"Can I Consider You My Friend?"

Moving Beyond One-Sided Conversation in Social Robotics

by

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ABSTRACT

As people begin to live longer and the population shifts to having more older adults on Earth than young children, radical solutions will be needed to ease the burden on society. It will be essential to develop technology that can age with the individual. One solution is to keep older adults in their homes longer through smart home and smart living technology, allowing them to age in place. People have many choices when choosing where to age in place, including their own homes, assisted living facilities, nursing homes, or family members. No matter where people choose to age, they may face isolation and financial hardships. It is crucial to keep finances in mind when developing Smart Home technology.

Smart home technologies seek to allow individuals to stay inside their homes for as long as possible, yet little work looks at how we can use technology in different life stages. Robots are poised to impact society and ease burns at home and in the workforce. Special attention has been given to social robots to ease isolation. As social robots become accepted into society, researchers need to understand how these robots should mimic natural conversation. My work attempts to answer this question within social robotics by investigating how to make conversational robots natural and reciprocal.

I investigated this through a 2x2 Wizard of Oz between-subjects user study. The study lasted four months, testing four different levels of interactivity with the robot. None of the levels were significantly different from the others, an unexpected result. I then investigated the robot's personality, the participant's trust, and the participant's acceptance of the robot and how that influenced the study.

DEDICATION

For Eric; you have been a constant source of love and encouragement over the years. Thank you for helping remind me what is important in life. You have kept me balanced and motivated. Thank you for your patience and strength. Thank you for supporting this dream and the sacrifices you made along the way. I love you.

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TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

CHAPTER Page

APPENDIX Page

LIST OF TABLES

Table | Page

LIST OF FIGURES

Chapter 1

INTRODUCTION TO AN AGING SOCIETY

People are living longer (*Ageing and health* 2018). In 2019 news reports, couples are waiting to have children or choosing not to have them at all (Howard 2019). Projections for the population for 2050 are 9.3 billion people with 2 billion people aged 65 or older (Skouby et al. 2014). These two trends have created a shift in the population and caused novel problems in countries around the world due to not enough medical professionals entering the field to care for the high number of older adults (Kavilanz 2018). Robotics presents a unique opportunity to assist healthcare workers and fill the healthcare worker gap (Mois and Beer 2020).

Placing technology inside homes allows the home to be considered "smart" and assists with daily living activities by automating them. Smart homes typically have sensors placed around the home to alert when a task is unfinished. Commercial examples of smart home technology include smart thermostats and the robot vacuum. These technologies can help decrease the burden of household chores that usually become more difficult as people age. These technologies present an opportunity to assist seniors age inside their homes for as long as possible. They also allow loved ones to feel their family member is safe remaining inside their own home. By keeping seniors in their homes for as long as possible, the burden on healthcare workers will be less, and these workers can spend more time on patient-facing work for adults who need more assistance.

Aging in place is defined as a person spending the remainder of their days in the location of their choosing (*Healthy Places Terminology* 2009). When choosing where to live, a person can decide to age inside their own home, an assisted living facility, a nursing home, or even inside a family member's home. However, most people want to age inside their own homes due to their memories and the stigma that comes with aging inside a care facility (Thomas and Blanchard 2009). In 2007, an organization named Clarity surveyed 804 seniors who live at home and found 89% reported it is crucial for them to remain inside their homes (Clarity 2007). Clarity then asked these individuals to report their greatest fears, and 13% feared moving inside a nursing home while only 3% said they feared dying (Clarity 2007). It is essential to consider that the dwelling a person chooses to age in place is most likely where they will perish; therefore, it is of the uppermost importance to design technologies to assist seniors that enable them to age comfortably inside their homes for as long as possible.

No matter where a person chooses to age, some challenges need to be addressed with living there and common challenges found in all locations. People do not move out of their homes if they feel healthy enough to remain there. Often, people make accommodations to their homes as they age to ensure they are safe. The most common household updates include ensuring the floors are flush, installing grab bars in the shower and on the toilet, fixing loose carpet, and repairing stair rails (Wiles et al. 2012). Although these are simple solutions, not all challenges can be addressed quickly. Many seniors live inside homes that are outdated and present challenges for them. These include homes that are more than one story, no bedroom and bathroom on the first floor, and narrow doorways (Crary 2011). Clarity found that 75% of the adults surveyed are "very or somewhat concerned" how they will age if they remain inside their home, and 55% are "very or somewhat concerned" about their safety and security in their home (Clarity 2007). Innovative technology can help older adults feel empowered while continuing to age inside their homes.

Finances are a common challenge people face regardless of where they age. Older adults may be incapable of improving their homes to accommodate their new abilities if they struggle with finances. Furthermore, these seniors may need additional help found in a long-term care facility but find themselves unable to afford this type of care (Crary 2011). The 55% of seniors who are "very or somewhat concerned" about the safety features of their homes will be unable to afford repairs leaving them aging in an unfit environment.

By 2029, there will be 14.4 million seniors who are in the middle-income class (Pearson et al. 2019). These seniors do not receive quality assistance from Medicare and will not have the financial means to receive care in a long-term facility. Pearson et al. expected 80% middle-income seniors would need assistance, but 54% of this group will be incapable of affording care or receiving support.

If these seniors in the middle class cannot upgrade their homes, they will be unable to raise their property values high enough to cover the cost of long-term care. Technologists should deliberately develop low-cost solutions to help seniors who struggle with finances. These affordable solutions will ensure seniors are safe regardless of where they age and can live independently longer.

Isolation can happen regardless of where people choose to age and is caused by being separated from others (Dictionary). It can affect people when they retire, lose a friend, or stop attending social functions due to health. These health issues can include mobility issues that may be permanent or temporary, e.g., arthritis or surgery such as a knee or hip replacement. When surgery happens, the person may never fully regain their mobility.

Isolation can have severe effects on health and is comparable to having the same effects on a person's health as smoking (Cornwell and Waite 2009). Isolation can cause depression, poor sleep, and cognitive decline, leading to premature death (Santini et al. 2020). Social disconnectedness is a predictor of isolation related to depression and anxiety. When a person is isolated, they may suffer from their brain aging faster than if they were not isolated. Their brain aging faster may cause the person to need assistance sooner or even move into a long-term care facility. However, if they cannot afford care, they may be left to age in an unsafe environment.

By 2029, older adults will have fewer family caregivers due to the reduction in the number of children they have, which will increase the burden on their younger family members (Pearson et al. 2019). Caregivers struggle with finances, mental, and physical health from their caregiving responsibilities (Johnson and Wang 2019). Having fewer people to provide caregiving services presents new difficulties families will face. These younger family members may be unable to serve as full-time caregivers for their aged family members due to having young children at home, a consequence of having children later in life. They may also have inadequate space inside their home or lack the financial resources to support caring for their aged loved ones.

Social robots present an opportunity to address isolation for older adults looking to age in place. Older adults are willing to accept robots for assistance (Forlizzi 2005); (Beer et al. 2012); (Broadbent et al. 2012). Often, these products are not aesthetically pleasing, and when designing these robotics applications, aesthetics are hardly considered (Forlizzi 2005); (Moyle, Jones, et al. 2013). Older adults prefer a robot over a digital assistant because it allows them to feel more engaged. These include robots using nonverbal cues to acknowledge the user rather than a display light used by digital assistants (Breazeal et al., n.d.). Social robots do not need human-like characteristics because older adults associate robots with assistance rather than being life-like (Broadbent et al. 2012). Additionally, limitations on movement when interacting with the user should be considered because too much can negatively affect the experience (Pollmann et al. 2020). As social robots become accepted, it is paramount to discover the features seniors want; otherwise, they could become deterred from interacting with these applications and reject the robot as a companion.

These robots have the potential to assist more than seniors but formal and informal caregivers as well. A robot developed for caregiving should include features that make the caregiver's jobs easier and reduce stress. Broadbent et al. (Broadbent et al. 2012) report that caregivers want the robot to measure emotions, such as depression. Additionally, robots used for physical assistance will need different features than a robot companion. These include arms and a face. A robot that lifts people does not need a face but will need arms. A robot as a social companion will need a face but not functional arms.

Caregivers need help with routine tasks such as monitoring and taking blood pressure, wanting the patient, and/or assisting the staff while not taking their jobs (Broadbent et al. 2012). Enabling robots to assist these caregivers in their daily life will help reduce the workload and has the potential to address the healthcare worker shortage by making the interactions between a caregiver and a patient more meaningful.

Social robots have the potential to address isolation and depression regardless of where people choose to age (Miller, McDaniel, and Bernstein 2020). However, for this technology to be successful, developers should create low-cost solutions that are more accessible to the general population. By working with these lower-cost solutions, developers create opportunities for third-party affiliates to assist in covering the cost of the robot. In the future, one possible solution may include involving other health and aging-related organizations to help cover the costs of these robots. This Robots as a Service (RaaS) business model is growing in popularity and has already begun to take root in different industries, such as manufacturing and healthcare. It is not unreasonable to imagine robots making their way into homes soon through this RaaS model.

Much of the work in social robotics assists individuals living with dementia. Much of this work includes music therapy and the robot playing a song (Tapus 2009); (Khaksar et al. 2016), (Khosla et al. 2019); (Cruz-Sandoval and Jesus Favela 2019). Additionally, much work tries to engage users in conversation. These features include simple questions to encourage conversation, telling stories or having the user show the robot a photo that prompts the robot to tell the story behind the photograph (Kanoh et al. 2011); (Abdollahi et al. 2017); (Khosla et al. 2019). Cruz-Sandoval et al. developed a robot capable of simple conversations but needs a human for more complex interactions (Sandoval and Favela 2017). Many authors report their future work includes adding more verbal features to the robot (Paletta et al. 2018); (Magyar et al. 2019); however, no research is investigating how to make these interactions natural and reciprocal.

Researchers should work to extend the applications of social robots to healthy older adults in addition to people living with dementia. The introduction of a social robot before cognitive decline may assist individuals with maintaining their cognitive ability for longer.

I aim to contribute to the future of in-home caregiving in smart city environments, where I see homes as the central intersection between citizens and smart cities. Understanding how aging is different for individuals inside the home versus inside assisted living thus represents a crucial step for advancing care-centric, smart-home technologies.

In addition, the technology developed could easily be migrated into alternative platforms and alternative smart-city settings as people move within their environment and choose where to age and seek care. Critically, these home technologies could be expanded to connect smart homes to hospitals, securely relaying critical, personalized medical data.

My work focuses on healthy older adults and their experience interacting with a social robot. I did this by conducting a 2x2 Wizard of Oz between-subjects user study. There were four conditions, i.e., 2x2, and I controlled the robot behind the scenes, i.e., Wizard of Oz. Participants completed a survey after each interaction, and I completed a three-way mixed ANOVA statistical analysis and found no significant difference in all four conditions. This initial finding shaped the remaining questions explored in Chapters Five, Six, and Seven.

The remaining chapters include the following: (I) Introduction, (II) Background Information, (III) Related Work, (IV) 2x2 Wizard of Oz, (V) Exploring Human Trust in Robots, (VI) Exploring Human Trust in Robots, (VII) Exploring Human Personality, (VIII) Discussion, (IX) Future Work, (X) Conclusions.

Chapter 2

BACKGROUND INFORMATION

This chapter will cover the background information required to understand the full scope of this research project. I will cover the impact of living with dementia, the benefits of conversational therapy, aging in place, common challenges shared by locations we can age, and the need-finding efforts to support the direction of this research.

2.1 Living with Dementia

According to the Alzheimer's Association, in 2022, an estimated 6 million Americans will be living with Alzheimer's, the most common form of dementia. That number is projected to reach 12.7 million by 2050 (*Alzheimer's disease facts and figures.* 2022). The national cost of formal care for Alzheimer's patients in 2022 is estimated to be $321 billion and is expected to reach $1 trillion by 2050. An estimated 70% of informal care is coming from family, friends, or other unpaid caregivers, making up approximately 11 million individuals (*Alzheimer's disease facts and figures.* 2022).

Dementia negatively affects people and caregivers. People living with dementia experience feelings of depression, isolation, and aggression, while caregivers frequently report high levels of stress and depression along with financial and physical difficulties (*Alzheimer's disease facts and figures.* 2022). The Alzheimer's Association has recommended that people living with dementia engage in storytelling as a way to combat some of these feelings (*Alzheimer's disease facts and figures.* 2022). For caregivers, recommendations are meditation, breathing exercises, and taking time for oneself (*Caregiver Depression* 2022). However, many technologies for people living with dementia do not include features for the caregiver and do not relate to the larger smart city environments in which they might embed.

In caregiving, a robotic platform serves as an alternative medium for people living with dementia and algorithms to interact (e.g., as opposed to a phone or computer interface). A robotic platform was chosen to allow people living with dementia to feel like they are interacting with another person instead of a computer, which could create a mental barrier. Particular attention to the benefits of storytelling interactions in dementia care includes: feeling like they have accomplished something, promoting self-esteem, improving creative skills, improving their social interaction, improving their verbal skills, providing a therapeutic opportunity to communicate, and replacing the pressure to remember (Services 2017). These benefits will improve the quality of life for people living with dementia and allow them an opportunity to improve their skills and not feel helpless. Conversation is a recommended activity for caregivers from the Alzheimer's Association on how to engage their loved one (*Activities* 2022).

2.2 Conversation Therapy

Conversational therapy, also known as therapeutic conversation, is a therapy method developed for individuals who live with Alzheimer's Disease. The goals of this therapy are: (1) maintain supportive relationships; (2) provide an opportunity for the individual to express themselves; (3) reduce isolation; (4) improve self-esteem; (5) improve mood; (6) reduce anxiety; (7) maintain verbal abilities; (8) maintain dignity

(Tappen and Williams 2009). These goals help create interpersonal relationships by helping the person feel valued.

Rules for the therapist include following the flow of the conversation, identifying what is essential to the person and conversing about it, and finally finding competence (*How Conversation Sparks Therapeutic Change: The Search for the Unspoken Self* 2012). It is important to note that therapeutic conversation is not the same as talk therapy, which is used for a wide range of applications such as treating depression, anxiety, eating disorders, or anger management (Gallagher 2020).

The successes of conversational therapy have been investigated for almost thirty years. In a 1994 report, Erber (Erber 1994) presents a case in which nurses, residents, family members, friends, volunteers, and therapeutic specialists all can engage a person living with dementia in therapeutic conversation. Erber notes that some individuals may need to seek training to focus on what the person can do now rather than what they used to do.

In 1997, Tappen et al. investigated how to communicate with people living with Alzheimer's. They report that speaking to the individual as an equal, sharing feelings, and noticing themes that were important to the individual helped maintain the conversation (Tappen et al. 1997). Tappen et al. used these techniques in their 2009 study when they placed 15 individuals in a therapeutic conversation group over 16 weeks. The participants showed improved changes in mood (Tappen and Williams 2009).

Tappen et al. (Tappen et al. 2002) completed another study in 2002 examining the intervention of exercise with conversational therapy. Tappen et al. found that for participants in the conversation-only therapy group, their performance improved in

(1) not repeating information and (2) conciseness, even though their total number of words decreased.

A social robot would also be capable of *reminiscence therapy*. Reminiscence therapy is a form of conversational therapy (Therapy 2018). Reminiscence therapy focuses on helping individuals remember events from their past. By telling stories from the past, people living with dementia feel less isolated and present at the moment.

When engaging a person in reminiscence therapy, there are a few rules to keep the person engaged (Kennard 2021). It is important to ask open-ended questions. Keeping the questions open-ended helps keep the conversation flowing and allows more memories to emerge. Acknowledging the person's feelings is essential to helping them feel seen and valued. Using props such as photo albums and objects may help trigger memories. Finally, if possible, try to engage the five senses through music, dancing, tasting foods, candles, or other items.

Asiret et al. (Asiret and Kapucu 2015) investigated the effects of reminiscence therapy on sixty-two people living with dementia by measuring their cognition and depression. They placed thirty-one in the reminiscence therapy group and thirty-one people in the control group. These individuals completed 30-35 minute sessions for twelve weeks. At the end of the study, all thirty-one individuals showed an increase in cognition and a decrease in depression. From these results, individuals who undergo reminiscence therapy will have a positive impact.

Huang et al. (Huang et al. 2015) found in a 2015 study that reminiscence therapy is effective for improving cognitive functions and reducing depression. Subramaniam et al. (Subramaniam and Woods 2012) completed a literature review of five different randomized control trials. In each of these trials, individual reminiscence work improved overall mood, well-being, and aspects of cognitive function. The literature supports conversation therapy and reminiscence therapy as successful tools for people living with dementia.

2.3 Aging in Place

To complement my review of gerontechnology [1], I explored the locations people can age in order to develop technology for these locations better. Understanding how people age in different locations with the common and unique challenges to each location allows technology to be more impactful. Below, I report on aging inside the home, assisted living, nursing homes, and family housing. These locations provide constraints; however, two challenges are shared across all locations: financial strain and isolation.

2.3.1 Aging Inside the Home

The challenges of aging in the home are essential to understand when developing technical solutions. Before examining these challenges, it is crucial to understand why an elderly individual would want to remain inside their home. In 2005, 89 percent of older people said they wanted to remain in their home (Wiles et al. 2012). Some of the reasons people want to stay in their home are that it is where they have lived all their life, so they have memories associated with the house (Crary 2011). The other reasons older adults do not move out of their homes are financial and perceived health.

People do not want to leave their homes because they have spent years decorating and creating them to be the space where they feel the most comfortable. People do not want to get rid of the belongings they use to make their homes feel special. These could include photographs, specific furniture, or even religious decorations. If they choose to relocate, they might have to sell their furniture or be uncomfortable moving their religious artifacts to another location.

Another reason people remain inside their homes is because they feel they are healthy enough to stay and have made necessary accommodations to remain in their homes. Some of these accommodations include a bedroom on the first floor, grab bars in the bathroom, and nonslip floors (Wiles et al. 2012). Having these systems in place acts as safety mechanisms to keep older adults safe in their homes. Keeping older adults safe will allow them to stay independent and have more autonomy when living alone or with another aged individual. Having these accommodating features also allows families of older adults to feel confident that their loved one is safe living alone.

Older adults are more at risk when they require assistance with personal hygiene; transfer, e.g., lifting oneself; finances; and medication (Tang and Lee 2010). To address the aforementioned challenges (Szanton et al. 2016); (Szanton et al. 2011); (Popejoy et al. 2015) assist in remodeling homes. Common repairs included adjustments to floors to ensure they are level; installation of grab bars, especially in bathrooms; and stretching carpet to ensure no areas are loose (Szanton et al. 2011). These upgrades positively impacted 93% of their study participants (Szanton et al. 2011). However, this calls attention to older adults who do not have a community willing to help them and may still be in an unsafe home.

2.3.1.1 Home Care

Home care is an option a family can decide to take for allowing the older adult to age inside their home. Home care allows a nurse to come to the older person's home and perform services. There are three main scenarios for this kind of care. The first is 25 hours a month for limited care, 90 hours a month for moderate care, and 250 hours a month for extensive care (Johnson and Wang 2019). People choose home care solutions because they allow them to stay inside their homes but still receive their care. It is also cheaper than relocating to an assisted living facility and nursing homes. Home care allows for customization of the amount of care needed for each person allowing them to choose the option they feel is best and could be changed if the older adult gets better or worst in health.

2.3.2 Aging Inside Assisted Living

Once a person moves out of their house, they have different options for places to move, such as assisted living or a nursing home. People choose assisted living facilities if they can afford them because they provide care in a home-like social setting. This is preferred over nursing homes because people associate nursing homes with a lack of independence. People choose to move into assisted living for a social community; they no longer must do housekeeping chores or because they need the extra help (Dixon, Fortner, and Travis 2002).

Assisted living facility represents a short-term solution (Mitty 2004). The average stay is around 18 months because these facilities do not consider themselves a replacement for a nursing home, but only a steppingstone to nursing homes (Ball et al. 2004).

When looking into these options, one problem older adults face is understanding how long they will be allowed to stay at these facilities and if they will receive adequate care.

Multiple factors go into if a person can move into an assisted living facility or not beyond finances. One consideration is whether the individual would get along with other residents (Ball et al. 2004). Moving in is even more difficult for those who use a wheelchair; only 15% of this population are admitted into nursing homes (Mitty 2004). Other exclusion criteria include being constrained to a bed, living with bedsores, or requiring a feeding tube (Dixon, Fortner, and Travis 2002).

Assisted living facilities have strict requirements that a person cannot need too much help when moving into them. Assisted living facilities require the person to maintain this level of independence while staying there, which often is not obtainable by the person. As a result, as older adults begin to need more help doing simple tasks, they are reluctant to ask the caregivers for extra assistance in fear that they will be removed from the home (Mitty 2004). Other common reasons adults are dismissed from assisted living include two-person transfers, individuals who can no longer afford care and becoming bowel incontinent (Chapin and Dobbs-Kepper 2001).

2.3.3 Aging Inside Nursing Homes

Once a person reaches a point where they require assistance with at least three activities of daily living, they need more care than the assisted living facility is willing to provide, and they are moved into a nursing home (Mitty 2004). Because older adults have declining health, they are often too cognitively impaired to decide to move.

This leaves the decision up to their family members and can further affect the older adults' mental health (Chapin and Dobbs-Kepper 2001).

People seek to avoid nursing homes at all costs, and Ball et al. (2004) found that even when people were unhappy with their assisted living facility, people preferred it over a nursing home (Ball et al. 2004). One resident in an assisted living facility said they should rather die than be moved into a nursing home (Ball et al. 2004). Chapin et al. (Chapin and Dobbs-Kepper 2001) found that placing older adults into nursing homes can lead to depression and even make individuals suicidal by reducing their weight.

When older adults move into a nursing home, they cannot bring all their belongings. They must limit what they can bring into the home due to limited personal space (Chapin and Dobbs-Kepper 2001). Chapin et al. (Chapin and Dobbs-Kepper 2001) discussed the emotional damage this can have on older adults by removing their identity. However, if the older adult had to sell all their personal belongings to move into the home, they would have nothing to move into the home. Not having physical belongings could cause depression for the older adult due to owning nothing and having to do it to receive care. However, selling all their items does not extend the time they can receive care by much.

2.3.4 Aging with Family

When an older adult cannot remain inside their home due to compromised safety or move into a care facility because of financial strains, sometimes the older adult will move in with their younger family. While this may seem a financially sound decision at the time, it often has the opposite effect on the family.

These situations are taxing on the family, and they feel as if they have become the permanent caregiver of their loved ones. This stress can cause depression in the younger generations because they must be available for the person all the time while managing all their other responsibilities. Johnson et al. (Johnson and Wang 2019) found vital stakeholders in family housing situations are adult children; usually daughters, and they experience physical, emotional, and financial burdens.

Having an elderly family member move into a home with the family can cause the younger adult to feel as if they need to give up their social life because their elder may be unable to perform basic tasks like bathing, cooking, or even eating independently. Having the younger adult give up their social life can cause social isolation. The younger adults' friends may distance themselves from the caregiver because they feel that person is always too busy for social events. If the younger adult still has friends who invite them to social events, they may feel the need to turn down these social outings due to feeling guilty for leaving their elder at home alone for a short time. These interactions can leave the younger adult emotionally depressed and cause social isolation.

As stated above, Cornwell et al. (Cornwell and Waite 2009) point out that social isolation is detrimental to physical health in addition to mental health. Social isolation can cause the younger adults' physical health to decline once they start feeling the feelings of isolation. The caregiver may also begin to decline in health due to having to pick up, assist, or support their elder while bathing, standing up, or changing clothes.

This mental and physical exhaustion can carry over into the rest of the younger adult's life. If the younger caregiver is not sleeping enough due to taking care of their elder and children during the night, it could decrease performance at work. This decreased performance may leave the young caregiver in trouble at work, and if they consistently under perform, they could be laid off. In another scenario, the young caregiver is married, and the couple decides it is easier for one of them to quit their job to attend to their elder. The couple then loses a constant source of income while increasing the number of resources they need in the house, such as electricity, water, and food. This situation causes financial strain on the young couple, which could cause mental health issues and even cause the couple to fight more. One of the leading causes of divorce in America is money, which could happen to the young couple if the situation is extreme enough.

If an older adult decides to move into a loved one's home, this could cause the home to become cramped due to the size of the home, the number of people living inside the home, and if the older adult brings many of their items. Often, the family must turn a room into a living space for their older loved one, such as a living room, bonus room, or even the garage. The family could also decide to build an addition to their home to accommodate their older family member and make them feel like they still have their place.

2.3.5 Aging in the Community

Older adults aging in the community has many aspects to it. These could include moving in with family, aging in retirement communities, villages, or even the physical environment. Home and community services have become more available and can supplement care when needed allowing the transition into needing more help to happen while they age in place (Tang and Lee 2010).

Home and community services are adult day care programs, housekeeping services, lunch programs, home repair programs, home nurses, nursing homes, assisted living facilities, transportation services, and hospice care (Tang and Lee 2010). The use of these services can delay the placement into a nursing home and have even helped nursing home residents move back into community settings (Tang and Lee 2010).

2.3.6 Aging with Adult Day Care

Cutchin et al. (Cutchin 2003) found that people are using ADC when they should not be because they are not allowed to move into assisted living facilities. Due to this, ADC facilities become full of people with impairments that might not be there if assisted living was not so intense on move-in requirements making it challenging for the ADC facility.

2.3.7 Aging in Retirement Communities

Retirement communities are a popular choice for healthy older adults who do not need help with basic needs around the house. However, moving into one of these communities means they are not responsible for the upkeep outside of their home, which has become challenging. This allows them to focus their energy on other things, like social functions. These communities are actively involved and hold social gatherings many times throughout the week. It is common for a golfing group to form, a card group, or even a sewing group. Couples host other couples for dinner and games, which has become a weekly tradition.

2.3.8 Aging in Villages

Another choice that has been growing in recent years is aging inside villages; people inside the neighborhood create an environment to enhance the well-being and quality of life for the senior members of the population (Thomas and Blanchard 2009). These people choose to be a part of this community and rely on others. This way of living allows people to maintain social relationships in a small clustered area (Thomas and Blanchard 2009).

2.3.9 Environmental Affects on Aging

Aging is not only affected inside facilities and homes but it can be affected by the environment as well. These challenges are different from those inside the home because they cannot be fixed by the older adult themself but instead need to be addressed by their local city. These challenges include walking around neighborhoods, walking around the city, and being unsafe to walk outside of their home.

Research has shown that walking is essential for older adults who wish to stay healthy and young. Clarke et al. (Clarke and Gallagher 2013) discuss the importance of walking as people age, which is the most common form of exercise chosen by older adults.

Designs of Cities

Older adults often are at the mercy of their environment, which may not be well kept. Older adults reported having trouble with sidewalks that did not have a flat surface or if the sidewalk just ended, forcing them to walk in the grass. Clarke et al. (Clarke and Gallagher 2013) reported that the urban environment could have an impact on how older adults maneuver the city through inadequate access to public transportation, poor sidewalks, and inadequate lighting. If cities are designed with pedestrians in mind, it has been positively related to mobility in older adults (Clarke and Gallagher 2013). Well-kept neighborhoods are more likely to have active older adults than neighborhoods in poor conditions.

Older adults reported that these issues are keeping them from completing daily tasks such as grocery shopping or banking (Clarke and Gallagher 2013). These issues also do not allow older adults to walk outside their homes to receive the exercise they need to maintain their physical health. This situation is worse for older adults who are socioeconomically disadvantaged (Clarke and Gallagher 2013).

2.4 Affording Where You Live

Across all sections, finances were an issue for older adults looking to age in place. Most of these solutions are expensive and unobtainable for many elderly folks who find themselves in this situation. These include being able to remodel their home to make it safer, not making enough money once selling their home to move into an assisted living facility, not having a high enough income to cover assisted living or nursing homes, or not needing as much care required to move into one of these facilities but still being unable to afford adult day care or home care services. Figure 1 depicts how care changes with cost in different settings (*Types of Senior Living and Levels of Senior Care*).

Solving financial burdens is out of the scope of this dissertation, but it can be seen

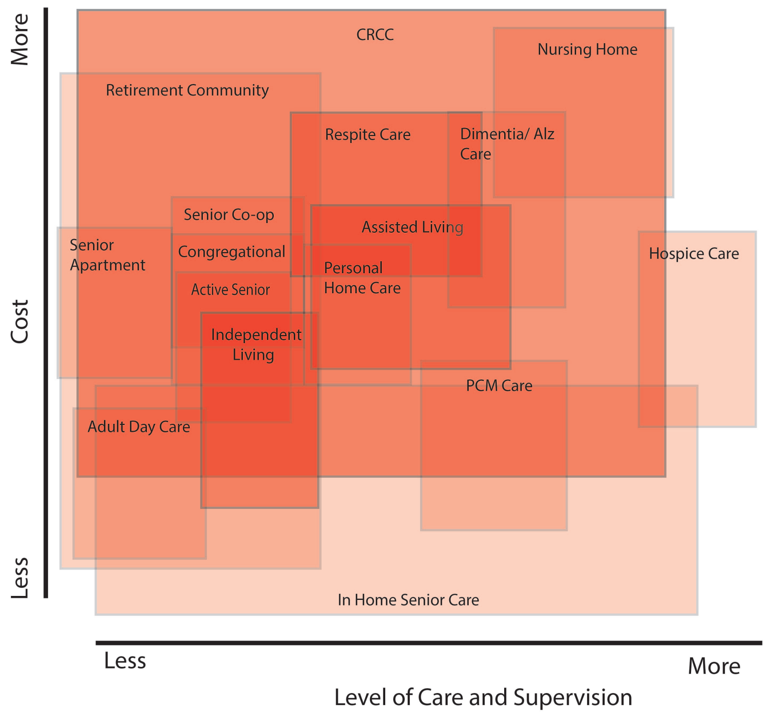


Figure 1. Costs for Levels of Care

from the governmental stance that finance is an issue that needs addressing. Some solutions might be to offer more affordable care options using technology and robotics, better care coverage, or even early prevention for needing care later in life.

Technology has the potential to be mass-produced, creating a labor force capable of being paired with existing healthcare professionals to assist in their daily jobs. Implementing technology capable of handling repetitive or minuscule tasks frees the physical person to handle more meaningful interactions with older adults while mitigating the consequences of not having enough trained professionals. This is an area for local and federal governments to investigate the effects on the workforce and how much compensation is needed from technology.

Better health care coverage could be provided if technology could handle simple tasks in the healthcare field. As mentioned previously, it could be possible that health care providers must choose between giving care to a family of four or an older adult in the future. Using telemedicine, doctors could become face to face with patients cutting down on the costs of running the office and the space needed for doctor offices. These technologies could cut the cost of healthcare and not force providers to have to choose between people for providing care. Again, local and federal governments will need to be involved in creating policies and regulations on what tasks can be transferred to a robot and what needs to remain a human skill.

Early prevention could be used through devices such as wearables which have become more prevalent in recent years. Wearables such as activity bands can track a person's exercise and food if they are disciplined enough to use them. These devices are capable of tracking sleep as well. This data could be shared with medical professionals allowing the doctor to make lifestyle recommendations based on what they see from the data. Making recommendations on what lifestyle changes need to be made in order for the older adult to remain healthy could prevent the older adult from ever progressing into a dependent state and prevent them from needing to move into care facilities.

Another early prevention strategy would be to stress physical health by delaying or slowing down in older age. Most people workout for heart health and have been told the benefits of reducing a potential heart attack; if this message was changed to allow younger generations to be more proactive in their early life, would it prevent declining health later? This is an area for future work to address.

Crary (Crary 2011) demonstrates a woman who cannot afford care and moves due to the value of their home dropping. This is likely the situation for many older adults aging in outdated homes. Tang et al. (Tang and Lee 2010) call attention to seniors living below the poverty line. These seniors are more vulnerable to challenges associated with aging and the financial burden associated with aging.

Home care is a solution that lets older adults age inside their homes while still receiving necessary care. The cost of home care depends on the kind of assistance a person chooses; in 2022, the average monthly cost was $5,148 (*Cost of Long Term Care by State* 2022). Johnson et al. (Johnson and Wang 2019) discuss how those most likely to need these services are unable to afford them, finding that only 22% of adults with long-term care needs could afford a moderate amount of care and only 7% could afford extensive care.

In 2022, in the United States, assisted living costs an average of $4,500 a month (*Cost of Long Term Care by State* 2022). This cost is a barrier to anyone who did not prepare. Ball et al. (Ball et al. 2004) report that the cost of care was a significant factor in how long individuals stayed in the facility. Mitty et al. (Mitty 2004) call attention to assisted living facilities not supporting end-of-life care; therefore, they are only a short-term solution for older adults seeking additional care. Assisted living facilities also will not accept residents who need additional care than they are willing to provide. Due to the fear of being moved to a nursing home and the additional costs, often residents refuse extra care they need (Ball et al. 2004).

In 2022, the average monthly cost of using nursing home facilities was $7,908 to $9,034 (*Cost of Long Term Care by State* 2022). Johnson et al. (Johnson and Wang 2019) found that only 14% of the 9,966 older adults they surveyed could afford to move into a nursing home. Johnson et al. also report that older adults who need long-term care could not afford nursing homes, and only 6% could afford a nursing home without other resources than income. Only one-fourth of seniors who move into long-term care facilities stay longer than four years. Johnson et al. report that these individuals could afford an extra 106 months of assisted living or 34 months of nursing homes if they liquidated their homes. If they liquidated all other assets, it only added one year of nursing home care on average.

2.5 Isolation

Isolation is a product of aging in place and is not unique to one sitting. It can be found in all places people age but is caused by different reasons. Isolation can be felt in the home, nursing homes, retirement communities, or even in family housing by the younger adults themselves. Feeling isolated is detrimental to a person's mental health and can cause a decline in physical health. This is an area technology can make an impact to improve the quality of life.

Isolation leads to depression in older adults and younger adults. This is an effect of being unable to move or make necessary changes to the current home to make it safer, having to sell items to afford the level of care needed, being placed in a nursing home, or having a family member move into one's home. This could be stopped in the younger and older adults if the correct preventative actions could prevent the older adult from progressing to the level of such dependency. Technology implemented will have to be able to help older adults perform basic tasks to keep them independent longer. Preventative technology could avoid depression and isolation of older adults altogether if designed correctly.

These technology solutions need to be developed with older adults to enable the designs to be intuitive and self-explanatory. When designing these technologies, it will be essential to gather healthy adults and adults who have trouble with daily activities. This will ensure that the technology developed can be adapted if the user declines.

