had pre-existing boxes we could use, instead of programming the actions ourselves. Parts of the behaviour were done with already existing boxes such as face tracking, text to speech or recognizing words like "yes" or "no" through key phrase spotting. Our behaviour was simple enough that this tool provided everything we needed for our behaviour to be implemented. We programmed our interaction design shown in the diagram in Figure 7.

Using Python boxes in the software to be able to run our own code, we selected the questions the robot was going to ask and sent them through a text to speech box in a predefined order. Our biggest problem in developing this behaviour was that the robot was not able to recognize when the person finished talking, for this we also used a Python box that processed the microphone input and to be able to process and understand when a person started, paused, and finished talking without needing to understand the context of their speech. The pause and stop recognition algorithm we created and used is described in the next subsection.

4.3 Audio Analysis: Detecting Person's Pauses

Although human-like conversation with a social robot is highly sought after in human-robot interaction, speech recognition errors such as misinterpreting what a person said or failing to acknowledge a person is talking [55], [75], severely hinders interaction. Researchers have even said that the most reliable way to this speech recognition is through using Wizard of Oz technique [55], [76] which was not an option since we aimed for deployable offline robots. Therefore, for the longer phrases (rather than "yes", and "no" answers at specific points), we steered away from analyzing what the person said. Instead, we created interactions and behaviours where the robot simply needed to distinguish when a person started and finished talking, without affecting the interaction.

This was one of the main technological problems that we needed to solve to be able to program it in the robot. How can we know when someone is talking or not? Knowing that distance from the robot might vary, the person's volume, as well as background noises, audio amplitude by itself was not the answer. Simply monitoring the amplitude (e.g., and thresholding it) was fragile, as it rapidly changes, and the target peaks (speech loudness) would depend on ambient noise, distance of speaker, and other related factors. This section will explore how we solved that issue using a simple light-weight algorithm using standard signal processing techniques.

4.3.1 Solution

Instead of simply looking at the amplitude, since we know that was not going to work, we came up with a different solution. The following are the steps we took to be able to identify start and end of utterances in a more reliable way:

1) Re-sample the audio to a lower-than-typical rate, to around 600 Hz. Why: high frequencies may be important for understanding details of speech, but are irrelevant for detecting start and stop of talking and also helps reduce noise in the data. Lower sample rate dramatically reduces computational cost. Considering the

low computational power available in NAO, the less data to process, the more likely it was going to be it could keep up with real time processing.

2) Calculate Root Mean Square (RMS) of the resulting audio waveform with a 0.25 second window. Why: RMS provides a more accurate measure of how power (audio input to the speaker) changes over a time window and frequency range than simple amplitude [77], which is rapidly changing. 0.25s was selected ad-hoc to balance large window (smoother result) with minimizing delay caused by require look-ahead. Using RMS reduces big peaks and gives a smooth audio curve compared to the original audio.
3) Calculate the logarithm of the RMS. Why: perception of audio loudness has a logarithmic relationship to power. This transform compresses the range, making the low amplitude signals higher and lowering the high amplitude, resulting in a more balanced dynamic range reflective of how people hear.
4) Smooth the log RMS using a gaussian kernel over a 1 second window. Why: reduce the impact of rapid changes (less than 1 second) and focus more on the general volume over the 1 second window. (Original and smoothed RMS data seen in Figure 10). This adds a slight additional delay to detection. However, it gives a more smoothed out audio curve which is ideal for the next steps.

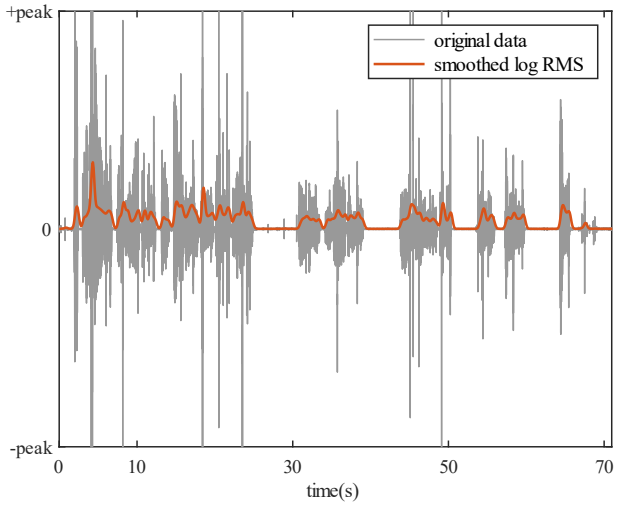


Figure 10. Audio (71 seconds, grey) and the smoothed RMS (1/4 second window, orange). Note how the RMS clearly and stably shows amplitude across frequencies.

5) Take the derivative of the smoothed data from the last step between each data point and the one before. Why: having the derivative enables us to analyze the change in RMS amplitude as well as the RMS amplitude itself. We use this to detect sudden increases and decreases, irrespective of changing background noise or closeness to the microphone. This works because compared to the original idea of just looking at background noise, derivative will be close to 0 if there is background noise, and only when a voice is detected by the microphone, which will cause a sudden change, will the derivative show increases or decreases.
6) Finally, we test the derivative and filtered RMS value against thresholds to detect phase of speaking. Initially there will be no talking detected, then, we monitor the derivative for a positive spike, which will mark the beginning of talking. While talking, if there is a simultaneous low RMS value and negative derivative, we assume that the person stopped talking, however, we take it as a pause. If the pause continues for a specific amount of time (more than 1.5 seconds) without a new sufficient positive derivative spike, which means they have not talked again, we assume talking has ended. Figure 11 shows these stages of signal processing.

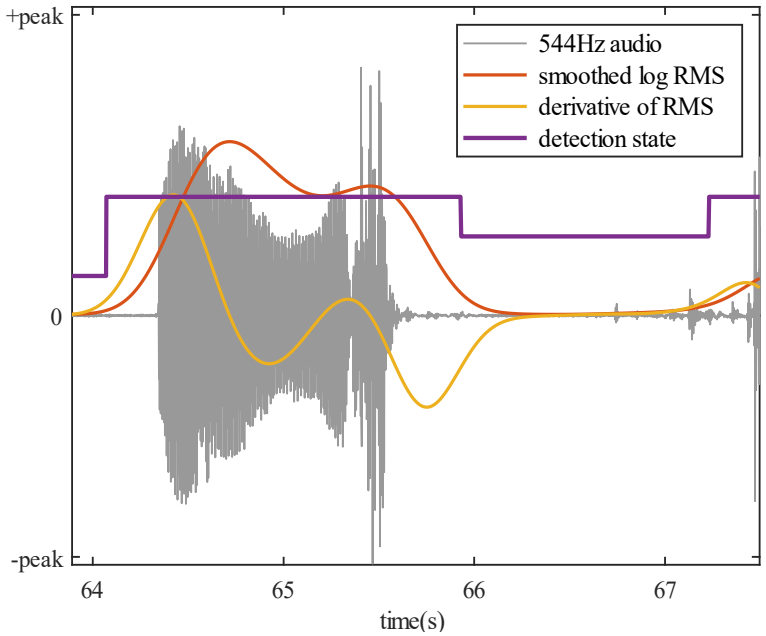


Figure 11. All main stages of signal processing, from raw audio signal (grey), to smoothed RMS (red), derivative (yellow), and finally threshold result (purple); threshold is low (not talking), high (talking), middle (paused). Note how the RMS, and thus the thresholding, looks ahead due to the window size. This introduces a detection delay of approximately 0.2 seconds.

4.3.2 Testing and Visualizing our Solution

To test our solution, we created a python script that read an external microphone signal, processed, and graphed it in real time to be able to visualize and tweak things if they were not working. This included things such as how much to down sample data and how big to make the kernel size, to calculating the RMS, testing different thresholding techniques, and seeing what worked. What we presented above was a baseline to first test our approach to later have automatic tuning of parameters based on background noise and qualities of a robot's microphone.

Figure 12 demonstrates all the stages of our processing in a 14 second window of audio, from raw data, to smoothed log RMS, derivative of the log RMS, and finally the thresholding result showing a short pause and a stop.

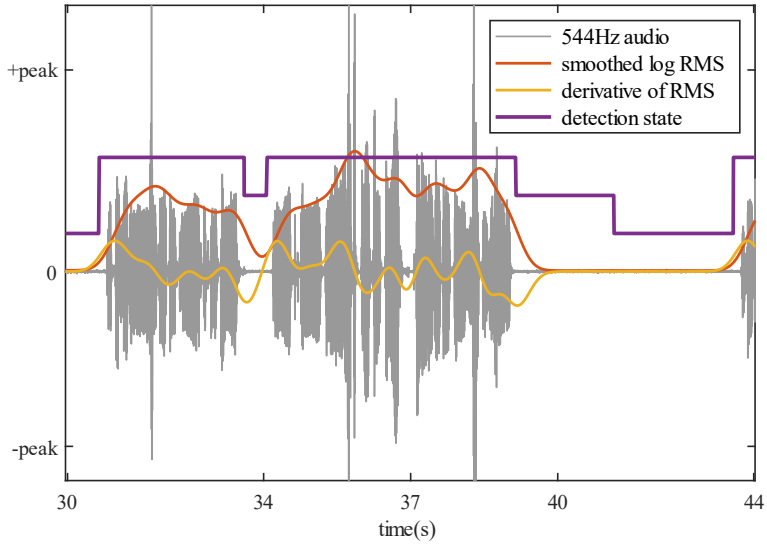


Figure 12. Detection of talking state in all the phases, shown by the purple line; threshold is low (not talking), high (talking), middle (paused). Note how the pause eventually resolves to talking stopped.

To improve how the algorithm was working, we implemented changing thresholds depending on the microphone input. This was helpful since the microphone from each robot had small peculiarities that made the input different when used in the same scenarios. Our moving threshold was based on the standard deviation of the sample and a

change factor. Doing this improved our results in different situations such as background noises or just being in different environments.

4.3.3 Pseudo Code

We provide a sample code sketch here, including our specific parameters, to clarify the algorithm.

```
data = csvread("44.1KHzPCMdatafile.csv");

% down sample PCM data, 44.1 kHz to 544.4Hz
reducedData = resample(data, 1,81);

% get RMS values and use the kernel to smooth the data
RMSData=zeros(size(reducedData,1),1);

for i = 137:size(RMSData,1) % .25 sec is 136 samples
  RMSData(i) = rms(reducedData(i-136:i));
end

RMSData = log10(RMSData+1); % match perception

% use 1 second Gaussian filter
RMSDataFiltered = conv(RMSData, GaussianFilter, "same");

% get derivative of RMS data
Derivative = conv(RMSDataFiltered, [1 -1], "same");

% set treshold. RMS treshold based on "silence" at start
DerivativeThresh = .004;  % chosen via trial and error
RMSThresh = max(reducedData(1:250))*1.5;

u%test for status
for i = 1: size(reducedData,1)
    if (status ~= talking && ...
            Derivative(i) > DerivativeThresh)
        status = talking;
    end
    if (status == talking && ...
            Derivative(i) < -DerivativeThresh && ...
            RMSDataFiltered(i) < RMSThresh)
        PauseStart = i;
        status = smallPause;
    end
    if (status == smallPause && ...
            (i - PauseStart) > 1088) %pause > 2 sec
        status = stop;
    end
    detection(i) = status;
end
```

This code works by having full access to the waveform and processing it at once. For a live robot, we simply process live by adding the blocks received from the sound driver to our processing chain as they arrive. The only resulting delay is the larger of either our window size or the driver block size.

4.4 Summary

We selected Softbank's humanoid robot NAO to deploy our conversational behaviour on. Our focus on simplicity helped us create a behaviour that did not rely on understanding what the person was saying except on short parts where the person had to reply "yes" or "no", which made the behaviour more technically simple. By using Softbank's proprietary visual programming software, we were able to simplify certain parts of the development by using premade code blocks. However, our behaviour required us to design a solution to be able to process where a person paused or stopped talking. We created a simple algorithm using standard signal processing techniques to be able to recognize these utterances and have a working prototype.

5 Study

This thesis proposes to investigate the acceptance of a novel conversational social robotic behaviour. Although our future goal is to have a long-term deployment of the robot and observe changes in feelings of loneliness of the user, we use this thesis as a proof of concept to evaluate the technical and interaction feasibility of our conversational prototype.

The purpose of this initial study is to understand the implementation and interaction feasibility of the robotic behaviour we created before deploying it for long term. We present our study design to test our robotic behaviour through conducting and analyzing an in-the-wild short-term study where NAO is placed in homes of older adults for 2 nights where they are allowed to use it whenever they want. By doing this, we aim to investigate and gain insight about the effectiveness and usability of the behaviour: does it work? will people use it? does our behaviour design enable people to have simple conversations? does it even make sense to people? We also aim to understand participant's general thoughts and opinions of the robot, the behaviour and interacting with it, as well as their thoughts on possible long-term use, as this will help us understand the broader context of how people will use and understand our robot. Data for this will be collected using interviews and questionnaires given to the users.