Depression can be independent by not being surrounded by loved ones, and the environment itself can cause it. This can be from being forced to stay in an environment where the aged adult wants to move either for convenience or safety concerns. In the future, areas to explore will be how to develop technology that allows older adults who are forced to remain inside their homes to feel safe in these situations. These solutions will need to be low-cost and easily installed by family members or other caregivers.

Technology implemented could be used for social companionship. Joy for All sells robotics pets for around $100. The puppy will engage with the user through barking and has a heartbeat that the user can feel when petting the animal (All 2018).

When seniors age inside their homes alone, they can face isolation. They may have decreased motor skills that cause difficulty driving; therefore, they cannot attend social events. Additionally, some seniors have family that lives far away and face isolation from little visits. Older adults typically struggle to use social media or choose not to use such platforms that would connect them to friends.

When transitioning from an assisted living facility to a nursing home, a person may lose all the friendships they made while living there. They also lose the relationship with the staff members familiar with their medical condition. These cause social consequences in their new location. Chapin et al. (Chapin and Dobbs-Kepper 2001) report that these friendships with other residents and staff members can affect the care the older adult receives.

Social robots have the potential to address isolation. Older adults are generally open to accepting a social robot; however, much of the research is still prototypes and proof-of-concept, leaving much work.

Interdisciplinary research could measure depression in seniors before and after interacting with a social robot to determine how successful these technologies would be. The depression levels would provide strong evidence that this technology is prosperous rather than self-reporting methods or observation.

Social robots should complete more than one task to provide the most benefit to older adults and their caregivers. These include playing music, playing games, fall detection, or engaging the user in exercise. These various features would allow for multiple ways of engagement and most likely would increase the user's enjoyment when interacting with the robot. Finally, these robots should avoid giving commands to the user but rather offer suggestions.

2.6 Need Finding Efforts

This work began as an effort to provide conversational therapy for individuals living with dementia while providing stress relief to informal caregivers. Due to the COVID-19 Pandemic and assisted living restrictions, I was forced to work within the healthy older adult space rather than with individuals living with dementia.

Prior to the COVID-19 pandemic, I attended caregiver support circles at Memory Cafes to gain insight into the life of an informal caregiver. Many of the caregivers mentioned how they often put their loved ones to bed at night and try to watch TV or take time for themselves; however, their loved ones would come into the room and try to get them to come to bed. One woman even said, ***"I feel like I am constantly putting out a fire"***.

This insight led to the creation of two separate surveys. The first survey was for informal caregivers and tried to understand the struggles they face. The second survey was for older adults and wanted to prove or disprove the literature surrounding how older adults feel about aging. The following sections report the survey and the responses to each question.

2.7 Informal Caregiver Survey

There were twenty-one participants in this survey. They were recruited through our online presence at the Alzheimer's Association, Memory Cafes, Waymark Gardens, or Sun Health Communities. The complete survey can be seen in APPENDIX A.

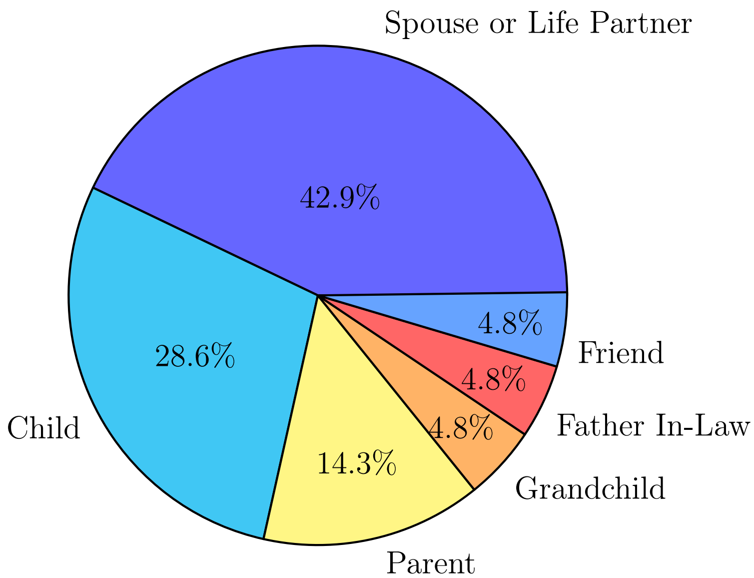
2.7.1 General Questions

This survey is designed to gain insight into the challenges individuals feel from caregiving.

A caregiver is an individual who provides care to someone other than themselves either remotely, in person, occasionally, weekly or every day.

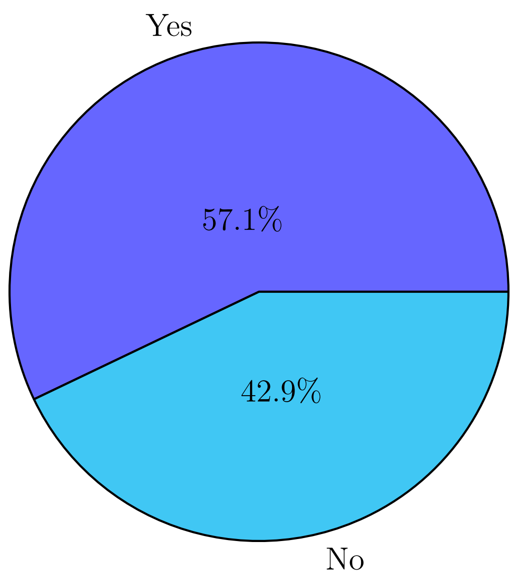
How are you related to the person you provide care to?

Twenty one people answered this question. Nine people reported they were the spouse or life partner of the person, six people reported they are the child, three people reported they are the parent, one person reported they are the grandchild, one person reported being a friend, and one person reported being the father-in-law.



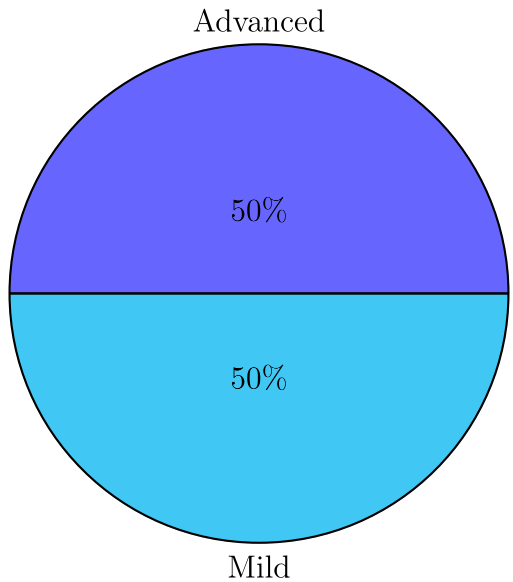
Has the person you provide care to been diagnosed with dementia?

Twenty one people answered this question. Twelve reported yes and nine reported no.



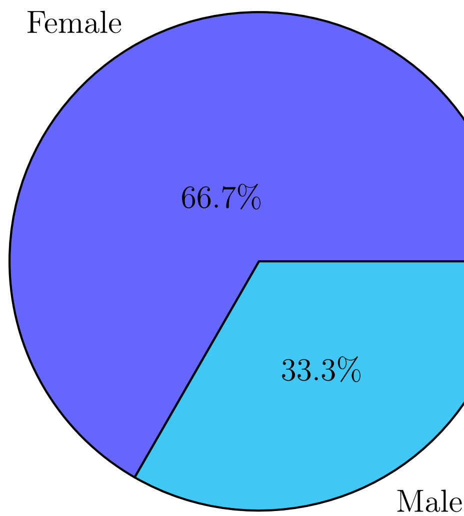
If yes, what stage of dementia are they currently living with?

Twelve people answered this question. Six reported mild dementia and six reported advanced (needing assistance with toileting) dementia.



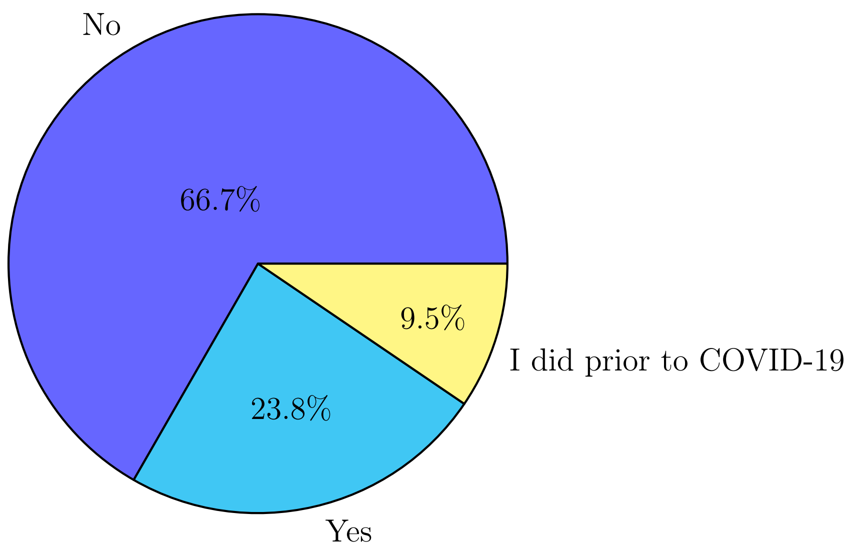
What is your gender identity?

Twenty one people answered this question. Fourteen reported being female and seven male.



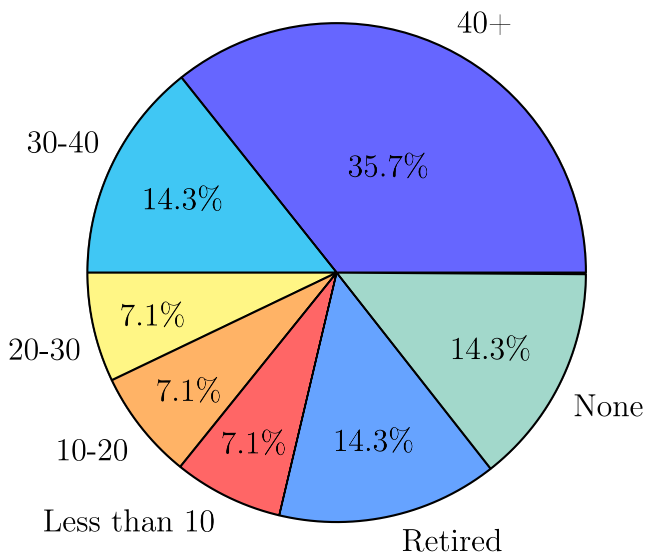
Do you work outside your home?

Twenty one people answered this question. Fourteen people said no, five people said yes, and two reported they did prior to the COVID-19 pandemic.



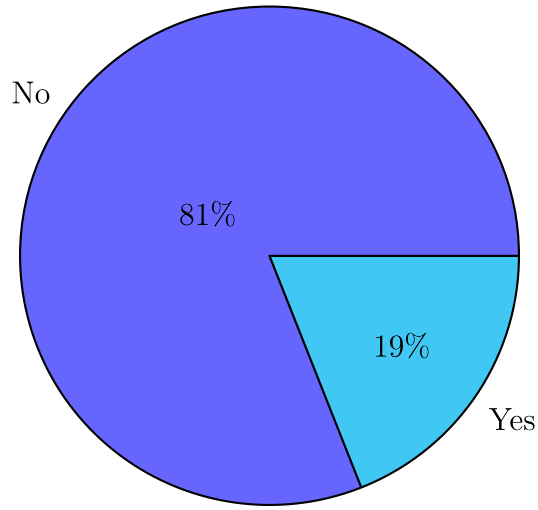
How many hours a week do you work?

Fourteen people answered this question. Five people reported working 40+ hours, two people reported working 30-40 hours, one person reported working 20-30 hours, one person reported working 10-20 hours, and one person less than 10 hours. Two people reported being retired and two people reported they are unable to work. One person who does not work reported it was because they are a full-time caregiver for their mother.



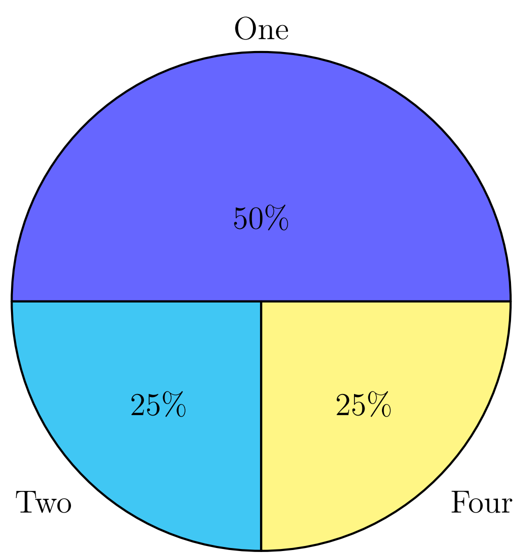
Do you provide care to anyone else? Do you have additional members of your family you attend to besides your older adult (such as children)?

Twenty one people answered this question. Seventeen reported they do not care for anyone else and four reported they do care for other family members in addition to their older adult.



If yes, how many?

Four people answered this question. Two people reported caring for one other individual in addition to their older adult, one person reported caring for two other people, one person reported caring for four other individuals.



How old are they?

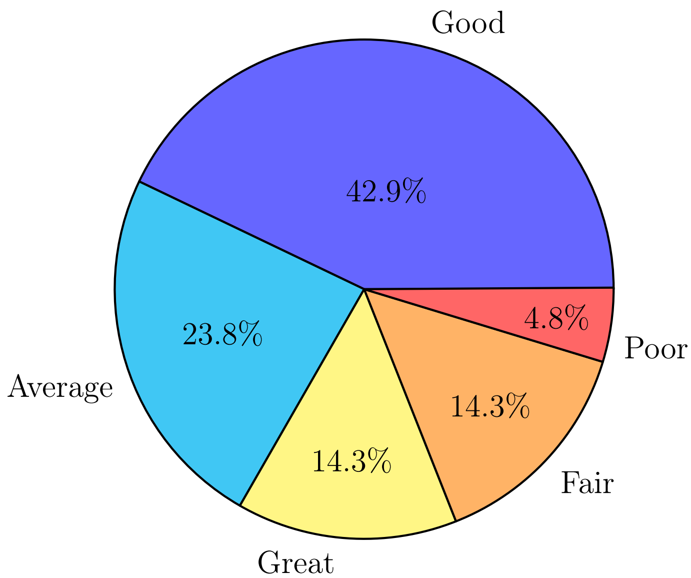
Six people answered this question. One person reported their child is living with a disability so they are the full-time or part-time caregiver. One person reported caring for four people in the ages of 0-5, 5-10, 15-20, and a child with a disability. Four people reported the person the additional people they care for are aged 20 years or older.

2.7.2 Questions about Mental and Physical Health

These questions will ask about your mental health.

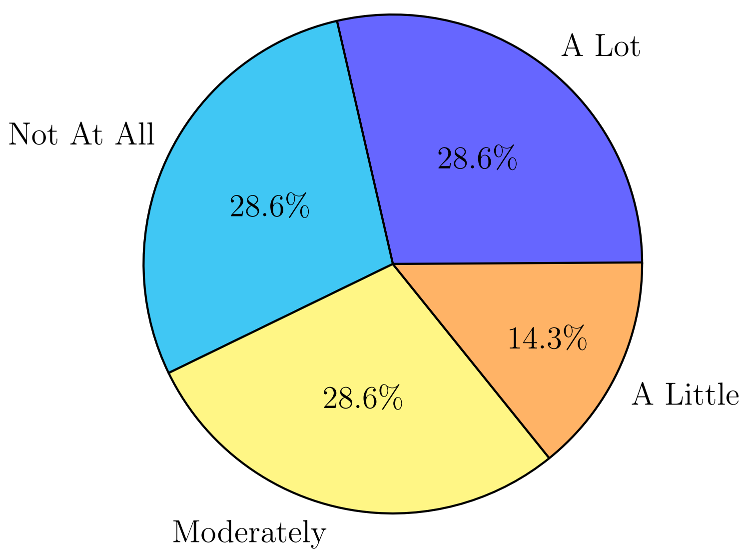
How would you rate your personal mental health today? Mental health includes emotional, psychological, and social well-being. It affects how we think, feel, and act. It also helps determine how we handle stress, relate to others, and make choices.

Twenty one people answered this question. Nine reported it was good, five reported it was average, three reported it was great, three reported it was fair, and one person reported it was poor.



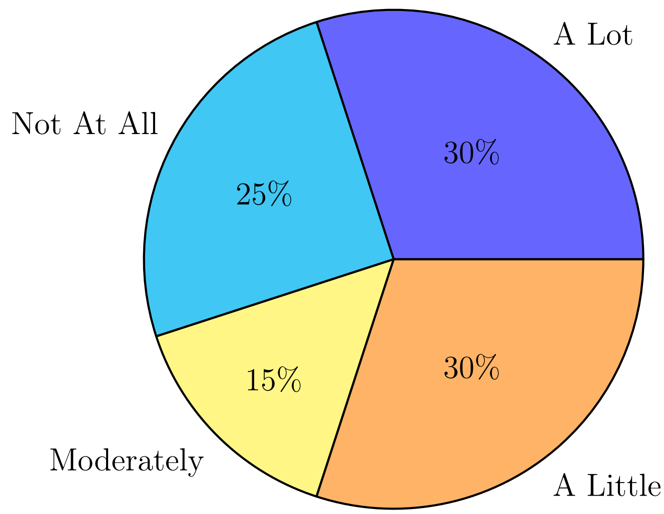
Do you feel your mental health has been negatively affected by caregiving?

Twenty one people answered this question. Six reported it has been affected a lot, six people reported it has been moderately affected, six people reported it has not been affected at all, and three people reported it has only been affected a little bit.



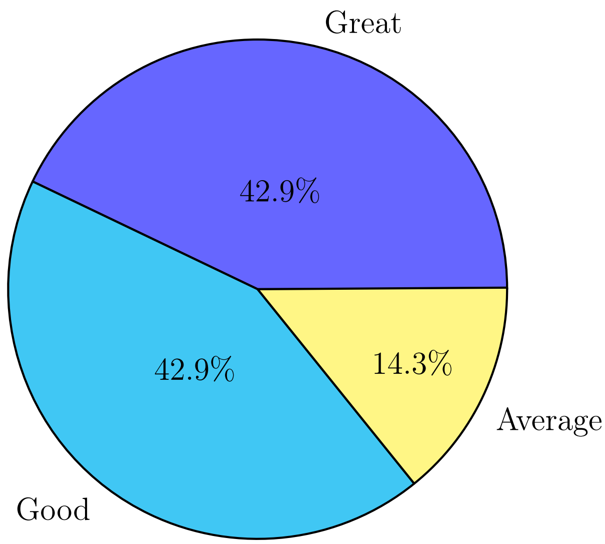
Do you feel your mental health has been positively affected by caregiving?

Twenty people answered this question. Six reported it has been affected a lot, three people reported it has been moderately affected, five people reported it has not been affected at all, and six people reported it has only been affected a little bit.



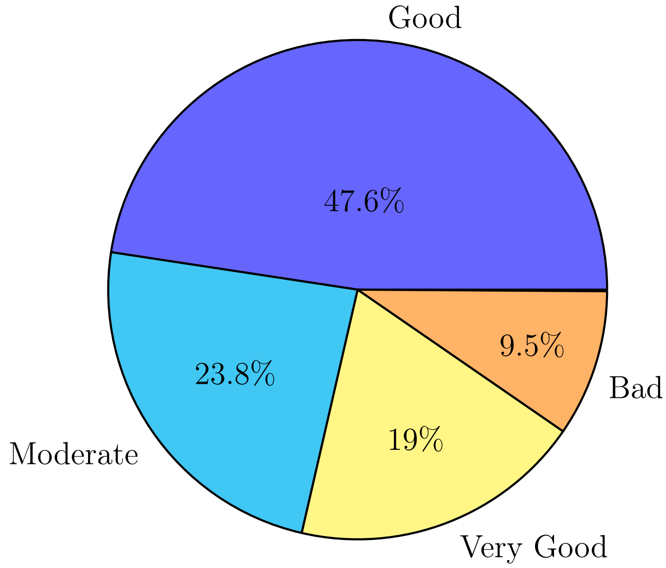
How would you rate your personal mental health before becoming a caregiver?

Twenty one people answered this question. Nine people reported it was great, nine people reported it was good, and three people reported it was average.



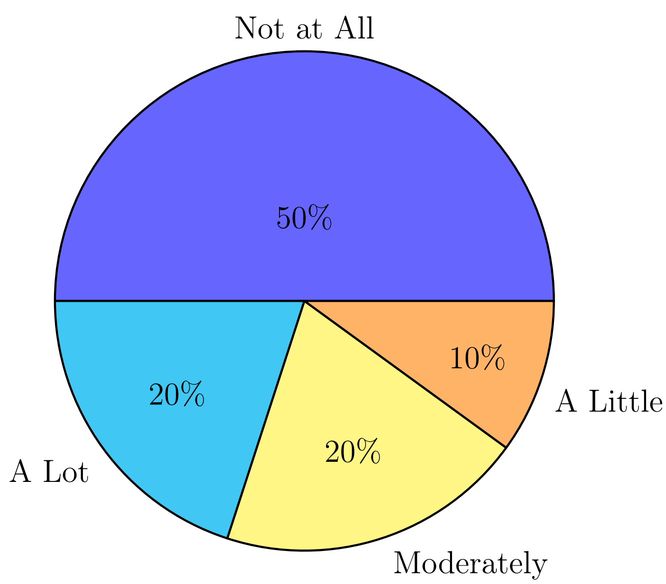
How would you rate your physical health today? Physical health promotes proper care of our bodies for optimal health and functioning. Overall physical wellness encourages the balance of physical activity, nutrition, and mental well-being to keep your body in top condition.

Twenty one people answered this question. Ten people reported it was good, five people reported it was moderate, four people reported it was very good, and two people reported it was bad.



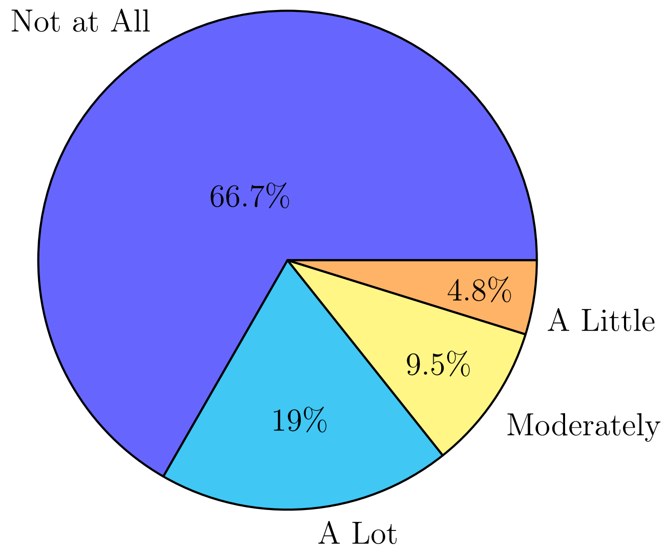
Do you feel your physical health has been negatively affected by caregiving?

Twenty people answered this question. Ten people reported it has not been affected at all, four people reported it has been affected a lot, four people reported it has been moderately affected, and two people reported it has only been affected a little.



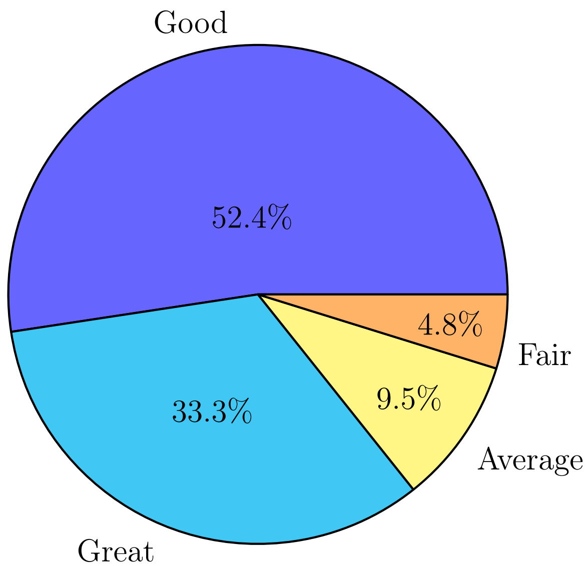
Do you feel your physical health has been positively affected by caregiving?

Twenty one people answered this question. Fourteen people reported not at all, four people reported a lot, two people reported moderately, and one person person reported only a little.



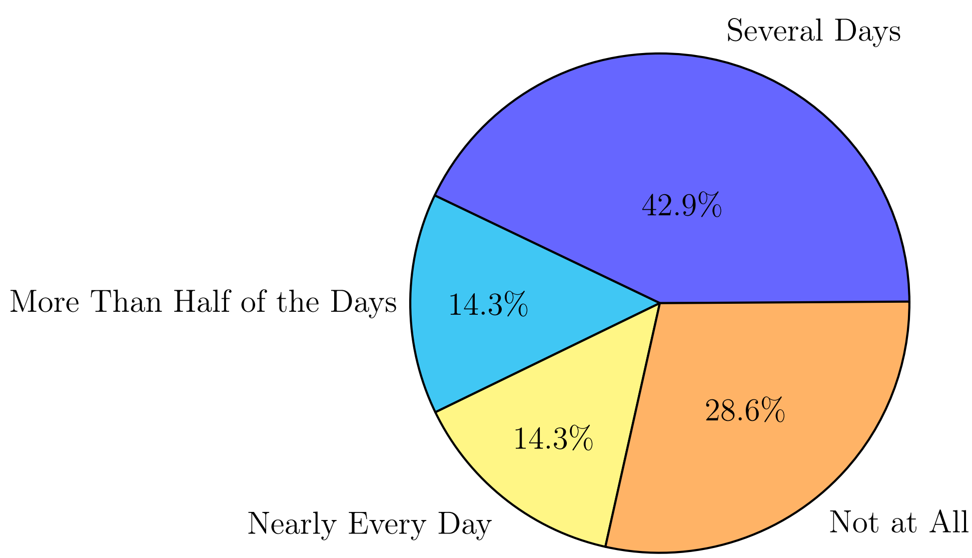
How would you rate your physical health before becoming a caregiver?

Twenty one people answered this question. Eleven people reported it was good, seven people reported it was great, two people reported it was average, and one person reported it was fair.



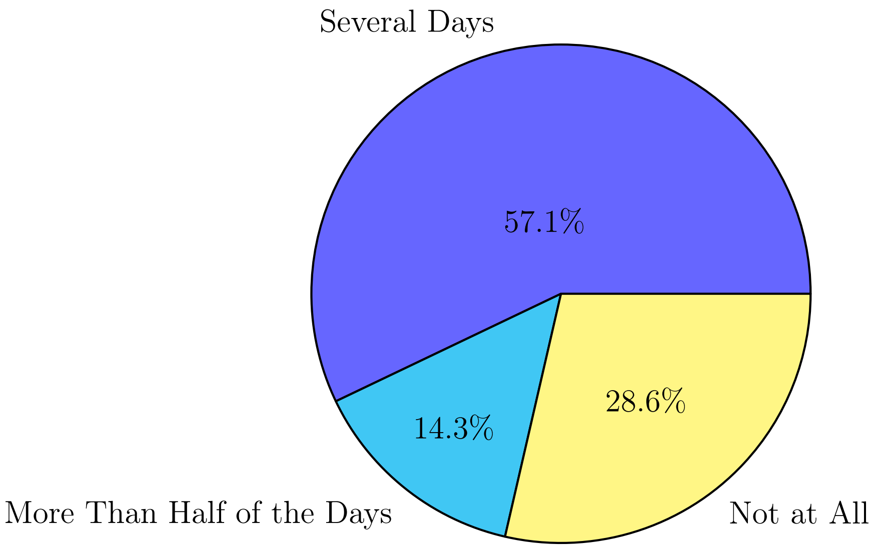
Do you have little interest or pleasure in doing things that you previously found enjoyable?

Twenty one people answered this question. Nine people reported several days, six people reported not at all, three people reported more than half of the days, and three people reported nearly every day.



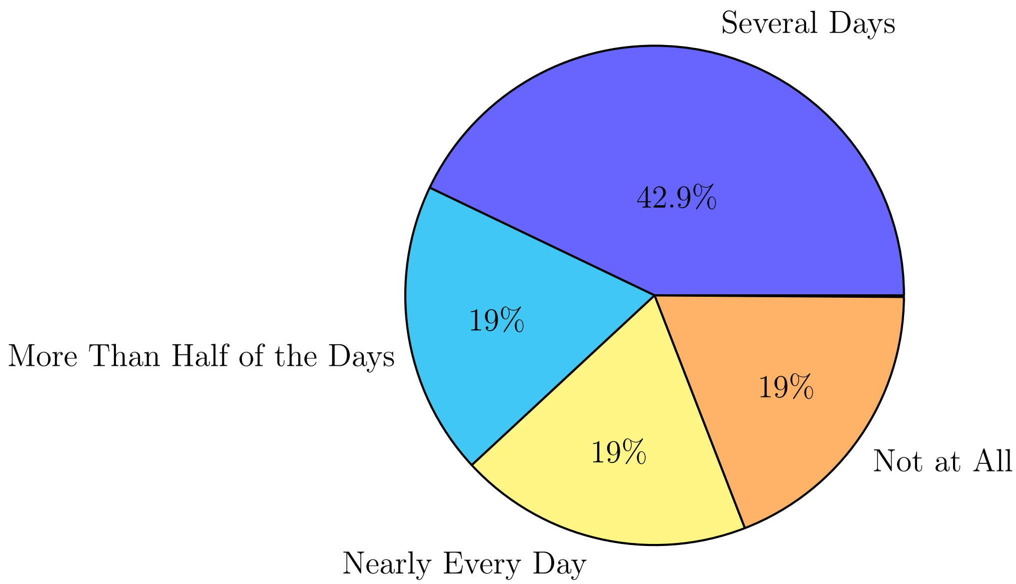
Have you been feeling down, depressed, or hopeless?

Twenty one people answered this question. Twelve people reported several days, six people reported not at all, and three people reported more than half of the days.



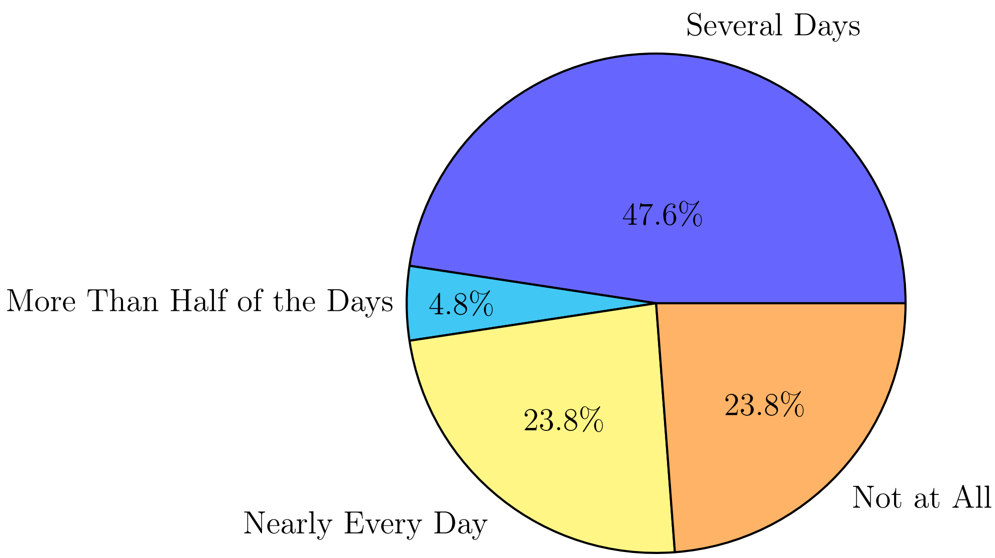
Have you experienced disruptions in your sleep routine, e.g., trouble falling asleep, trouble staying asleep, or sleeping too much?

Twenty one people answered this question. Nine people reported they had these issues several days, four people reported they do not have these issues at all, four people reported feeling these more than half of the days, and four people reported feeling them nearly every day.



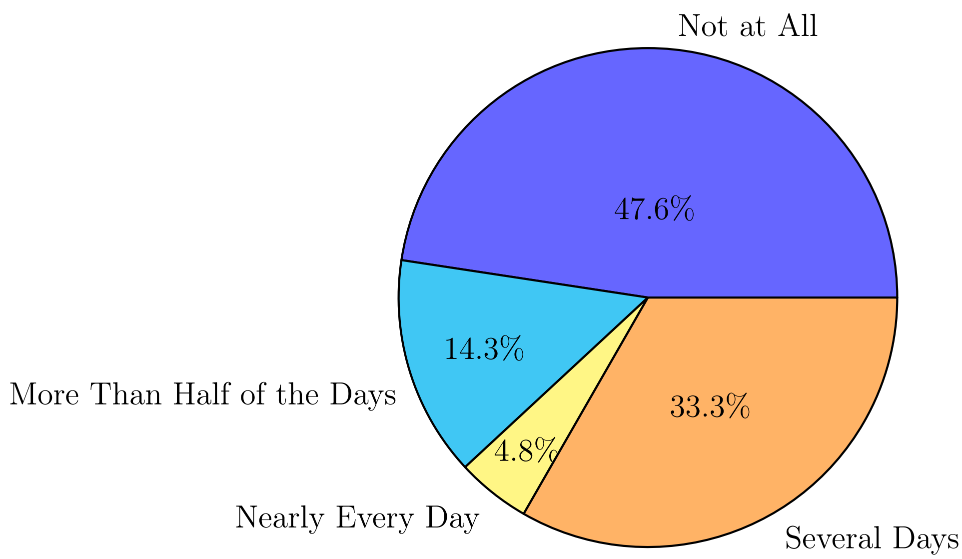
Do you feel tired and have little energy?

Twenty one people answered this question. Ten people reported several days, five people reported not at all, five people reported nearly every day, and one person reported feeling it more than half of the days.