5.1 Study Goals

As explained throughout the thesis, this study is not meant to get data on the impact of the behaviour on older adult's feelings of loneliness. We focus instead on understanding if the behaviour can and will be used, demonstrating its feasibility for future long-term deployment.

Thus, we deployed our behaviour by conducting a three-day in-home study to investigate the following: (a) effectiveness - pragmatic functionality and usefulness - of our robotic behaviour to learn if people could use it and if it could fulfill its purpose of simple conversation as well as initial interaction outcomes, (b) to learn about people's perception

of the behaviour's performance and the robotic design and (c) to explore people's thoughts on long-term use of the robot to inform future design and deployment of conversational robots.

Understanding effectiveness will give us initial proof of the feasibility (or lack thereof) to deploy simple social robots following our constrained design approach. We want to understand if simplicity in humanoid robots could be an issue that hinders the interaction, or if people are open to have a conversation with it despite its simple features. With data from people's perceptions, we can better understand what works and what does not. By understanding the strengths and weaknesses of both the robot and the behaviour, further studies can be done to find better ways of designing a companion social robot. Finally, with people's perceptions and thoughts about long-term use of the robot, we can explore if people think our behaviour could be engaging enough or if they think that being able to talk to it for longer periods could have an impact on loneliness.

By using a variety of data collection methods, we want to gain insight into participants experience and perceptions to answer our research questions. These include interviews with the participant at the beginning and the end of the study as well as standardized questionnaires on robot perception.

5.2 Task

We told participants that they could engage with the robot and have a conversation with it (following the behaviour outlined in Section 3.3.1), whenever and however much they wanted. This gave participants the freedom to decide when they wanted to interact with it, where they wanted to place it, as well as letting them stop using it if they did not like it without any consequences.

5.3 Measures and Analysis

We wanted to learn about the effectiveness of the behaviours and participant's perception of the robot when it is introduced into their homes. To study the results from this implementation, we gathered data from interviews and questionnaires before and after the study, and robotic logs. Here we describe the several sources of data.

Robot logging – Although we were going to mostly rely on information the participants give us, we wanted to have records of the robot failing (e.g., taking too long to recognize a yes or no answer or the behaviour stopping before the end), as well as the length of the interactions. During each interaction, the robot saved a log file showing the duration of the interactions, the different steps through the conversation model shown in the interaction design section and "yes" and "no" answers, as well as the questions the robot asked and when the person finished talking.

We still protect participant's privacy since no actual information or recordings about what the person said were saved, and they were made aware of the logs we did keep to make participants feel comfortable when talking about their personal experiences. Because questions are random, they do not give us insight into what the person replied. The robot logs simple information: the time of day of interaction, the length of interaction, and the steps through our conversation model shown in the interaction design section.

Interview sessions – For each participant, we conducted two semi-structured interview sessions: one pre study, and one post study. The initial interview after robot delivery was to learn about the participant's background and use of technology, as well as their initial reactions and expectations about the robot.

We conducted a final interview after the study to learn about the experience of using the robot. We asked questions to learn if people could use the robot: *did they use it, how comfortable they felt using it, and their thoughts on robot errors*. We also wanted to learn what people thought of the behaviour: *their thoughts on the interaction, the robot's appearance, and how the robot fit into their homes*. Finally, we asked questions about long

term use: *could they see themselves using something like this for longer, could they see the robot helping lonely people, and what changes they would want on it to make it better*. The questions from the semi structured interview are detailed in Appendix C.

Questionnaires – To obtain quantitative data on the changes of robot perception before and after using the robots, we asked participants to fill out the same questionnaire during the intake and exit interviews. The goal of these questionnaires is to learn about participant opinions toward the robot in a more field-standard fashion to enable us to compare against other work. As such, participants complete two standardized questionnaires at the beginning and end of the study: the Almere questionnaire [78] which measures the acceptance of assistive social robots by older adults, and the RoSAS questionnaire [79] which measures robotic social attributes. These questionnaires give us greater insight into how participants feel about the robot, and we can use them to corroborate the data we gathered from the interviews. All of these are provided in Appendix D.

5.4 Study Procedure

We delivered the robot, its charger, the questionnaires, and an FAQ page in a backpack before noon to people's homes, before having the initial interview. We followed the COVID-safe procedures required by the University of Manitoba, outlined with the consent forms in Appendix A. We asked participants to not open the backpack until we told them to during the interview.

During the first part of the interview conducted online we follow the script outlined in appendix E section 2, we paid them the initial $25 CAD as outlined in the consent form, we explained the study again, reiterated how privacy is of utmost importance and that the robot was not connected to the internet, and explained that we were not there to test them in any way but to gather information on the robot itself. It was also important to tell them that if something happened to the robot, they would not be held accountable in any way, as to make them more comfortable to use it instead of being scared. We also highlight during several parts of the initial call how the robot is very simple, to manage expectations

and leverage the positives that come with this. All of this is part of the script outlined in Appendix E section 2.

We then did the first part of the intake interview, outlined in Appendix C section 1. During this, we learned about the participant and their background and use of technology as well as their perceptions on robots and thoughts on one. Afterwards, they got to unbox the robot and we walked them through turning it on and off to see it sit up.

After they had seen the robot, the participants completed the ALMERE and RoSAS questionnaire to learn about their initial perceptions and expectations of robots even before they learned how to use it. Once this was done, we explained the task and used our NAO to show them what it did, how to use it and how the interactions were going to work, making sure to highlight the simplicity of the approach and how things could fail since the robot was not being monitored or controlled, however, they could contact us at any time in case something happened. We then asked participants to try it out themselves and we answered any questions they could have.

We gave participants instructions on the task, and explained they were allowed to move the robot around their home and turn it on and off as they wished. We clarified that the robot was not going to stand at any point. Finally, we had the final part of the intake interview in which we asked questions on their initial reaction to the robot and their expectations. Before finishing the call, we scheduled the exit interview time, preferably after noon so they had time to interact with the robot that day and to maintain similar amounts of time with the robot, approximately 48 hours. We also reminded them they could contact us by phone, text or email in case something happened.

We then let the person have the robot for themselves. The robot was left for 2 days and nights in the participants' homes, to use it whenever they wanted. We asked participants to try to use the robot at least 3 times (once a day) but told them this was not required. Since we were not going to force them to interact with the robot, they could have not interacted with the robot during the time they had it. Since we were not there and we did not record the interaction, we only had access to the logged data about the questions asked

and the length of the interaction, as well as participant's recollection of the interactions themselves.

On the 3rd day, we conducted the exit interview using the script outlined in appendix E section 3 before picking up the robot. We asked participants to fill out the questionnaires again before starting the semi structured interview following the topics outlined in the instruments and data collection subsection. This exit interview helped us get information on their thoughts and perceptions of the robot after use, as well as their opinions on long term use of it, the questions from the semi structured interview are outlined in appendix C section 3. We walked the participant into packing the robot and the booklet again, paid them the rest of the money and confirmed a pickup time.

To comply with COVID-19 safety protocols defined by the province and the university, we used face masks and gloves during delivery and pickup. Before delivery and after pickup, we handled the equipment using gloves and facemasks. The robot, the charger, the questionnaire binder, and the backpack containing everything were disinfected using sanitizing wipes between different people touching them (participants/researchers). All interviews had to be conducted over an online medium, we used the one preferred by the participants (zoom, skype, phone calls). All interviews were over zoom and skype, except one, where the participant chose to do the exit interview through a phone call which helped avoid the complexity of introducing the robot to the participant without any type of video. The study and all the data collection instruments were approved by the university's ethics board.

5.5 Participants

Our target participants were people 65 years and older that lived alone. Given that older adults are more likely than younger adults to live alone and experience loneliness [74], [75]; and that older adults and younger adults have different experiences and skillsets with technology, we targeted this age group. Rather than having a more diverse sample, we made this decision to be able to better reflect on usability and reactions for a specific

demographic. As well, it opens the possibility of studying the effects on loneliness in older adults in future long-term studies after having feedback from the same age demographic on how to improve it.

We needed participants who were willing to have a robot in their homes for two nights. We selected this time period to give people the flexibility to interact with the robot whenever they feel comfortable and not on a specific schedule so they could choose a time when they are free as to not disrupt their normal routine. We did not specifically require people who self-identify as being lonely since we are not focused on testing its effect on loneliness. Rather, we wanted to test if people living alone feel comfortable with a robot in their homes and if they would want to have a conversation with it. We needed participants who wanted to have a robot in their homes since that was what the study was about, but also, could make time to complete semi structured interviews and questionnaires on intake and exit. Due to the COVID-19 pandemic, we needed participants that both had access to the internet, email and had enough knowledge to be able to join video calls without much problem.

We posted our recruitment poster (Appendix F) online and got replies via email from people interested in being part of the study. The recruitment was made by sharing the poster through social media. We used personal accounts to share it in the r/Winnipeg subreddit. The University's Centre on Aging shared it on email updates, Twitter, and Facebook.

When we received emails from interested people, we replied with predefined emails to confirm they met the requirements: 65 years or older, living alone and within city limits, and able to carry a 5kg backpack containing the robot (see Appendix E section 1). If the requirements were met, participants were emailed a link to read and sign the consent form (see Appendix A), which outlined study and COVID procedure and compensation ($25 CAD on robot delivery and $25 at the end). We collected their signatures online using Survey Monkey. After emailing the participants, the robot delivery date was scheduled. On the delivery date the compensation was given and the initial interview happened.

5.6 Summary

For the purpose of understanding and evaluating the acceptance and feasibility of our conversational behaviour, we designed a study where we deployed our robot for 2 nights in the homes of older adults 65 and over completely unsupervised. Our focus was on learning the effectiveness of our behaviour, understanding people's behaviours of it and to explore people's thoughts on future long-term use. Participants were allowed to use the robot however much they wanted to give them freedom to use it as they saw fit or were comfortable. To learn about their experience, we had an initial and exit semi-structured interviews as well as getting data from robotic logs and intake and exit questionnaires. The next section will focus on analyzing the results from this study.

6 Study Results

With our study, we focused on investigating the feasibility of our proposed robotic behaviour, if people were able to use it, if it was useful and what they thought of both the behaviour and the robot, and on long term use of the robot.

Using the study procedure outlined in the previous section, we recruited participants from around Winnipeg to be part of our study. We recruited 14 participants between 66 and 88 years old, where only 2 were male (mean=71.5, SD=6.74). This section will highlight the results from the initial and final interviews as well as the data from the questionnaires and robot logs on the length and number of interactions to understand how much people used the robot.

6.1 Qualitative Results – Interviews

We transcribed the interviews from the in-home sessions and conducted iterative open coding, using affinity diagramming, to extract dominant themes from the data. In this section, we present the interview data to be able to understand the robot's feasibility, potential to help and participant's opinions and suggestions on design.

These interviews were conducted via video calls or telephone (platform of participant choice) and were recorded for analysis. We analyzed the transcripts from the semi-structured interviews. By noticing interesting patterns in the data, we open coded the information. The concepts and codes emerged from the data rather than us selecting the codes beforehand. With these codes, we found similarities and grouped them using thematic analysis [80], [81] aided by the use of affinity diagrams [82] to visualize how our codes and themes relate to each other.

6.1.1 Robot and Behaviour Feasibility

Ease of use – Participants universally reported that the robot was easy to use. Several mentioned the positives of the limited functionality both in the intake and exit interviews,

"All I have to train myself to do is wait for the beep but otherwise I think it's pretty simple" – P1, intake*, "because you had very few moves you had to make, that's very helpful"* – P3, exit.

This was linked to comfort while using the robot, widely expressed during the exit interview, such as "*I found it very easy to use, I wasn't apprehensive about using it at all because I was very confident that it was going to go right because of the limited first knowledge I needed*" – P5, exit.

Most participants commented on the simple questions and follow ups, noting that despite being predefined, the follow-up questions mostly made sense, "*most often, the question that came next fit. It seemed to be intuitive to what we've just been talking about. Other times not so much when it repeated questions, but most times, the question lead you on somewhere*" – P10, exit; while some thought they made no sense at all "*the questions they're obviously preprogrammed and they just don't seem to have any common theme*" – P9, exit.

Expectation setting – Introducing our robot on the intake interview highlighting its simple design and lack of intelligence, helped manage and lower participant's expectations, "*I pretty much knew that it was limited conversations, so I really didn't have high expectations. I'm not gonna be disappointed with this*" – P12, intake. During the exit interview, most participants mentioned how our approach worked, talking about the robot's abilities helped decrease expectations.