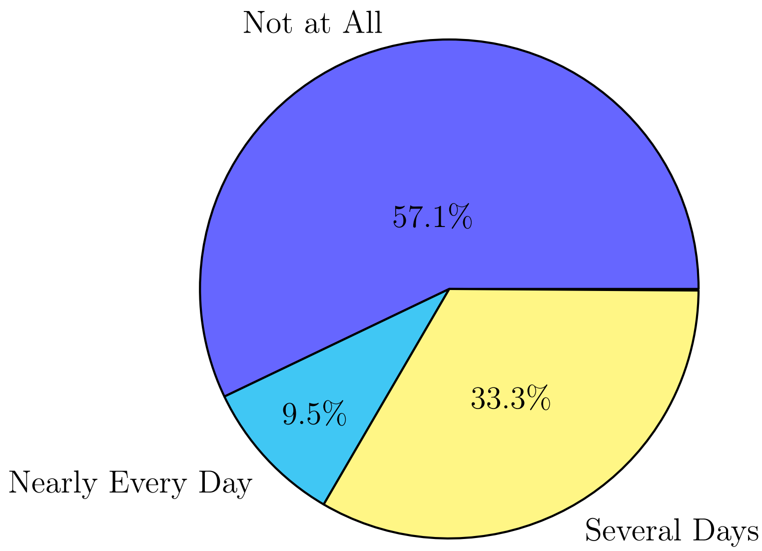
Do you have a poor appetite or find yourself overeating?

Twenty one people answered this question. Ten people reported not at all, seven people reported several days, three people reported more than half of the days, and one person reported nearly every day.



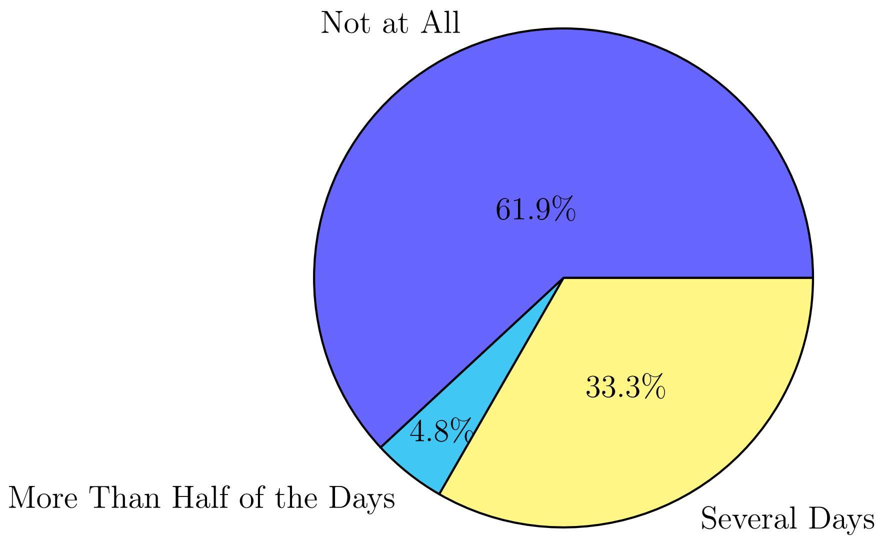
Do you have trouble concentrating on things such as reading or watching television?

Twenty one people answered this question. Twelve people reported not at all, seven people reported several days, and two people reported nearly every day.



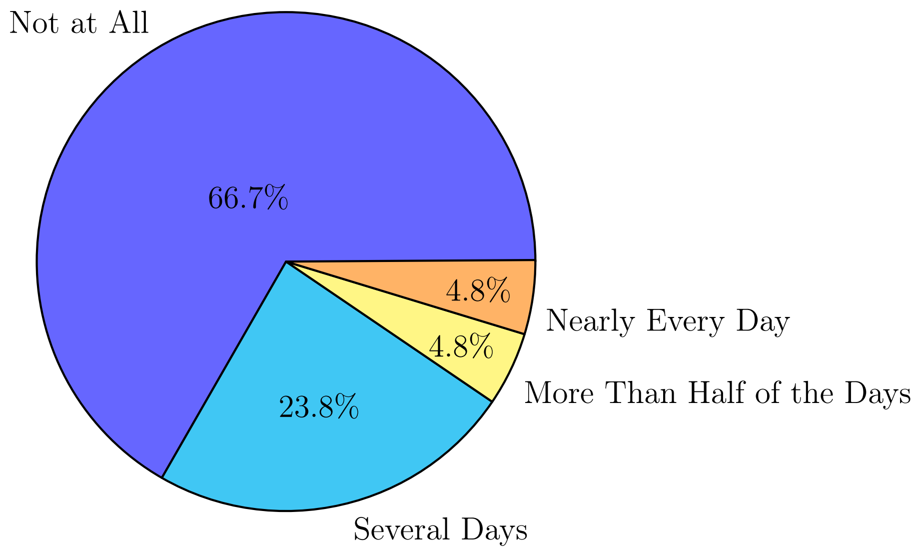
Do you feel bad about yourself – that you are a failure or have let yourself or your family down?

Twenty one people answered this question. Thirteen people reported not at all, seven people reported several days, and one person reported more than half of the days.



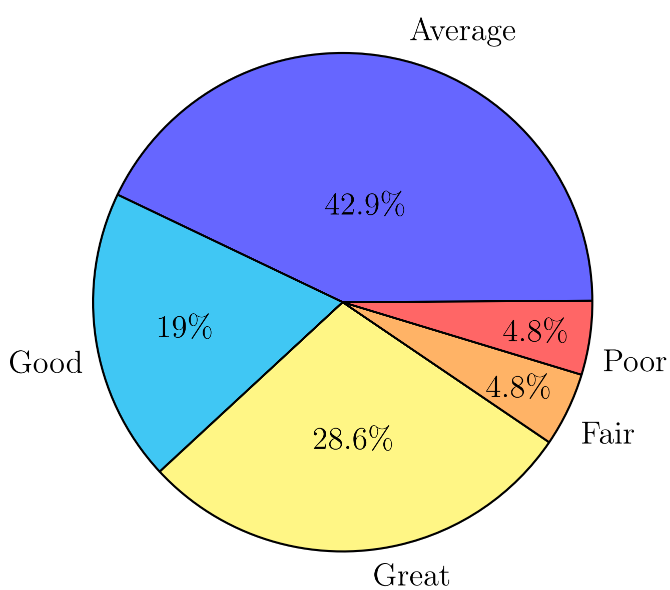
Have you been moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual?

Twenty one people answered this question. Fourteen people reported not at all, five people reported several days, one person reported more than half of the days, and one person reported nearly every day.



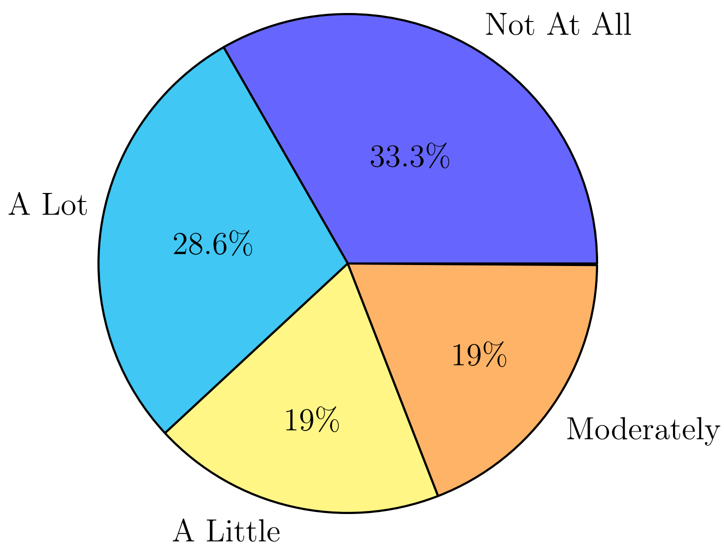
How would you rate your quality of sleep before becoming a caregiver?

Twenty one people answered this question. Nine people reported average, six people reported great, four people reported good, one person reported fair, and one person reported poor.



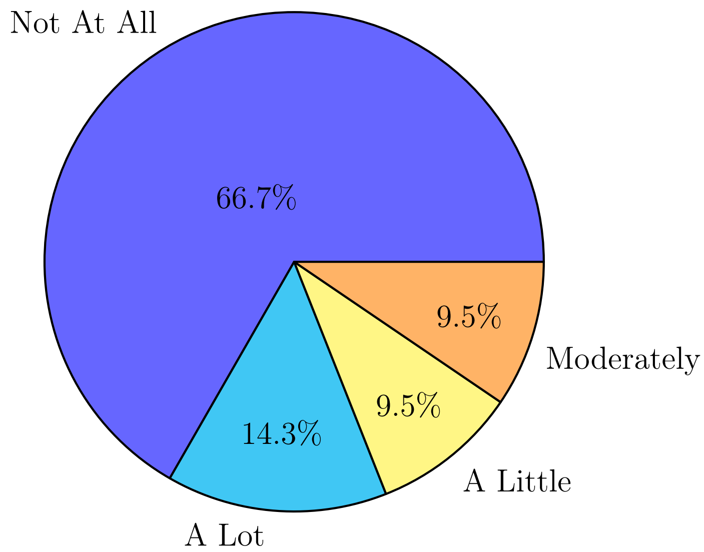
Do you feel it has been negatively affected by caregiving?

Twenty one people answered this question. Seven people reported not at all, six people reported a lot, four people reported moderately, and four people reported a little.



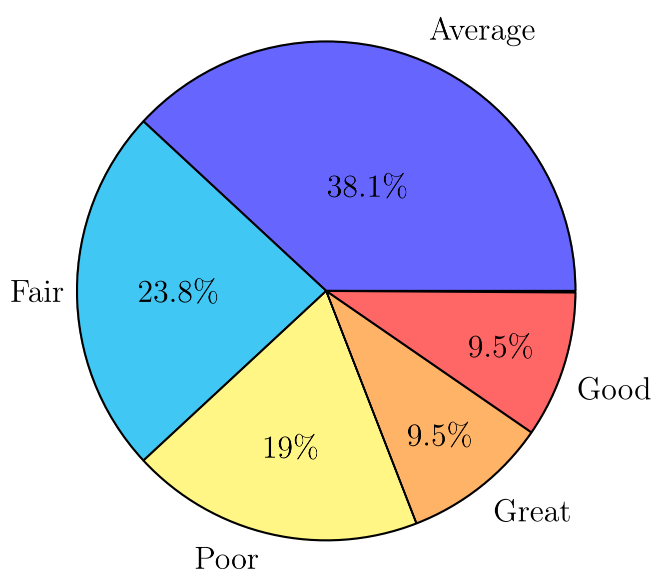
Do you feel it has been positively affected by caregiving?

Twenty one people answered this question. Fourteen people reported not at all, three people reported a lot, two people reported moderately, and two people reported a little.



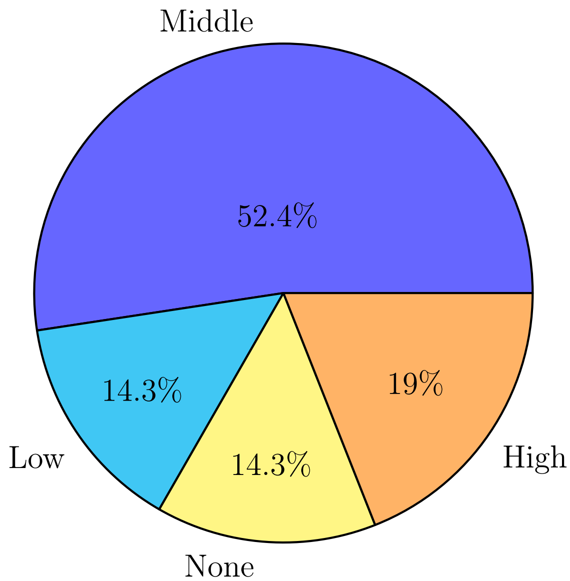
How would you rate your quality of sleep today?

Twenty one people answered this question. Eight people reported average, five people reported fair, four people reported poor, two people reported great, and two people reported good.



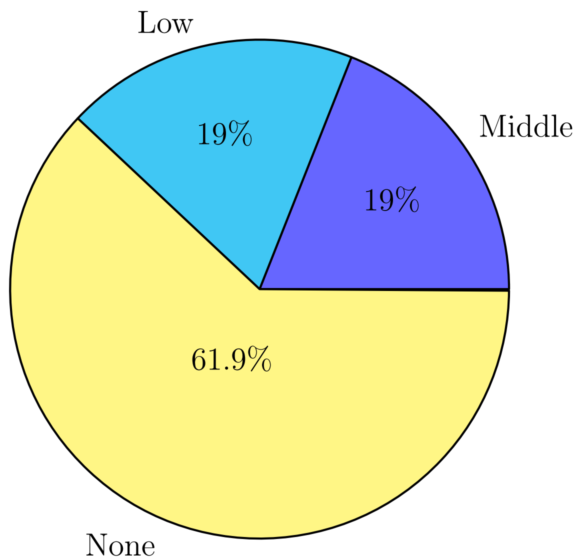
What level of stress do you feel from caregiving?

Twenty one people answered this question. Eleven people reported middle levels of stress, four people reported high levels of stress, three people reported low levels of stress, and three people reported no stress.



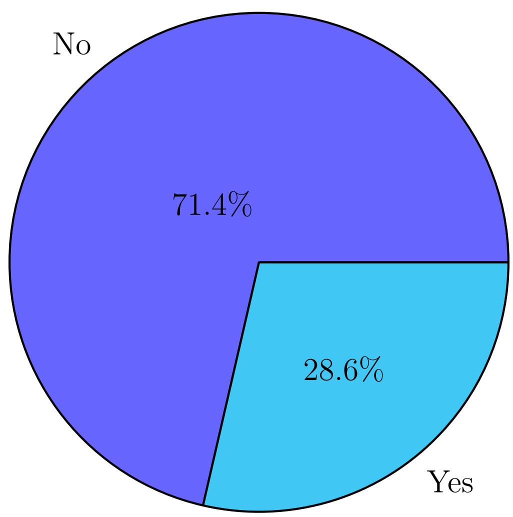
What level of physical pain do you feel from caregiving?

Twenty one people answered this question. Thirteen people reported none, four people reported middle levels, and four people reported low levels.



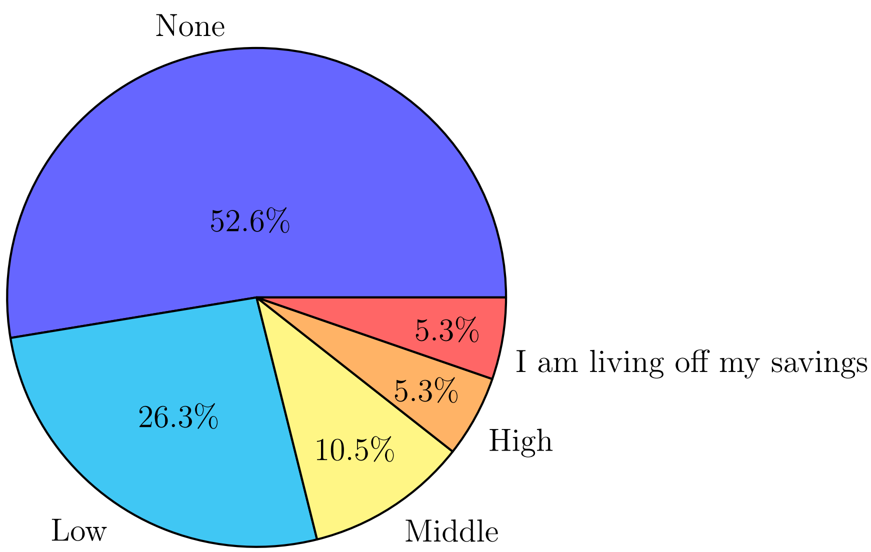
Do you feel you have financial struggles from caregiving?

Twenty one people answered this question. Fifteen people reported no and six reported yes.



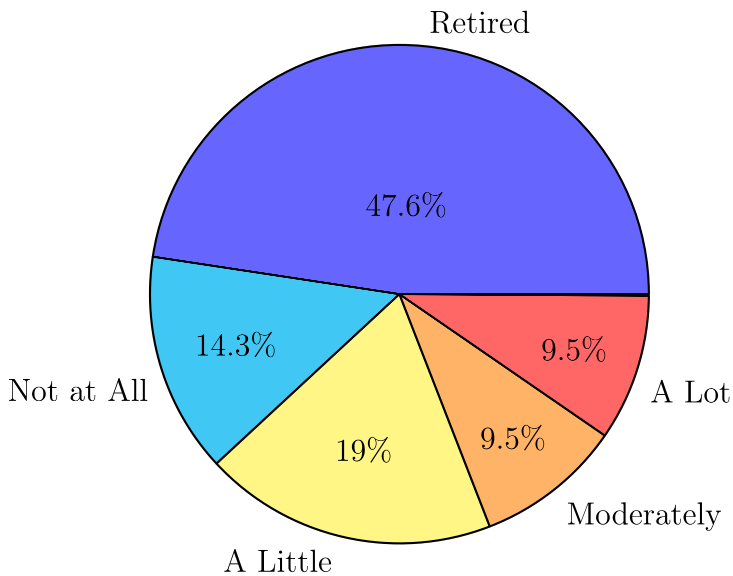
What level of financial struggle are you experiencing?

Nineteen people answered this question. Ten people reported none, five people reported low levels, two people reported middle levels, one person reported high, and one person reported living off their retirement savings due to caregiving.



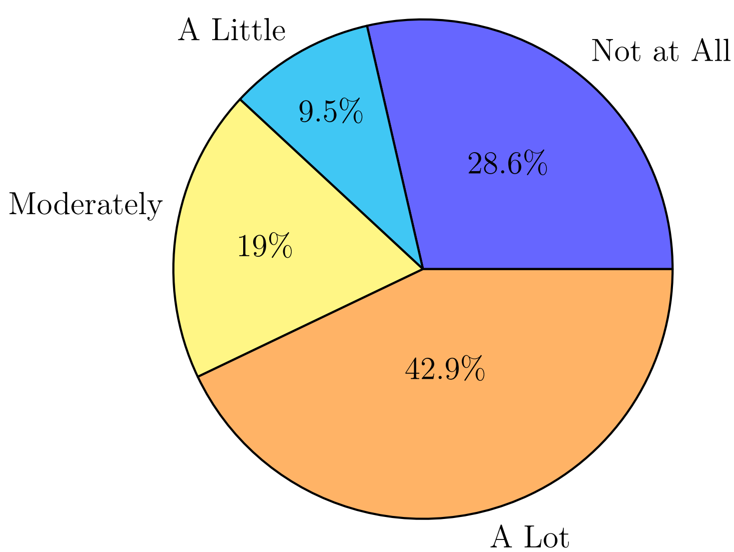
Do you feel your work performance has suffered as a result of your caregiving?

Twenty one people answered this question. Ten people reported they are retired, four people reported a little, three people reported not at all, two people reported a lot, and two reported moderately.



Do you feel the COVID-19 Pandemic has made any of the above symptoms worst for you?

Twenty one people answered this question. Nine people reported a lot worst, six people reported not at all, four people reported moderately, and two people reported a little.



If COVID-19 affected any of the above symptoms negatively, would you please tell us which ones got worse along with how and why?

These are the following responses:

- "My stress has increased because I have to keep taking the person I am catering to to the hospital and I am scared they will contact COVID in the hospital and make things worse. So I feel anxious every time we have to visit the hospital"
- "Pleasure in doing things. With everything closed or because of the fear mongering I don't want to go or do anything"
- "I just hugged my dad for the first time last week in over a year. The stress of not seeing him has been horrible. And the hardest thing with this pandemic is not being able to plan anything. Having to take life one day at a time not knowing what next week will bring. My anxiety has been ten fold this last year."
- "The constant isolation makes the days boring as heck for 'pop', & myself."
- "You can't trust people to be taking precautions. Which means you have less community and family to call lawn for help and support. You're more on your own... I am on my own, those I am caring for our afraid to ask for help from others. "
- "Stress more at the beginning when it was difficult to get supplies. Also it has been a continual battle with the woman who takes care of my mom's cats five days a week and shops once a week to get her to remember to mask up"
- "Overeating, tired, lack of interest in things that used to excite me. Lack of social contact is the worst problem. My husband who has Parkinson's disease is unable to carry on a conversation unless it is about something that happened in the past, so I feel very lonely at home a lot of the time."

- “Due to COVID-19, there has been limited in-person interaction which has impacts on physical and mental health for both caregiver and care-receiver.”
- “Stress levels increased because I was not allowed to see my mother, or to help her, or talk with her. She became lost and on the few occasions I was able to see her, she only responded to my voice.”
- “Well, I can’t go see stepmom at carehome”
- “ Sleep has been restless and short. Overeating has been common. Social isolation increased. Frustration with other family members not helping out increased. Physical fitness reduced due to little chance to go to the gym.”
- “Mental stress and sleep from worry, not being able to visit carer (parent), not being able to screen living places for carer, stress from carer having positive COVID diagnosis and going into hospital 4 times during COVID”
- “COVID made worse getting caregiver help and visits from friends /family. Made isolation feelings very bad. If I could afford a caregiver so I can work/ there was no jobs available.”

Were there any that got better due to COVID-19? Would you please tell us why and how?

These are the following responses:

- “One good thing is the treatment is completely at home. We have to visit the hospital once or twice in two weeks for test unlike others that have to visit the hospital everyday or get admitted for the same condition”
- “Stress of caregiving, kids were able to go back to school”
- “The extra money from government has helped”

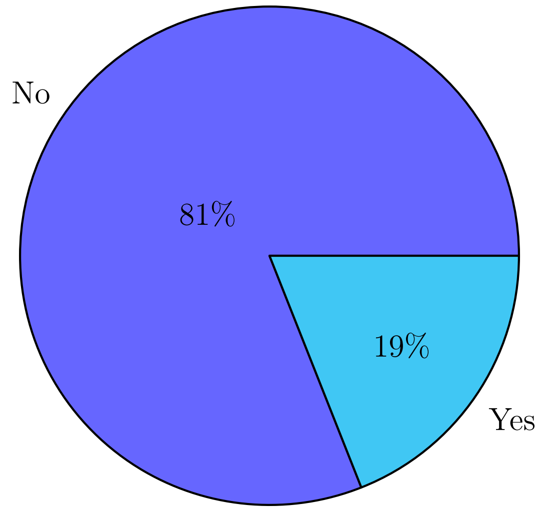
- "The expectation to work remote makes it easier to be remote and the caregiving while working. I wind up working a lot at night after they've gone to bed, which hasn't been great for sleeping. I sleep OK once I go to sleep, but I kind of have to force myself to stop doing other things... Like this survey I'm doing at midnight"
- "Not as much stress regarding dividing time between helping mom and social events since I have not socialized except over Zoom in about a year, except to see my mom and chat with the paid caregivers and visit with visitors. Before COVID, i had to cancel my social events to help mom."
- "I got understand other aspects of my care-receivers due to restrictions of COVID-19 which I believe I could not have found out otherwise. That knowledge help me to sort out better ways to care for them."
- "I became gradually more confident that I could be a competent caregiver."
- "I actually got a break from caregiving because I wasn't allowed to do in person visits"

2.7.3 Questions About the Person you provide Care for

Questions relating to the person they provide caregiving services.

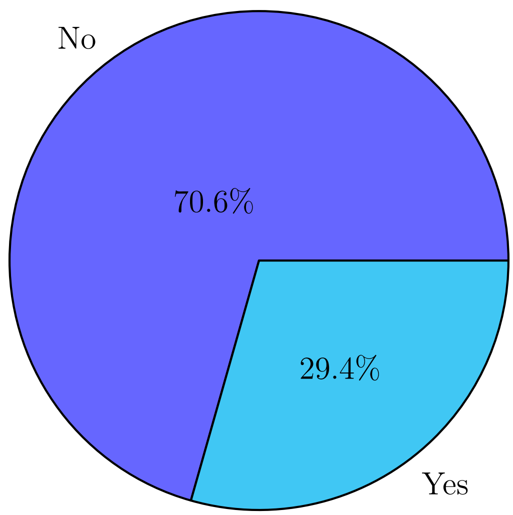
Does your loved one live in a care facility?

Twenty one people answered this question. Seventeen reported no and four people reported yes.



Did they move into your home before the care facility?

Seventeen people answered this question. Twelve reported no and five people reported yes.



How long did they live on their own once they began needing help before moving into a care facility?

The following are the responses:

- 70 Years
- 3 Years
- 3 Months
- 83 Years -18 my grandmother lived independently. Then she fell and lived in a care facility which was terrible for her. I supported the decision to bring her home. She has only been at home for a week so far and I have been staying with her and my grandfather.
- My husband and I have lived together since we got married about 10 years ago. We moved to a new house about 2 and half years ago where is 2 blocks away from my mother in law's house. I care for both of them.
- 10 Months
- Never, we are married.
- 80+ Years
- We have been married 49 years.
- 13 Months

How long have they been living in the care facility?

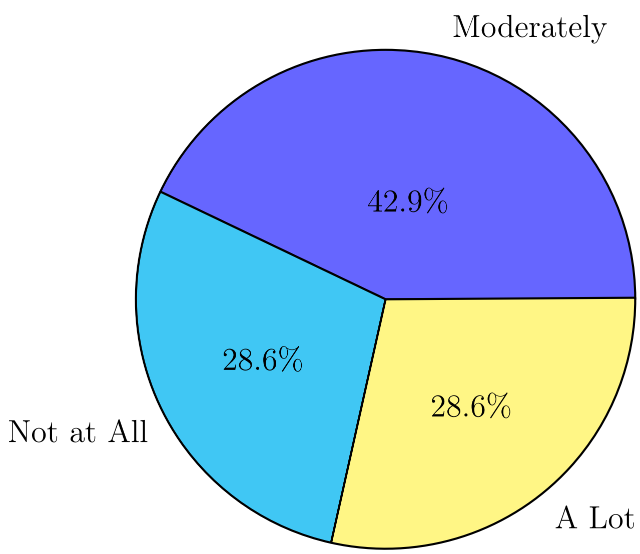
The following are the responses:

- 3 Years
- We are about to make the transition from home to nursing facility

- She lived in a care facility for a month and a half and it was going very badly.
- 17 Months
- 5-10 Years
- 4 Years

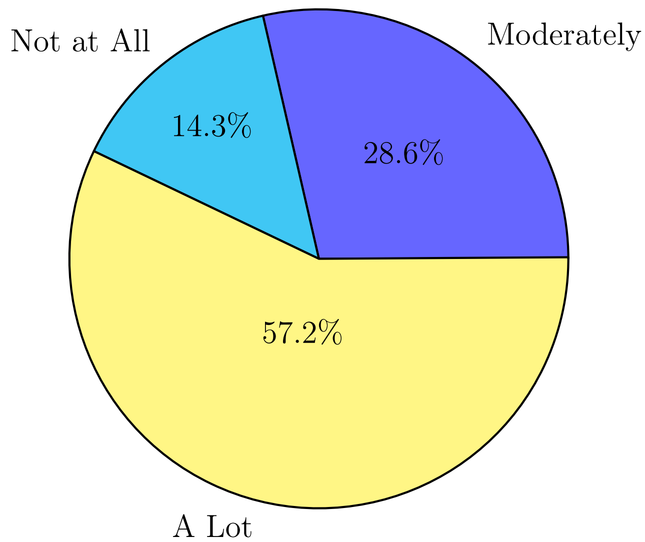
Is your loved one happy in the care facility?

Seven people answered this question. Three reported moderately, two reported a lot, and two reported not at all.



Is your loved one comfortable in the care facility?

Seven people answered this question. Four people reported a lot, two people moderately, and one person reported not at all.

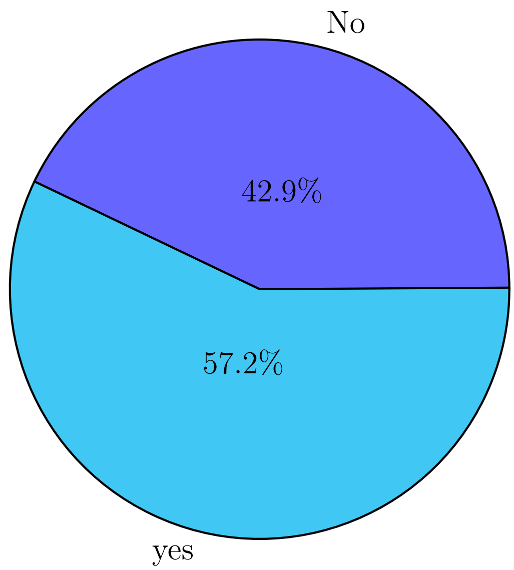


2.7.4 Living In Home

Questions about if the person they care for lives with them.

Does your loved one live with you currently?

Twenty one people answered this question. Twelve people reported yes and nine people reported no.



If they live with you, how long have they been living with you?

These are the following responses:

- 27 Years
- 22 Years, 19 Years, 7 Years 5 Years
- 5 Years
- I am staying with her, at her home as it is better suited to her needs
- Our entire married life, which is 22 years.
- My husband and I have lived together since we got married about 10 years ago. We moved to a new house about 2 and half years ago where is 2 blocks away from my mother in law's house. I care for both of them.
- 63 Years
- 47 Years
- 49 Years

- 4+ Years.
- Always from our marriage.
- 48 Years

Why did you choose to move them in with you instead of a care facility?

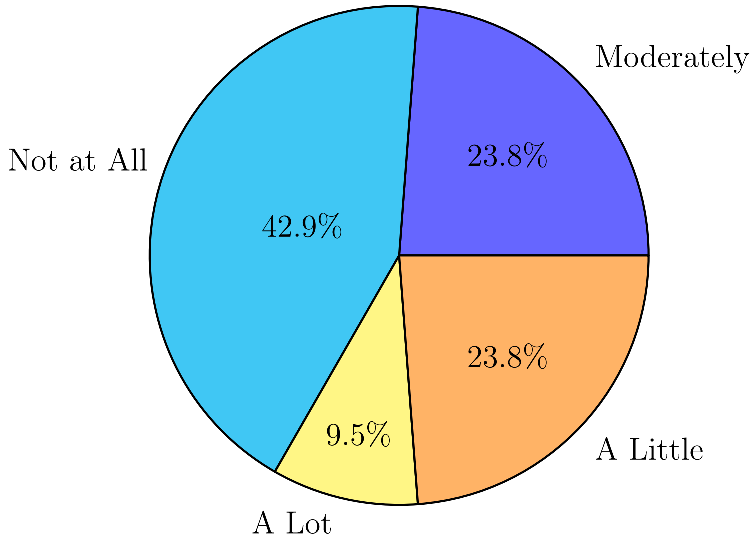
Ten people answered this question. Four people reported it was because they could provide better care than the facility could. Four people reported they already lived together from their marriage or partnership and having the person already live there. One person they were not informed clearly on how to access care facilities with financial resources. One person said their mother was not ready for a nursing home when they made the decision.

2.7.5 Additional Questions

Additional questions for caregivers.

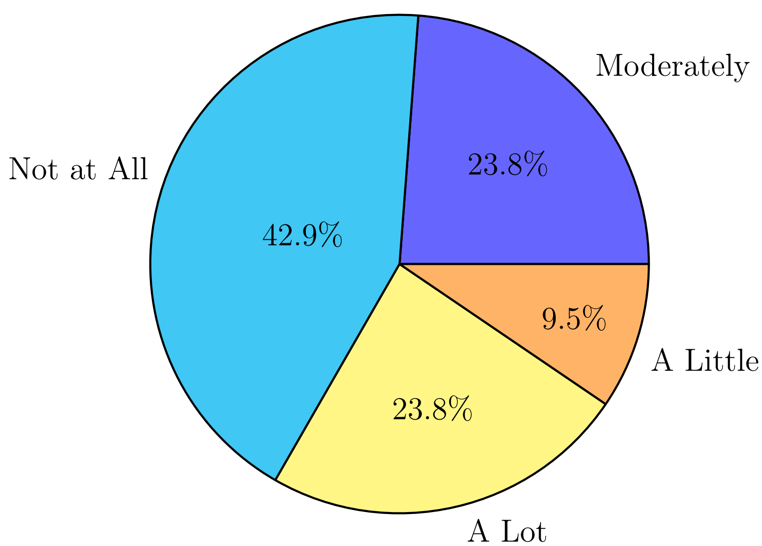
Do you feel your loved one suffers from isolation which is defined as not seeing or speaking with anyone for 1 week?

Twenty one people answered this question. Nine people reported not at all, five reported moderately, five people reported a little, and two people reported a lot.



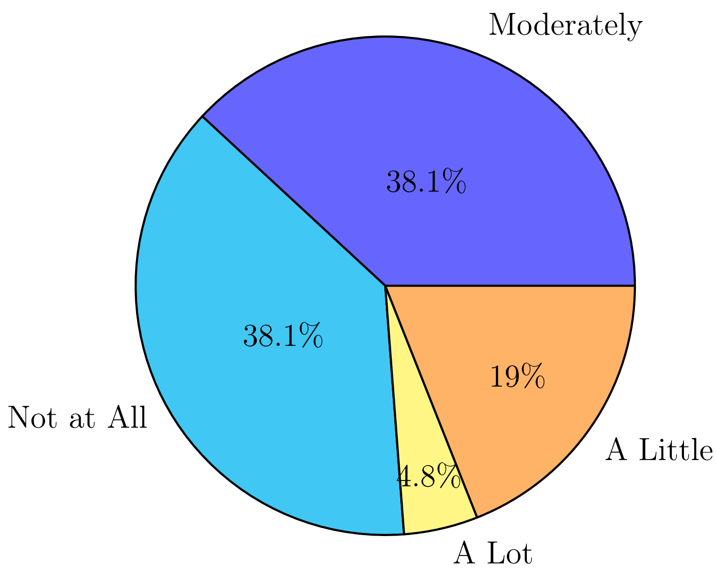
Do you feel your loved one experiences loneliness?

Twenty one people answered this question. Nine people reported not at all, five reported moderately, five people reported a little, and two people reported a lot.



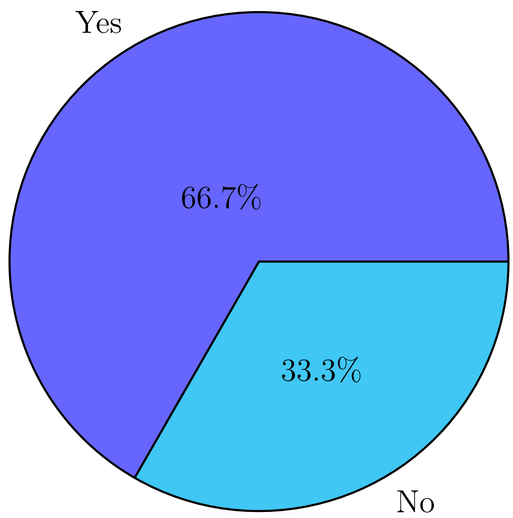
Do you feel your loved one suffers from depression?

Twenty one people answered this question. Eight people reported moderately, eight people reported not at all, four people reported very little, and one person reported a lot.



Do you think technology would assist you with your caregiving?

Twenty one people answered this question. Fourteen reported yes and seven reported no.



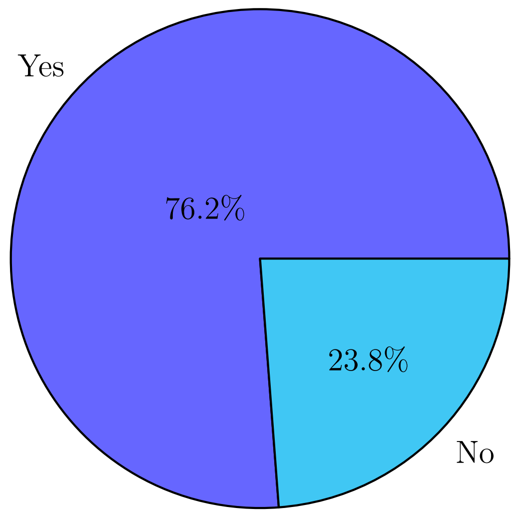
If yes, what do you wish it did?

These were the responses:

- Relieved my mental stress [11]
- Helped with physical activities [8]
- Watched my loved one (so you could wash dishes, go to the store, etc.) [9]
- Detect sleeping patterns [5]
- Relieve their mental stress [9]
- Address my isolation [5]
- Address their isolation [7]
- Address my depression [6]
- Address their depression [5]
- *Written in* Helped maintain activities of daily living [1]
- *Written in* Monitor remotely [1]
- *Written in* Cure [1]

Do you think technology could assist your loved one?

Twenty one people answered this question. Sixteen reported yes and five reported no.



How do you feel technology could assist your loved one? (Check all that apply)

These are the following responses:

- Social Skills (conversation) [11]
- Physical assistance (getting dressed) [4]
- Cognitive Skills (puzzles) [9]
- Just for fun (music) [10]
- Exercise (walking, physical therapy, etc) [8]
- Reminiscing [7]
- *Written in* Logistics, note taking, and reminders... My grandmothers arthritis is so bad that she can't take notes. When she makes calls and gets information her hand can't move to write it down. She does very well with Siri for text

messages. Also, presenting her schedule and information the changes frequently like her visiting nurses. She forgets accurate information in the short term [1]

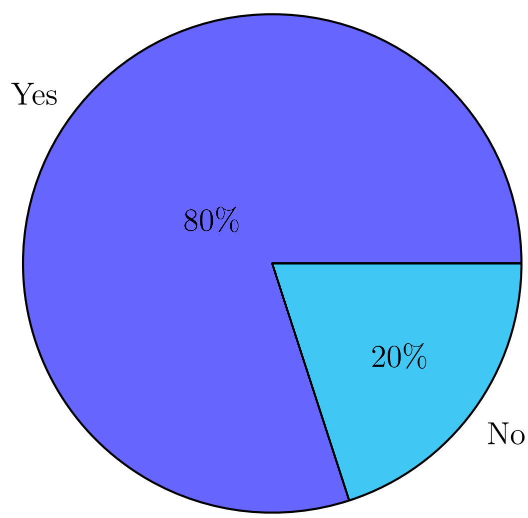
- *Written In* Visiting remotely; having adjustable volume for hard-of-hearing [1]

If you were to invest in technology to assist with caregiving, how much would you be willing to spend if money was not a factor?? (this does not include if you are able to do so)?

Nineteen people answered this question. Six reported they would spend $\$0 - \$500$, five reported $\$1,500 - \$2,000$, three reported $\$500 - \$1,000$, two reported $\$1,000 - \$1,500$, two people reported a substantial amount of money, and one person reported their insurance would influence what they purchased.

Are you able to spend as much money you indicated in the question above? (This is the amount you could afford to spend)

Twenty people answered this question. Sixteen reported yes and four reported no.



If no, how much would you budget?

Only six people answered this question. Two people reported $100, someone said it would depend on the features because they may spend more, one person said none at the moment, another said under $500, and one person said they could afford a few thousand but it would be required to move the needle and provide enough value.

Is there anything else you would like to tell us that we did not ask you?

These are the following responses:

- "I'm on a Facebook group of caregivers for Parkinson's disease, and most of them are going through hell. Examples: PWP (person with Parkinson's) urinates all over the bathroom including walls, and will not sit down to urinate. PWP loses temper and throws objects at caregiver. PWP needs constant 24/7 care, caregiver cannot afford a care facility, and caregiver is burned out, depressed, and at their wits' end. I'm not sure technology is the best answer for most of these problems. Qualified care assistance, respite care so caregiver can get away and sleep, are the best solutions."
- "We really do not know what to expect but have open mind and be hopeful that technology will help us out."
- "I am separated by distance from my mother"
- "The pandemic has made caregiving even more isolating."
- "My care receivers smile and conversations are priceless
- "Her mental and physical health is terrible. My grandfather's mental health is seriously deteriorating being separated from her, and not being able to see

her because of COVID. COVID made the care facility absolutely impossible, unlivable. My grandparents are not lonely because they have each other right now. My grandmother could've died of loneliness in the care facility. My grandparents do much better together, but they definitely need help."

- "My mom has an iPad and we Zoom doctor appointments, lectures, book clubs, and friends. However, my mother, for whatever reason, can't grasp how to use it without my help. She can read her email, but deletes it and doesn't answer it, which makes for trying times when a link is needed for an appointment. My mother lives in her own home with 24/7 paid caregiving. I do not get paid."

2.7.6 Demographics

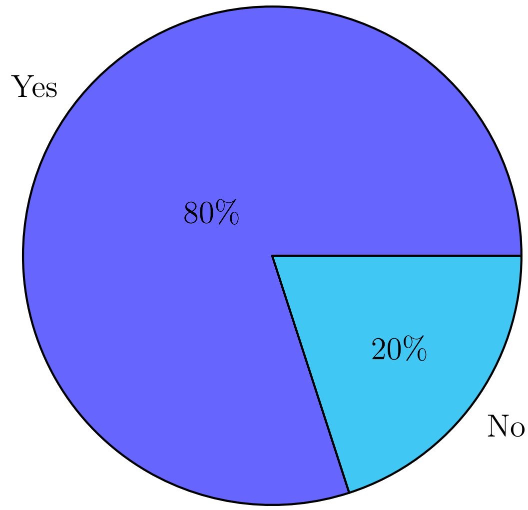
Questions about demographics of the person filling out the survey.

What is your age?

One person is 26. Two people were 37. One person is 46. One person is 49. One person is 54. One person is 56. One person is 57. One person is 58. One person is 59. One person is 62. Two people are 64. One person is 67. One person is 69. One person is 72. One person is 74. One person is 77. One person is 78. One person is 85.

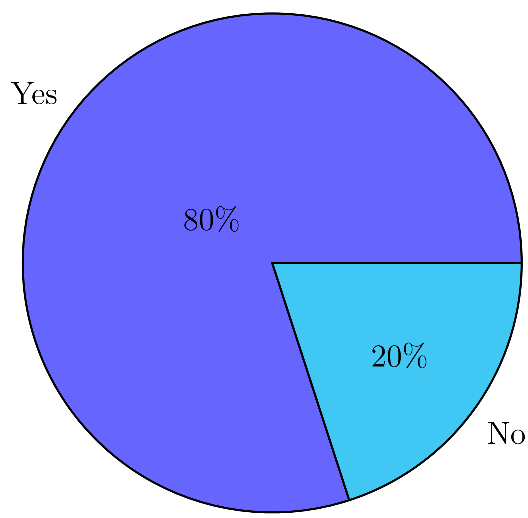
What is your annual household income?

Ten people reported $\$50,000 - \$100,000$, six reported less than $\$50,000$, two reported $\$150,000 - \$200,000$.



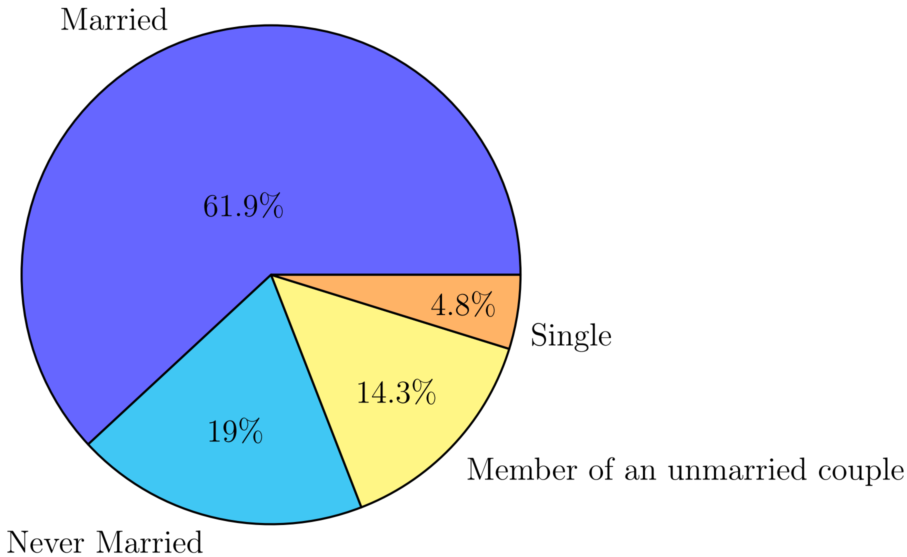
What is your education level?

Eleven people reported holding Master's Degrees, three people reporting holding Bachelor's Degrees, two people reported holding Associates Degrees, one person reported holding a High School Diploma, one person reported holding a GED, two people reported some college, and one person with some post-graduate work.



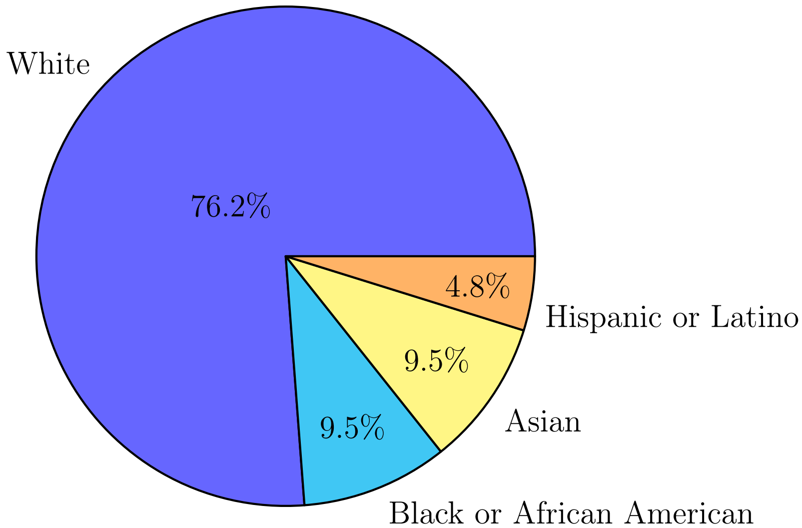
What is your marital status?

Thirteen people reported being married, four people never married, three people being a member of an unmarried couple, and one person is single.



What is your race?

Sixteen people reported themselves as white, two people as black or African American, one person Asian, and one person Hispanic or Latino.



2.8 Older Adult Survey

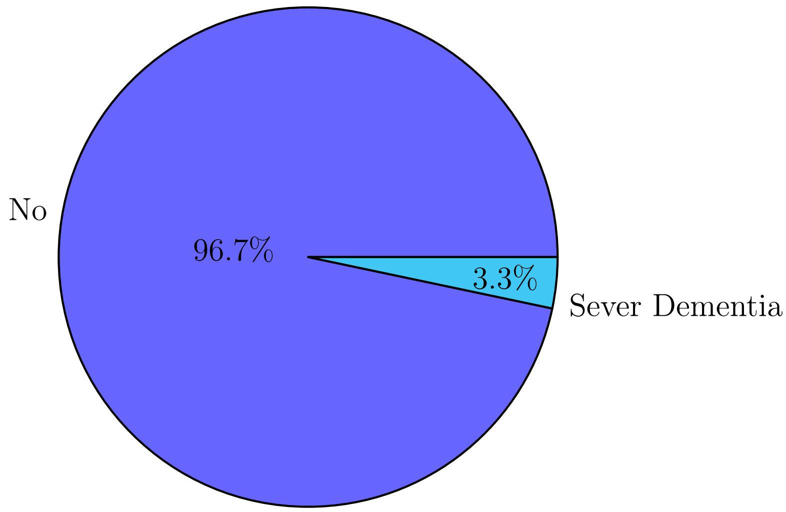
There were thirty participants who took this survey. Fourteen participants were recruited through our online presence at the Alzheimer's Association, Memory Cafes, Waymark Gardens, or Sun Health Communities. The remaining sixteen participants were involved in the 2x2 user study discussed in Chapter Four. The full survey can be seen in APPENDIX B.

2.8.1 General Questions

This survey aims to gain a deeper insight into the lives of older adults and their challenges.

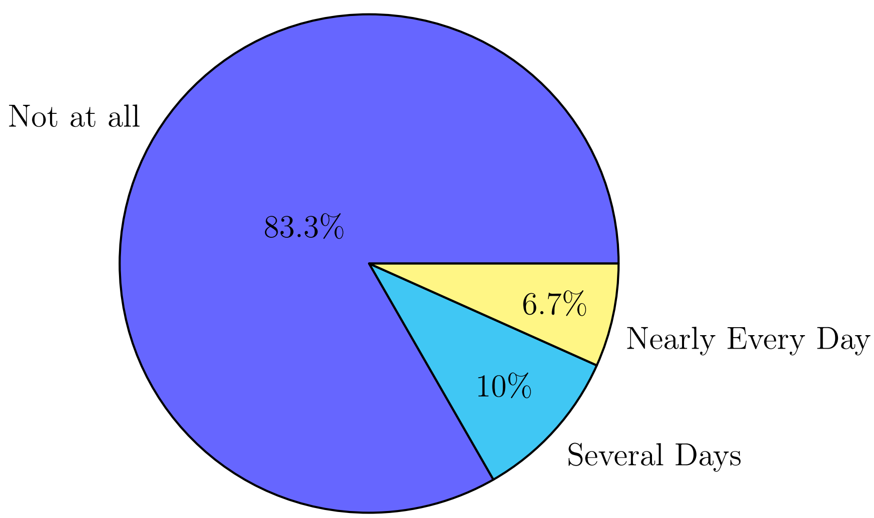
Are you living with dementia?

Thirty people answered this question. Twenty-nine people said no. One person said yes and reported it was sever.



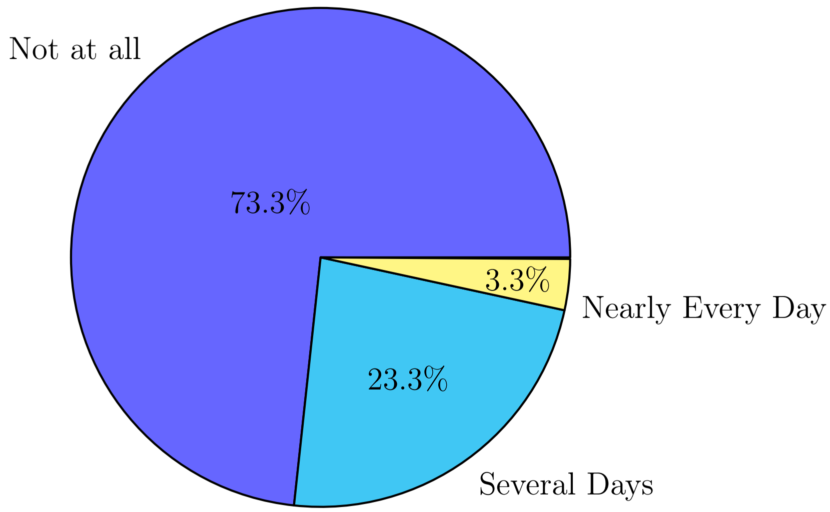
Do you have little interest or pleasure in doing things?

Thirty people answered this question. Twenty-five people reported not at all, three people reported several days, and two reported nearly every day.



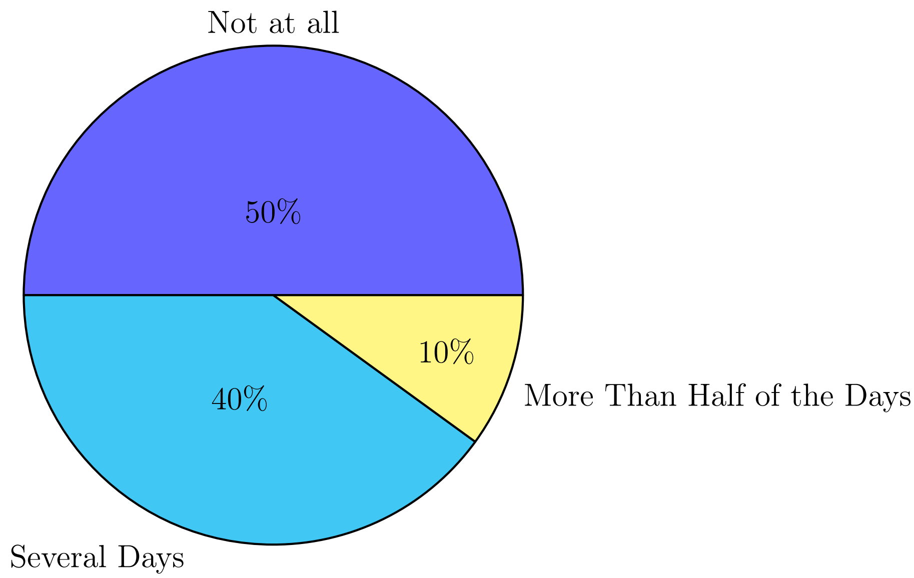
Have you been feeling down, depressed, or hopeless?

Thirty people answered this question. Twenty-two reported not at all, seven reported several days, and one reported nearly every day.



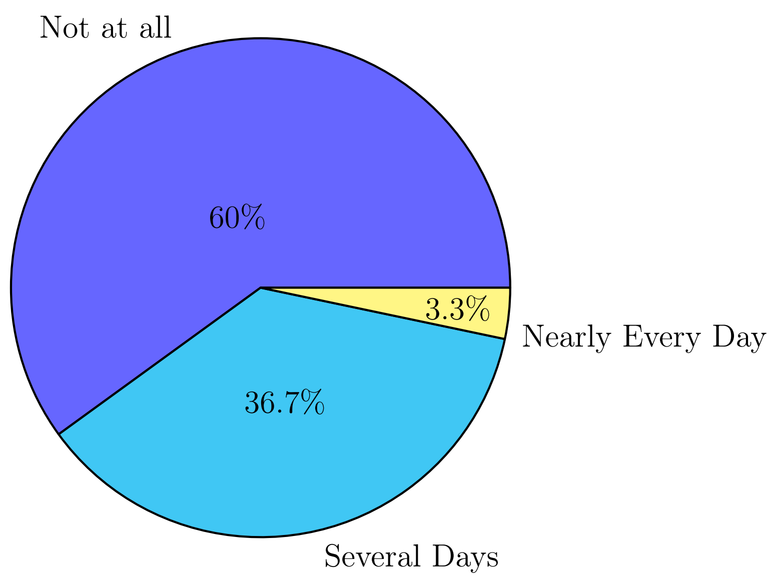
Have you experienced disruptions in your sleep routine, e.g., trouble falling asleep, trouble staying asleep, or sleeping too much?

Thirty people answered this question. Fifteen people reported not at all, twelve reported several days, and three reported more than half of the days.



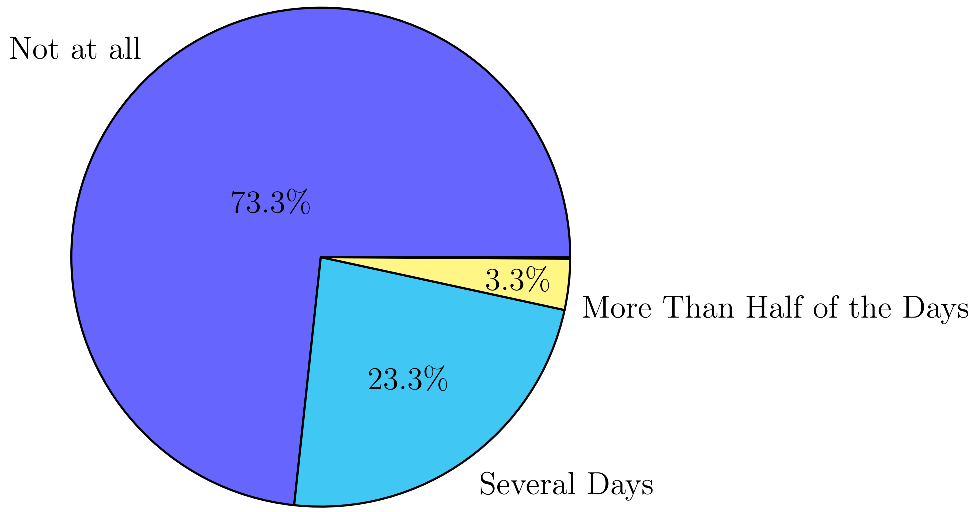
Do you feel tired and have little energy?

Thirty people answered this question. Eighteen reported not at all, eleven reported several days, and one reported nearly every day.



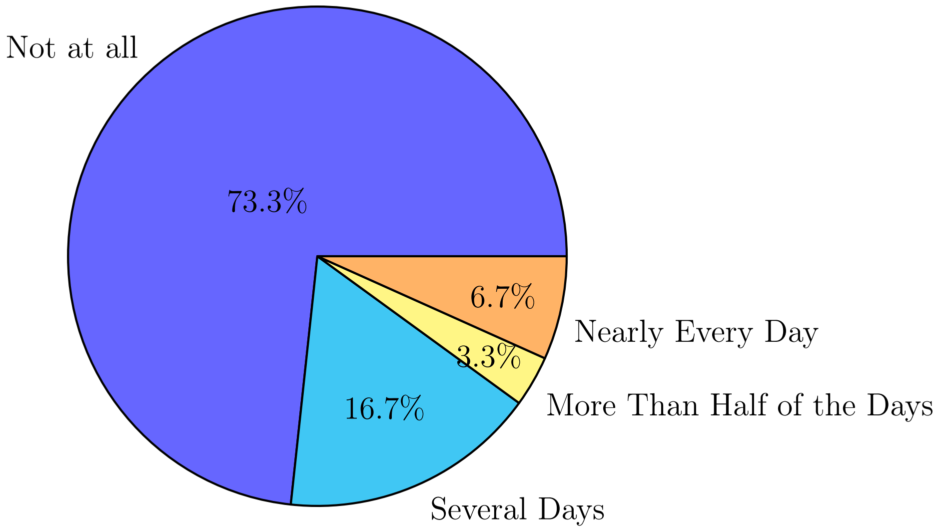
Do you have a poor appetite or find yourself overeating?

Thirty people answered this question. Twenty-two reported not at all, seven reported several days, and one reported more than half of the days.



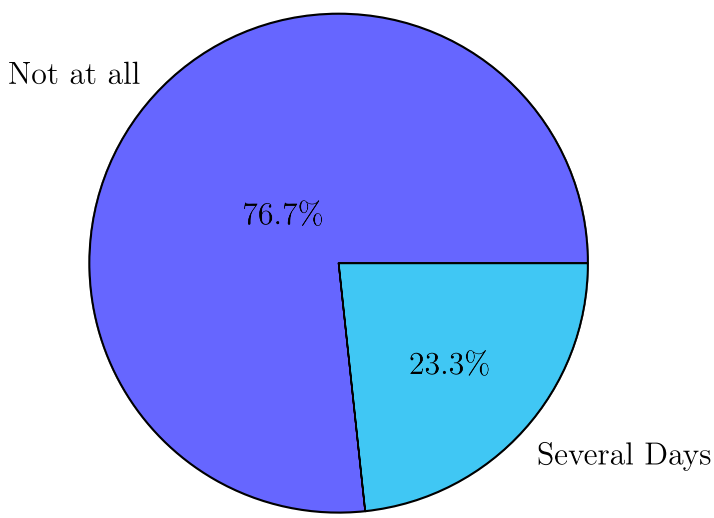
Do you have trouble concentrating on things such as reading or watching television?

Thirty people answered this question. Twenty-two reported not at all, five reported several days, two reported nearly every day, and one reported more than half of the days.



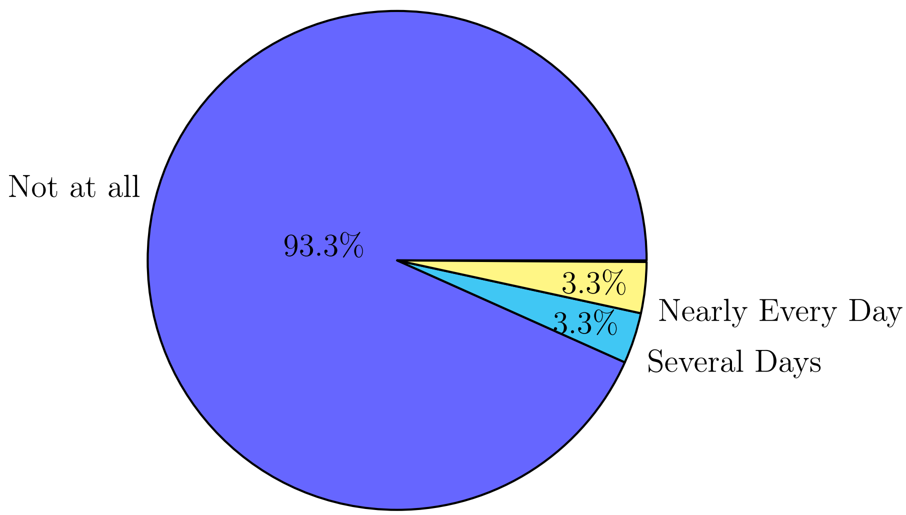
Do you feel bad about yourself – that you are a failure or have let yourself or your family down?

Thirty people answered this question. Twenty-three reported not at all and seven reported several days.



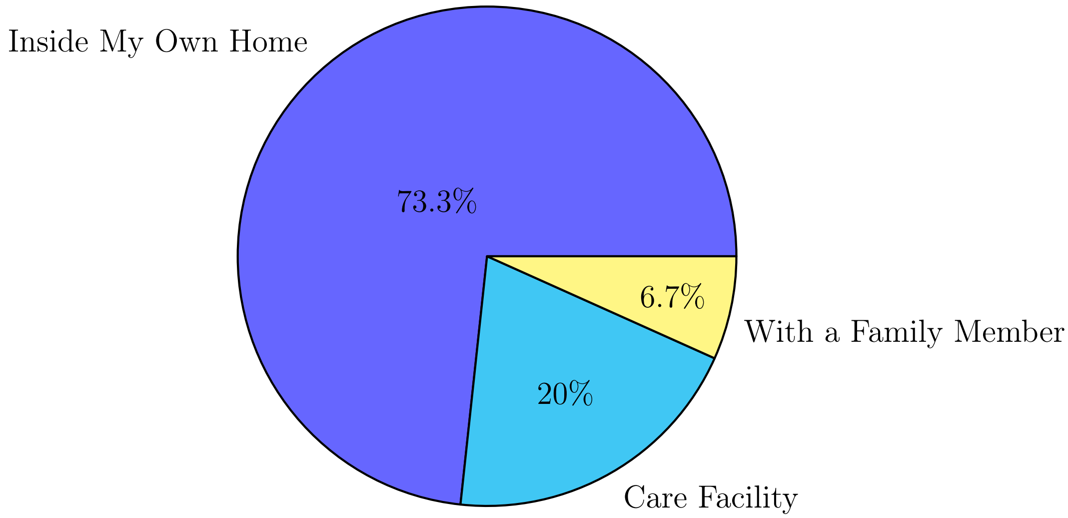
Have you been moving or speaking so slowly that other people could have noticed? Or the opposite being so fidgety or restless that you have been moving around a lot more than usual?

Thirty people answered this question. Twenty-eight reported not at all, one reported several days, and one reported nearly every day.



Where are you living?

Thirty people answered this question. Twenty-two people reported inside their own home, six people reported inside a care facility such as a nursing home or assisted living, and two people reported living with a family member.

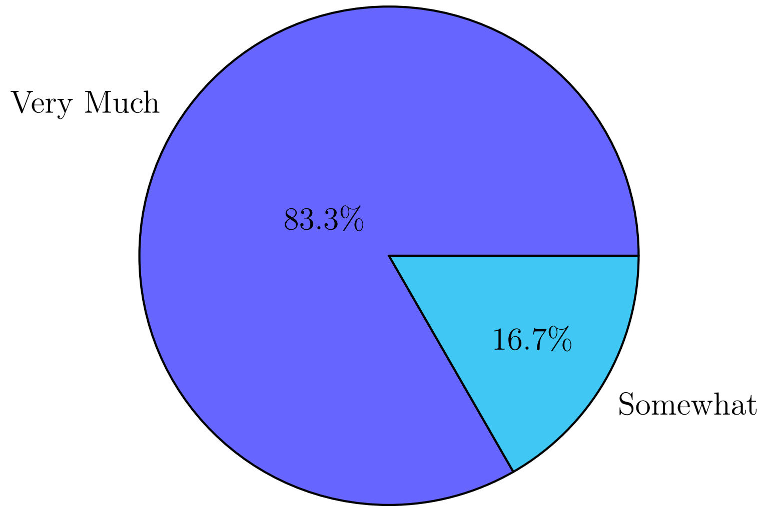


2.8.2 Care Facility Questions

Questions about living in a care facility.

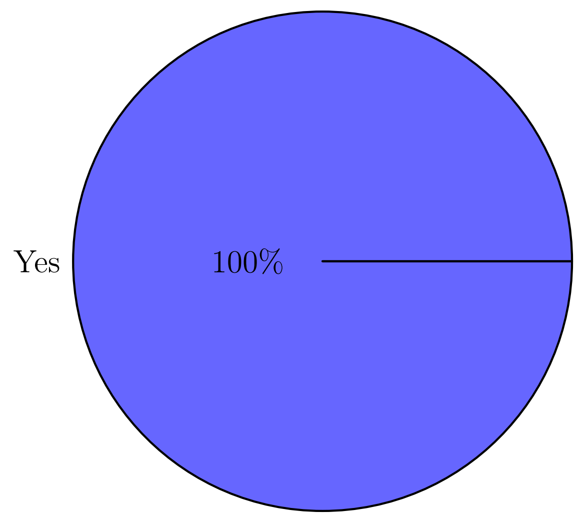
Are you happy in the care facility?

Six people answered this question. Five reported very much and one reported somewhat.



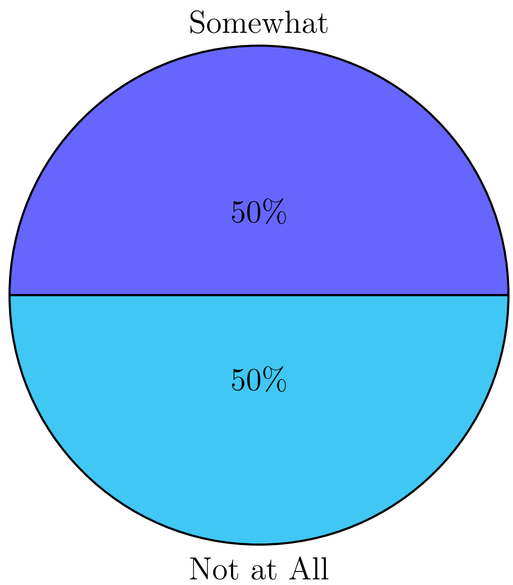
Was it your decision to move into the facility?

Six people answered this question. All six reported yes.



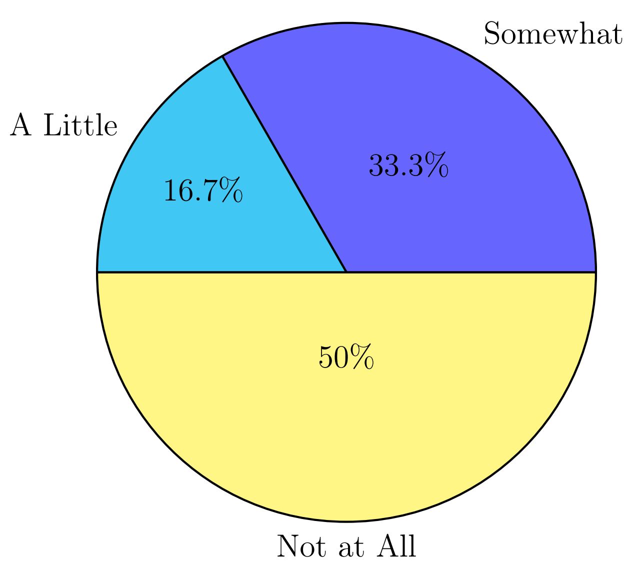
Are you concerned about asking for more help from the care staff?

Six people answered this question. Three reported somewhat and three reported not at all.



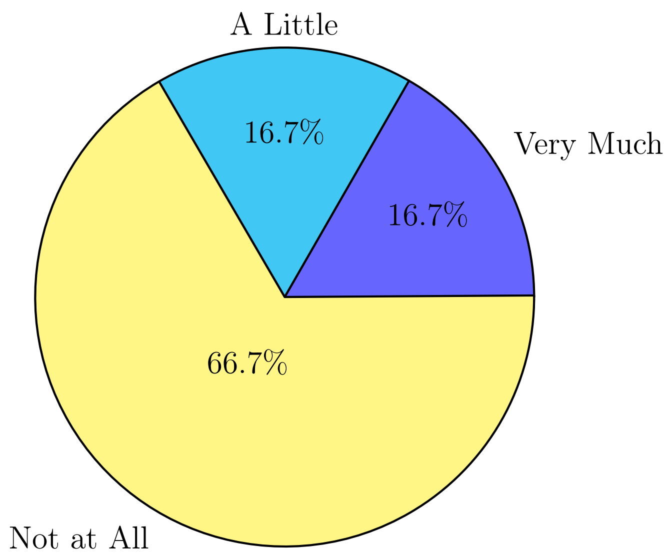
Do you fear nursing homes?

Six people answered this question. Three reported not at all, two reported somewhat, and one person reported a little.