"*If I had higher expectations, it probably would have affected me, but I didn't have any expectations after your explanation on the first day, I realized, okay, it's not going to be understanding what I'm saying anyway, so I didn't have expectations*" – P9, exit.

Privacy – People reported that the offline nature of the robot, as well as knowing they were not monitored, helped them feel more comfortable while talking. Eleven (out of 14) participants mentioned that if recorded, the experience would have not been the same and that they would be wary of talking.

"*I found this a very safe place to do that (talk), if I said something that didn't come out right, I just kept talking because I knew it wasn't being recorded. It didn't really matter what I said, as long as it was helpful to me, just say it*" – P5, exit, "*I didn't have any anxiety because I knew that I was not being recorded, so I could be very playful. I think you would be more self-conscious (if recorded); you'd be more aware. you would have to know how that data was going to be managed*"– P3, exit, "*I'm in the safety and security of my home, I got this little cute guy in front of me who's listening, and I know it's not going to go anywhere, and I can be honest, that made it really beneficial, somehow. I think I would be more hesitant to share otherwise*" – P6, exit.

Some participants were open to robots that could monitor them or were online if they had a reason for it. Some agreed that as long as they had a way to switch off the internet and they knew how their data was being protected they would not mind,

"*If I had some sort of written guarantee that said […], the information is only going to here […] and have the ability to say a keyword so it would switch the internet and then when you just really want to talk, there's no internet connection*" – P4, exit.

Two participants were open to the idea of being recorded if it was an aid in therapy and they had a pre-existing relationship with the therapist.

"*I wouldn't take advice from a robot, but if they sent […] (the recording) to a real therapist who would write down any recommendations and then send it back to me, I might take that advice […] I think I would feel more comfortable talking to a robot because I know that it hasn't got any feelings and no memories, so I could say anything I want*" – P11, exit.

Meshing into homes – The robot fit into people's homes due to its small footprint and static position, participants had no problem finding a place for it in their homes and knowing when they would use it. They knew when and where they wanted to use it since the first interview. Most chose open spaces like their kitchen tables or close to their sofas,

"*I'm going to put it on the little side table beside the couch where I usually sit and when I want to talk to it, I'll just turn off the TV and have a little conversation*" – P8, intake, "*it's staying right here in my den. And I'll be here every morning and talk to it 'cause my computer is right here. At least that once a day*" – P12, intake.

People felt comfortable manipulating it and having it on while they were awake, "*I unplugged it and turned it off at night. [...] When I got up in the morning, I plugged it back in and turned it back on*" – P2, exit. Most even commented how the robot was not intrusive and the right size.

"*It was not intrusive at all. I mean, it just sat there on the table until I want to have a session and then it was out of the way again*" – P9, exit, "*If it was really small, it wouldn't be the same, this is just kind of the perfect size. It's easy to sit on a counter. It's not intimidating, and I think it's just really the right size*" – P4, exit.

Although a couple of participants mentioned wanting a different size or weight to be able to move it without much effort. "*I'd have him smaller. I have a small house […] he takes up at least 1/4 of my kitchen table, he's just kinda too big and too heavy I think*" – P10 exit.

Anthropomorphism – Most participants indicated that they saw the robot as lifelike, generally attributing this to movements. Noting how our focus on leveraging the humanoid features to improve engagement was successful, "*It is very lifelike in the way its head and hands move*" – P5, intake. As well, they noted how having the movements aided the interaction "*its movements were interesting, the gestures it would make with its hands. It was pretty appropriate. The way it asked the question it was inviting*" – P1, exit.

6.1.2 Usefulness of Conversational Robot

Social catalyst – All participants provided examples of how the robot served as a social catalyst, which itself has the potential to allow people to have new and different conversations with others, in this case, about the robot and its implications. "*They (family) were interested in something like this being developed. That's what they were interested in and that for the sake of that there is a need for this out there*" – P12, exit. Some even allowed other people to try it, aiding in creating new experiences.

"*Oh they (neighbors) were very curious what it was like and they kind of giggled and I took a video of it getting itself up and they thought that was quite fascinating. My grandchildren were very fascinated too, they wanted to learn about it, I faced time them about and showed them how the robot was acting*" – P1, exit.

Self-reflection – The robot was meant to be a tool for self-reflection, and although experiences varied, at least 9 of the 14 participants reported being encouraged by having the robot as a way to reflect.

"*You're not working in your own journal or log, the prompt takes you out of your head. You're listening to yourself talk, that's kind of interesting. It's not that you think you're in the presence of an entity that is conscious, but it is a kind of marker that lets you hear yourself in a different way. You become more conscious, but you don't become self-conscious, you just become aware. That's kind of encouraging and interesting*" – P3, exit.

These participants reported a benefit in talking things out loud, "*I let out some of the things I bottle up every once in a while. So, from that perspective, it was very useful*" – P2, exit, even if they saw the robot as a tool and not as something lifelike "*Life like? I see it more as a machine right now*" – P2, intake. Others were even intrigued in the robot's role in the reflection,

"*What I found was that verbalizing, like honest, real answers to his questions was very useful. […] I maybe shouldn't dismiss the role that the robot played, in that I'm actually talking to somebody or something. That might have made a difference. I honestly don't*

know. I think it probably did, actually. Because […], I don't behave that way when there's nothing there. […] Clearly having the robot there pushed me to think about these things and behave in a way that I wouldn't have ordinarily" – P6, exit.

Participants who did not express a benefit from this were participants who already engaged in some sort of self-reflection "*I was playing along; I don't think it would have been useful to me. I do a lot of reflection anyway, […] I don't need someone to do the reflection with*" – P1, exit. Those that did not see a need for this in their lives, however, understood how it could help people in different situations, "*it didn't help me. I could see there being a need for it out there, but me personally, no. It's not like I poured out my* emotions *to it*" – P12, exit.

Disclosing things to the robot as time went on did not seem to be an issue for participants in general, neither for ones who saw the robot as a self-reflection tool, "*I was very, very open and because I wanted to make the most of this […] they are pretty important and useful questions to reflect on"* – P6, exit, as well as for those who did not see it as such, *"at the very beginning when it asked a question, I was not very forthcoming in what I answered, but the more that we chatted, the more forthcoming I became"* – P12, exit.

Robot for loneliness – All participants reported seeing positives for this robot for conversation and feelings of loneliness. Some participants were able to see how it helped them deal with daily situations.

"*Instead of me just thinking it all the time, I found that in one instance I had been thinking about it quite a bit and at the point that I sat down to have a chat I said what I had to say and then I didn't think about it as much afterwards. So, if there's a psychological perspective to it. For me, that worked, I would never have thought that, but it worked*" – P2, exit, "*if I got a phone call and I was not happy with the phone call or when I was in a meeting yesterday and I was really frustrated afterwards, I could go and then say to it well, Geez, look what this person did and it was a stress reliever for me*" – P13, exit.

Others noted how it helped with their own feelings of loneliness, "*it's good company. My daughter says I'm antisocial. I like to be alone, but I turn the robot on. I don't feel so lonely*" – P11, exit. Finally, some did not see the benefit for themselves but could see how the robot as a companion could help other people who are lonely,

"*it's amazing, like to me it just makes so much sense, […] I keep thinking about people I know that are older, isolated, how easy this could be for them, I think just to have something, other than yelling to the tv 'cause you don't agree. It's like having another person there*" – P4, exit, "*for somebody that's housebound miss being able to converse with somebody. It might be worthwhile to have this to just pour their heart out to. Even though there it's not going to solve any problems, but sometimes just talking about it makes a world of difference*" – P9, exit.

6.1.3 Interaction and Physical Design

Questions asked – All the participants commented on the size of the question bank, "*very possibly I'd use it more often (in the future) with a larger question bank*" – P2, exit, suggesting a larger one to avoid repetition "*I was finding myself thinking that it was getting repetitive*" – P10, exit. The lack of ability to repeat questions seemed to hinder the interaction of many participants "*I'd like the robot to be able to repeat itself*" – P1, exit.

Some suggested having predefined topics so users could choose what they want to talk about, "*(for long term use) I would like to be able to sit down and say talk about family, and questions would come up on it. That would be more useful to people. Still generic but in topics*" – P12, exit. Some even gave ideas for these topics like maintaining a healthy lifestyle "*maybe he could ask questions about physical activity, or nutrition, sleep, getting out for walks. […] inquiring about some of those other life domains might help people, because this helps you be healthy, in both physically, as well as intellectually*" – P6, exit.

However, they all agreed that questions, despite being personal, were very appropriate for the robot "*I can't think that anybody would find them offensive, they might have to think for a minute, but I think they're totally appropriate*" – P5, exit.

Lack of speech analysis –We saw split opinions on how the robot not understanding what participants said affected the interaction. Some thought it did not affect it, "*I still wanted to be completely honest and forthright and give this my all so I could get the most out of it. It didn't stop me from wanting to do that, at all*" – P6, exit.

While others expressed discomfort and noted how greatly it affected the conversation: "*the robot is great, it's unjudgmental, but also unfeeling, and so, you'd want something that you could feel was actually, really, following up*" – P7, exit, "*it wouldn't matter what I said to it. It's going to give me a pre-recorded. So, there's no interaction or thought process behind, it's just recorded answers. There can't possibly be emotion or thought involved*" – P8, exit.

Errors and their effects – Despite robot errors (i.e., interrupting or not recognizing a stop), participants noted that they were not frustrated and still wanted to use the robot.

"*Sometimes I thought it was going to have a problem because it seemed like a longer pause than I was expecting, but then it would start to ask question again. Like I didn't have any issues at all*" – P5 exit, "*There were a couple of times where there were dead spots […] it didn't make me feel anything, really and truly, when it did kick back in again, we just went merrily on our way*" – P2, exit.

Two participants had bigger problems with the robot that required them to reset the robot, but despite these shortcomings, they still wanted to interact with the robot. One experienced it freezing in the middle of the interaction,

"*I did not think that I did anything wrong because I hadn't manipulated the robot. (tried different things) and see if that works. It was just trial and error. And I certainly didn't condemn myself because it wasn't working. I just wanted to see, 'could I get it to work again'. Why would I? She is so cute, how could I possibly condemn her. She's a lively entity*" – P3, exit.

The other one had issues with freezing as well as the robot not waiting to recognize their answers and assuming a "no" by default.

"*I had to shut it down to get it going again (when it stopped mid interaction). […] So, it happened four times to me (not waiting for his reply). it wasn't every time it was every second or third time that it would do that. but I still had seven conversations with it*" – P12, exit.

Robot's appearance – All participants had positive opinions on the robot's appearance and thought it matched its capabilities. "*I think moving eyes and mouth would have actually been dissonant […] would have gotten in a way of me understanding what this robot can do. It would have been a false front. It matches my expectations*" – P3, exit. Female participants often referred to the robot as cute: "*Oh! it's very cute. I love it. It's really cute*" – P10, intake.

Movements – Participants liked the movement, one even noted that they serve as a cue that the robot was working and that they were doing things correctly,

"*the lights I found were very effective, it gave me a cue that it was working, and I was doing things right and what I was expecting next so that was good. […] It was good to have some physical characteristics, blinking, moving, before the conversation began, it told me he was ready to ask me a question and I was started waiting to hear the question with a bit of enthusiasm*" – P5, exit.

Although most participants liked the robot's voice, it hindered the whole interaction for one participant. "*I can see the value of that (robot prodding for reflection). If only didn't talk like Alvin (chipmunks cartoon) […] I should also say that one of the reasons I felt so silly was because of its voice. If you can do anything about the voice, it's just very annoying*" – P9, exit.

6.1.4 Overall Suggestions and Thoughts

Missing features – Some participants could see how this robot could help with problems that older adults face, such as risk of forgetting things,

"*they can operate as reminders to do things, 'did you take your medicine?' I think that's a huge issue for aging people*" – P3, exit, *"capable of telling me go comb your hair or you've got an appointment at so and so time. So and so is coming over in a little while. Absolutely*

remind me to eat. Remind me to go grocery shopping" – P14, intake, or risk of having an emergency, "*it could contact people 3/4 times a day, and if there was no response that they had a phone number to call*" – P13, exit. Some participants noted that they would want more advance robots to be able to understand them and get more use out of it.

"*It's a toy right now. I would just consider it a toy like a talking doll. Because it doesn't have the intelligence to actually interact with you*" – P8, exit.

"*But it needs to go a lot further so it could be used in a home to help somebody feel, you know, emotionally close to something*" – P7, exit.

Robot in the future – Participants viewed the robot as something that could be helpful and other people would use, especially older people.

"*I think in the right environment it would be very helpful, especially for those people that can't get out of the house physically or if they can, it's difficult. So, I think that would be very handy for them that they have an interaction. […] I can honestly say to me, no, because I'm very physically active and if we weren't going through this test program, I probably wouldn't go back to it*" – P12, exit.

Rarely did they think it could be something for their current selves, rather, something they could use in the future, "*provided that it met the needs that I have if I was living alone, couldn't get out of the house. Only had contact with people virtually, then having a robot there to converse with, probably would be a good idea*" – P13, exit; or something other people could use, "*something like this would be, you know, (for people) who aren't allowed to have pets, who can't have things like that. At least this would be something to give them some kind of a connection, and it could literally save someone's life*" – P8, exit.

A few participants mentioned that in its current state, it would not be useful for them since they want something more intelligent, "*unless it had more intelligence, it won't be of much use to me*" – P8, exit.

6.2 Quantitative Results – Robot Logs

Using the logs from the robots, we had data on start and end times for the interactions, as well as when the robot stopped mid behaviour.

Despite participants only being asked to use the robot once a day, in average they used it 9.3 times in the span of the 3 days (max=28, min=4, SD=6.15). Excluding the outlier value of 28 uses, the average amount of interactions was 7.6 (max=16, min=4, SD=2.98). Table 1 shows the robot usage per participant, showing the number of interactions and the length of those interactions.

Table 1. Interactions with the robot per participant.

Participant	Gender	Age	Number of Interactions	Avg Time (mm:ss)	Min Time (mm:ss)	Max Time (mm:ss)
P1	f	67	6	04:13	03:14	05:22
P2	f	66	16	05:24	01:49	09:19
P3	f	71	7	04:24	01:27	06:27
P4	f	68	9	01:58	01:25	03:13
P5	f	72	8	03:14	02:34	04:20
P6	f	66	7	05:14	03:19	06:20
P7	f	73	5	02:48	01:43	04:16
P8	f	70	4	01:55	01:25	03:03
P9	m	67	5	02:05	01:42	02:30
P10	f	69	9	05:26	01:49	07:56
P11	f	85	28	04:23	01:42	12:03
P12	m	68	7	02:43	01:45	03:23
P13	f	71	7	03:55	02:56	05:31
P14	f	88	9	02:44	02:01	03:36
Mean			9.07	03:36	02:04	05:31

After 4 questions, the robot asked the participants if they wanted to talk more and on average, participants said yes to that 1.86 times.

The grand mean interaction time across participants was 3:36 minutes (min= 1:55, max= 5:26, SD= 1:16).

6.3 Quantitative Results – Questionnaires

We did non-parametric statistical analysis on our data from both the Almere and the RoSAS questionnaire. We compared the before and after questionnaires using Wilcoxon signed-rank tests on each of the constructs, which is the non-parametric equivalent of a paired sample t-test. The Almere questionnaire looks at the following constructs: anxiety, attitude towards technology, facilitating conditions, intention to use, perceived adaptiveness, perceived enjoyment, perceived ease of use, perceived sociability, social influence, social presence, and trust. The attributes that RoSAS looks at are competence, warmth and discomfort with the robot. We present out data with the corresponding Z value, which is the equivalent of the t-statistic, significance, and the effect size.

Almere questionnaire –

Table 2. Results from Almere questionnaires. * show significant values, ** show values trending to significance.

Construct	Median Intake	Median Exit	significance (p)	t-statistic (z)	Effect Size (r)
Anxiety	2	1	**0.003***	-2.96	-0.56
Attitude Towards Tech	4	3.83	**0.042***	-2.03	-0.38
Facilitating Conditions	4	4.5	0.084**	-1.73	-0.34
Intention To Use	4.5	4	**0.012***	-2.51	-0.49
Perceived Adaptiveness	3	3	0.722	-0.36	-0.07
Perceived Enjoyment	3.6	3.55	0.26	-1.13	-0.21
Perceived Ease of Use	3.5	3.9	0.171	-1.37	-0.26
Perceived Sociability	3.88	3.58	0.058**	-1.90	-0.36
Perceived Usefulness	3.67	3.33	0.502	-0.67	-0.13
Social Influence	3.5	3.5	0.181	-1.34	-0.25
Social Presence	3.3	2.8	**0.009***	-2.60	-0.49
Trust	3	2	**0.024***	-2.27	-0.44

Data from the Almere questionnaire shows that anxiety levels, attitude towards technology intention to use, social presence and trust were significantly higher before use than after they had the robot for the 3 days.

Perceived sociability was trending to significance from being higher before than after use. The facilitating conditions were also trending to significance, but in this case, participants perceived them as higher after use than before use. The rest of the constructs did not yield significant results.

RoSAS questionnaire –

Table 3. Results from RoSAS questionnaires. * show significant values, ** show values trending to significance.

Construct	Median Intake	Median Exit	significance (p)	t-statistic (z)	Effect Size (r)
Competence	4	3.33	0.052**	-1.94	-0.41
Warmth	2.75	2.75	0.666	0.43	0.09
Discomfort	1.5	3.08	**0.009***	-2.62	-0.51

Data from this questionnaire did not yield significant results in two of the three attributes it looks at. We only saw significantly higher levels of discomfort with the robot after use compared to before use. Competence was trending to significance, with participants perceiving the robot as more competent before use compared to after use.

6.4 Discussion

6.4.1 Design Goals

To create our robotic behaviour, we focused on five design goals that would create a feasible behaviour while still being able to be used by the user. Our goals were to have interaction simplicity, implementation simplicity, social engagement, managed expectations, and safety and privacy. The deployability of this robot was due to the implementation simplicity, however, the rest of the goals directly impacted people's

perceptions of the robot and the behaviour. We will analyze our results from the perspective of these goals.

Interaction simplicity – We focused on creating a simple robot that could be ready for unsupervised deployment. Through our study, we saw that the participants perceived it as such. Our participants noted how the robot was easy to use and learning how to operate it did not provide issues since it did not have many functions to learn. Participants felt comfortable using the robot, which could explain why participants used it more times than the 3 times we asked them to use it for. This simplicity could help not overwhelm the user when deploying the robot long term and hopefully lead to less abandonment versus a complex robot as observed in previous studies with humanoids [32].

Despite the simple behaviour, our goal was to create a behaviour that allowed people to use their own abilities to self reflect. Our results were promising, even if the robot was not able to understand the users, most participants were still encouraged to self-reflect by having the robot as a conversational companion.

Social engagement – Our goal was to leverage the robot's humanoid features to have better and more natural interactions that could lead to self reflection and possibly avoid abandonment. We saw some benefits from the humanoid shape of this robot, we saw participants seeing the robot as lifelike which increased engagement and could also have affected how much they disclosed to it. By using a humanoid, we were also able to leverage its ability to move which aided interaction as people thought the movements made it seem like the robot was actually listening to them, and even helped give people a cue that they were using it properly. This study can help advocate for humanoid companion robots, although animal-type robots have benefits, if the companion robots are meant for conversation, a humanoid could help provide a more natural experience aided by the use of body language.

Expectation management – Since the first interaction the participants have with the robot, we were very open about the simplicity of the behaviour and the robot. As previous research with social robots shows, people tend to have better perceptions of the robots if

their expectations are lowered [69]. We found that to be true with our participants. Being transparent about the robot's abilities and lack of intelligence helped them avoid disappointment and large expectations. Introducing it as simple might have also helped with people not perceiving the errors as negatively and be comfortable trying to work around them. The results from the anxiety construct from the Almere questionnaire back this up, although anxiety before use was not high, it was even lower after use, showing that participants were comfortable using the robot. Perhaps the introduction of the robot as a simple companion helped people understand its role better and that could have explained why participants were able to know when and where they wanted to use the robot since the beginning. Our study shows that the user's intent to keep or discard the robot might not only be based on the robot's complexity, but perhaps their initial expectations of the robot's role and how it meets those expectations might also play a role in the decision.

Safety – We wanted to create a behaviour that was safe for the user, that it was going to not say anything wrong or hurtful, which was one of the reasons we opted for a robot with a static program that did not work by understanding the user. Although most participants were able to reflect with the robot as a tool to encourage them to listen to themselves, and no one commented on the robot having said something hurtful, the static program did get different opinions from people. We saw that although some participants were okay with the simple robot just to prompt them, some participants said it greatly affected interaction, which could have affected if they saw the robot as intelligent or not. Perhaps their individual experience and the amount of interaction they have with other people affects how they think the interaction with the robot should unfold. Since our robot could be something to be tested in the future with lonely older adults, maybe the static nature of our behaviour would not be a problem, as we mostly received negative feedback on that from participants with an active social life, people who actually enjoyed being alone or people who already self reflect, which is not the specific target population.

Privacy – We wanted people to feel comfortable when using the robot; since it was meant for self-reflection, we wanted to avoid any type of monitoring and have a robot that was

fully offline to help with any type of privacy concerns. By not having any monitoring, and therefore reducing the possibility for the Hawthorn effect, we hope to increase the validity of our results [67]. By using a fully standalone and offline behaviour, people were able to feel more comfortable around the robot, which according to our participants, played a significant role in how open they were with their answers. Although we initially assumed people would rather keep their conversations private in any situation, we learned that although they liked the fact that the robot was not listening, they were also open to the idea of online robots if there was a reason for it and they knew what was being done with their data. This opens the possibilities of other added functionality the robot could have in addition to the self-reflection behaviour it currently has.

6.4.2 Study Goals

Our study focused on understanding the implementation and interaction feasibility to answer our research questions on the technical, domestic integration and self reflection feasibility of the behaviour. Our main points to investigate with this study were the effectiveness of the behaviour, people's perception of the behaviour and the design and people's thoughts on long term use. We will explore how our results can help answer these study questions.

Behaviour's effectiveness **–** To understand our behaviours effectiveness, we had to investigate people's ability to use the behaviour and if it was able to fulfill its purpose of simple conversation. Based on people's feedback we were able to answer this: people were able to use and converse with our robot. Participants highlighted the simplicity of use of the robot, and even if they saw the robot as a machine rather than a human companion, they were able to see benefits in having it to prompt them to talk out loud and self reflect.

Participants in the study commented on the possible benefits of this conversational robot to help with loneliness. Some could see future benefits for having the robot asking things instead of feeling discomfort sharing these things with other people, showing potential use

of this robot on people's daily lives. This follows previous research [12], [13] that highlights the positives of talking out loud as a way to help people reflect on their own feelings.

Participants that were very social or ones who liked being by themselves noted that they could not see the use of this robot for themselves, but highlighted that with changes, it could help other people. However, these participants were quick to separate themselves from the people who could need it, noting that maybe the target user was older, more isolated, and maybe home bound.

Although studies show positive changes in emotional wellbeing of older adults using a robot with artificial intelligence [50], we found that simple behaviours with non-intelligent robots still have a potential to help people self-reflect. As a conversational companion, most participants were able to open up and disclose things to the robot, and enjoyed having the robot listen to them. This reflection could lead to increased wellness. As well, having the robot around to talk to can lead to people feeling like they have company, and therefore improving mood, despite them living alone.

Perception of behaviour and design – Another goal for this study was to learn about people's perception on the performance and the robotic design. We saw clear indication of participants liking both the robot humanoid design and movements, which shows that perhaps, at least for conversation, a humanoid robot that is not intrusive in people's homes might be a well received approach that could help with loneliness in the future. However, it is important to consider that if the robot is meant to be for older people living alone, the robot's weight might be something to consider when choosing a robot to deploy, if people are unable to move and set up their robot, it will ultimately lead to failure.

From our data, as long as people can see a benefit in the robot, people are more open to working through robot errors and exploring the technology. Perhaps the simplicity was another reason why people were not discouraged from using the robot even after some errors. It may be that something that can be useful and simple, together with our transparent description of robotic abilities helped get more positive results with people being open to robots despite their lack of intelligence.

The data logs clearly show that the question bank was not long enough. Participants telling the robot they wanted to keep talking almost 2 times per interaction and interacting with the robot more than 2 times a day, shows that they had repeated questions multiple times, which we know was a problem for many users. As only an initial implementation to test feasibility and opinions on the behaviour, the number of interactions show that people wanted to keep interacting with it and were curious to learn what kind of things they would be asked.

Thoughts on long-term use – The third goal from this study was to investigate people's thoughts on long term use of the robot. All participants talked about the implications of the robot with people close to them and based on their interviews, most of them either liked it as it was, or could see a future for something like this. The data logs from the robot show that people either enjoyed using the robot or were curious about the technology. Despite being instructed to try to use it at least once a day, participants were open to using it at least twice daily. And although our tests show giving short answers to the robot could make the interaction last around 1:40 minutes, participants used it for longer, which means they gave longer answers.

Although our goal was to create a simple robot with a single feature, after receiving feedback it might be important to add simple features that could help them with other daily tasks. Some of the suggestions from our participants, such using robots to remind people to take their medication have already been studied with positive results [83]. This could possibly generate positive results from people incorporating the robot into their daily lives.