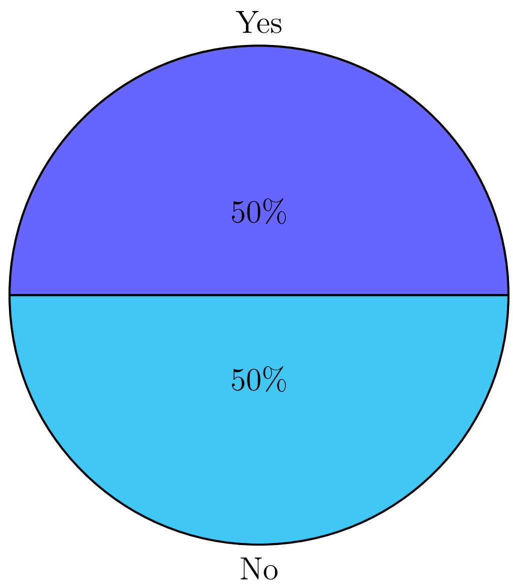
Do you feel isolated?

Six people answered this question. Four reported not at all, one person reported very much, and one person reported a little.



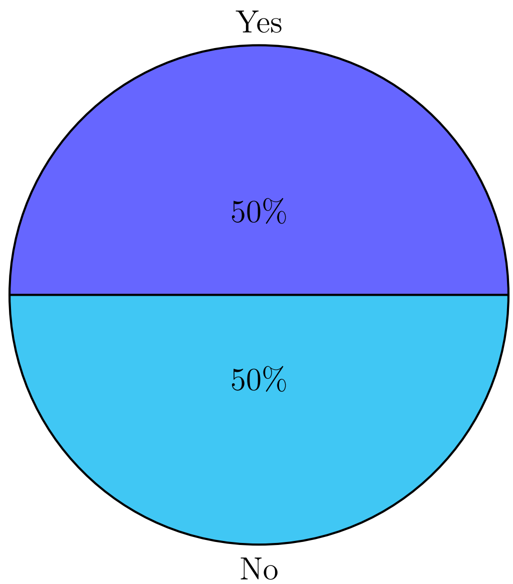
If yes, is it due to moving into the care facility?

Two people answered this question. One person said yes and one person said no.



Do you wish you had more meaningful conversations with someone?

Six people answered this question. Three reported yes and three reported no.



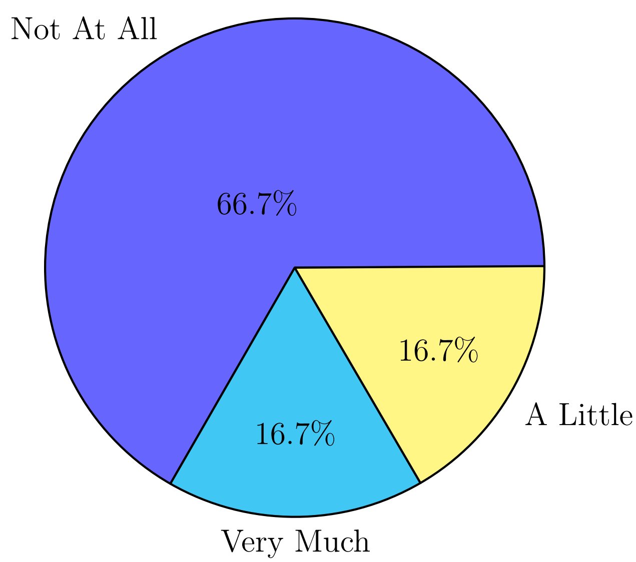
Which of the following has brought about feelings of isolation? Check all that apply.

Four people answered this question.

- Living far from family [4]
- Retiring [2]
- Limited social interactions [2]
- Limited mobility prevents me from attending events [2]
- Living in the care facility [2]
- COVID-19 [2]

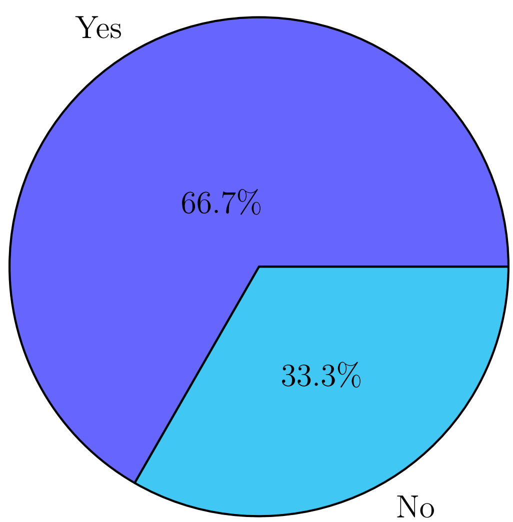
Do you feel depressed?

Six people answered this question. Four reported not at all, one reported very much, and one reported a little.



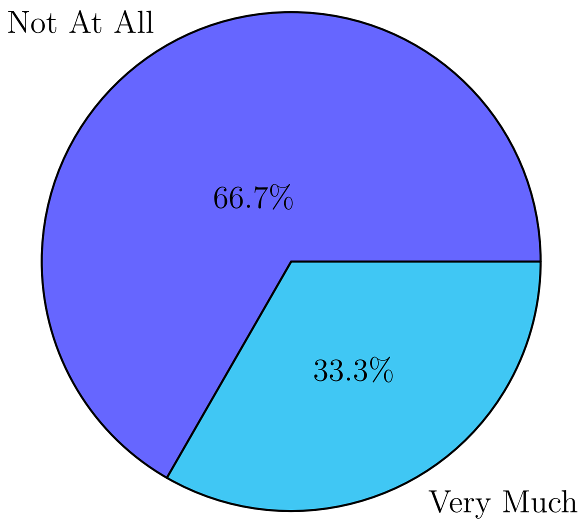
If yes, is it due to moving into the care facility?

Three people answered this question. Two reported no and one reported yes.



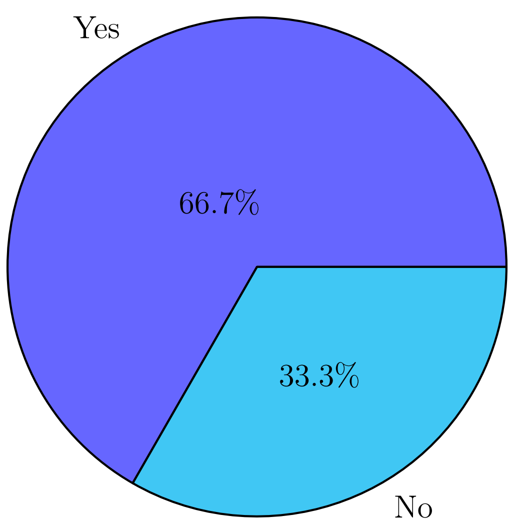
Do you face financial struggles from living in the care facility?

Six people answered this question. Four reported not at all and two reported very much.



If yes, did you financially prepare for moving into the care facility before moving?

Three people answered this question. Two reported yes and one reported no.



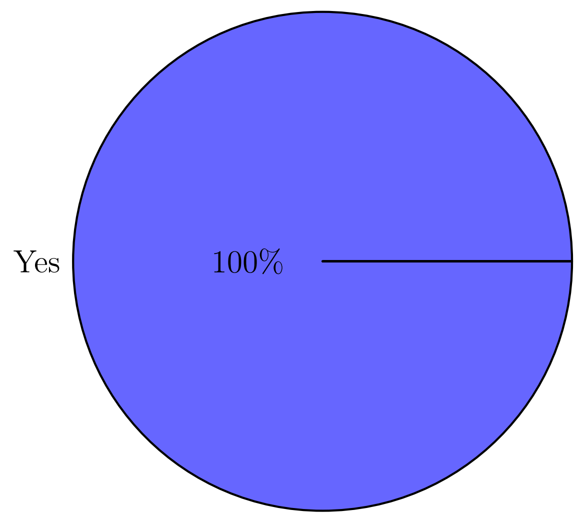
If no, why not? Check all that apply.

Two people answered this question.

- Sudden Change [1]
- I did not have the means to do so [1]
- Never thought I would end up in one [1]

Do you feel technology could assist you in your home?

Two people answered this question. Both reported yes.



If yes, what do you wish it did? (check all that apply)

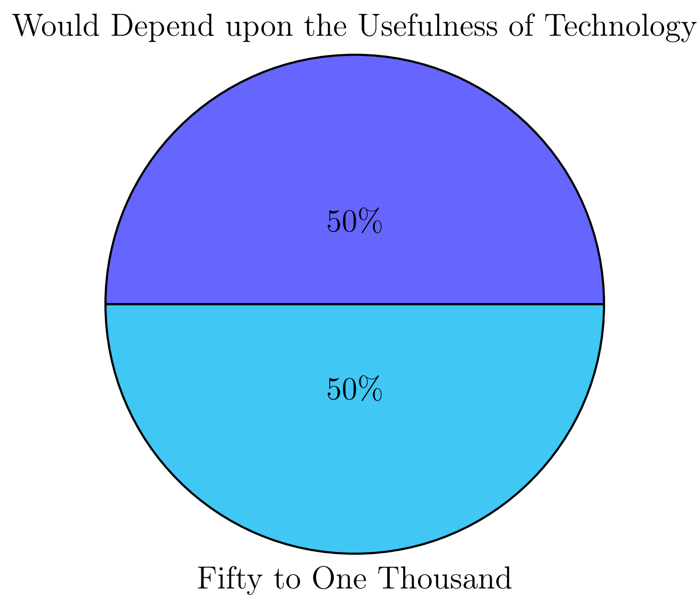
Two people answered this question.

- Just for fun [2]
- Chores [1]

- Exercise [1]
- Help Visual Impairment [1]

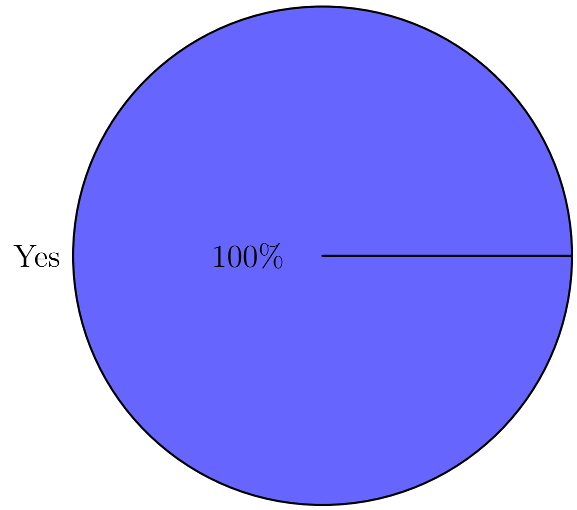
If you were to invest in technology to assist you, how much would you be willing to spend (this does not include if you are able to do so)?

Two people answered this question. One reported $\$500 - \$1,000$ and one reported it would depend on how useful the technology was to them.



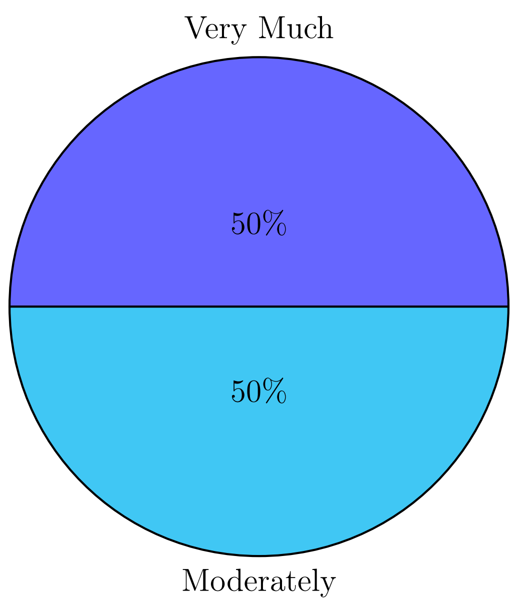
Are you able to spend as much money you indicated in the question above?

Two people answered this question. Both reported yes.



Do you feel the COVID-19 Pandemic has made any of the above symptoms worst for you?

Two people answered this question. One reported very much and one reported moderately.



If yes, would you please tell us which ones got worse?

Two people answered this question. One said, “Feeling isolated from seeing people and going out to eat, travel, shop and go to the movies”. One reported, “Some what concerned about social interaction.”

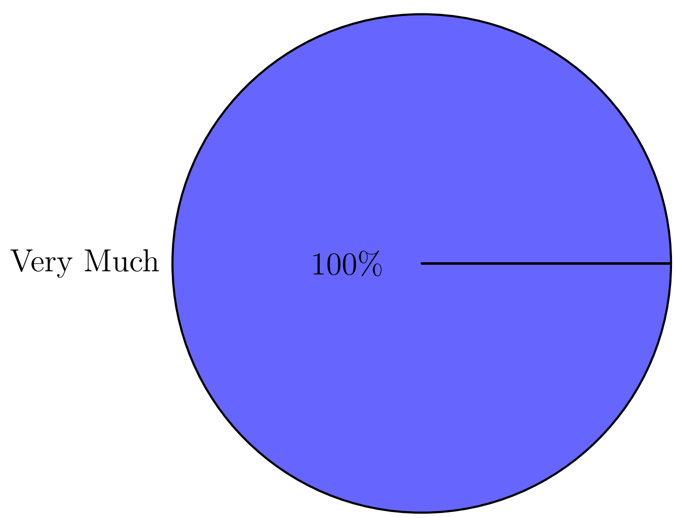
Were there any that got better due to the pandemic and why?

One person answered this question and said, “I got closer to my sister”.

2.8.3 Living Inside Your Own Home Question

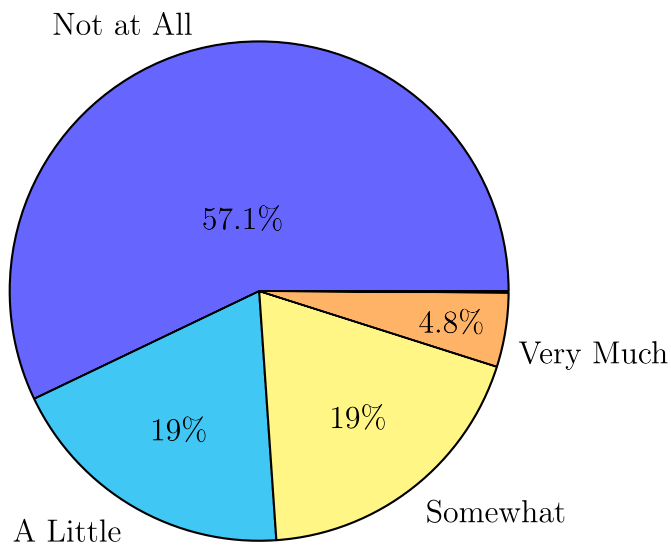
Do you feel safe to remain inside your home?

Twenty-two people answered this question. They all reported very much.



Did you make accommodations to your home to stay there?

Twenty-one people answered this question. Twelve reported not at all, four reported somewhat, four reported a little, and one reported very much.



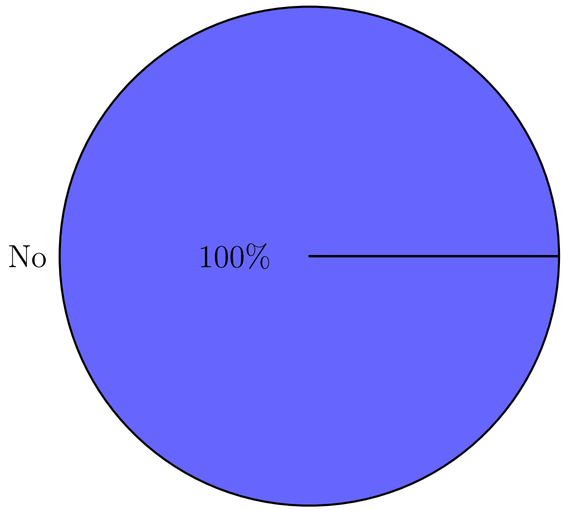
If yes, what were they? (check all that apply)

Nine people answered this question.

- Grab bars in the bathroom [8]
- Moved into a different home that was more accommodating [7]
- Transformed the first floor into the master bedroom [1]
- Transformed the first floor bathroom into the primary bathroom [1]
- Nonslip floors [1]

If no, do you need to make physical accommodations to your home?

Eighteen people answered this question and reported no.

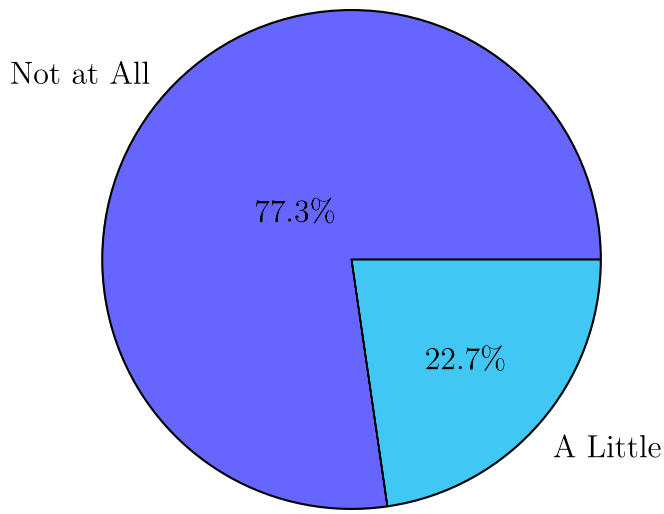


If yes, what were they? (check all that apply)

One person answered this question.

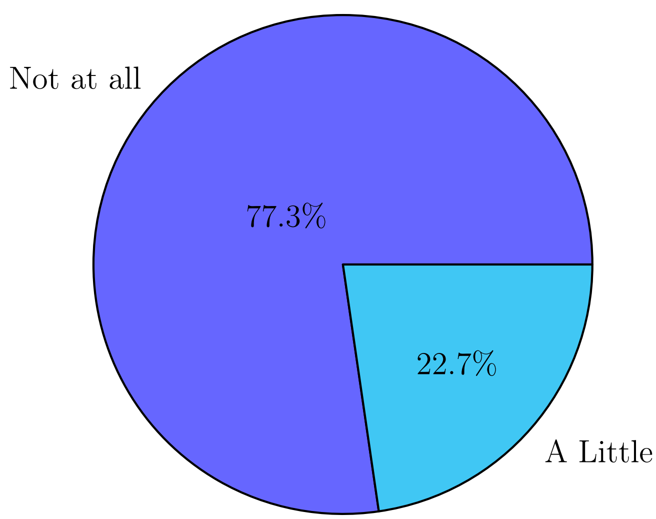
- Grab bars in the bathroom [1]
- Move into a different home that is more accommodating [1]
- Move to the first floor of my home [1]
- Transform the first floor bathroom into the primary bathroom [1]

Did you make accommodations to your home to stay there?

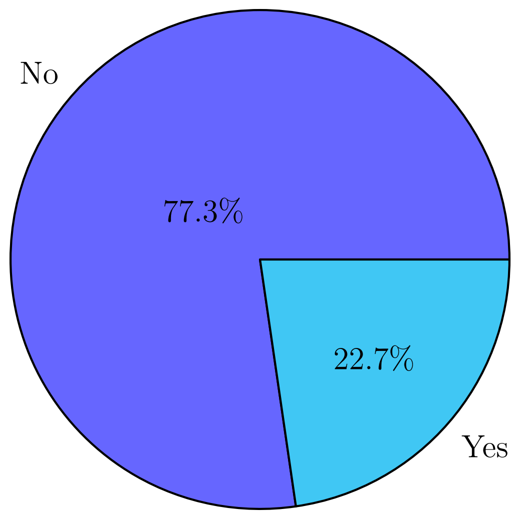


Do you feel isolated?

Twenty-two people answered this question. Seventeen people reported not at all and five people reported a little.



Do you wish you had more meaningful conversation with someone?



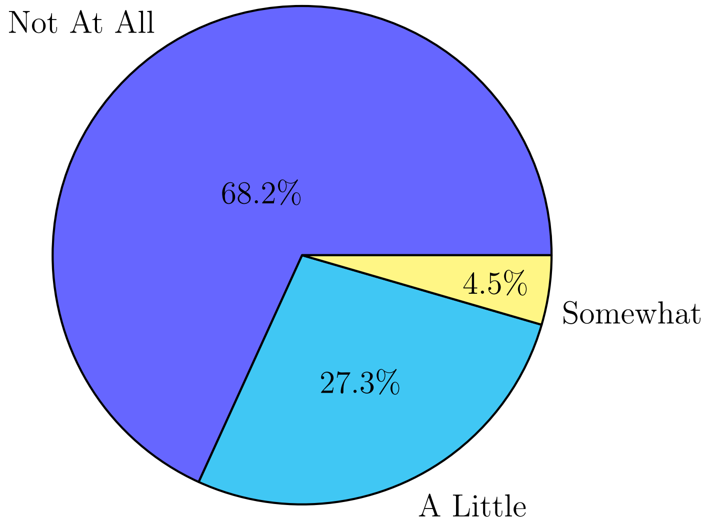
Do you feel isolated from which of the following?

Eight people answered this question.

- Living far from family [3]
- Limited social interactions [3]
- COVID-19 [1]
- Community is mostly couples making it hard to interact as a single [1]

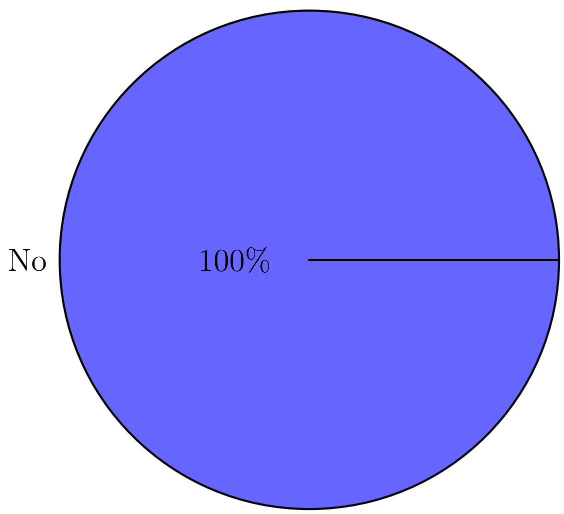
Do you feel depressed?

Twenty-two people answered this question. Fifteen reported not at all, six a little, and one somewhat.



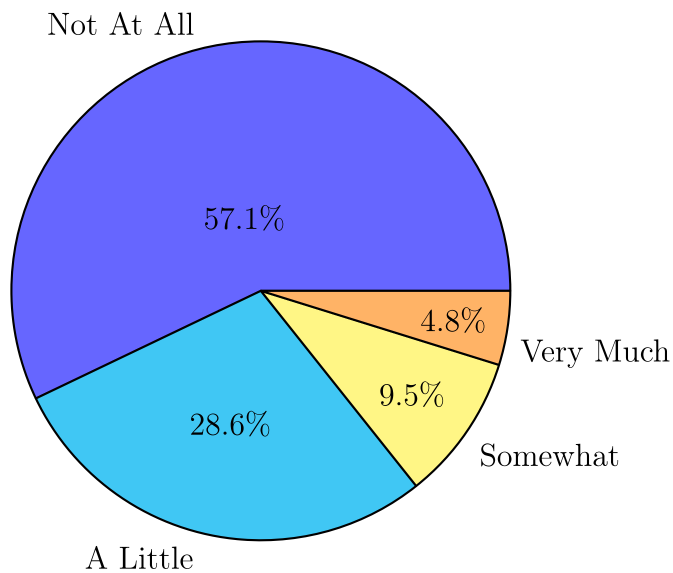
Do you wish you were living in a care facility instead of your home?

Twenty-one people answered this question and all reported no.



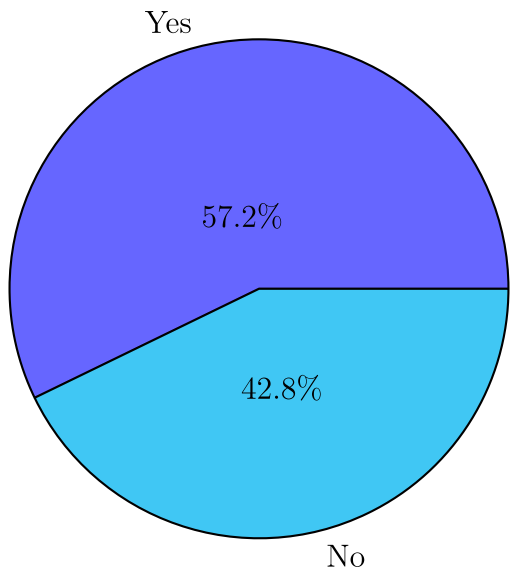
Do you fear care facilities?

Twenty-one people answered this question. Twelve reported not at all, six reported a little, two reported somewhat, and one reported very much.



Do you feel technology could assist you in your home?

Twenty-one people answered this question. Twelve reported yes and nine reported no.



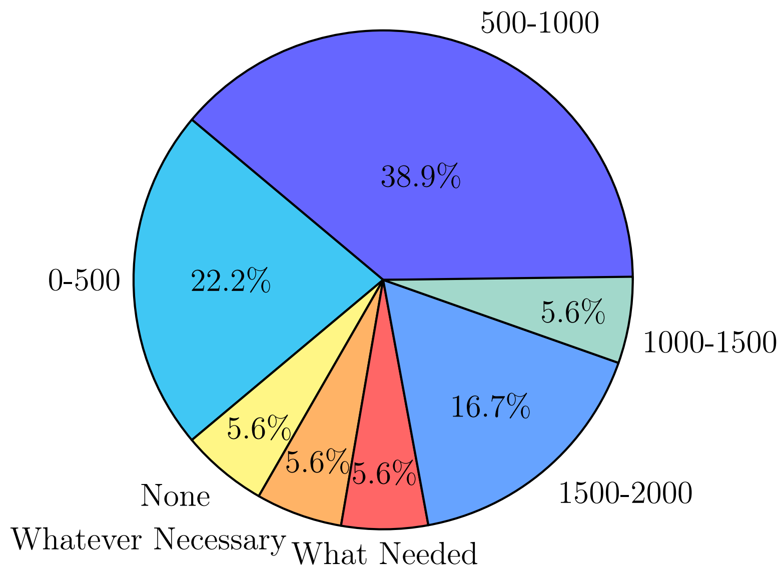
If yes, what do you wish it did? (Check all that apply)

Twelve people answered this question.

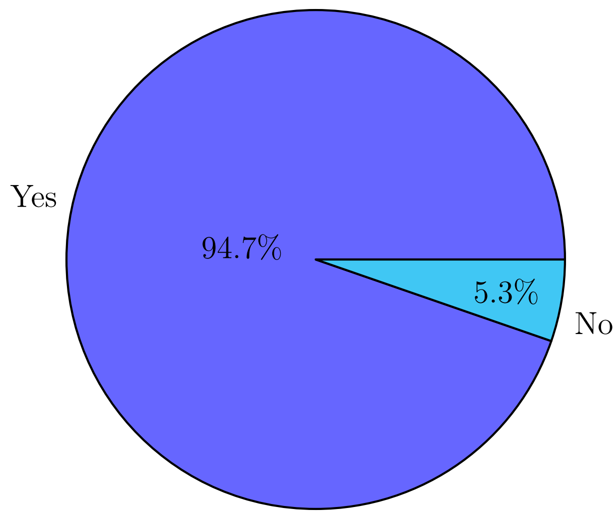
- Just for fun (music) [9]
- Exercise (walking, physical therapy, etc) [6]
- Cognitive Skills (puzzles) [4]
- Social Skills (conversation) [2]
- Chores [3]
- Reminiscing [1]
- Using more computer applications, using more iPhone applications, etc. [1]

If you were to invest in technology to assist you, how much would you be willing to spend (this does not include if you are able to do so)?

Eighteen people answered this question. Seven people reported $\$500 - \$1,000$, four people reported $\$0 - \$500$, three people reported $\$1,500 - \$2,000$, one person reported $\$1,000 - \$1,500$, one person reported none, and one person reported they would spend whatever is needed.

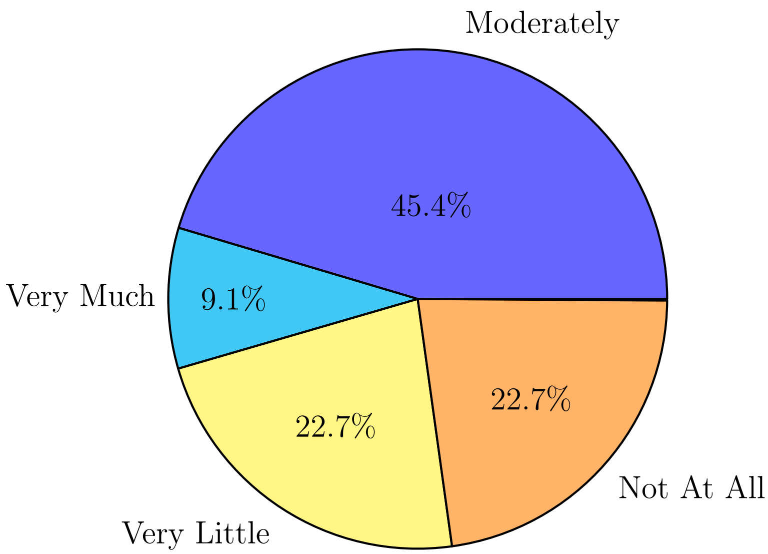


Are you able to spend as much money as you indicated in the question above?



Do you feel the COVID-19 Pandemic has made any of the above symptoms worst for you?

Twenty-two people answered this question. Ten people reported moderately, five people reported very little, five people reported not at all, and two people reported very much.



If yes, would you please tell us which ones got worse?

These are the following responses:

- “Grandchildren not able to visit”
- “Really miss going to the theater, museums, lectures, trips, etc. because of COVID”
- “Fatigue”
- “Physical isolation”
- “Lack of physical interaction with family and friends”
- “Family can’t travel”
- “Social interaction, out-of-home recreation (movies, concerts etc.)”
- “Interactions with new people, shopping, outdoors activity”
- “Travel to see family, socializing with friends, etc.”
- “Slight isolation due to lack of travel opportunities”
- “Isolation from distant family members”

- “Real sense of isolation in 2020 before vaccines became available”

Were there any that got better due to the pandemic and why?

These are the following responses:

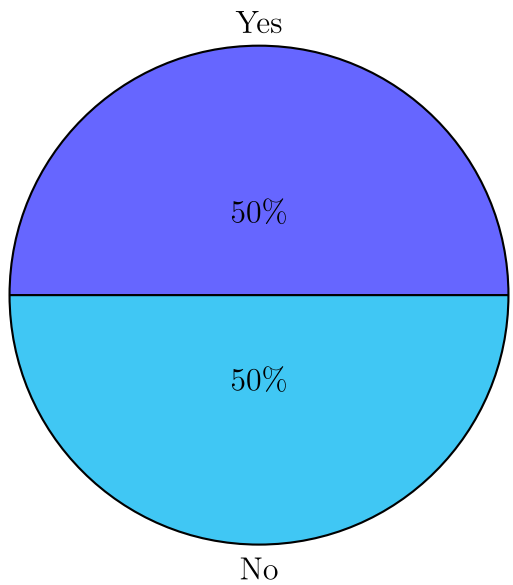
- “Move to Mirabella & vaccine availability”
- “Being able to take a break from some responsibilities”
- “Relationship with wife improved.”
- “Cooking at home”
- “Spending more time with my husband.”
- “Able to spend more time on hobbies”

2.8.4 Family Housing Questions

Questions about living with family members.

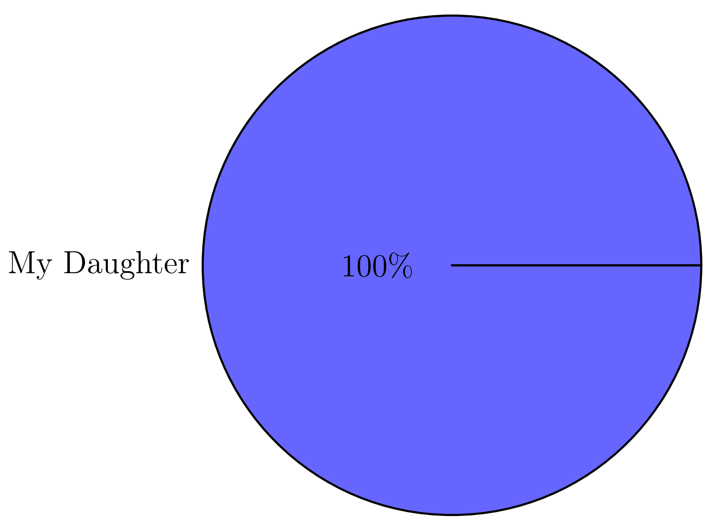
Do you live with your younger family members (or family friend, etc)?

Two people answered this question. One reported yes and one reported no.



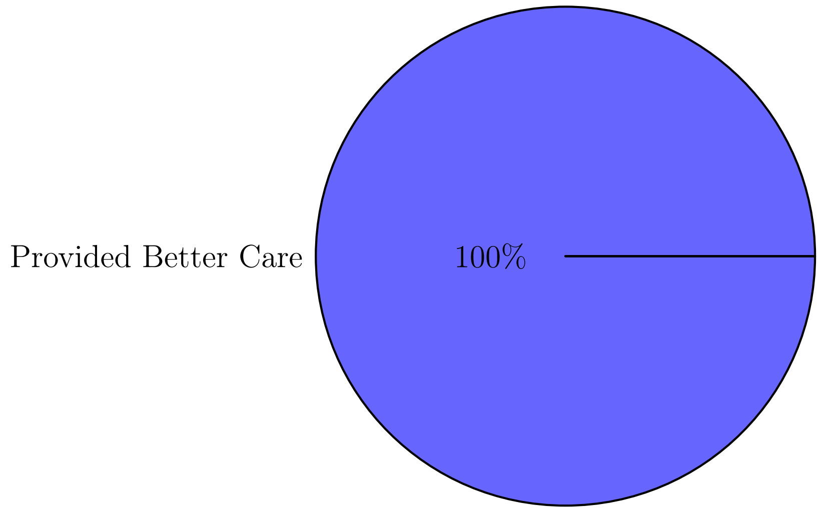
If yes, who do you live with?

One person reported living with their daughter.