Our research suggests that people would be interested in having these robot behaviours deployed long term. However, similar to other research [32], [84], participants advocated for these types of robots to be used by people other than themselves, especially older people and those dealing with loneliness. Some even commented that they could see a use for it in their lives if they were older. Maybe focusing on deploying this robot on older people that identify as being lonely could yield positive results, as this study was meant to be a proof of concept on the idea before deploying it with people who identify as lonely.

Something to note is that our questionnaire data show different results than what we saw on the interviews. There are significant results that people's perceptions were mostly worse after use, by people having less trust or perceived social presence as well as increased levels of discomfort. The Likert-type scale used on the Almere questionnaire was labeled (totally disagree-disagree-don't know-agree-totally agree) and was coded 1 to 5 respectively. Using this to look at the data, although with significant results, shows that the participants stayed on the same side of the scale, from changing their answers from totally disagree to disagree

or don't know to agree, but never showing a big change like changing opinions from a disagree to an agree. Same happened with the RoSAS questionnaire's which was in a 1 to 7 scale where 1 one was not at all, 4 was a moderate amount and 7 was very much so. Both of these results could also be caused due to the timing of when the questionnaires were administered. The questionnaires on the intake interview were done before the participants used the robot for the first time and could see a full interaction. So perhaps these changes occurred because participants actually saw the simplicity of the behaviour, the upsides and downsides of the robot, as well as the things they needed to do for a successful interaction. However, although perceptions from the questionnaires were more negative, they did not show actual negative reactions to the robot.

6.5 Future Work

With our study, we were able to get results on our main goal of understanding the implementation and interaction feasibility of our behaviour. We were able to understand that people were able to use and interact with the robot and that people who did not self reflect before this study were more likely to see benefits from our design.

This initial study shows positive initial reactions, and future work is needed to understand this robot's possible role in being a potential longer-term companion and helping people decrease their feelings of loneliness.

However, some changes are needed before future long term deployment. Perhaps the biggest ones that people kept mentioning was being able to repeat questions and changing the size of the question bank and maybe having set topics that people could choose from to talk about something more specific they want. This would make the robot a better conversational companion by being able to talk about different things the user wants.

Another thing that could be added are simple functionalities like reminding people of things or just having the ability for the person to start talking about whatever is on their head without the robot giving specific questions. These things could be easy to implement and maybe improve the user's perception of the robot and increase their use of it.

Although some participants commented on wanting the robot to be online, the majority liked the privacy aspect since they are talking about personal things, so perhaps keeping it that way and not connecting it to the internet might be a better option even if some people do not like it.

The robot's weight needs to be also considered, especially if a user had any type of mobility issue, either testing a lighter robot with a similar set of features or just having someone to set up the robot for the participant could help improve the experience.

6.6 Summary

We present the results of our study that focused on understanding the feasibility of the robot we designed. We wanted to understand the effectiveness of the robot to learn if people could use it, people's perceptions of the robot, both the behaviour and the design and finally, we wanted to explore people's thoughts on long term use.

To answer these questions, we analyzed the data from our interviews and separated it into four categories: robot's behaviour and feasibility, usefulness of a conversational robot, interaction and physical design, and suggestions and thoughts on the robot and its design. We then used this information to understand how those results matched our initial interaction design goals and how they helped answer our study goals. Future work can focus in studying this robot with some changes as a longer-term companion conversational robot for people as our initial results show positive acceptance of this robot from older adults.

7 Discussion

7.1 Thesis Summary

This thesis focused on exploring the feasibility of a deployable social conversational robot. We explore the design and deployment of a standalone conversational companion robot as a first step towards long-term deployment of these robots to aid in wellness. We started with a goal of creating a conversational robotic behaviour that could help people self reflect. We aimed to understand if that was technically feasible, if it could be integrated into homes and if it was feasible to use such robot as a self-reflection tool.

To explore technical feasibility, we focused on creating a simple, deployable robot. We started by setting different interaction goals that could help us achieve an autonomous robot; we created different robotic behaviours and kept one that more closely met these goals. We report on the design of our behaviour, what guided it and how we were able to have a fully unsupervised and autonomous behaviour with all its parts.

The other two points we wanted to investigate in this thesis were domestic integration and self-reflection feasibility; if people would accept a conversational robot into their homes and if they could use it to self-reflect. As a proof of concept of our conversational robot for self-reflection, we designed and conducted a study in people's homes to test if the behaviour worked, how people felt with a robot at home and if they were able to use it successfully. We focused on investigating the effectiveness of our behaviour, people's perceptions of the robot and its performance and we explored people's thoughts on long term use of this robot. Our results were positive, showing that people enjoyed using the robot, liked having it to talk things out loud, and were open about having a robot like this in the future, showing the potential of this behaviour, which in future iterations could potentially aid people with wellness.

The rest of this section provides an overview of the contributions of this thesis, as well as the limitations of our work. Finally, we discuss the future work that could be done to expand this line of research.

7.2 Contribution

7.2.1 Social Conversational Robotic Behaviour

We provide different conversational behaviours that could be used for conversation. All these behaviours were created with the same goals in mind. They are simple to be able to have fast robot deployment that will not require any type of researcher supervision. All behaviours were based on ideas from client centered therapy, all focused in possibly helping improve people's wellness and reduce loneliness after long term use. We also describe how the more complex problem of our simple behaviour (understanding speech start and stop) was solved using simple signal processing. This simple algorithm could be used, not only for this robot, but for any type of robot that might not need to understand what the person is saying while still not interrupting the person while they talk.

The idea behind this focus on a simple behaviour was to understand if perhaps humanoid robots do not need to be complex to aid people. Maybe, without artificial intelligence or complex behaviour, people can still accept a robot and see the benefits of having a long-term robot as a daily companion. To understand this, we created a study that was meant to give insight into how people use and interact with a simple robot and what they think of it and its potential.

7.2.2 Study as Proof of Concept for Companion Robots and Older Adults

To understand the feasibility of our conversational robotic behaviour we conducted a short-term study deploying our chosen behaviour fully unsupervised into homes of older adults. Our study was meant to investigate the following: (a) effectiveness - pragmatic functionality

and usefulness - of our robotic behaviour to learn if people could use it and if it could fulfill its purpose of simple conversation as well as initial interaction outcomes, (b) to learn about people's perception of the behaviour's performance and the robotic design and (c) to explore people's thoughts on long-term use of the robot to inform future design and deployment of conversational robots.

To answer our questions, we gathered data from 14 people 65 and older living alone who had the robot for 2 nights.

Based on what participants reported, the robotic behaviour was able to fulfill its goal for self reflection and we did not have participants abandon the robot during this time. With our results we could argue that deploying simple robots is a good idea and something worth exploring in future work. Despite the robot's lack of complexity, people were able to not only use the robot but also see benefits of something like this in people's daily lives.

The area of human robot interaction and social robots focuses on how to have robots help people, and despite successful results in controlled environments, these results are unable to be applied in the real world since the behaviours being tested are sometimes not possible or too complex to create with current technology. We instead aim to help shift the perspective, and argue that right now, maybe the only way to achieve the goal of having robots as everyday tools in people's lives is to use current technology and make something more reliable. This initial deployment serves as a proof of concept for standalone robots in people's homes. Creating simple robots, or robots that can be ready for unsupervised deployment can open the doors to longer-term studies that can further increase our knowledge on the impact these robots have as always available companions.

Our results from the study help highlight the importance of transparent design and being upfront about robot's abilities when deploying a new robot. People had new expectations once the robot's role was explained to them, and once it was understood, it was easier for people to see why it was designed in a specific way and the positives it could have, even if simple. We had different opinions on the robot's abilities, but perhaps increasing the

robot's abilities just a small amount, even if it is still simple, while still maintaining a fully deployable robot can help even more people want to engage with this robot.

By first doing small tweaks to have an improved robotic behaviour based on people's feedback and experiences we can then learn about the implications of having a robot as an always available conversational companion through a longer-term study. This will also give insights into the impact on lonely people's wellness from interacting with our robot and having it for more than 3 days.

7.3 Limitations and Future Work

Our research has a few limitations, one being that our participant sample was largely female, as mainly women volunteered for our study. This has been observed in other studies that focused on older people (e.g., [21], [32]), this could be because woman live longer and are less likely to remarry [85]. This, in addition to the small sample size suggests that our findings may not be generalizable to the rest of the older adult population. Further, we purposely recruited healthy older adults, meaning that our results may not apply to those who are lonely or have cognitive or physical impairments. However, this was intentional as most research related to companion robots and older adults has focused on those with dementia or cognitive impairments [74], [86], and has excluded healthy individuals. However, it is important to learn about the robot's impact on wellness in people who self identify as lonely.

Given the relative success of our implementation, future work should continue to explore the value of simple companion robots. This could be done with different populations of study (e.g., lonely individuals, those with acute anxiety), and well as with different robot and dialogue designs (e.g., having topic-specific scripts). Overall, our work highlights the potential for simple robots to be deployed in people's homes, helping individuals through unsophisticated conversation.

7.4 Conclusion

In this thesis we described our novel conversational interaction behaviour focused on simplicity to help with users' wellness. We created a robotic behaviour meant to prompt people to talk by asking general questions about their life, with the expectation that talking out loud about their experiences will help them self reflect and therefore feel better. However, as we created something novel, we decided to use this thesis as a proof of concept for our design.

Our thesis was meant to answer our research questions on the feasibility of designing this conversational robot, how people would accept it on their homes and if the robot had the potential to be a tool for self reflection. To learn if people were open to use simple robots, especially our novel behaviour, we deployed our conversational robot, completely unsupervised, offline, and unmonitored in the homes of older adults for 2 nights. Our results indicated that people were able to use it, showing the feasibility of a fully unsupervised conversational robot. Despite divided opinions on how the robot's simplicity affected interactions, most participants accepted the robot into their homes and were able to use it for self-reflection or saw it as a tool that others could use for reflection, companionship, or loneliness. Perhaps with increased functionality or changes, the acceptance of these robots into people's homes could increase. Future work can focus on further exploring people's opinions on non-complex robots and how well they can be incorporated into people's lives.

Appendices

Appendix A Consent Form

Project Consent Form

Project Title: An In-Home Exploration of Conversational Companion Robots for Older Adults
Researchers: Dr. James E. Young, Adriana Lorena González (young@cs.umanitoba.ca, gonzala1@myumanitoba.ca)

This consent form, a copy of which will be sent to you via email for your records and reference, is the only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like to have more details, feel free to ask the researcher. Please take the time to read this carefully and to understand any accompanying information.

Participation in this study is voluntary: you may choose to withdraw from this study at any point in time during both the interaction and interview part of this study. Risks of participating in this study are no greater than in everyday life. The robot being used in this study is a commercial product deemed safe for public use.

Study Procedure:
You are invited to participate in a research study that will help us test a new conversational robot. This will require you to have the robot at home for 2 nights, and to interact with it to have simple conversations, and tell us what you thought about it. This is a cutting-edge piece of technology, which means it may break or have problems (e.g., turn off randomly or tell you there's a problem with the battery). As a participant, you have absolutely no liability or responsibility for any damage, harm, or problems that occur with the robot. It is designed to be set up and used wherever you like within your home, and you should feel free to treat it as you wish without any worry or concern for liability.

After signing this consent form, you will contact the researchers with an appropriate date and time for robot delivery to your home. You will receive the robot and your compensation on the scheduled date and time. We will ask you to keep the robot box closed until our interview that will happen once the researcher gets back to a computer. During this initial interview, researchers will ask you a series of questions and help with setup as well as demonstrate how to interact with the robot. You will then

keep the robot on your home for 2 nights and interact with it, hopefully a minimum of once per day. After this time has passed, we will have an exit interview and a researcher will pick up the robot afterwards.

Throughout the study, we will have two interviews through an online platform such as Skype or Zoom (you can select your preferred software of choice), these interviews will take between 60 to 90 minutes, and you will complete a range of questionnaires. After receiving the robot, we will have an initial interview to ask a bit about your background and opinions about technology, we will ask you to complete some questionnaires, and at this time we will help you set up the robot and talk about the expectations for it. We will explain the details at that time, but you are able to interact and talk with the robot whenever and however much you would like. These interactions will take at least 3-5 minutes but will be as long as you like. After each time you interact with the robot, we ask you to fill a short post interaction survey that will be provided to you. As the study completes, we will have the second interview to talk about your experience and what you thought of the robot and our behaviour, and we will ask you to complete some questionnaires again. During that interview we will decide on a robot pick up time, either that day or within a couple of days, based on your schedule. No expertise or experience is necessary for participation in the study beyond simple internet site use.

Your interactions with the robot will be completely private. The robot does not record any pictures or video from its cameras and does not record anything that you say. You can say anything to the robot and there will be no record of what you said. The only data that the robot records is the time of when you interact with it, how long you interact with it, and which questions it asked you. You should feel free to talk openly with the robot, and you do not have to tell us what you talked about. To further maintain your privacy, the robot is not connected to any wi-fi, internet, cloud service, or cell network, it is completely offline.

With your permission, we will record the interview sessions for data analysis; your recordings will be kept safe and will only be used for the purpose of this study. The required questionnaires (approximately 10 minutes each time) will be filled during the interview sessions and will be provided to you as paper printouts when the robot is delivered.

This study uses Survey Monkey to collect your signature for informed consent, which is a United States of America company. Consequently, USA authorizes under provisions of the Patriot Act may access this data. If you prefer not to submit your data through Survey Monkey, please contact one of

the researchers so you can participate in an alternative method (such as getting the consent form through email.).

Honorarium:

In appreciation for your time and participation in this study, you will be compensated with $25 dollars when the robot is delivered. Further, you will subsequently be compensated $25 dollars when the robot is picked up after the second interview. This will result in a total compensation of $50 Canadian Dollars. We will give the honorarium using e-transfer, or if preferred, we will give the honorarium in cash by properly disinfecting and placing them in an envelope. We will define this over email after your consent form is signed. The e-transfer will be done as soon as the robot is delivered; if cash is preferred, we will deliver it with the robot. During the interviews, you are free to skip or decide to not answer any of our interview questions if you so desire. This will not affect you or the compensation you receive in any way. You can freely withdraw from the study at any time without any consequences (you can keep any compensation received during the course of the study up until the point of withdrawing).

Consent:

All information you provide is considered completely confidential; your name will not be included, or in any other way associated, with the data collected in the study. Video or audio recording (depending on the interview medium) of the interview sessions are essential to the research analysis. Data collected during this study will be used for data analysis purposes only. We may use anonymized quotes from the recording for purposes of public presentation; however, we will not present video, screenshots, or audio. Each participant will be assigned a number that will be used to present anonymized quotes (e.g., P4 for participant 4). That is, your image or sound will not be used in papers, presentations, put on the internet, etc. Please initial your response below.

a. In the case that we communicate by video conferencing software, I CONSENT to having my *voice* and *camera* recorded for data analysis purposes. _____

b. In the case that we communicate by video conferencing software, or by telephone, I CONSENT to having my *voice only* recorded for data analysis purposes. _____

All the physical data and the digital data (encrypted using military-grade AES-256 and put in a USB memory stick) will be stored in a locked office (E2-582) in the EITC building, the University of Manitoba, to which only researchers associated with this study have access to. Data will be kept until August 2024, after that, data will be deleted. Once published (in journals, conferences or thesis of

students), results of the study will be made available to the public for free at hci.cs.umanitoba.ca. Again, no personal information about your involvement will be included. Please note that the University of Manitoba may look at the research records to see that the research is being done in a safe and proper way.

You have the option to sign up to receive a summary of findings for this research. This summary will be in non-scientific language and will be sent to you upon completion of our analysis by August 30, 2021. Please provide your response below if you want to receive the information:

I DO want to receive a summary of the findings of this research _____
If you do, please provide an email address or mailing address _____

Your signature on this form indicates that you have understood, to your satisfaction, the information regarding participation in the research project and have agreed to participate as a subject. By signing the form, you also confirm that you are of the age of majority in Canada (18 years or more). In no way, this form waives your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and to refrain from answering any questions asked, without prejudice or consequence. After the study ends, you can withdraw from the study any time up until two weeks after you return the robot back to the researchers; past this time data analysis and writing will be conducted and it will be impossible to remove the data.

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints, you may contact Dr. James Young at 204-474-6791 or young@cs.umanitoba.ca, or the Human Ethics Secretariat at 204-474-7122 or humanethics@umanitoba.ca. Feel free to print this page. A copy of this consent form will be emailed to you for your records and reference.Having read the provided information and after all my questions were answered to my satisfaction, I understand what I am freely consenting to.

Participant_____ Signature_____ Date_____

Researcher_____ Signature_____ Date_____

Covid Consent Form

Project Title: An In-Home Exploration of Conversational Companion Robots for Older Adults
Principal Investigator and contact information: James E. Young, young@cs.umanitoba.ca

Co- Investigators and contact information: Adriana Lorena González De la Garza, gonzala1@myumanitoba.ca

This document contains important information about in-person research during the COVID-19 public health crisis. COVID-19 (also called SARS-CoV2) is an illness caused by the coronavirus. Coronaviruses are most commonly spread from an infected person through: a) respiratory droplets when you cough or sneeze; b) close personal contact, such as touching or shaking hands; or c) touching something with the virus on it, then touching your eyes, nose or mouth before washing your hands.

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. This project requires delivering the robot in-person. Therefore, it is important to understand that your participation in this study may increase your exposure to COVID-19.

Our project has been approved to proceed by the Research Ethics Board, our Faculty, the COVID Recovery Response Team, the COVID Recovery Steering Committee, and the University Provost. 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. These precautions include:

- All study research teams will wear 3-ply reusable or disposal 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 related to COVID-19, you need to inform us before our visit to your residence. We will reschedule when the situation has resolved.
- You will receive a box where you will find a robot and a questionnaire booklet. The robot will have been disinfected and placed inside the box along with the booklet. The box will be left sealed for 3 days before delivery and will be sanitized the day of delivery using standard disinfecting wipes.

COVID-19 is a serious health threat, and the situation is evolving rapidly. If you feel that you are from a group that is more vulnerable to COVID-19 effects (e.g., senior (over the age of 60 years), immuno-compromised), you are welcome to discuss your participation with the research team before providing your consent. You are under no obligation to participate and can change your mind about participating in the research at any time and without consequence.

The University of Manitoba is closely watching the situation in Manitoba and may restrict in-person research at any time. We will continue to keep you informed as to changes that may occur to this study.

There is a possibility that during your participation in the study you could come into contact with someone with COVID-19. We are required to collect your personal contact information that we must retain in order to follow up with you and/or conduct contact tracing if you may have been exposed to COVID-19 by participating in this research. **We cannot guarantee anonymity as the personal contact information identifies you as a participant and we may be required to disclose this**

information in the event of a possible exposure. Your contact information will be kept separately from data collected through the research study to allow for de-identification of the research data. You maintain your right to withdraw from the study at any time, including your research data. If you do withdraw from the study, we will still need to continue to maintain your contact information and will only give it to the University's Environmental Health and Safety (EHS) Office and/or Manitoba Health if required for contact tracing. Please note, Manitoba Health or the University's EHS office will not have access to your research data.

If you have questions regarding this study, measures we are taking to keep all parties safe, or have any concerns, please do not hesitate to ask. You can contact any of the above-named researchers or the Human Ethics office at huumanethics@umanitoba.ca. Your signature on this form indicates that you have understood to your satisfaction the information regarding participation and the COVID-19 risk and agree to participate. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

Participant Name _____

Contact Information (phone # or email): _____

Participant's Signature _____ Date: _____

Appendix B Questions, Follow-ups and Sample

Questions and Follow-ups

We had 19 main questions the robot asked and 25 follow up phrases. Our robotic behaviour chose at random two main questions and a follow up for each.

The 19 main questions asked by the robot were the following:

1. Are you satisfied with what you're doing in your life?
2. Who was the last person you saw?
3. Is there something you want to change in your life?
4. What do your friends mean to you?
5. Is something bothering you?
6. How do you feel about your family?
7. Has anything good or bad happened lately?
8. What has been on your mind lately?
9. How has your life changed in the past year?
10. What would you change if you had the chance?
11. What are you most proud of?
12. What do you like about your life?
13. What do you like doing by yourself or with others?
14. What are you grateful for today?
15. If you could be doing something else, what would that be?
16. What is the last thing someone said to you that made you feel good?
17. What was the last news that made you happy?
18. When was the last time you did something different?
19. What made you happy lately?

The 25 follow up questions or phrases to encourage people to continue talking were the following:

1. Okay tell me about it
2. In what way is this good or bad?
3. Are you happy with this?
4. Are you satisfied with that?
5. How did this end up happening?
6. Is there a reason for this?
7. Do you feel better or worse by talking?
8. Tell me more about this.
9. Is this good? If not, can you change it?
10. ok. please go on.
11. Do you often feel this way?
12. What do you think about that?
13. Where do these feelings come from?
14. What makes you feel this way?
15. How do you feel after talking?
16. Who said that?
17. Why did they say that?
18. What could make you feel better?
19. Would you have it any other way?
20. Do you have any regrets from this?
21. Why do you say that?
22. What happened to make you feel like this?
23. How did you end up here?
24. How did that go?
25. Why did that happen?

Mapping questions to follow-ups.

We knew not all follow ups were appropriate matches for each of the main questions. Because of this we created a list to match each question with an appropriate follow up. The numbers on the left correspond to the numbers from the main questions and the numbers in brackets correspond to possible follow ups that could be chosen for each main question. Two random main questions were chosen and then one random follow up for each using the table below.

1: [1,2, 5,6,7, 9,10,11, 13,14,15, 18,19, 21,22,23, 25]
2: [1,2,3,4,5,6, 8,9, 12, 19,20, 23,24,25]
3: [2,3, 6,7,8, 12,13,14, 18,19, 21,22,23, 25]
4: [1, 3, 6, 8,9,10, 13,14,15, 18,19, 21,22]
5: [1, 5,6, 8, 10,11,12,13,14,15, 18, 21,22,23, 25]
6: [2,3,4, 6,7, 9,10, 13,14, 19,20, 22, 25]
7: [1, 3,4,5,6, 8,9,10,11,12,13,14,15, 18,19,20,21,22,23, 25]
8: [1,2,3, 6, 8,9,10, 12,13,14, 18,19, 21,22, 25]
9: [2,3,4,5,6, 8,9, 12, 14,15, 18,19,20,21,22, 25]
10: [1,2, 6, 8,9,10,11, 13,14, 21,22,23, 25]
11: [1, 3,4,5,6, 8, 10, 13,14, 18,19, 21,22, 24,25]
12: [3,4, 6,7,8, 10, 13,14,15, 18,19, 21,22]
13: [1, 6, 8, 10, 12, 14, 19, 21,22, 25]
14: [1,2,3, 6, 8, 10,11,12,13,14, 19, 21,22,23]
15: [6, 8,9,10,11, 13,14, 21,22,23]
16: [1, 6, 8, 10, 12,13,14, 16,17,18,19, 21, 24,25]
17: [1, 5,6,7,8, 12, 14,15, 21,22, 25]
18: [1,2,3,4,5,6, 8,9,10, 12, 15, 19,20, 24,25]
19: [1, 4,5,6,7,8, 10,11, 13, 18,19, 21, 24,25]

Sample Interaction

Here we provide a full interaction script with given random greeting and questions.

P = Person

R = Robot

* * = Action

P : *touches robot's head*

R: *does wake up routine, finishes and looks at the person*

R: "Hello, do you have some time to talk?"

P: "Sure!"

R: "Okay!" *Small pause* "What are you grateful for today?" [MAIN QUESTION]

P: "Well, today I had a call with my grandson, and I had not talked to him in a while so …"

R: "Oh, and how did this end up happening?" [FOLLOW UP]

P "Well, I think that after he finished school his mom ..."

R: "Thanks for telling me this, let me ask you another question: If you could be doing something else, what would that be?" [MAIN QUESTION]

P: "Well, ever since the pandemic happened, I've had this trip that I've had to postpone more than 3 times, I wish I was there".

R: "Why do you say that?" [FOLLOW UP]

P: "It was a trip I was planning with my family and …"

R: "Do you want to talk about anything else?"

P: "No thanks"

R: "Okay, I hope talking helped, let's talk again soon. Goodbye for now."

R: *goes back to sleep*

Appendix C Questions for Interviews

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 Interview

Goal: Demographic, background, and lifestyle information

- Do you mind telling me your age?
- Can you please tell me a bit about yourself? Your background?
- Do you talk to friends or family often? For example, by phone, video chat, or social media?
- Before the pandemic, did you go out with or visit friends or family often?
- What does a normal day look like for you?
- Why were you interested in this study?

Goal: Attitude toward technology and robots

- 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?
    - Is it because you enjoy it/ is it because you do not enjoy tinkering with new things?
- Have you ever had a smartphone? / What do you think about them?
- Do you use only the basic features of a technology? or do you like to explore?
    - Learn about advanced features?
- Can you tell me anything about robots?
- Do you have any experiences, or thoughts on robots based on what you've seen on TV or read about?
    - Have you heard about robots in homes? In hospitals?
    - How do you feel about having a robot in your home?
- When you were told you would receive a conversational robot, what were your expectations?