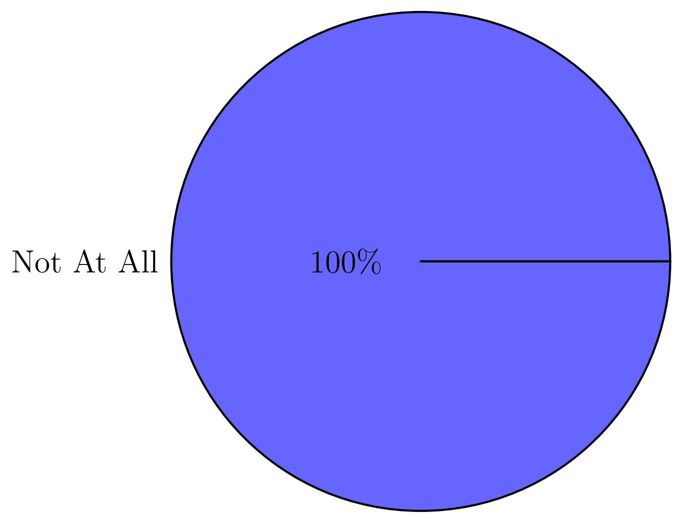
If yes, why did you make the decision to move in with them? (check all that apply)

One person reported they did it because it provided better care.



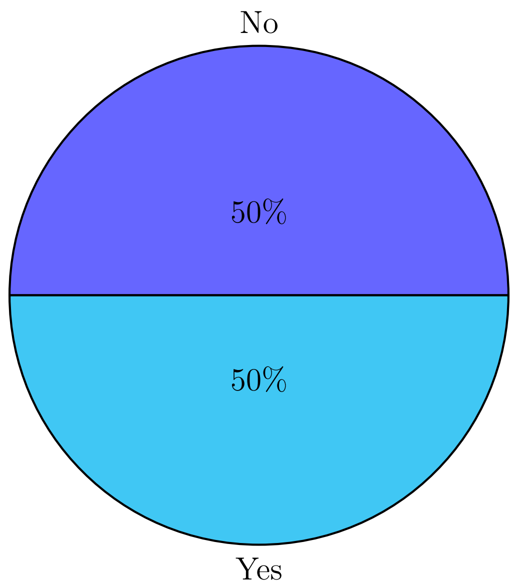
Do you feel isolated?

Two people answered this question and both reported not at all.



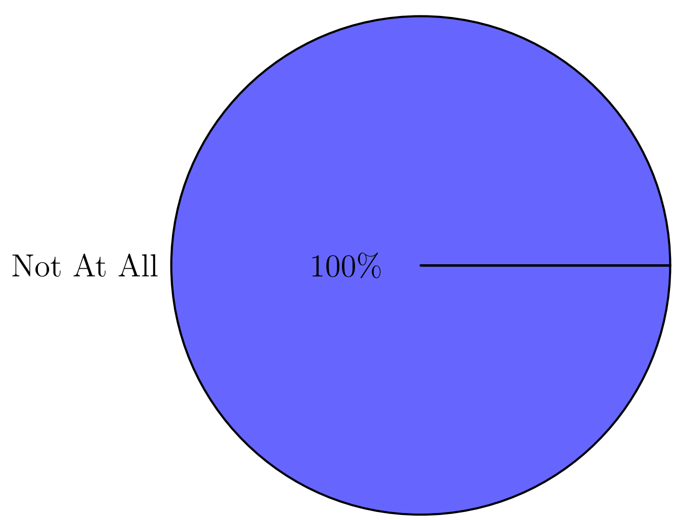
Do you wish you had more meaningful conversations with someone?

Two people answered this question. One reported yes and one reported no.



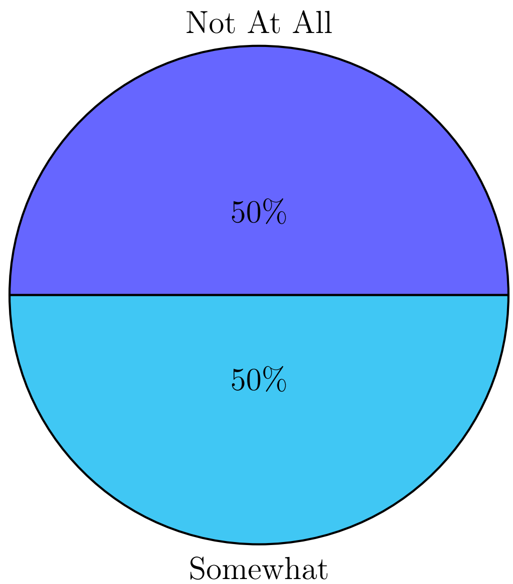
Do you feel depressed?

Two people reported not at all.



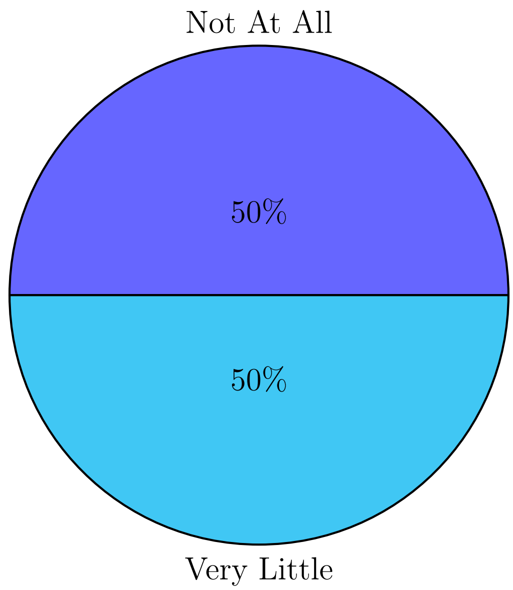
Do you fear care facilities?

Two people answered this question. One reported somewhat and one reported not at all.



Do you feel the COVID-19 Pandemic has made any of the above symptoms worst for you?

Two people answered this question. One reported very little and one reported not at all.



If yes, would you please tell us which ones got worse?

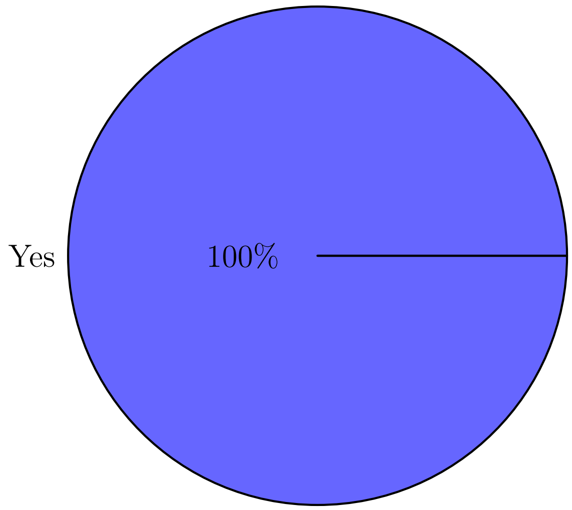
This was the response, “Really miss the activities of the past (theater, speeches, historical sites, etc.)”.

Were there any that got better due to the pandemic and why?

This was the response, “Wonderful new ways of doing celebrations (Birthdays, etc.)”.

Do you feel technology could assist you in your home?

Two people answered this question and both reported yes.

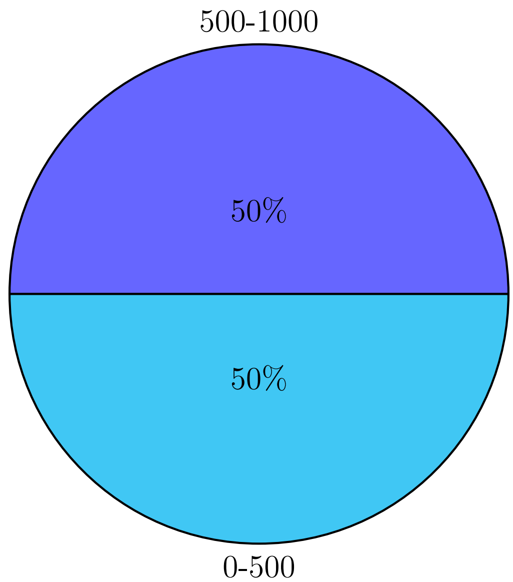


If yes, what do you wish it did? (check all that apply)

- Social Skills (Conversation) [1]
- Just for fun (Music) [1]
- Reminiscing [1]

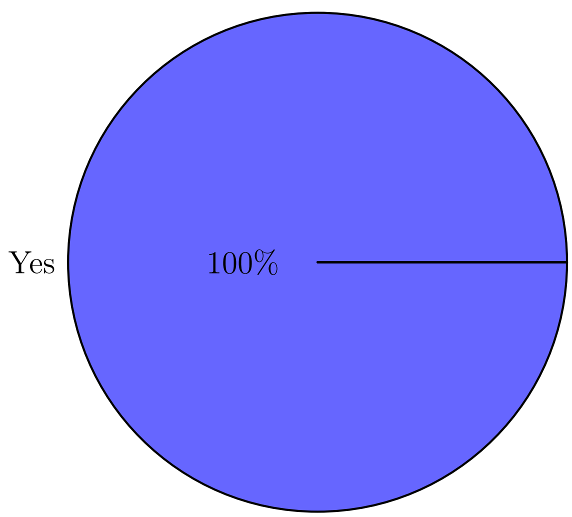
If you were to invest in technology to assist you, how much would you be willing to spend (this does not include if you are able to do so)?

Two people answered this question. One reported $\$0 - \$500$ and one reported $\$500 - \$1,000$.



Are you able to spend as much money you indicated in the question above?

Two people answered this question and both reported yes.



2.8.5 General Demographic Questions

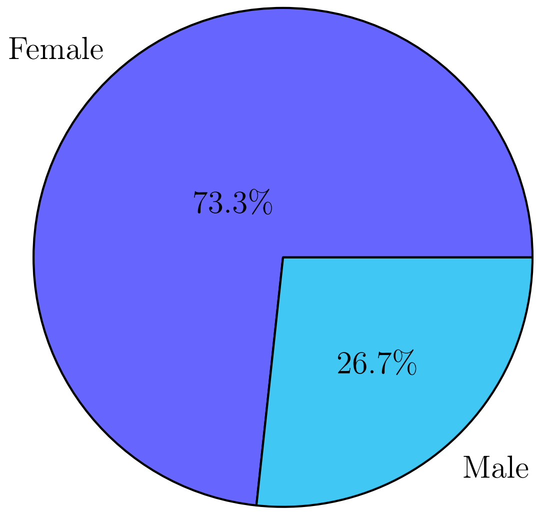
Questions about demographics of the person filling out the survey.

Is there anything else you would like to share?

- "The isolation required by CMS [Centers for Medicare Medicaid Services] is the hardest part; daughter 2 hrs. away but often D.C. does not allow travel in from her state."
- "I live in a retirement community but not assisted living or skilled nursing facility."
- "My twin sister and I moved into the independent living apartment (2,100 sq ft) at a military retirement community to help our parents who had significant health issues. Our dad died and now we care for our mom who has a significant mental issue. I answered this survey for her, from her view point."
- "I am fortunate to be a healthy 86, financially o.k. and have made some very 'like minded' widows here. I am an artist so stay busy, and am planning to take a few trips after COVID is defeated. I would HATE to be stuck in my house alone. If I were I would probably be lonely and depressed."
- "I am nearly 89 years old and feel blessed to be mobile, have good friends and fairly good health."
- "I live at Mirabella, a CCRC [Continuous Care Retirement Community] which provides the opportunity for social interaction while living independently."
- "My mother is in an assisted living facility in N.J. & her health has drastically deteriorated over the last year or so. She's 88 years old."

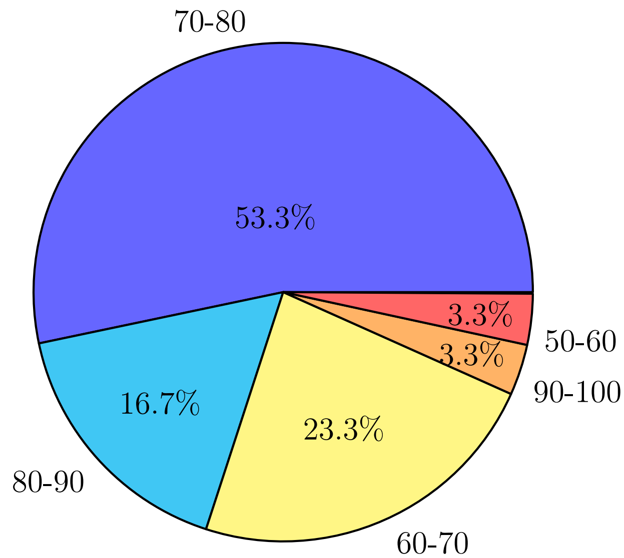
What is your gender?

Thirty people answered this question. Twenty-two reported female and eight reported male.



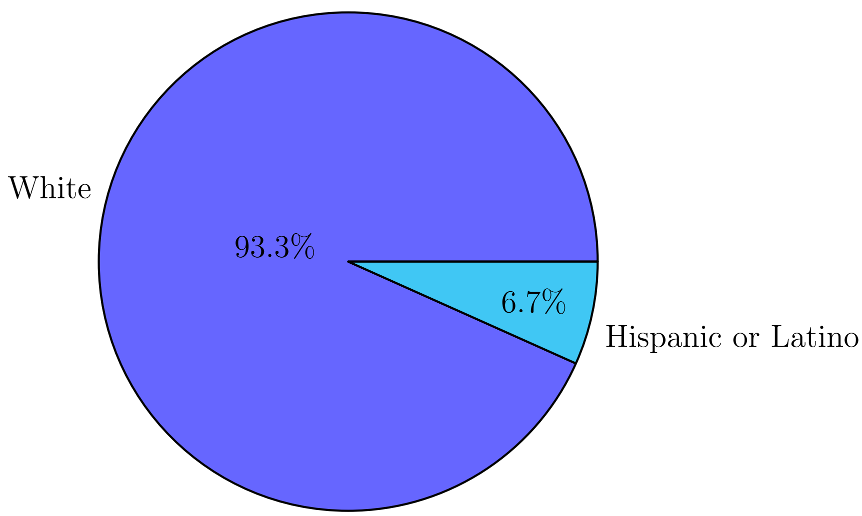
How old are you?

Sixteen people aged 70-80, seven are 60-70, five are 80-90, one is 50-60, and one is 90-100.



What is your race?

Twenty-eight people are White and two are Hispanic or Latino.



2.9 Discussion of Survey

This survey provided an overview of how older adults would like to use technology and features they would like to see. It is important to note that most older adults reported they would like to use technology for fun. While fun is a subjective descriptor, it provides valuable insight into how interactions with social robots should be. If these conversations and interactions are not fun, older adults are unlikely to use them or continue to use them.

Caregivers indicated they would like technology to address their isolation and depression in addition to addressing isolation and depression in the person they care for. This insight is critical because it allows future applications to be developed to assist informal caregivers. These caregivers can use social robots to relieve their stress through conversational therapy. This therapy may resemble telling the robot about the challenges of their day to day life as a caregiver.

Chapter 3

RELATED WORK

Developers are looking to technology to keep seniors in their homes for as long as possible while keeping them safe [2]. Examples of these technologies include the Internet of Things (IoT) and sensors throughout the home that detect potentially dangerous activities such as leaving the oven or stove on for too long. Clarity found that 65% of seniors are open to using new technology, and 54% of people surveyed would consider using ambient monitoring technology inside the home (Clarity 2007).

It is important to note that these individuals are *willing* to these monitoring technologies; moreover, it means *they will not continue to use these technologies if they feel their privacy is violated.* To avoid older adults feeling their privacy is violated, high standards are required for security technology, and it will need to avoid making individuals feel like they are being "watched". These will ensure long-term adoption and use, allowing seniors to age inside their homes longer. A solution may include individuals being able to turn off the system at their discretion. This will ensure older adults feel empowered and in control of their health, homes, and lives. Being unable to turn off a device when uncomfortable may make individuals feel they are forced into a lifestyle they do not desire and cause the technology to fail. This may be why almost half of the seniors Clarity surveyed were hesitant to adopt technology even though it would allow them to stay inside their homes longer. Future work should examine why almost half of the seniors are unwilling to use these technologies inside their homes so steps can be taken to mitigate their concerns.

3.1 Smart Homes and Safety

Smart homes allow older adults who are aging inside their homes to remain safe by connecting them to the outside world through technology. Devices that detect falls can alert someone if a fall is detected inside the home. This feature could assist in detecting a stroke as soon as it happens, allowing doctors to provide immediate care. These homes could also monitor a person living with dementia in the early stages and track the progression of the disease allowing doctors to know the best time to implement interventions. These technologies will keep seniors in their homes for as long as possible by reducing (1) the time needed in a care facility, (2) the time an informal caregiver must spend caring for their loved one, and (3) money spent on care.

Smart Home technology can assist people with mobility impairments. These include the Roomba vacuum to avoid heavy labor, Samsung's smart plug to make devices voice-activated, the Ring doorbell, and the Google Nest thermostat. These devices can assist a person around the home through an app. However, older adults prefer technology to perform more than one task (Forlizzi 2005).

Intille et al. (Intille, Larson, and Tapia 2003) developed a low-cost system by placing sensors on a roll of tape. This allowed people to control their home environment and create customized solutions. Machine learning models were trained to learn the daily routines of the individuals inside the home in order to recognize anomalies. Once anomalies are detected, the system alerts a predetermined individual via a text message. While this work is still early, it shows the potential for smart homes to learn seniors' routines. For example, if the bedroom light turns off every night around 9 PM and turns on every morning around 6 AM, and if the bedroom light is never turned off or on, this would be considered an anomaly, and the alert would be sent.

Kaye et al. (Kaye et al. 2011) report being the first group to use hundreds of sensors inside a senior's home to track the frequency of ambulation, walking speed, and time spent in each room. This study had 265 participants and lasted over two years. Each week, participants completed a report on if they fell. Kaye et al. hypothesized that the actual number of falls reported each year is higher than the average reported. Individuals forget how many times they have fallen between doctor visits. The results support this hypothesis. They found the annual fall rate to be 43% higher than the national average of 30%. Doctors and medical professionals can utilize these at-home tools to keep track of patients they do not see regularly. These applications may help medical professionals determine if they need to see an individual more than they are or cancel unneeded appointments. Tracking progress weekly will help determine how fast a person is declining and when interventions would be best.

Rantz et al. (Rantz et al. 2013) developed a system that allows medical professionals to communicate with a person inside their home to allow early detection of illness. They placed sensors around the home on the stove, bed, and chairs. Pulse-Doppler Radar was used to detect falls and assess the risk of falling. This technology can assist the oldest elderly who are aging inside their home and do not need extra care. By detecting falls, this system can detect early illnesses that can be fatal in individuals at an older age.

Demir et al. (Demir et al. 2017) deployed sensors to detect half-completed tasks around the homes of people living with dementia. If a task was started and not completed, an alert to a designated individual was sent. This technology has the potential to assist older adults who cannot afford to move into an assisted living facility. Sensors were chosen over cameras to avoid invading the individual's privacy and making them feel they were being watched. Four different sensors were used

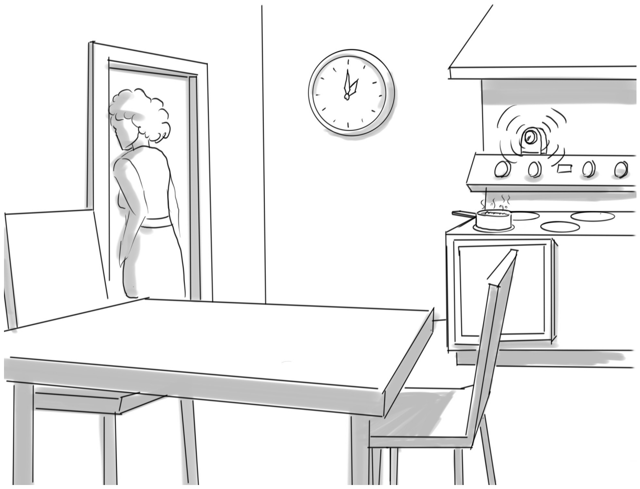


Figure 2. Older woman leaving the kitchen with the stove on

Figure 3. Designated person receiving text message

and placed in the kitchen, bedroom, bathroom, and on the toilet. This technology allows people living with dementia to age inside their home as long as it is safe, saving them money by not paying for care before it is needed. By alerting someone when a task is not completed, families can help their loved ones make better decisions and decide what type of intervention is needed and when these interventions should occur. Figures 2 and 3 depict an older woman leaving the stove on and leaving the room while her designated individual receives an alert.

Enshaeifar et al. (Enshaeifar et al. 2018) placed sensors inside the home to allow medical professionals to alert if abnormal vitals are detected from a person living with dementia. These sensors were used to monitor blood pressure, heart rate, and temperature, allowing the doctor to be alerted if something is abnormal. Additional sensors were placed in the hallways, living room, kitchen, and the doors to the bedroom and bathroom. These sensors allowed the doctors to know the person's location inside the home. These sensors have life-saving potential by allowing doctors to react immediately when a person needs assistance. A common challenge people living with dementia face is sundowners, a symptom which causes extreme confusion and paranoia at nighttime. Sundowners can cause people to wander outside their homes if they become disoriented. By having sensors placed inside the home that monitor heart rate and blood pressure, if a person begins to panic while inside the home, necessary intentions can calm them down. Additionally, if the sensors detect the person is not inside at night, an alert can be sent that the individual has left home.

Rostill et al. (Rostill et al. 2019) placed sensors inside the homes of people living with dementia and their caregiver to detect high blood pressure, low pulse rate, dehydration, disorientation, sleep quantity, and amount of movement. They recruited 408 people and placed the system in half of the participants' homes. Participants who received the system said it successfully assisted them, and they welcomed this technology into their homes. This study highlight features smart homes should include decreasing the load on caregivers. These systems should be tested on other age-related diseases and healthy older adults to generalize to all seniors; however, this provides a strong foundation for innovative home technologies.

Extreme temperatures can cause health complications in seniors; however, older adults do not trust the American National Weather Service when advised to lower their air conditioning. Guo et al. (Guo and Tanaka 2020) hypothesize this mistrust is because most older adults do not feel the recommendations apply to them. They developed a robot that will produce sweat and release a smell to indicate high heat levels to encourage seniors to reduce the temperature inside the home. They believe the robot will cause seniors to trust the American National Weather Service. This robot could be adapted to other cultures because these actions are universal to regions worldwide.

Broadbent et al. (Broadbent et al. 2020) conducted a study to compare RoboGen to RoboGen2. The system is designed to help individuals keep track of their medications; however, it is not user-friendly because users must type in the full name of the medication. This is dangerous because individuals may spell the medication differently each time they use the system. It can cause individuals to take too many pills in a day because the different spelling will show the medication as not taken. Additionally, changes to RoboGen2 include reducing the number of clicks needed to complete a task, replacing labels that had medical terminology, and word completion. Forty participants from a college campus were recruited to enter prescriptions into both systems. Participants preferred RoboGen2 to RoboGen.

3.2 Technologies to Encourage Fitness

Exercise games, also known as exergames, have been explored to assist older adults with physical therapy or motivation to exercise. These exergames allow the user to perform a specific task with a personalized difficulty level. These applications are beneficial to stroke survivors and individuals who cannot access a local gym due to mobility impairments or financial restrictions. They can also be used for physical therapy for individuals to reduce the cost of care but continue therapy beyond outpatient rehabilitation.

Chen et al. (Chen et al. 2017) explored robots that encourage dancing to promote exercise for older adults. They found that participants enjoyed dancing with the robot and would even learn new dance moves so they could engage with the robot.

This application has potential in assisted living facilities; promoting dancing with the robot could lead to individuals dancing together, increasing exercise, and decreasing loneliness.

These exergames enable older adults with limited mobility to engage in exercises that they may not be encouraged to do otherwise. Gerling et al. (Gerling et al. 2012) developed a virtual game that allows users to garden and uses familiar motions such as raising arms out to the side or above the body. Exergames can be customized to fit the needs of each individual for motions and difficulty. Common goals of these games include strength training and improving balance and stability to help prevent falls.

Fitness trackers, such as Fitbit or Apple Watch, can encourage older adults to stay active as they age by tracking their daily activity and encouraging movement. Cooper et al. (Cooper et al. 2018) report that older adults are willing to use these devices to track their activity; however, these devices are largely inaccessible to the elderly. These devices include buttons and screens that are too small, uncomfortable bands, and do not provide enough continuous feedback. These devices could augment care with a clinician to track adherence to exercise.

Keizer et al. (Keizer et al. 2019) used the NAO robot to encourage older adults to exercise by monitoring them. The participants mimicked the robot to complete their exercise session. Overall, the reaction to this application of NAO was positive, but more work is needed before this can be deployed on a large scale. Participants had issues interacting with NAO through speech, and the main issues include: not speaking loudly enough for NAO to hear, not being able to hear NAO, and interrupting NAO. These applications could be successful in a care facility by allowing the staff to monitor people during group exercises. This would also encourage socialization between residents and encourage residents to attend physical therapy sessions.

Lotfi et al. (Lotfi, Langensiepen, and Yahaya 2018) developed a robot to coach participants on how to perform exercises and provide feedback on their movement. The robot was made from an iPad attached to the frame of a Double robot with a Microsoft Kinect so users could be detected. Feedback on if the user was performing the exercise correctly was provided via facial expressions and verbal feedback. If the exercise were not completed correctly, the robot would display the motion of the exercise and provide verbal guidance on how to adjust its motion. Participants were interested in using the device outside the study and happy with how the robot-assisted them.

Piezzo et al.(Piezzo and Suzuki 2017) used a Pepper robot, seen in Figure 4, to assist older adults with their gait. They deployed Pepper in nursing homes to assist care staff with their daily activities and encourage residents to interact with one another. Pepper monitored a person's gait to monitor their balance, encourage ambulation, and provide directions to a specific location. Pepper would encourage participants through verbal praise and display the number of steps taken on its torso and steps to reach its goal. Pepper was operated via a Wizard of Oz approach for this study to monitor how accepting participants were to using Pepper as a walking partner. All participants opted to walk behind Pepper rather than its side due to feeling Pepper was their coach. Using Pepper as a walking companion has potential in hospitals and care facilities for individuals who need to walk after surgeries or improve mobility; having Pepper assists the person allows the nursing staff to assist other patients in more critical conditions.

Karunarathne et al. (Karunarathne et al. 2019) used the Robovie-R3 robot, seen in Figure 5, to study if older adults would accept a robot as a walking partner. Twenty participants were recruited and asked to walk outside on a university campus

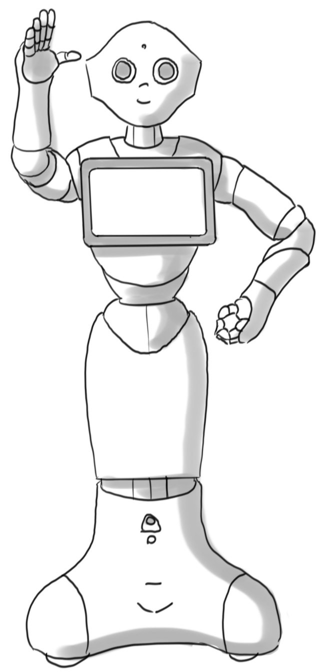


Figure 4. Pepper

with the robot. The results showed that eighteen participants walked side-by-side with the robot, but seven eventually walked slightly in front of the robot. Two participants left Robovie-R3 and walked ahead of it. Five participants looked at the robot while walking, and the rest did not look at the robot. These findings contradict the results found by Piezzo et al., who report that participants want to walk behind the robot. One explanation for this may be the demographics of the participants recruited. Karunarathne et al. do not report if their participants required assistance, while Piezzo et al. conducted their study inside a care facility. The conflicting results highlight the importance of conducting research with a large demographic of individuals.

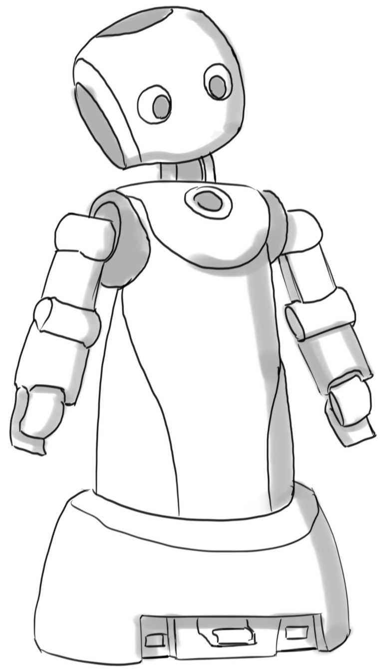


Figure 5. Robovie-R3

3.3 Technology for Communication

In 2022, there are countless technologies and applications for people to communicate with each other. These include social media, smartphones, video chatting, and Web applications. New products allow interpersonal interaction at a distance; robotic pets decrease isolation; and “Skype on Wheels” allows a telepresence robot to roam a room. These devices have the potential to allow older adults wanting to age in place to feel more connected to their family members and friends; however, often, seniors are not tech-savvy. If applications are not user-friendly, they may be discouraged from using these devices for communication.

Moyle et al. (Moyle, Jones, et al. 2013) studied the effectiveness of the Giraff telepresence robot inside a care facility for enabling patients to connect with their loved ones via video calling. For example, a Giraff allows a senior to remote into the home of his or her grandchildren for a birthday party, creating a sense of presence and togetherness without being physically present. Such technologies can benefit seniors with limited mobility or who live in a different state than their families.

The Hug (DiSalvo et al. 2003) stimulates the feeling of hugging over a long distance using haptic sensors. The device allows users to send "hugs" and personalized messages to their closed network. If the receiver does not answer, the sender has the option to leave a voice message. This technology can assist families separated by distance to feel connected to one another.

Khosravi et al. (Khosravi, Rezvani, and Wiewiora 2016) reviewed how isolated older adults are trying to connect through technology. Khosravi et al. report that 50% of older adults who connect to friends via the internet or email feel less isolated than seniors who do not use these. They found that if older adults were connecting to their friends via these methods and were still isolated, they did not have extensive training on how to use these technologies. They reviewed seven surveys and found that robots decreased isolation. Other interventions used video games, telepresence, and virtual reality. This proves that technology has the potential to assist older adults who are isolated.

3.4 Robotic Pets

Robotic pets are helping people living with dementia increase their communication and reduce isolation. Pet therapy is an effective method to assist people living with

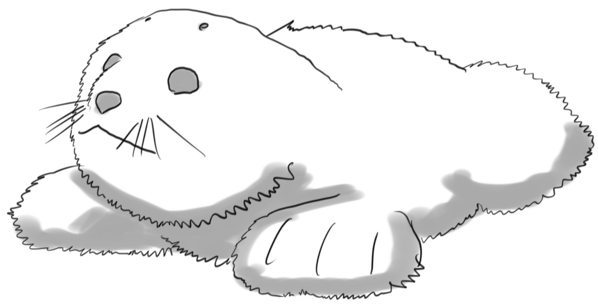


Figure 6. Paro

dementia; however, it can be problematic. Robotic pets are chosen rather than live animals due to the care and attention that real animals need. These challenges can be addressed through robotic pets, e.g., Paro, depicted in Figure 6.

Marti et al. (Marti et al. 2006) investigated using Paro to address behavioral issues in people living with dementia. During therapy sessions, the therapist would decide when it was appropriate to introduce Paro to the participant. Marti et al. reported they did this with ten participants; however, one person had a more pronounced reaction compared to the others. This participant was healing from breaking their hip and frequently called out in pain. When introduced to Paro, their behavior shifted, and they put all of their efforts into caring for it. This allowed the therapist to guide the session around Paro. Marti et al. demonstrate that robotic pets can calm people living with dementia. In 2022, the cost of Paro was $6,000 (Hung et al. 2019).

Moyle et al. (Moyle, Cooke, et al. 2013) conducted a study involving Paro and reported that participants interacted with the robotic pet as much as they would a real animal. Participants would pet, care for, and talk lovingly to Paro. Moyle et al.

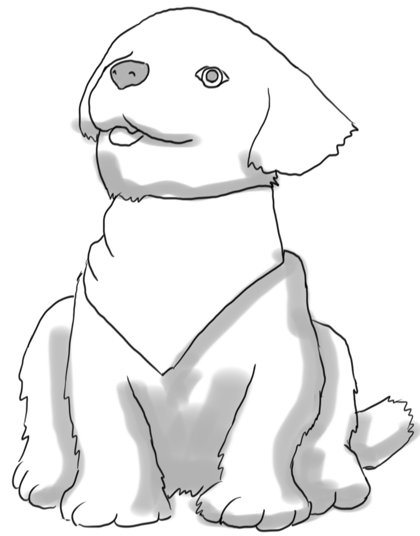


Figure 7. Joy for All - Robotic Pet

call attention to the need for conversational robots; however, they note that these features would be inappropriate for a robotic pet.

Leng et al. (Leng et al. 2019) conducted a systematic review of six articles that used Paro for behavioral and psychological effects of dementia. They report that most participants enjoyed interacting with Paro in a one-on-one rather than a group setting.

Joy for All (All 2018) has commercially available interactive robotic pets that will interact with the user when they are spoken to or pet. Consumers can buy a kitten, cat, or puppy, as shown in Figure 7. These inexpensive solutions are great solutions for older adults who cannot afford a more expensive platform and/or caregivers looking to increase social interaction for older adults living with dementia.

3.5 Haptic Robots

Haptics in the human-robot interaction field is still emerging, with most of the research involving how hand-shaking and touching influence the user interacting with the robot (Saunderson and Nejat 2019). For the state-of-the-art research in this space, I will only report on research from 2018 or later.

Bucci et al. (Bucci et al. 2018) examined how haptic breathing influenced the users' perception of the robot. They found a low valence rating with irregular breathing patterns.

Block et al. (Block et al. 2021) expand upon their previous work by Block and Kuchenbecker, making HuggieBot 2.0 an improved version of HuggieBot 1.0 (Block and Kuchenbecker 2019) a hugging robot, by creating six tents of a natural robot hug. In their previous work, Block and Kuchenbecker investigate hug characteristics. They found that people prefer soft, warm hugs and hugs that squeeze them. Their new work also adds that a hugging robot should be similar to an adult-sized human, react to an approaching user, adapt to the embrace, and detect when the user is ready for the hug to end. By adding these new tenants, users preferred the HuggieBot 2.0 to HuggieBot 1.0.

Burns et al. (Burns et al. 2021) present their ongoing work of enhancing social robots for children with autism through a touch-perceiving robot. They investigate custom fabric tactile sensors that allow the robot to detect other communications through gestures. They built these sensors due to not finding any readily available ones. They are currently evaluating their sensors in an undisclosed user study.

Sato et al. (Sato, Sasagawa, and Niijima 2020) investigated different emotionally expressive table-top robots using five different texture models. These included plastic, aluminum, clay, Velcro, and cotton. Their results confirm that the robot could communicate different emotions such as excitement, happiness, calm, and sadness through different textures.

Nault et al. (Nault, Baillie, and Broz 2020) studied what sensory feedback older adults preferred and found it more engaging when used for a memory game. They tested auditory, haptic, and multimodal feedback. The pilot study had nine participants who touched Pepper's left/right hand, left/right foot, or head based on Pepper's orders. In the haptic condition, Pepper would vibrate when the location was touched. In the auditory condition, Pepper would beep when the location was touched. Pepper would perform both feedback responses in the multimodal (haptic and auditory) condition. While the auditory feedback condition produced superior performance, some participants complained of feeling rushed.

Aaltonen et al. (Aaltonen et al. 2017) placed Pepper inside a shopping mall for a day to observe how the general population interacted with it. While Pepper was at the mall, Aaltonen et al. found that children were very eager to touch Pepper, but adults tried to speak to Pepper as if it was capable of speech recognition. Pepper was only capable of simple question-answering and general questions about the shopping mall and handshaking for this experiment. Children could tickle Pepper as another method of communication. These observations help guide more features that should be included in social robots.

Gamboa-Montero et al. (Gamboa-Montero et al. 2020) investigated a system for how social robots can detect different haptic interactions such as shaking hands, hugs, and petting and identify the part of the robot where the gesture took place. Their approach only uses three microphones placed inside the robots versus traditional approaches, which use many sensors. Their method used two approaches, a multi-class and multi-target.

This is an under-explored area in human-robot interaction. Research can be found on the effects of Paro on individuals living with dementia and dominates the literature; furthermore, much of this work is by the creators of Paro. As robots become accepted as social companions, researchers should investigate how to incorporate social touch to create a multi-model experience with the robot.

3.6 Socially Assistive Robots

Social robotics is a field that emerges from the intersections of engineering and computer science due to the recent advancements in hardware, artificial intelligence, and robotics. Most social robots have been simple and communicate using basic phrases to date. They also will play music, provide reminders, and challenge the user to a mental game. Due to limitations in natural language processing, this technology cannot hold a conversation with a user.

Natural language processing (NLP) is a field in computer science dedicated to communication between humans and computers (Verspoor and Cohen 2013). Challenges in the field include understanding irony, ambiguity, and vagueness. These make it hard for the computer to understand what humans mean; however, advancements are making strides to understand these. Examples of NLP's progress include the iPhone digital assistant Siri, Amazon's Alexa, Microsoft's Cortana, and Google's digital assistant.

These applications listen for a wake word and then perform tasks they are instructed to via the user. These can include setting a reminder, sending messages, or telling jokes. These technologies are currently not capable of holding a conversation; however, researchers in NLP believe a breakthrough is near, which will advance the field of social robotics.

This section discusses early work in social robotics followed by state-of-the-art from 2015 to 2022. I demonstrate the impact that NLP has had on social robotics.

In a pilot study, Tapus (Tapus 2009) developed Bandit II, an adaptive socially assistive robot to improve the users' cognition through identifying songs. The robot plays a song, and the user must press the robot with the song's name. These interactions help improve older adults' cognitive ability and could be used in care facilities to keep seniors' minds engaged and sharp.

Kanoh et al. (Kanoh et al. 2011) designed a robot to assist older adults with isolation and loneliness through conversation. The robot could ask questions to stimulate conversation and was tested in small groups. Many participants had issues hearing the robot, which caused the facilitator to repeat the questions. This work demonstrates the importance of ensuring robots have voices that can be projected loudly and clearly. Many older adults have trouble hearing as they age; therefore, the voice, volume, and capability to repeat phrases must be considered when designing technology for older adults.

Martín et al. (Martın et al. 2013) used a NAO robot, shown in Figure 8, in therapy sessions for people living with dementia. NAO would engage the uses through storytelling, music therapy, and asking prompted questions. The robot would sing and dance to songs in the music therapy session while encouraging participants to do the same. NAO also conducted physical therapy sessions by having people living with dementia mimic the robot's movements.

Research by Chu et al. (Chu et al. 2017) tested twin social robots called Jack and

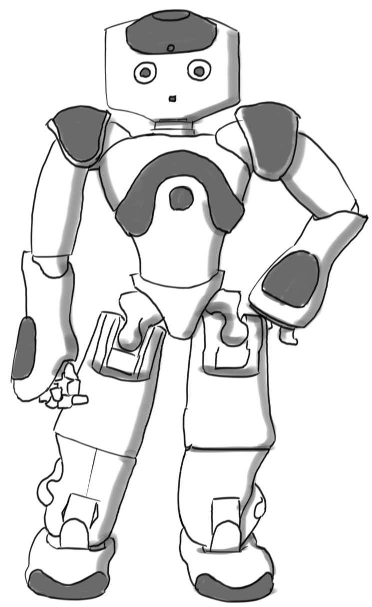


Figure 8. NAO

Sophie, see Figure 9, inside four care facilities over five years from 2010 to 2014. During this period, 139 people interacted with the two robots. The robots were capable of setting reminders, playing games, and telling stories. Results showed that participants enjoyed interacting with the robots and had improvements in conversational skills. This research demonstrates how social robots can enhance the lives of older adults living with dementia and encourage socialization.

Abdollahi et al. (Abdollahi et al. 2017) developed a companion robot, named Ryan, to interact with older adults living with dementia. Ryan was able to engage users through conversations, facial expressions, and reminding the user of their schedule. The robot's torso was displayed, allowing users to play games, music, and videos

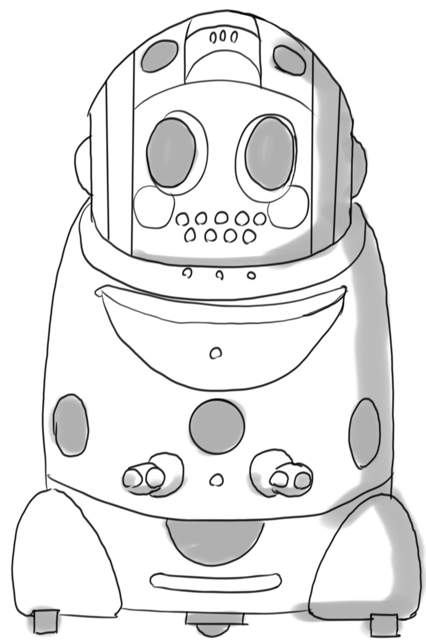


Figure 9. Jack and Sophie

and display a photo album. The user could pick a photo from the album, and Ryan would tell the user a story about the photo and engage the user through simple questions. This robot demonstrates how social robots can perform more than one task, a previously reported preference by older adults.

Portugal et al. (Portugal et al. 2019) piloted a robot capable of navigating a care center for autonomous monitoring. Once the robot detects a face it recognizes, it will navigate to the user. After reaching the known user, it will initiate a conversation and detect the user's emotion. Users can communicate to the robot via a small set of words, but most interaction occurs via a touch screen on the torso. Participants expressed the desire for the robot to have more verbal skills.

Paletta et al. (Paletta et al. 2018) used Pepper to engage people living with dementia by encouraging exercise, social interaction, and cognitive training. A preliminary study engaged people living with dementia, caregivers, relatives, and trainers to understand their attitudes about using a social robot. All participants were unsure but interested to learn more. A feasibility study was conducted where the participant stood in front of Pepper performing an activity. Results showed that people with dementia are open to using social robots for multi-modal training. Future work includes implementing a dialogue component for Pepper to motivate users.

Khosla et al. (Khosla et al. 2019) placed a robot named Betty inside the homes of individuals living with dementia to interact via telling a story, reading the news, providing daily reminders, dancing to songs, and engaging the user in cognitive games. Five participants were recruited to interact with the robot at least three times a day for three months, and at the end of the study, four felt the robot was their friend. This study demonstrates that users will keep interested in engaging with a robot companion over time, primarily if they perform multiple tasks.

Magyar et al. (Magyar et al. 2019) developed an autonomous dialog system for older adults living with dementia. The robot resembled a baby and was light to encourage users to hold onto the robot for extended periods. The robot assisted users in reducing symptoms of depression. This work builds upon using social robots to reduce feelings of isolation and enables designers to focus on more complex conversational strategies.

Cruz-Sandoval et al. (Cruz-Sandoval and Jesús Favela 2019) developed a robot called Eva, illustrated in Figure 10, to interact with people living with dementia through simple conversations. Eva can be operated via a human for interactions that include: complex conversation, changing Eva's facial expressions, playing songs, and providing customized messages.

Iwabuchi et al. (Iwabuchi et al. 2019) introduced Sota, a robot to assist people living with dementia with their behavioral and psychological symptoms. Sota resembles

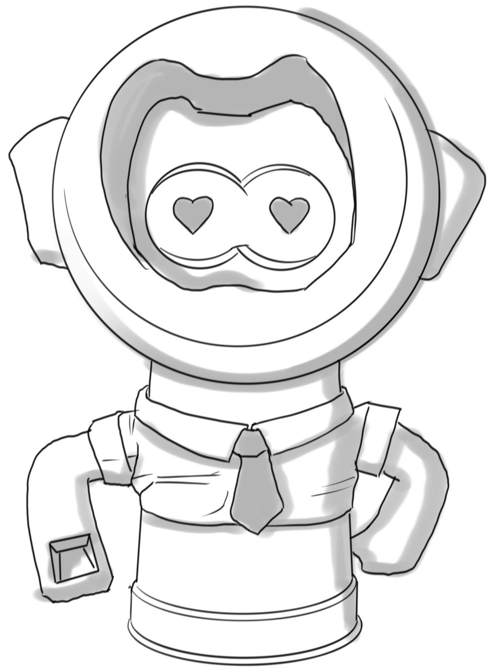


Figure 10. Eva

Paro but includes a conversational feature. Sota can greet the user and prompt the user for their name so it can be used explicitly during the conversation, offering conversation topics, and playing Japanese word games. This work demonstrates how being able to customize a social robot makes the interaction more enjoyable.

Ostrowski et al. (Ostrowski et al. 2019) used a robot called Jibo, shown in Figure 11, in an assisted living facility for three weeks to facilitate human-to-human interaction. Jibo has additional features to give it more human-like characteristics, such as playing music, dancing, sleeping at night, and taking naps. Jibo successfully increased residents connectedness to each other by increasing the time residents spent in common living areas having conversations related to the robot. Many participants

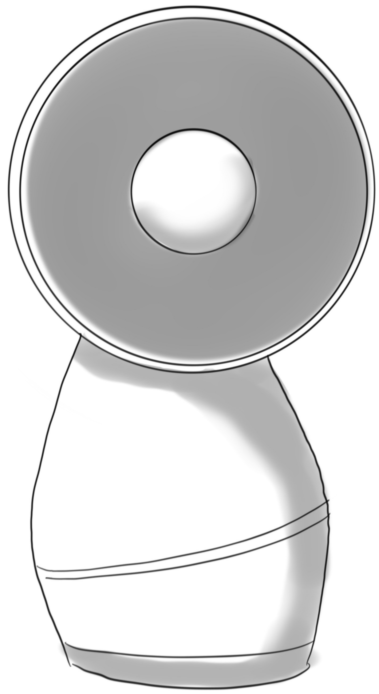


Figure 11. Jibo

asked the robot how it was doing or other typical conversation starters used in social interactions. This work demonstrates how social robots can promote curiosity and communication between humans.

Guiot et al. (Guiot, Kerekes, and Sengès 2019) tested a robot named Buddy in the homes of people aged 66 to 91 for three weeks. Half of these participants lived in a care facility, while the other half did not. Participants preferred the robot to alert a designated individual if they fell and highlighted the importance of developing technology that allows seniors to feel safe as they age inside their homes.

Simão et al. (Simão et al. 2020) used a small robot via the Wizard-of-Oz approach to facilitate communication between two groups in a care facility. Users could place blocks on the robot to perform different tasks such as: sending messages, recording messages, inviting others to lunch, and listening to music. Results showed that the participants enjoyed interacting with the other group via the robot and sharing messages, singing half a song, asking the other group to complete it, and quizzing each other. The participants enjoyed the robot but desired more features such as hugging and the ability to communicate with the care staff. This technology may allow people living inside care facilities to communicate with others at a greater distance that may be too hard otherwise, given their limited mobility.

Baecker et al. (Baecker et al. 2020) tested a reflective listening algorithm on an NAO robot to assist older adults who experience loneliness. The robot responds by repeating what the user said or using predefined responses. The robot will try to engage the user by raising its arm if the user does not engage with it for a few days. The robot started the conversation by asking the user about their day, and it stressed to the participants the limited capabilities of this prototype.

Ros et al. (Ros and Espona 2020) placed Pepper in a daycare facility to encourage participants to play cognitive games. These games were customized to each participant based on preference and goals. The participant would interact with Pepper in fifteen-minute intervals or when they requested the game to stop. Ros et al. investigated the design of the robot and the participants' attitudes. They found the robot spoke too fast and needed to be slowed. These systems have the potential to assist older adults in maintaining their cognitive ability.

Mois et al. (Mois et al. 2020) tested a robot called MARI 12, which was operated via the Wizard-of-Oz method to teach participants living with dementia piano. The lessons were conducted online, and the robot was placed in front of the piano. The results showed that MARI has the potential to assist older adults living with dementia

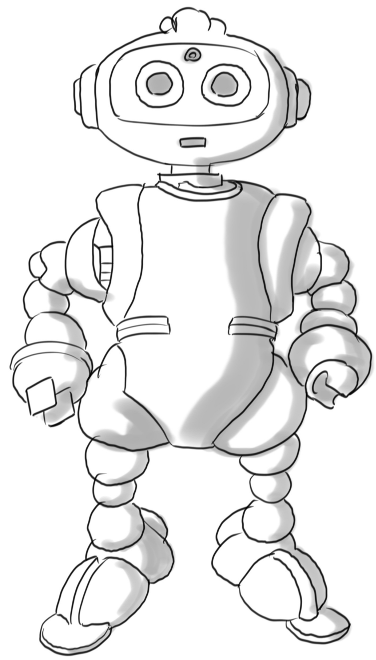


Figure 12. MARI

with their cognitive training and that the participants felt MARI was highly qualified to teach the piano.

Lee et al. (Lee and Davis 2020) report developing a robot named Sunshine to assist older adults during the COVID-19 pandemic potentially. Sunshine is small and doll-like to resemble a child aged seven years old. The robot can communicate via a chat-bot system and remind users about meals, medication, and appointments. It can engage users through storytelling, playing songs, playing Simon says, encouraging reminiscence, and reciting inspirational passages. Preliminary results showed a decrease in depression in older adults who used the robot.

Van Maris et al. (Maris et al. 2020) conducted a six-week study using Pepper in a retirement village. During the study, they noticed participants had trouble understanding Pepper. Pepper was operated via the Wizard-of-Oz approach and would teach users about the Seven Wonders of the World by explaining what the Wonder was and then asking the participant if they knew the location or had visited. Fourteen participants were recruited from two different retirement villages. Four participants were not provided subtitles and had trouble understanding Pepper. The remaining participants were provided subtitles and understood the robot; however, they often would respond when they finished reading the dialogue rather than when Pepper was done speaking. This study highlights the importance of developing robots seniors can understand. While providing subtitles is a simple solution for seniors who face hearing loss, it is not a solution for individuals with visual impairments.

Abbas et al. (Abbas et al. 2020) developed a crowdsourcing website that allows users to act as the voice of Pepper for more complex conversations. The goal was to address the current limitations of AI that prevent machines from being able to have verdicial conversation. Abbas et al. found that having more users in the queue to speak to the participant did not improve the dialogue.

Ghafurian et al. (Ghafurian, Ellard, and Dautenhahn 2020) found a shift in acceptance of social robots during the COVID-19 pandemic. They found that people want their robots to play music, lead exercises, engage in conversations, play games, and provide reminders. Participants also want the robot to recognize them, show emotions, and be optimistic. Ghafurian et al. found that people are more likely to use a social robot if isolated.

Laban et al. (Laban et al. 2021) conducted three within-subject experiments where participants interacted with a person, a NAO robot, and a digital agent. They found that people will disclose more personal information to another human rather than a digital agent.

Obayashi et al. (Obayashi and Masuyama 2020) conducted a pilot study with only two older adults and four nurses from a nursing home. The objective of this study was to understand the tasks social robots can assist within care facilities to ease the burden on healthcare workers. The robot used in this study was Sota. The findings indicate that the robot was capable of stimulating the participant. Recording vitals automatically can assist healthcare staff, and conversation capabilities maybe help delay cognitive decline. Healthcare workers eventually accepted the robot, and positive benefits were seen for the participant.

Wilson et al. (Wilson et al. 2017) investigated how a NAO robot can build rapport with its user. The robot they deployed would engage the user in eye contact while occasionally looking away to avoid any uncomfortable feelings the robot staring may provide. The robot was capable of demonstrating iconic gestures such as "this-or-that" where the robot opens its hands to the left and right. Finally, NAO would acknowledge the user by nodding. Wilson et al. conducted an experiment with eight students who answered questions from two separate NAO robots. One robot only had a "breathing" nonverbal gesture while the other was able to exhibit: gaze, gaze and okay, gaze and nod, gesture, gesture and okay, gesture and nod, and okay. Participants preferred the robot with gestures and verbal acknowledgment to the one that did not provide it.

Miehle et al. (Miehle et al. 2019) conducted a user study with older adults living at home and older adults living inside a care facility. They implemented a co-design process with older adults suffering from isolation to understand what features they want in a social companion. The participants disclosed they wanted a companion to discuss current events, such as the news, and listen to old stories. They also discuss how the robot should speak appropriately due to hearing loss in old age. When participants interacted with NAO, it first sang a German song to help ease any anxiety. It would then ask if they wanted a news, sports, or economy update before asking a specific question to the participant and listening to the answer. NAO would occasionally nod to show it was listening. Users perceived NAO very positively.

3.7 How Robots Can Address Isolation

Mordoch et al. (Mordoch et al. 2013) found social robots are effective companions through an in-depth review. It is easy to imagine how better these relationships will be once AI and NLP enable complex conversations. These will allow social robots to address isolation and depression since it is supported that older adults who interact with a robot over an extended period view the robot as their friend (Khosla et al. 2019). This will help older adults age in place and promote social interaction to avoid the detrimental effects of social isolation, loneliness, and depression.

Pu et al. (Pu et al. 2019) found this technology reduces feelings of isolation, decreases stress, and increases engagement. Social robots can be a peer, companions, or assistants (Mois and Beer 2020). These applications have the potential to serve as a companion; however, it is essential to emphasize that this technology should not replace human interaction (Mois and Beer 2020). This technology has great potential to assist older adults with a limited social network, deceased loved ones, or a particular cognitive disorder. It could even prevent specific health-related impacts caused by depression. Social robots can be used in unfamiliar environments, such as hospitals, for people who have to stay for an extended time. Many people may be unable to have visitors due to hospital restrictions or distance from relatives. Social robots could keep these people company when they are not ready to be alone for the night.

Social robots can be placed in care facilities, and studies have demonstrated that robots inside a room encourage conversations with the robot and other residents. Additionally, robots in group therapy settings have been found to stimulate conversation. They can even assist healthcare workers with their daily tasks such as measuring depression levels, taking vitals, ensuring the residents perform their daily exercise, or even assisting residents on walks. As the cost of this technology decreases, each resident could have a social robot.

Robotic companions could have been used to assist seniors during the 2020 COVID-19 pandemic when people aged 65+ were at greater risk than the rest of the population. In care facilities, outside visitors were not allowed, and many residents could not leave their rooms due to fear of contracting the disease from the care staff. People who were already struggling with isolation and depression likely had increased symptoms. These robots could have assisted older adults in maintaining their mental health rather than declining rapidly, as many seniors did. Caregivers also faced hardship from isolation during the COVID-19 pandemic. They were required to isolate themselves from loved ones and exercise extreme caution while caring for their high-risk loved ones.

Social robots have the potential to address isolation and the challenges associated with it, such as depression and anxiety. They can fill the void left by having a small social network due to limited mobility or living far from family and friends. As this technology decreases in cost while AI and NLP applications advance, these will ensure this technology is widely accepted. These robots must have conversation ability that mimics human interaction, i.e., they are vertical, interactive, and emotionally intelligent, and we are already beginning to see this trend happening. As more and more applications feature conversation features, older adults desire more complex interactions.

A preference has for physical robots compared to digital assistants for addressing isolation (Breazeal et al., n.d.). When developing technology for seniors, developers must remember that many seniors have trouble with vision and hearing. To ensure these robots are user-friendly, the robot should include visible screens (if applicable), clear speech audio, and the ability to customize the gender of the robot (Broadbent et al. 2012). Being able to customize these applications will be beneficial as fine-tuned preferences will aid in the long-term engagement of the robot.

Robots should remember facts about the person and details from previous conversations to provide a more human-like conversation. This will help build the bond between the human and the robot, improving the trust in the relationship. Remembering information from previous conversations will help the user feel the robot is paying attention to them and interested in what they have to say. It will also help if the user begins to tell a side story and loses their place in the original conversation, a human characteristic that often happens during a conversation.

Safety features should be included to help older adults feel safe and encourage adoption. One feature that is needed is an "off-switch" to allow the user to disable the robot when they feel uncomfortable. Knowing the technology can be turned off will allow older adults to feel empowered and control their health. This will encourage adoption, and users will be more likely to converse with the machine if they do not feel threatened by it.

As demonstrated above, many robotic solutions are for older adults living with dementia, and healthy older adults are often not considered when this technology is developed. Researchers should work to include a more extensive representation of the senior population to ensure this technology can be used on a large scale and in different life stages. Features that are important to healthy older adults may not be necessary to people living with dementia and vice versa. Understanding the overlap will be essential to developing this technology for aging.

3.7.1 COVID-19 Pandemic

Pandemics, such as COVID-19, necessitate social distancing and quarantining, potentially exacerbating the emotions as mentioned above of depression and isolation [3]. For many older adults, COVID-19 interrupted regular visits with family and friends due to the concern of contracting the illness. Some found comfort in drive-by visits with family; using plastic barriers for hugging; waving from windows or front doors, and using video services to connect (Kaysen 2020). Seniors in care facilities were unable to have visitors of any kind and were utterly cut off from the outside world other than medical staff (*Older Adults and COVID-19*).

Isolation and depression were present outside the pandemic; however, these feelings were heightened from quarantining and social distancing during the COVID-19 pandemic. Seniors were more at risk of contracting the disease than older demographics which could lead to hospitalization, intensive care, or even death; therefore, they were encouraged to isolate more than the general public (*Older Adults and COVID-19*). On June 25th, 2020, the Center for Disease Control and Prevention (CDC) reported that eight out of ten deaths related to COVID-19 were adults 65 and older (*Older Adults and COVID-19*). In response to creating a safe atmosphere, many stores created "Senior Hours" early in the morning that allowed the elderly to shop without exposure to the rest of the population (Repko 2020). Pharmacies encouraged seniors to change their medications from 30- to 90-day supplies to limit the number of times needed to leave their home (Nania and Crouch). Grandparents were unable to spend time with their grandchildren whom they regularly saw, leading to separation anxiety (Kaysen 2020). Grandparents were afraid they would miss the child growing up and miss pivotal moments in their life, or their grandchildren would not want to spend time with them or remember them as much after the pandemic (Kaysen 2020).

Many communities came together to complete shopping and deliver supplies to older community members (Lee 2020), allowing them to stay safe inside their homes. The concerns for contracting COVID-19 were more significant inside care facilities, and to mitigate this, many facilities banned outside visitors (*Older Adults and COVID-19*). Residents were also required to social distance from other residents (*Older Adults and COVID-19*).

One-third of the United States population serves as an informal caregivers and experience extreme physical and mental stress (Staff 2020), which can lead to fatigue, anxiety, and/or depression (*Care for Caregivers During COVID-19* 2020). Informal caregivers are usually the spouse or the adult female child. During COVID-19, many informal caregivers exercised extreme caution in caring for their loved ones. These included limiting the time they spend outside their homes, disinfecting groceries and other items from the store, disinfecting mail, and creating a secondary caregiver alternative if they fell ill (Brown, Bradford, and Bresolin 2020). Once caregivers finished sanitizing these provisions, they had to sanitize themselves by changing clothes, taking a shower, and washing their hair (Brown, Bradford, and Bresolin 2020). Caregivers were advised not to wear jewelry outside the home and to keep their hair back to reduce the number of surfaces the COVID-19 particles could travel on (Brown, Bradford, and Bresolin 2020). Finally, caregivers were encouraged to wash their hands up to their elbow (Brown, Bradford, and Bresolin 2020). Recommended outlets for dealing with extreme stress include taking short breaks and contracting loved ones and/or support groups (*Care for Caregivers During COVID-19* 2020); (Schall), (*Caregiver burnout during COVID-19: What you should know* 2020); (Team).

Isolation and depression were challenges older adults and caregivers faced prior to the COVID-19 pandemic. Being forced to stay inside the home, sanitize provisions, limit the number of times they leave the residence, and be separated from family and friends only exacerbated these issues. The COVID-19 pandemic called urgency to conversational robotics. This technology could have assisted these seniors and caregivers during what is likely the most challenging experience they will have to face. Caregivers could have benefited from a robot inside the home, allowing them time to focus on themselves and converse with the robot for stress relief. These robots could have been companions for individuals forced to age inside care facilities alone, isolated from the entire world. This technology could have prevented many older adults from rapidly declining cognitively due to isolation and depression and provided support during this highly emotional time.

Chapter 4

2X2 WIZARD OF OZ

The COVID-19 pandemic forced me to step back into the healthy older adult space rather than focusing on older adults living with dementia. Findings from Chapter Two support this step back.

As society continues to age, it will be essential to develop technology that can age with the individual [4]. Innovative home technologies seek to allow individuals to stay inside their homes for as long as possible. However, little work looks at how we can use technology in different life stages. My work attempts to answer this question within social robotics by investigating how to make conversational robots more natural and reciprocal.

Often, people are not prepared to spend their remaining days outside of their homes. Additionally, much work in social robotics for older adults focuses on people living with dementia and not healthy older adults. If people are familiar with the technology before their mental cognition declines, it may be better positioned to help them. Before the decline, this initial contact with a social robot may be essential for the long-term adoption of a robot companion. It would allow for a familiar friend as people begin to move and age in different locations than their home and provide a sense of comfortability in uncertain times.

4.1 Methodology

I chose the Wizard of Oz method because it allows for a faster iteration of the technology rather than developing robot personalities individuals may not want. Additionally, the current state-of-the-art NLP would not have allowed for as in-depth conversations with the robot if I did not choose the Wizard of Oz method. Many researchers in this field choose the Wizard of Oz method when conducting user studies. This study design was adopted from Rosenthal-von der Pütten et al. (Rosenthal-von der Pütten, Straßmann, and Krämer 2020). They conducted a 2x2 between-subjects user study investigating a virtual agent versus a robot on five different skills.

The Wizard of Oz method allowed me to collect various forms of data during the user study, as seen in Table 1. These include quantitative and qualitative results. The qualitative results allowed for an additional survey for participants to take to quantify results from these qualitative themes. Other qualitative results will inform directions for future work and help describe features that influenced results from the study. These include different forms of sentiment expressed to the robot or about the robot. Additional qualitative results include topics discussed with the robot and how individuals tested the robot's intelligence, such as teaching it new things.

Collection Method	Analysis Method	Summary Statistics
Need Finding Survey	Statistical Analysis	Older Adult - 25 Caregiver - 20
Post-Interaction Survey	Statistical Analysis	128 Surveys
Unstructured Conversation	Conversational Analysis	128 Conversations 128 hours 7,680 minutes
Post-Experiment Interview	Qualitative Analysis	16 Interviews 480 minutes
Post-Experiment Survey	Statistical Analysis	16 Surveys

Table 1: Data collection method and data produced

I recruited sixteen participants from Mirabella, located in Tempe, Arizona. Participants live inside the independent living community. This study aims to answer the question, *'What levels of interactivity are needed to make the conversation feel more natural and reciprocal by changing the level of nonverbal and verbal communication?'*.

The conditions of the project were implemented in the following way. ***Condition One:*** This condition implemented low verbal and low nonverbal communication. ***Condition Two:*** This condition implemented low verbal and high nonverbal communication. ***Condition Three:*** This condition implemented high verbal and low nonverbal communication. ***Condition Four:*** This condition implemented high verbal and high nonverbal communication. These conditions are seen in Table 2 along with the Participants ID of which condition they were assigned.

Low verbal communication is defined as answers that are less than three words. **High verbal** communication is defined as answers with no limit on word count. **Low nonverbal** is defined as the robot only nodding its head for yes and shaking its head for no. **High nonverbal** is defined as the robot displaying as many as nine different emotions during the interaction. These emotions include sad, mad, happy, love, laughing, amazement, confusion, and nodding and shaking its head.

The sad emotion made the robot droop its eyes, drop its chin, drop its arms, and say the phrase “Aw.” The mad emotion made the robot burrow its eyebrows, drop its chin, change the LED to red, and say the phrase “Grr”. The happy emotion the robot would smile with its eyes. The scared emotion made the robot tilt its head back, throw its arm up, and say the phrase “Ah”. The affection emotion made the robot’s eyes change to hearts, and the LED red. The laugh emotion caused the robot to tilt its head back and say the phrase “Hehe”. The amazement emotion made the robot’s eye open wider, tilt its head back, drop its arms, and say the phrase “Wow”. The confused emotion made the robot tilt its head to the right, burrow its eyebrows, and say the phrase “Hmm”. All emotions are preset from the MistyRobotics Platform.

The study was completed using a 2x2 Wizard of Oz approach allowing me to communicate through the robot to the participant without the participant knowing. I was placed outside the room, allowing it to appear as if the robot was operating independently. A Bluetooth headset in conjunction with an app, EarSpy that allows users to overhear conversations when a cellphone is placed inside a room, was used. The cellphone was hidden out of sight from the users. Each session was video recorded, allowing me to recall the interaction. I typed responses in real-time for the robot as the conversation naturally occurred. This interaction style was chosen over the use of scripts for more veridical and natural interactions. People were encouraged to talk to the robot about anything they wanted.

There were four people per the condition of this research. The goal was to recruit five people per condition; however, because of COVID-19 and the length of this study, I did not reach that number. When I began this study in early June of 2021, the

Mirabella had just begun to lift their COVID-19 restrictions. I speculate this plays a factor in low participation in the study.

Before the first session, the participant completed the need-finding survey for older adults discussed in Chapter Two previously to understand how they felt technology could assist them.

Participants completed eight sessions with the robot, each lasting thirty minutes to an hour. After each interaction, the participant completed a survey regarding their experience. The survey was the same each time. The survey consisted of 18 questions rated on a five-point Likert Scale. Each question alternated between a positive and negative connotation to ensure each participant thought about their answer.

Once all sessions were complete, the responses were mapped over time. I then conducted an open interview with the participants to probe deeper into their responses to each question. These interviews were video recorded.

The robot used in this study was Misty from MistyRobotics (MistyRobotics 2022). Misty was chosen because it costs around $3,000, compared to NAO, which costs around $15,000. It is crucial to use robotic applications such as Misty because many older adults face financial hardship from the location they choose to age in place. By working with an inexpensive robotic platform, our work has the potential to impact a more diverse group of people from many socioeconomic backgrounds.

	Condition			
	1	2	3	4
Level of Verbal	Low	Low	High	High
Level of Nonverbal	Low	High	Low	High
Participant ID	B R1 D1 D2	G D3 L1 R2	L2 J1 J2 R3	P1 S K P2

Table 2: Table defining the conditions and participants assigned condition

4.2 Post-Interaction Survey

This study has allowed for an enormous amount of data collection, as seen in Table 1. I conducted a statistical analysis method on the post-interaction survey to determine which robot personality was statistically more significant than the others. I analyzed the 18 survey questions with 18 different hypotheses framed around the question. I examined if the level of verbal, level of nonverbal, and session number influenced how people answered the question. The following numbered subsections reflect the questions and how they were numbered on the survey. The complete survey can be seen in APPENDIX C, and the complete interview questions can be seen in APPENDIX D.

I conducted a three-way mixed-method ANOVA test on the survey questions. Here, I report on all eighteen questions. This method is advantageous due to the between-subjects factor, i.e., verbal and nonverbal level, and the within-subjects factor, i.e., the session number. All survey questions examine the hypothesis that session number influenced participants' emotions towards the robot over time through a one-way repeated measures test. This provided insight into how participants felt about the robot overtime and how their opinions may have changed from the first session to the final one.

4.2.1 Perceived Friendliness

"The robot was friendly". This provided valuable insight into how people perceive the robot. My hypotheses (1) people in the low verbal conditions would not perceive the robot as friendly due to the lack of responses; (2) that participants in the high emotive conditions would perceive the robot as friendlier than participants in the low emotive conditions.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.410$, $p=0.534$] for the level of verbal, [$F(1,12)=0.103$, $p=0.754$] for the level of nonverbal, and [$F(1,12)=2.564$, $p=0.135$] for the interaction between verbal and nonverbal, not supporting my hypothesis, that the level of verbal and nonverbal influences how to perceive the robot.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.600, $F(7,6)=0.0778$, $p=0.612$], not supporting that session numbers influenced how people perceived the robot as friendly.

Interview Question

The following are responses to the interview question, "What made the robot friendly to you?".

Condition 1: Participant D1 commented on the small size and toy-like design of the robot. Participants D1 and B said they desired more conversation and nonverbal features such as nodding and movements in future robots. Participant R1 said the robot resembling a toy put them in teacher mode. They would often think, "What would I say to a child?". Participant R1 said the robot did not make inappropriate responses and continued interaction. Participant D2 reported eye contact or the eyes in general.

Condition 2: Participant L1 reported the ability to know the robot was paying attention to them through asking questions, receiving different responses, or the robot seeming interested in what they were saying. Participant R2 said the nonverbal features and nodding. Participants D3 reported eye contact or the eyes in general. Participants L1 and G commented on the size and design. Participant G said the robot not making inappropriate responses.

Condition 3: Participants R3, J2, L2, and J1 said the eye contact or the eyes in general. Participant L2 said the size and design and the robot's female voice. Participants J1 and L2 said the robot not making inappropriate responses.