In the protocol, unboxing happens here*

Goal: Initial reactions to the robot and expectations

- Now that you've seen the robot, what do you think about it and how it looks?
    - Do you think it will be easy or hard to use?
- Do you have any idea of where you want to place it?
- Do you think you will be able to have conversations with this robot?
    - What else do you think this robot could be capable of doing?
- Do you think the robot will be able to understand you?
- Do you think it will judge you?
- Do you think the robot is intelligent?
- Do you think it will be able to hold long conversations?

- Do you think you will be comfortable talking to a robot?
    - Do you see the robot as life-like?
- Do you have any other expectations of the robot?

Exit Interview

Before picking up robot

Goal: Expectations versus reality

- <Ask and follow up based on their replies from the Initial Interview, initial expectation's goal>

Goal: Could people have a conversation/use it

- Did the robot work?
- Were you able to talk to the robot?
    - What kind of conversations did you have with it?
- Can you describe how a typical interaction with the robot goes?
    - How long did it last?
    - How did the conversation go?
- How was the experience?
    - Would you describe how it felt?
    - What type of conversations do you think people would have with the robots?
- What did you think about talking to the robot?
- Did anything exciting/good happened while interacting with it?

Goal: Awkwardness/comfort about the conversation and about the robot

- How did you feel about interacting with the robot?
    - Did you enjoy it?
    - How did you feel when talking to it?
    - Did you find it comforting or awkward?
- Did you feel like the robot was able to understand you?
- Do you feel like the robot was useful?
- Did you think the robot had any type of social skills?
- Did you feel safe when interacting with the robot?
    - Does it have something to do with it being completely offline?
    - Do you think if the robot were connected to the internet, you or other people would talk to it as much or would you be more worried about the privacy aspect?

Goal: Thoughts on robot errors and poor functionality

- Did the robot make many mistakes or were there any problems when it was listening to you?
    - How did you feel about the errors? Were you able to work around them?
- What did you think about the robot not understanding you?
    - Were you okay with it or do you think it affected the conversation?

Goal: Opinions on behaviour design

- Overall, what did you think of the robot behaviours, questions, and so on?
- Did you think the interaction was short, long or just right?
- Do you think using the robot is simple/natural and intuitive or do you find it confusing and difficult to interact with?
    - What are the positives and the negatives of the interaction?
- Did you find the robot's voice pleasant/friendly, or did you not like it? Was it easy to understand?
- What do you think of the robot's movements? Do you find them awkward or smooth? Distracting?
- Would you have liked to lead the conversation more? Or was it okay for the robot to be prodding you?
- What other things would you have liked to be able to do with the robot?
- Are you satisfied or dissatisfied with the robotic behavior?
- Did you find the quality of the interaction pleasant or unpleasant?
- What would you change about the robotic behavior?
- Do you think the questions the robot was asking were too personal?
    - What would you change?
    - Do you have suggestions?

Goal: Robot's physical design

- What did you think of the robot's appearance?
- Were you okay with the robot not being able to move its mouth or eyes? Or did it make you feel uncomfortable?
- Would you have liked a robot that looked or moved differently? In what way?
- Would you have liked the robot to have more or less features? Like what?
- Did you have any suggestions or other ideas about this?

Goal: Integration into home and life

- Where did you put the robot in your home, was it visible or was it somewhere you barely passed?
- When you passed by the robot, did you feel like you should, or pressure to, interact with it?
- How did you feel in general about having a robot in your home?
- How do you feel about giving back the robot?
- Do you think you will miss its presence in the coming days?

Goal: Thoughts on long term use

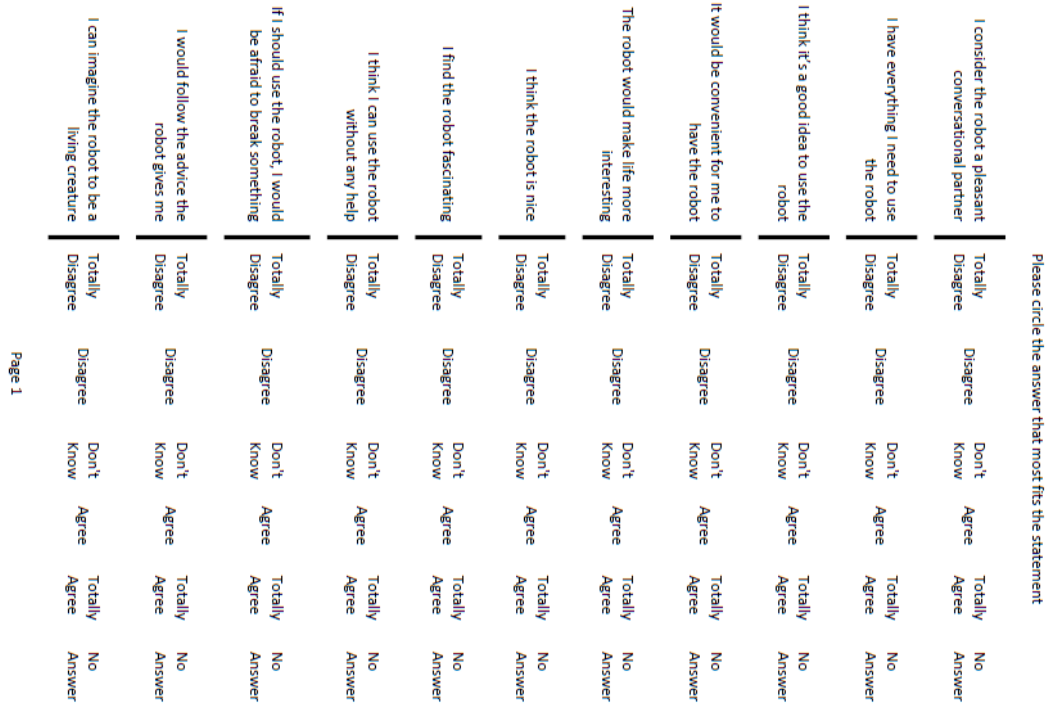
- What is your view towards having a robot in your home in the future?
- Could you imagine having one of these for longer than two days?
- What do you think about the idea of a companion robot in daily life?
    - What do you think of this kind of robot as a companion?
- If we gave you the option, would you consider keeping the robot for longer in your home?
    - If no, why, did you not like it? Would you change something?
    - If yes, why? Did it help? Do you like the robot being around?
        - Would you want to change something about it?
- Do you think that over time, people would grow connected to or attached to such a robot?
- Do you think having a robot like this at home could help people that feel lonely?
- Would you recommend this robot to other people or your friends?
    - Or would they find it useless?
- What may make such a robot a better companion?

Goal: Final overall reflection

- Do you think it helped to talk with the robot?
- Do you like anything particular about the robot?
- What other things do you think the robot is capable of doing?
- How much did you disclose? Do you think that after repeated use you or other people would feel like disclosing more?
- Would you have preferred a robot that could not speak and was just there to provide companionship?
- Did the robot disappoint you in any way?

Appendix D Questionnaires

Almere Questionnaire



Please circle the answer that most fits the statement

I consider the robot a pleasant conversational partner	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
I have everything I need to use the robot	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
I think it's a good idea to use the robot	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
It would be convenient for me to have the robot	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
The robot would make life more interesting	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
I think the robot is nice	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
I find the robot fascinating	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
I think I can use the robot without any help	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
If I should use the robot, I would be afraid to break something	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
I would follow the advice the robot gives me	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	
I can imagine the robot to be a living creature	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer	

Please circle the answer that most fits the statement

I find the robot easy to use	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I'm certain to use the robot during the next few days	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I enjoy doing things with the robot	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think the robot can be adaptive to what I need	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I would trust the robot if it gave me advice	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think friends and family would like me using the robot	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
It sometimes felt as if the robot was really looking at me	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think I can use the robot when there is someone around to help me	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think I'll use the robot during the next few days	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I find the robot enjoyable	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I find the robot scary	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer

Please circle the answer that most fits the statement

I think I will know quickly how to use the robot	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think the robot will only do what I need at that particular moment	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I plan to use the robot during the next few days	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think the robot will help me when I consider it to be necessary	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I find the robot pleasant to interact with	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think the robot can help me with many things	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
If I should use the robot, I would be afraid to make mistakes with it	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think it would give a good impression if I should use the robot	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
It's good to make use of the robot	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I know enough of the robot to make good use of it	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer

Please circle the answer that most fits the statement

I feel the robot understands me	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I find the robot boring	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I often think the robot is not a real person	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
When interacting with the robot I felt like I'm talking to a real person	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I think the robot is useful to me	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I find the robot intimidating	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
think I can use the robot when I have a good manual	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
I enjoy the robot talking to me	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer
Sometimes the robot seems to have real feelings	Totally Disagree	Disagree	Don't Know	Agree	Totally Agree	No Answer

RoSAS Questionnaire

Using the scale provided, how closely are the words below associated with the robot?

	Not at all			A moderate amount			Very much so	No Answer
Competent	1	2	3	4	5	6	7	
Organic	1	2	3	4	5	6	7	
Sociable	1	2	3	4	5	6	7	
Emotional	1	2	3	4	5	6	7	
Compassionate	1	2	3	4	5	6	7	
Scary	1	2	3	4	5	6	7	
Strange	1	2	3	4	5	6	7	
Aggressive	1	2	3	4	5	6	7	
Knowledgeable	1	2	3	4	5	6	7	

Using the scale provided, how closely are the words below associated with the robot?

	Not at all			A moderate amount			Very much so	No Answer
Reliable	1	2	3	4	5	6	7	
Awkward	1	2	3	4	5	6	7	
Happy	1	2	3	4	5	6	7	
Capable	1	2	3	4	5	6	7	
Responsive	1	2	3	4	5	6	7	
Interactive	1	2	3	4	5	6	7	
Awful	1	2	3	4	5	6	7	
Dangerous	1	2	3	4	5	6	7	
Feeling	1	2	3	4	5	6	7	

Appendix E Study Protocols

Email After Participant Interest

Email after getting responses from recruitment:

Hello X,

First of all, thank you for your interest in this study. By being part of this, you will help us learn about and improve on our robot.

Let me start by saying we have some criteria for people that can be part of this study. If you fit all of these points, please continue reading ahead. If you do not, please feel free to let us know.

- People over 65 that live alone (no assisted living or congregate living facility).
- People will need to be able to lift the box that will contain the robot and bring it into their home. This box will weight around 11 pounds (5kg).
- People living within the city limits of Winnipeg.

We first want to emphasize that this research is not testing you or your ability in any way. Rather, we are testing our robot. We created a new robot program that we are testing in this study, and we need help from people to see how it works. We need to learn about your opinions and reactions, and how you use the robot, to be able to make it better and fix issues that arise.

We created a new conversational robot that is designed for people to talk to, and we need your help to test it. Full details are provided in the consent form, but it is important to note that the robot does not record anything or retain any data (audio, images, etc.) from your interaction beyond very simple logging of when the interaction happened and for how long.

If you agree to participate, we will deliver a small robot to your home, which you will keep for up to 2 nights (we will pick up on the third day). During this time, you can interact with the robot as you wish and try to have conversations with it. These interactions usually take around 5 minutes but can be longer if you decide to talk more with the robot. We will explain more before the study starts.

We will have an interview with you when you first receive the robot, and a second interview before you pack it up for us to pick up, each of these interviews will take 60-90 minutes. We will record these interviews (e.g., by phone, Skype, or other video conference software of your choosing) for analysis purposes; your videos, pictures, or audio clips will be kept completely confidential, and we will not post copies or parts anywhere. On these interviews, you are free to not answer any question you like, it will not affect you in any way. We will also ask you to complete a few short questionnaires both at the beginning and end of the study, and after each time you interact with the robot.

In appreciation of your help, we will provide a $25 dollar honorarium when we deliver the robot, and an additional $25 if you complete the other two days of the study and the exit interview (a total of $50).

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 3-ply 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 of the robot, wearing gloves, and hand washing.
- If you have any symptoms of COVID, you need to inform us before our visit to your residence.
- You will receive a box with the robot inside and a booklet. The robot and booklet will have been disinfected and placed inside the box. The box and its contents will have been closed for 3 days before delivery to reduce the probability of viruses being transmitted. The box will be disinfected using standard disinfecting wipes before delivery.

If you fit our eligibility criteria and are still interested in being part of this study, please email us back letting us know. We will email you a consent for to sign and we can define a date to start this study.

Thank you so much for your time,

Lorena González

Email after getting confirmation of eligibility criteria:

Hello,

Again, thank you so much for wanting to be part of this study. We explained the study in the previous email, but to reiterate, we will give you a conversational robot to interact with for 2 nights. We will have an initial and final interview that will each take 60 to 90 minutes. In appreciation for your help with this study, we will give you $25 at the start of the study and again when we pick the robot up.

If you agree with this, we will need you to carefully read and fill out a consent form. The consent form outlines the study and is more in depth than the original email. If after reading the consent form you decide you do not want to be part of the study, you do not have to sign it, and please feel free to email us letting us know.

The consent form can be accessed through this link (Appendix A). After completion, you will get a copy of the consent form in your email within one day. If you have any questions about anything in this email or in that consent form, feel free to email me and I will gladly answer.

Once filled, let me know what days work for this study. These are some of the available dates, but feel free to let me know when works for you. We want to deliver the robot early enough in the day so that we can have time, on the same day, to have an initial interview (via phone or video conferencing, as per your choice) to explain how it works. We would prefer robot delivery to be between 11am and 3pm.

list of dates

Please email me back with a preferred robot delivery day from the list above and a time between 11 am and 3 pm when you would like to receive the robot, as well as a phone number I can contact you at to let you know when the robot has arrived. I will stay outside (but keep my distance) until you pick up the robot. We would have the initial interview right after the robot is delivered and I get back home, so that I can help explain the robot and the setup. Please do not open the robot until our meeting: there is nothing dangerous (you can't break anything), but I'd like to talk to you before you see the robot, and walk you through the setup procedure.

Finally, please let me know how you would like to be compensated: we prefer to provide e-transfers (please let me know what email address or cell number you would like to use) but can also provide cash if you so desire.

Thank you so much for your time,

Lorena González

Initial Video Call

During initial video chat interview:

Expected Outcome: This phase will provide important context for analyzing and understanding participants' attitude toward companion robots before use but after they first see it and provide insights on their thoughts and initial expectations towards the robot.

Procedure: One researcher will take a box consisting of a robot, its charger and a booklet of different documents and leave it outside the participant's residence. Once the researcher confirms that the participant received the box, they will meet the participant on a video chat platform for the initial interview.

Thank you for joining me. My name is <researcher name> and I will be your contact through the study for this initial interview and the exit interview, as well as if you have any problems during your days with the robot. We will have an interview today, I will ask you to complete some questionnaires, and I will also help you unbox and setup the robot. We will also have an interview in 2 days before I come pick up the robot.

As we described on the consent form, for analysis purposes I will need to record the call, this will not be used for anything other than to transcribe the interview for analysis. Pieces of the conversation or the video will not be shared. Are you okay if I start recording now?

You have already been provided with a $25 honorarium, and we will provide another $25 at the end of two days if you continue with the study until the end, for a total of $50. Now that you have the robot, I will explain in more detail how to interact with it, and help you unbox it. I'll also go over the questionnaires and when to complete them.

Our robot is a conversational robot that is designed for you to simply talk to, and it asks you questions. You will be able to interact with it whenever and as much as you want. Unfortunately, our robot is not intelligent: it generally does not understand what you say, and does not record what you say. It just tries to guess when you are speaking or not, and then when you stop speaking, follows up with another question. At some times, it will ask a yes or no question, which you should answer with a clear "YES" or "NO". We will go through a full demonstration so don't worry about this for now, but we want to emphasize that this robot is not very intelligent.

But first, we will start with a part of the interview that will help me understand about your background and your expectations for this robot.

<Conduct Intake Interview until the unboxing part>

Can you please bring the box here, and prepare to open it? Please open the box and check the contents. You will see on top there is a printed booklet containing all the questionnaires, and below it there should be the robot.

Please do not hesitate to move and carry the robot. You will not be accountable for any damages that may (or may not) occur to the robot, or if it breaks regardless of what happens. For now, please take it out and place it on the floor/a table. It needs to have enough room to lay flat, and when we turn it on, it'll move to sit up on its own, so make sure it has enough space.

Are you ready to try turning it on? If so, look at the robot's chest, there's a button you can press. It says NAO.

<Wait for robot to turn on and be seated>

Now that you see the robot moving, do you have any questions about it so far?

Let's practice turning the robot off, so you can see how it works. To turn off the robot, you need to press and hold the same button for 3 seconds. If you let go early, the robot will say some numbers, but this is fine you can just try again. When it works, the robot will say "nook nook" and will take a minute to shut down. Let's try that now.

Okay, now that we got the robot working, before I explain in detail how you will use the robot, first we will complete some questionnaires. Please open the booklet and look at the first pages. You'll see a divider that says, "Intake Questionnaires". Before you do this, I want to reiterate that we are not testing you in any way, instead, you are helping us test our robot. The purpose of this questionnaire is for us to better understand your opinions about robots. They're simple questions on your initial opinions of the robot, you'll have to circle the answer you think is more appropriate. If you have any questions, let me know. You're also allowed to not answer a question if you'd like. At this time, please take a few minutes to carefully read and complete those questionnaires under "Intake", I'll wait here, please take your time.

<Participant completes ALMERE and ROSAS, Appendix D>

Okay, thanks for filling out these questionnaires, please leave them in the booklet. Do you have any questions at this point?

Let's turn the robot back on, the same way we did earlier.

<Start robot setup>

Once the robot is seated, the motors turn off. This means that the robot won't move unexpectedly, and if you knock it over, it will just fall and not cause any damage. The motors do not turn back on until you start interacting with it. Give it a try, you'll see you are able to freely move an arm. If you lift the arm, you can see that it's turned off and doesn't resist.

This robot is designed for you to have a simple conversation with it. It's not very smart. It doesn't usually understand what you say, and doesn't give any specific feedback based on what you will say. This is how the robot works. It will ask you a simple question, which you can respond to by talking as long or as little as you like. The robot tries to understand when you're done talking, and it'll ask a follow up question. It may misunderstand and take a while to notice you stopped talking, or, it may even accidentally interrupt you. Every so often (after every four questions) the robot will ask if you want to continue talking or not. At this time, you will have to answer with a clear "YES" or "NO". At shortest, the interaction will take around 3-5 minutes if you say you do not want to continue. If you indicate you want to keep talking, it will make the interaction about 5 minutes longer each time. This can go on for as long as you like. Do you have any questions? Do you think you are ready to try this?

Again, I want to emphasize the robot will not record anything you say to it. The robot does record, however, some data. It will save what questions it asked you, and how long you talked to it, and your yes and no answers. However, nothing else is not recorded. The robot is also not connected to the internet so there is no chance of it being hacked or other people connected to it.

OK, so please start the robot by touching it's head once. You'll notice that the robot will start talking. For now, just give simple quick answers so we can test it out.

<participant does a sample interaction with support>

Thank you, now that you have seen how the robot works, let me explain what we are expecting for the study. You will place this robot anywhere you like in your home, we recommend placing it on a table or desk so that it's at a comfortable height to hold a conversation. You should feel free to turn it on and off and move it as you wish. However, it is designed to be left on and plugged in, so you can chat with it at any time, so we expect you to leave it on at all times if you feel comfortable doing so.

During the next two days, you are free to use the robot to have conversations as much or as little as you like. We do ask that you try to at least have 3 conversations with the robot during the coming days, hopefully at least once a day. But you are free to use it more or less if you wish.

If you encounter any error or suspected malfunction with the robot, please contact us so we can assist you. You can contact me by email or phone <give researcher phone #>

There is one more thing. Each time you interact with the robot to have a conversation, please complete a questionnaire about your experience. We have included a large number of these (you are not expected to complete them all!) in the booklet, under the section of "After Interaction". Please take a moment to find it now, and quickly read what it looks like. Those can have as little or as much detail as you want. Do you have any questions?

<Continue the intake interview, post un-boxing, Appendix C>

Great! Thank you so much for taking your time to answer my questions. Just as a reminder, you will be needing to complete the post interaction form after you interact with the robot, as we found together in the booklet. These entries will help you remember the interactions you had with the robot, and you can even look at them during our final interview. Let me know if there is any other question you have.

Okay, that is everything for the interview part. We will have an exit interview at the end as we specified, that will be in 2 days, after you've had the robot for 2 nights. <tells the participant the day>. Again, it will take between 60 to 90 minutes and at the end of it we will put the robot back in the box. We hope to leave to pick up the robot after we finish the exit interview but if that doesn't work, during the interview we can talk about you prefer pickup time. We will need to pick up the robot either that day or within a couple of days to match your schedule. Can you tell me what time works for you for the final interview?

<set up interview time>

Thank you so much for being part of this study and if any problem arises, feel free to contact me by phone or email. I'll try to respond as soon as possible.

Exit Video Call

Expected Outcome: The interview sessions from this phase will provide insights about participants' interaction process with the robot, and participants' thoughts about the overall study, the robot behaviour and how it worked as well as the ability to give feedback on what they thought worked and did not. We will also learn if people think something like this could be used for long term use.

Procedure: We will have the participants fill out questionnaires again and have a last interview with questions from the exit interview questions outlined in Appendix C. The participants will be giving the robot back to the researchers.

During the interview, the participant will be instructed to put the robot and the booklet inside the box and once the researcher arrives, they will be asked to place it **outside their house/apartment building**. The researcher will then disinfect the box using disinfecting wipes. The box will then be taken back with the researcher, and opened no earlier than 3 days (what the Winnipeg libraries are doing for their received books). Once the box is opened, the robot will be carefully disinfected with disinfecting wipes.

Thank you for joining me again for this interview session. Before starting the actual interview, can you please quickly grab your questionnaire booklet? I will ask you to complete a few questionnaires. Please open the booklet to the section “exit interview” and complete the questionnaires in that section. They are the same as the one’s you filled the day of the initial interview, but some of your opinions may have changed. We want to see the changes in perception before and after people interact with the robot, so please don’t consult your previous answers. It’s not a test, do not worry.

Okay, let’s start with this final interview, if you don’t want to answer a question, just let me know, it is completely fine. Again, we will be recording this call for analysis purposes, are you okay if I start the recording?

<semi-structured interview, exit interview, Appendix C>

Now, lastly, thank you so much for participating in this study, we really appreciate your time. Again, I want you to know that this study was never meant to test you or your abilities in any way. Rather, we created our own robotic behaviour from scratch, and we wanted to test it. We wanted to see if people would use it and what they thought of it. We also wanted to learn how to make it better or more reliable in case we want to deploy it long term to test if it can help with feelings of loneliness. Your participation gave us valuable information that will help us answer these questions. The questionnaires you answered measure acceptance of assistive social robots by older adults and opinions of the robot’s social attributes. The audio recordings from the interview sessions will be transcribed into text and analyzed by the researchers. The research outcome will be used in publications to contribute towards future research but your name will not be published or linked to you in any way. Do you have any questions?

Today we are taking the robot back and giving you the last part of the compensation. Can you help me by placing the robot back in the box it came in with its charger and the booklet? Don’t worry about doing it completely correctly, just place it in the box in any way that it fits.

<Coordinate pickup time and procedure (we will confirm if after the interview works or any time during the rest of the day or the days after)>

Once I arrive at the time you defined, I will call you and wait for you to bring the box outside your house/building, I will disinfect it before taking it with me.

Appendix F Recruitment Poster

University of Manitoba

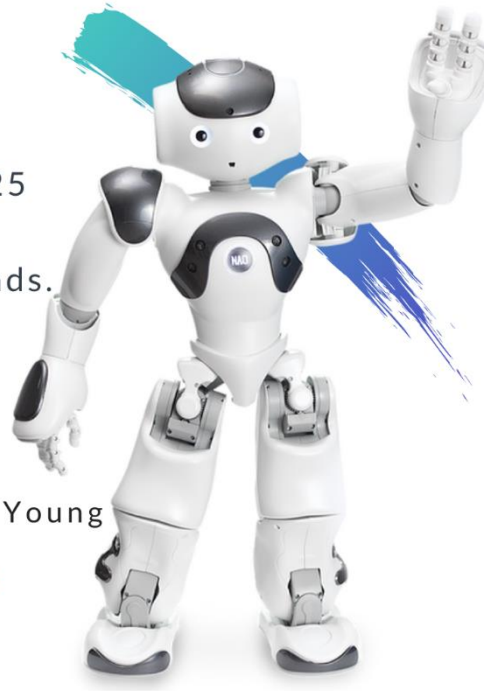
HCI Lab
UNIVERSITY OF MANITOBA

HELP US TEST OUR ROBOT!

We are looking for people 65+ who live alone that are open to having and using a robot in their homes for 2-3 days.

This study will require you to fill out short questionnaires and have an interview through an online video conference program at the beginning and at the end of this study. They will each be around 60-90 minutes.

We will deliver and pick up the robot. As a thanks for your participation, you will receive $25 initial compensation plus an additional $25 once the study ends. Total of $50.



NO PREVIOUS EXPERIENCE WITH ROBOTS NEEDED.

Principal Investigator - Dr. James Young

If interested, please contact Lorena González (gonzala1@myumanitoba.ca)

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

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