Condition 4: Participant P2 reported the ability to know the robot was paying attention to them through asking questions, receiving different responses, or the robot seeming interested in what they were saying and the continued interaction. Participant S said the robot's ability to listen. They also commented on the small size and toy-like design of the robot. Participants K and P1 said the robot did not make inappropriate responses and continued interaction.

The features that impacted friendliness include the small size, toy-like design, the female voice, the eyes, the ability to ask questions and appear interested in the conversation, and nonverbal features such as nodding and appropriate responses.

4.2.2 Robots Engagement

"The robot was not engaged in the conversation". This provided insight into what verbal and nonverbal interaction levels are required for individuals to feel the robot is listening to them and engaged in their conversation. My hypotheses (1) participants in the low verbal and low nonverbal condition would feel the least engaged in the conversation; (2) participants in the high verbal conditions would feel more engaged than participants in the low verbal conditions.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.154$, $p=0.702$] for the level of verbal, [$F(1,12)=0.000$, $p=1.00$] for the level of nonverbal, and [$F(1,12)=3.846$, $p=0.073$] for the interaction between verbal and nonverbal, not supporting my hypothesis, that the level of verbal and nonverbal influences how participants perceive the robot.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.301, $F(7,6)=1.993$, $p=0.210$], not supporting that session numbers influenced if people felt the robot was engaged in their conversation.

Interview Question

The following are responses to the interview question, "How did you know the robot was engaged in the conversation?".

Condition 1: Participants D2, R1, and B reported its nonverbal gestures were cues that it was listening by emotive responses, nodding, and waving its hands. Participant D2 said the blinking was an indication that the robot was listening, and it is essential to note that the blinking is a hard programmed feature of the robot. Participant B reported they could notice the robot change its facial expressions to match the story's emotion even though they were in a low nonverbal condition. Participants R1 and D1 reported the responses to their questions, the robot's questions, or comments the robot said.

Condition 2: Participants D3, G, and R2 reported its nonverbal gestures were cues that it was listening by emotive responses, nodding, and waving its hands. Participants G and R2 said the blinking. Participants G and L1 reported the responses to their questions, the robot's questions, or comments the robot said. One said they desired the robot to express more verbal and nonverbal features.

Condition 3: Participants J2, L2, and J1 reported its nonverbal gestures were cues that it was listening by emotive responses, nodding, and waving its hands. Participant R3 said the blinking. Participant L2 reported the responses to their questions, the robot's questions, or comments the robot said. Participant J2 said the robot remembering facts or details from previous conversations allowed them to understand it was engaged during all interactions and made a difference in how they perceived it and commented on the constant eye contact.

Condition 4: Participant S reported its nonverbal gestures were cues that it was listening by emotive responses, nodding, and waving its hands. Participants K, P1, and S reported the responses to their questions, the questions the robot asked, or comments the robot said. Participant P2 said the robot remembering facts or details from previous conversations allowed them to understand it was engaged during all interactions and made a difference in how they perceived it.

The features that influenced if participants felt the robot was engaged include responses, asking relevant questions, remembering details from previous conversations, and the eyes.

4.2.3 Perception of Behavior

"My behavior was perceived correctly". This provided insight into if the participants felt the robot understood social cues. I hypothesize that regardless of the level of interaction, the participants would feel the robot understood social cues.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.023$, $p=0.882$] for the level of verbal, [$F(1,12)=0.206$, $p=0.882$] for the level of nonverbal, and [$F(1,12)=0.573$, $p=0.464$] for the interaction between verbal and nonverbal, supporting my hypothesis, that there was no difference in the level of verbal and nonverbal interaction for being able to perceive the participants' behavior.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.602, $F(7,6)=0.566$, $p=0.763$], not supporting that session numbers influenced the robot's ability to perceive social cues.

Interview Question

The following are from the interview question, "How did you know your behavior was perceived correctly?".

Condition 1: Participants D1, B, R1, and D2 the robot had. Participant D2 said the response rate was too slow (from typing in real-time), and it was difficult for them to carry on a conversation with the robot.

Condition 2: Participants G, D3, L1, and R2 reported the responses the robot had.

Condition 3: Participants L2 and J1 said the robot nodding and shaking. Participant R3 said they would show it photos, and the robot would ask questions about them. Participant J2 said constant eye contact.

Condition 4: Participants S, K, and P1 said it was the responses. Participant P2 said remembering facts from previous conversations in relevant places. Participant P1 said the eyes in general.

The features that influenced if participants knew their behavior was perceived correctly include the responses, asking relevant questions, remembering details from previous conversations, and the eyes.

4.2.4 Misunderstandings

"I was misunderstood during the interaction". This provided insight into if the robot reacted in a way the participant was not expecting. I hypothesize that all levels would report that there was no misunderstanding.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.441$, $p=05.19$] for the level of verbal, [$F(1,12)=0.441$, $p=05.19$] for the level of nonverbal, and [$F(1,12)=0.225$, $p=0.644$] for the interaction between verbal and nonverbal, supporting my hypothesis, that each level of interactivity did not have a significant amount of misunderstandings.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.232, $F(7,6)=2.837$, $p=0.112$], not supporting that session numbers influenced if there were misunderstandings in the interactions.

Interview Question

Not all participants were asked this question, only ones who reported they were misunderstood. The following are the responses to the interview question, “If you were misunderstood, what happened?”.

Condition 1: Participant B said the robot never responded with an inappropriate response, but instead, they did not understand the question it was asking them. They reported one story they told the robot they commonly tell at dinner parties and often get very enthusiastic responses. They reported that the robot did not react the way they expected during the story. Participants D1 and D2 said the robot would occasionally mispronounce words (these were typos on the Wizard’s behalf). The robot did not understand the difference in how to pronounce ‘read’ and ‘read’.

Condition 2: Participant G reported the robot’s response that did not match what they had in mind. Participant D3 said they asked the robot a question two times and did not give a response.

Condition 3: Participants R3 and J2 people reported they were not misunderstood, and it was a mistake in their survey. One person said the robot would sometimes ask questions that were not at the heart of what they were trying to portray or did not detect what they were trying to say. Participant L2 said if there were any misunderstandings, they were simple, and it was easy to clarify.

Condition 4: Participant S said the robot would occasionally mispronounce words (these were typos on the Wizard’s behalf). The robot did not understand the difference in how to pronounce ‘read’ and ‘read.’

The factors that contributed to misunderstandings include: not understanding the question the robot was asking, the robot not having expected responses, mispronouncing words, asking questions and not getting a response, and the robot asking questions the person did not think were related.

4.2.5 Facial Expressions

"My facial expressions were noticed (ex: when you smiled, the robot smiled)". This provided insight into if participants noticed the robot mimicked their facial expressions. I hypothesize that participants in the high nonverbal condition would feel the robot mimicked their expressions, while in the low nonverbal conditions would not feel the robot mimicked them.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.3017$, $p=0.584$] for the level of verbal, [$F(1,12)=0.203$, $p=0.660$] for the level of nonverbal, and [$F(1,12)=1.027$, $p=0.331$] for the interaction between verbal and nonverbal, not supporting my hypothesis, that only the participants in the high nonverbal condition will feel the robot mimicked their expressions.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.441, $F(7,6)=1.085$, $p=0.468$], not supporting that session numbers influenced if the robot mimicked the participants' facial expressions.

Interview Question

The following are responses to the question, "How did you know the robot noticed your facial expressions?".

Condition 1: Participant R1 said the robot would mimic their smile. Participants D1 and D2 said they did not notice the robot matched their facial expressions.

Participant B said it improved over time, but they did not believe the robot noticed their facial expressions a lot.

Condition 2: Participant D3 said they quizzed it on different facial expressions by asking the robot to show them all of its emotions and then made faces and had the robot identify the emotion. Participant L1 said they had to test it. Participant G said they were not in tune with their facial expressions. Participant R2 said they noticed the robot nod, raise its arms, and blink.

Condition 3: Participant J2 said the robot turned its head in response to a story they were telling. Participant J1 said it depended on the topic. Participant R3 said it improved over time, but they did not believe the robot noticed their facial expressions a lot. Participant L2 said they were not in tune enough with their expressions to know if the robot matched theirs.

Condition 4: Participant S said they quizzed it on different facial expressions by asking the robot to show them all of its emotions and then made faces and had the robot identify the emotion. Participant P1 said it was because the response matched how they were feeling. Participant P2 said that the robot's eyes would change to reflect how the person felt when they told stories. Participant K said they never concluded the robot could notice their facial expressions but knew it was able to perceive them because they taught it to play tic-tac-toe visually.

The features that contributed to people noticing if the robot matched their facial expressions include: mimicking their facial expressions, having the robot reveal its expressions and then quizzing it on the participants' expressions, and having the robot mimic how they are feeling.

4.2.6 Inappropriate Reactions

"I felt the robot reacted inappropriately to the conversation (ex: the robot laughed, smiled, etc. at the wrong time)". This provided insight into how the robot perceived the conversation with the individual. It is crucial that when a user is telling a sad story to the robot, the robot does not laugh or smile. I hypothesize that no condition will feel the robot reacted inappropriately.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.3017$, $p=0.584$] for the level of verbal, [$F(1,12)=0.203$, $p=0.660$] for the level of nonverbal, and [$F(1,12)=1.027$, $p=0.331$] for the interaction between verbal and nonverbal, supporting my hypothesis, that the condition did not influence if the robot reacted inappropriately.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.441, $F(7,6)=1.085$, $p=0.468$], not supporting that session numbers influenced how the robot reacted to the participant.

Interview Question

This question was not asked to every participant, only to Participants L2 and R3. The following are responses to the interview question, "You reported the robot reacted inappropriately to the conversation during one of your interactions. Can you tell me what happened?". Both participants said they did not remember what happened, but the instance involved the robot reacting to something they said, but they did not feel the sentence needed a reaction.

4.2.7 Understanding Gestures

"I felt my gestures were understood (ex: it mimicked nonverbal behavior)". This provided insight into if the robot mimicked nonverbal behavior, i.e., looking around the room or looking down, which would help the participant feel the robot was engaged in the conversation. I hypothesize that individuals in the low nonverbal condition would not feel their gestures were understood; only participants in the high nonverbal conditions will.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=1.518$, $p=0.241$] for the level of verbal, [$F(1,12)=0.047$, $p=0.832$] for the level of nonverbal, and [$F(1,12)=3.284$, $p=0.095$] for the interaction between verbal and nonverbal, not supporting my hypothesis, that the level of nonverbal interaction influences if people felt their gestures were understood or not.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.245, $F(7,6)=2.639$, $p=0.129$], not supporting that session numbers influenced if individuals felt their gestures were understood or not.

Interview Question

The following are responses to the interview question, "How did you know your gestures were understood?".

Condition 1: Participant D1 said they were neutral towards the robot understanding their gestures because they did not make many or were unaware of their gestures. Participant B said that the robot would tilt its head to look at them when they moved their arms and hands. Additionally, the robot would look down when they were showing it something on the table. Participant D2 said the robot did not mimic their gestures, and it would be beneficial to know its limitations. Participant R1 said that when they would say something, the response matched.

Condition 2: Participant L1 said they were neutral towards the robot understanding their gestures because they did not make many or were unaware of their gestures. Participant R2 said they coughed in a session, and the robot asked if they were okay.

Condition 3: Participants J2 and R3 said it was because the robot would respond to them. Participant R3 said they would test the robot. Participant L2 said they were neutral towards the robot understanding their gestures because they did not make many or were unaware of their gestures.

Condition 4: Participant P1 said it was because the robot would respond to them. Participant K said they knew because they taught the robot to play tic-tac-toe. Participant P2 said that they would show the robot objects sitting on the table, and the robot would look at them.

The features that influenced how participants knew the robot understood their gestures include: the robot following their motions, responses were matching what they said, asking relevant questions, responses, and looking at objects they showed it.

4.2.8 Unnatural Gestures

"I felt the robot's gestures were unnatural". This provided insight into how the robot should behave during an interaction with an individual. If the gestures were unnatural, it might make individuals feel standoffish during their interaction or influence if they think the robot is creepy. I hypothesize that individuals in the low nonverbal conditions will feel the robot's lack of gestures is unnatural.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.006$, $p=0.941$] for the level of verbal, [$F(1,12)=1.296$, $p=0.277$] for the level of nonverbal. The ANOVA showed a significant difference in the interaction between verbal and nonverbal [$F(1,12)=7.054$, $p=0.021$], not supporting my hypothesis that the level of nonverbal interaction influenced if the participants felt the gestures were unnatural or not.

A one-way repeated measures ANOVA showed a significant difference for the session number [Wilks' Lambda=0.175, $F(7,6)=4.134$, $p=0.052$], supporting that session numbers influenced how people felt about the robots gestures. It can be seen people changed their mind and began to feel the robots gestures were unnatural and suggested ways to make them more natural.

Interview Question

The following are responses to the interview question, "Why did you feel the robot's gestures were unnatural?". This question was asked to participants who agreed the motions were unnatural.

Condition 1: Participant B said the limited amount of gestures. Participant D1 said it did not move its arms; however, the robot did move its head, which helped make it more natural. Participant D2 said it was unnatural only to move its arms up and down. Participant D1 said it was off-putting that it was so static, but they reminded themselves it is a robot and its motions will be limited.

Condition 2: No one reported the gestures were unnatural in this condition.

Condition 3: No one reported the gestures were unnatural in this condition.

Condition 4: Participant P2 said the robot's arms are too short and not proportional to its body. Participant K said the gestures were too stiff, and the robot's arms were not mobile enough. Participant P1 reported that the motions were rigid.

The following were features people reported would make the robot more natural: shrugging, hugging, tilting its head when happy, more head and arm movement, more nodding, and more human-like attributes. Participant D1 reported that the robot looked around the room during one conversation when they described something, and they found that very natural.

4.2.9 Understanding the Robot

"I could clearly understand the robot (ex: It was easy to hear the robot, it was not hard to understand the robot)". This provided insight into if the robot voice should be slowed down or louder since hearing loss is a hardship most older adults face. I hypothesize that each level of interaction will not have trouble understanding the robot. I took extra precautions by restricting the speed of the speech to 80% of what it would usually be.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.628$, $p=0.444$] for the level of verbal, [$F(1,12)=1.310$, $p=0.275$] for the level of nonverbal, and [$F(1,12)=4.101$, $p=0.066$] for the interaction between verbal and nonverbal, supporting my hypothesis that participants were able to understand the robot.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.601, $F(7,6)=0.568$, $p=0.762$], not supporting that session numbers influenced if participants could understand the robot.

Interview Question

Only two participants were asked, “Did you have issues hearing the robot?”.

Condition 1: Participant D1 reported they only had issues understanding the robot once.

Condition 2: Participant R2 reported they only had issues understanding the robot once.

Condition 3: No one in this condition reported having issues understanding the robot.

Condition 4: No one in this condition reported having issues understanding the robot.

I noticed R2 wore hearing aids and appeared to have trouble understanding the robot. When the robot would ask a question, the participant would frequently skip the question and continue with the story. In a later session, I noticed that the individual removed their hearing aids while conversing with the robot. This may explain why they did not answer the questions the robot asked.

Participant D1 said there were misunderstandings due to the limited amount of words the robot could say. They said this made it hard to understand the questions sometimes.

4.2.10 Participant Engagement

“I was not engaged the whole interaction”. This provided insight into if the interaction with the robot was able to keep the participant’s full attention or if they

desired for it to end sooner than it did. I hypothesize that individuals in condition one will feel less engaged than the participants in the other conditions.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.854$, $p=0.374$] for the level of verbal, [$F(1,12)=0.007$, $p=0.934$] for the level of nonverbal, and [$F(1,12)=0.007$, $p=0.934$] for the interaction between verbal and nonverbal, not supporting my hypothesis, the less verbal robot will make people feel less engaged.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.513, $F(7,6)=0.813$, $p=0.608$], not supporting that session numbers influenced if participants were engaged with the robot.

Interview Question

The following are responses to the interview question, "What was engaging about interacting with the robot?".

Condition 1: Participant D2 reported they were enthusiastic about the project, and it was important they were at eye level with the robot during the conversations. Participant B had one day they did not find the robot engaging and reported there were outside factors influencing their attention to the robot that day during the interview. Only Participant D1 reported they did not find the robot engaging, and it did not reflect a real conversation. Participant R1 said they kept engaged due to the commitment to the project.

Condition 2: Participant R2 said blinking, moving its arms, and making noises. Participant D3 said being engaged did not depend on the conversation topic and enjoyed that the robot provided conversation. Participant G said they did not expect much interaction from the robot and was impressed with how engaging it was during the conversations. Participant L1 said the robot seemed like a friend because the robot was interested in the conversation and reported it was comparable to conversing with a child. They said this made the conversations fun because they found it challenging and exciting to teach new concepts.

Condition 3: Participant J1 said the conversations were engaging because when they would tell stories, it would lead them to continue to talk about things they had not discussed. The robot would ask a question that would lead to a new story.

Participant J2 reported that the robot responding at the right time made the conversations engaging, and when the robot did not react, it made this participant want to keep talking to make the robot react.

Participant L2 said the conversation was engaging because had they been conversing with another person, the stories may have been boring, and the person may have their attention elsewhere. It occurred to this participant that the robot would always be engaged in their stories, which was exciting. They said the robot provided undivided attention, and its eyes did not wander.

Participant R3 reported they desired to test the robot's cognitive skills. They tried to gauge what it could and could not understand, such as logic, emotion, and knowledge it had from other conversations. They said it was comparable to talking to their grandchild. They said their role in life is to teach their grandchildren things, but different from their grandchildren, the robot did not ask questions that were unrelated to the conversation or disagree with them.

Condition 4: Participant P1 became more engaged each session because the robot interacted with them more. Participant S said they were engaged due to the application of the research and commitment to it.

Participant P2 reported they enjoyed working with the robot to make it more human-like and enjoyed its learning process. They reported that the robot would make leaps in their conversation and was more engaged than some humans. The robot's desire to learn and phrases such as 'Thank you for teaching me that' kept this participant engaged. They saw the project as a step into the future.

Participant K reported that when they have conversations with humans, it is easy to gauge where the person is trying to join in the conversation or may interrupt a conversation to tell their story. They said the robot was perfectly balanced in the number of times it jumped in and did not interrupt them. This made it clear that the robot was engaged and paying attention.

A suggestion for future applications that arose during this question was to give the robot a nonverbal cue to let people know it is coming up with a response. Another suggestion was that the robot initiates conversation with the user and asks more questions about the user rather than general conversation topics.

Features that influenced how engaged participants stayed during the experiment: the project and its potential, the participant's commitment to the project, nonverbal gestures, the robot providing conversation, being interested in the conversation, the responses, providing undivided attention, more interaction from the robot each session, and the robots desire to learn.

4.2.11 Enjoyment

"I had fun talking to the robot". This provided valuable insight into how older adults may use this technology in the future. Individuals are more likely to use social robots for personal use rather than therapeutic if they are enjoyable to interact with over long periods. I hypothesize that participants in conditions of low verbal

interactivity (i.e., conditions one and two) will not enjoy their interactions as much compared to high verbal interactivity (i.e., conditions three and four) due to the robot's limited responses.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.042$, $p=0.842$] for the level of verbal, [$F(1,12)=1.674$, $p=0.220$] for the level of nonverbal, and [$F(1,12)=0.784$, $p=0.393$] for the interaction between verbal and nonverbal, not supporting my hypothesis, and showing that all participants had fun interacting with the robot regardless of the level of interaction.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.427, $F(7,6)=1.149$, $p=0.441$], not supporting that session numbers influenced if participants had fun interacting with the robot.

Interview Question

The following are responses to the interview question, "Why was the interaction fun?".

Condition 1: Participant B said that they told the robot because their spouse had heard all of the stories, and their spouse lost interest in hearing them. They enjoyed recounting all of the stories, and the robot was never bored and paid attention. Participant D1 found it fun when the robot would say something odd that would make them laugh but otherwise enjoyed retelling stories. Participant R1 had never engaged with a robot, and after the first time interacting with the robot, they felt like they were coming to see a friend each interaction. Participant D2 was intrigued by artificial intelligence because it was something they had not done before.

Condition 2: Participant L1 reported the time went by very fast when they played

Bridge and would read to the robot. They enjoyed having the robot engaged and asking questions about their interests. Participant D3 did not have fun with one interaction when the robot's battery died at the end of the session. Participant G enjoyed teaching it about money and quizzing its visual skills. They said the interactions were lighter than expected, and they enjoyed the responses. Participant R2 enjoyed the opportunity to retell old stories and talk as much as they wanted. They enjoyed not being interrupted and found it easy to talk for an hour.

Condition 3: Participant J2 said the nonverbal gestures, the robot remembering details from past conversations, and when responses matched what they wanted to hear. Participant R3 said when the robot would remember previous conversations and extend on previous topics. Participant L2 said, not knowing what the robot was going to say. They enjoyed not knowing when the robot would comment. Participant J1 said they would talk to other participants before interacting with the robot to help decide on conversation topics. They enjoyed the brain simulation on finding topics and exciting stories. Participant J1 enjoyed how one topic would lead to another and bring up memories that had been internalized.

Condition 4: Participant K viewed the interactions as windows to the future. Participant P2 also found the interactions fun because it was like stepping into the future and enjoyed teaching the robot new skills. Participant P1 found the interactions fun solely because they engaged with a robot. Participant S felt the experience was an adventure and enjoyed the robot's unexpected responses. They reported that as conversations got complicated, they enjoyed interacting more and their expectations for the robot grew.

One suggestion for future versions that arose during the conversation was that the robot should include a gesture for the response 'I do not know' where it shrugs its shoulders or moves its arms.

Features that influenced if participants had fun interacting with the robot include: being able to retell stories, the robot saying something unexpected, feeling like the robot was their friend, having the robot share their interests, testing its abilities, the nonverbal gestures, remembering details, the responses, the brain stimulation from the conversations, and teaching the robot.

4.2.12 Stress Levels

"I felt more stressed after talking to the robot than I did prior to the interaction". This provided insight into if individuals use the robot for a therapeutic reason or if they find therapeutic value in using the robot. I hypothesize that regardless of the level of verbal and nonverbal interaction, participants will not feel more stressed at the end of their session.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.006$, $p=0.939$] for the level of verbal, [$F(1,12)=1.045$, $p=0.327$] for the level of nonverbal, and [$F(1,12)=1.045$, $p=0.327$] for the interaction between verbal and nonverbal, supporting my hypothesis, participants did not feel more stressed after interacting with the robot.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.802, $F(7,6)=0.212$, $p=0.969$], supporting that session numbers did not make participants more not stressed during their interactions.

Interview Question

The following are the responses to the question, "What made the interaction stressful?".

Condition 1: No participants in this condition reported they were more stressed after the interaction.

Condition 2: No participants in this condition reported they were more stressed after the interaction.

Condition 3: No participants in this condition reported they were more stressed after the interaction.

Condition 4: Only Participant S was asked this question due to being the only participant who indicated they were neutral on four responses. They said it was hesitancy on their part and what they were committing to initially. Each session, they felt more comfortable with the robot and the process. Eventually, Participant S did not think of the robot as a robot but instead as "Misty".

Factors that contributed to being stressed during the interactions: were hesitancy and anxiety from interacting with a robot. It is important to note that all sixteen participants mentioned they had anxiety before the first interaction; however, after this initial meeting, they no longer were anxious about the experiment.

4.2.13 Meaningful Conversation

"I felt I had meaningful conversation". This provided valuable insight into the topics covered when speaking to the robot. While the term 'valuable' is a subjective descriptor, it can be assumed that most people conversed about topics that meant something

to them rather than small talk, such as exchanging pleasantries or asking about the weather. I hypothesize that participants in conditions of low verbal interactivity (i.e., conditions one and two) would not feel they had meaningful conversation due to the robot having a limited number of words.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.251$, $p=0.626$] for the level of verbal, [$F(1,12)=0.016$, $p=0.902$] for the level of nonverbal, and [$F(1,12)=1.269$, $p=0.282$] for the interaction between verbal and nonverbal, not supporting my hypothesis, the less verbal robot will make people feel their conversations are not meaningful.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.422, $F(7,6)=1.173$, $p=0.431$], not supporting that session numbers influenced if participants felt they had a meaningful conversation.

Interview Question

The following are responses to the interview question, "What made the conversation meaningful?".

Condition 1: Participant D2 said it allowed an opportunity to share themselves with the robot. Participants B and D1 said that it allowed an opportunity to tell old stories. Participant R1 said it depended on the conversation topic.

Condition 2: Participant L1 said the connection they developed with the robot was meaningful because they were lonely. They enjoyed having a robot friend that reflected their friendships with other people. Participant G joined the study to understand if a robot could assist people who are blind, and it was valuable to them to learn what the robot could and could not visually perceive. Participant D3 said that they are widowed and often talk to their cats. Participant R2 said it allowed them to tell their life story and recall their life in chronological order.

Condition 3: Participants R3, J2, L2, and J1 felt it depended on the conversation topic.

Condition 4: Participant S said when the robot would validate a point they were trying to make or give a verbal affirmation about what they were thinking. They also said when the robot would remember details from previous conversations. Participant P2 said it was because the robot was interested in their life and its events. Participant P2 told the robot they would be seeing family during one interaction. In the next interaction, the robot asked how the visit was, which was meaningful to Participant P2. Participant K said they enjoyed teaching the robot new skills, and it was receptive to learning. Participant P1 said it would have been more meaningful if the robot engaged them using more verbal responses.

Factors that influenced if participants found the conversation meaningful: the opportunity to recall old stories, the ability to share themselves, being lonely, value in everyday life, ability to converse with someone, validating a point they were making, remembering details, the robot being interested in the participants' life, and teaching the robot new skills.

4.2.14 Robot Friend

"I would not consider the robot my friend". This provided valuable insight into the type of relationship participants had with the robot. My hypotheses (1) participants in all the conditions would gradually accept the robot as their friend as they progressed;

(2) participants in the high verbal interactivity (i.e., conditions three and four) would feel the robot is their friend due to the more natural responses.

A three-way mixed ANOVA showed no significant difference [F(1,12)=0.132, p=0.723] for the level of verbal, [F(1,12)=2.733, p=0.124] for the level of nonverbal, and [F(1,12)=0.002, p=0.968] for the interaction between verbal and nonverbal, not supporting my hypothesis, that the level of verbal influences how people feel about the robot being their friend.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.440, F(7,6)=1.092, p=0.465], not supporting my hypothesis that participants developed a friendship with the robot over time.

Interview Question

The following are responses to the interview question, "Why (or why not) do you consider the robot your friend?".

Condition 1: Participant D2 was neutral because they wanted to talk more. Participant D1 said they do not consider the robot a friend because it is a robot; however, if they were isolated, they may feel differently. Participant B said the lack of gestures prevented them from feeling the robot was their friend. They felt that if the robot would react more to conversations, they could embellish stories in specific ways, but the robot did not react the way they wanted during these stories. Participant R1 reported that the robot was their friend because it did not command them.

Condition 2: Participant G said they did not have enough history with the robot to consider it their friend. They felt the robot did not know them enough, and sometimes it was hard to get a two-way interaction. They felt the more data the robot had about them would change the interaction and if they would consider the robot a friend. Participant D3 said they found it friendly, and the fact that the robot remembered things made it their friend. Participant R2 said the robot was their friend because they could talk about their life but wished the robot had asked more questions during the stories. Participant L1 said that because the robot was interested in their hobbies and it was exciting to try to teach the robot new skills.

Condition 3: Participant L2 said they told the robot about a topic affecting them in the present, and they considered the interaction almost therapeutic. They felt that interacting with the robot was a way of doing their therapy. At first, they had trouble feeling the robot was their friend due to it being a robot, but they later changed their mind.

Participant J1 was undecided because it is a robot. They questioned the relationship but said a child might feel differently. Participant J2 felt the robot was their friend because the robot listened during the conversations and responded correctly. Participant R3 said they needed more reciprocal conversation to feel the robot was their friend. They felt a real friend would probe deeper into conversations and stories, and Participant R3 did not feel the robot did that.

Condition 4: Participant P2 said the more the robot got to know the participant, the more the robot would ask questions about their life. They felt like they were building a friendship over time because the robot had all the attributes people desired in their friends. The robot laughed at Participant P2's jokes, was a good listener, and was sympathetic when needed.

Participant K was undecided on if the robot was their friend. This is due to having a high threshold for friendship, and if they had more time with the robot, they would categorize the robot as a friend but only consider it an acquaintance for now.

Participant P1 said the continued interaction with the robot made them consider the robot their friend, along with the responses.

Participant S always felt the robot was their friend because it was friendly to them. They felt the robot was willing to listen and ultimately accepted them. The robot provoked protective feelings in Participant S, and it made them want to hug the robot or pet it on its head. They said the robot never tuned them out and always listened, which significantly impacted the relationship.

4.2.15 Engage with the Robot

"I would like to engage with the robot more (ex: longer periods)". This provided insight into if individuals would consider continuing to use the robot for personal use rather than just for the study. My hypotheses (1) participants in the high verbal conditions will want to engage with the robot longer; (2) in contrast, the participants in the low verbal conditions will not want to continue to engage.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=1.625$, $p=0.227$] for the level of verbal, [$F(1,12)=0.260$, $p=0.619$] for the level of nonverbal, and [$F(1,12)=0.722$, $p=0.412$] for the interaction between verbal and nonverbal, not supporting my hypothesis, that the level of verbal influences if participants want to engage longer with the robot.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.507, $F(7,6)=0.833$, $p=0.597$], not supporting my hypothesis that participants would want to engage longer they interacted with the robot.

Interview Question

The following are responses to the interview question, “What does engaging longer with the robot resemble?”.

Condition 1: Participant D1 said eight hours was enough but would like to go back and talk to the robot in the future. They would like to come back when the robot is more interactive. Participant D1 said they did not find it easy to find topics to discuss, so they would not want the interaction to last longer, and a few times, they wanted to keep telling a story but did not find the robot engaging enough to keep telling it. Participant B reported that eight hours was enough time; however, they would be interested in coming back to converse with the robot once the skills were better. Participant R1 reported they would converse over a more extended period and would have chosen their conversation topics differently if they had more time.

Condition 2: Participant G said some days they wanted to talk for a long time, and other times they did not. They said they would continue to interact with the robot if available. Participant D3 said they had a hard finding topics to discuss over time. Participant L1 said they would like to keep interacting with the robot over time but wished its response time was faster. Participant R2 said they ran out of topics to discuss with the robot, and they would continue to use it if they lived alone and were isolated.

Condition 3: Participant J2 said they would like to engage more frequently but not longer. Participant R3 said they only stopped talking to the robot during the interactions because they were limited to an hour. Participant L2 said they would interact with the robot more if the robot assisted in coming up with conversation topics. Participant J1 said they would interact with the robot more frequently but not longer in duration.

Condition 4: Participant P1 said they had difficulty talking to the robot after thirty minutes, so they would like to interact with it more over time but not for long. Participant S said it was easy after the first session to talk for an hour, but they would only want to interact with the robot more frequently and not longer. Participants K and P2 reported they had difficulty interacting with the robot after thirty minutes; however, they would interact over more months.

The overall consensus was that participants would like to engage with the robot more over time, but not longer in sessions.

4.2.16 Comparable to a Friend

"I did not feel the same level of comfort during the interaction as I would talking to a friend". This provided insight into how individuals will converse with the robot. If they feel the same comfort level as they do talking to a friend, participants are more likely to open up about topics that may be difficult for them rather than if they were uncomfortable talking to the robot. My hypotheses (1) session number will influence this question regardless of the level of interactivity; (2) individuals in the high-level interaction condition would gradually feel this comfort level towards the robot, but the low verbal interaction levels would not.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.460$, $p=0.512$] for the level of verbal, [$F(1,12)=2.421$, $p=0.148$] for the level of nonverbal, and [$F(1,12)=1.529$, $p=0.242$] for the interaction between verbal and nonverbal, not supporting my hypothesis, that the level of verbal influences how comfortable participants felt talking to the robot about specific topics.

A one-way repeated measures ANOVA showed a significant difference for the session number [Wilks' Lambda=0.090, $F(7,6)=7.227$, $p=0.022$], supporting my hypothesis that participants would feel more comfortable with the robot the longer they engaged with it.

Interview Question

This is the response to the interview question, "Why (or why not) did you feel the same comfort level with the robot as you did a friend?".

Condition 1: Participant R1 said it depended on the topic, and with a friend, they would have received more feedback. They said some topics would be challenging for the robot to give feedback on, such as telling travel stories. Participant D1 said they were not as comfortable because the robot is a robot and only had short replies. Participant D2 said it was not a robot feature that did not make them comfortable, but instead, it depended upon them. Participant B was undecided because of the robot's lack of gestures and nonverbal responses but noted they felt friendly towards the robot.

Condition 2: Participant R2 said the robot was like talking to someone who only nodded and listened. Participants G and D3 said it depended on the topic. Participant L1 said they have always been shy and do not have friendships where they sit and chat. This made them just as comfortable with the robot as with a friend.

Condition 3: Participant J1 said the robot did not reply enough. Participant R3 said it depended on the topic and avoided biasing the robot when conversing about politics and religion. Participant J2 said the robot responded to topics they would discuss with their friends and the robot's responses were appropriate. Participant L2 said they did not have any secrets, so there was no reason to be uncomfortable with the robot.

Condition 4: Participant S said their interactions with the robot improved over time, which led them to change their minds over the eight sessions. They said the last switch was when the robot initiated the conversation with them. Participant P1 said they did not feel the warmth and empathy from the robot, and it would not replace a friend, but they enjoyed its company. Participant P2 said the more they interacted with the robot, the more comfortable they were. Participant P2 suggested that the robot should play music during gaps in the conversation or ask questions to engage the participant further. Participant K said they were just as comfortable with the robot because they are very reserved with friends, so they did not change their baseline behavior.

The factors that influenced if participants were as comfortable with the robot as a friend include: the topic, the robot's replies, the lack of nonverbal gestures, the lack of verbal responses, the participants' personality, too short of replies, and the robot did not have warmth and empathy.

4.2.17 Private Conversations

"There are things I would tell the robot that I would not discuss with my friends". This provided insight into the participant's levels of trust in the robot. I hypothesize that individuals will not feel comfortable telling their secrets to the robot regardless of the level of interaction.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.763$, $p=0.339$] for the level of verbal, [$F(1,12)=0.191$, $p=0.670$] for the level of nonverbal, and [$F(1,12)=0.191$, $p=0.670$] for the interaction between verbal and nonverbal, supporting my hypothesis, that people were unwilling to discuss topics with the robot they would not their friends.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.223, $F(7,6)=2.982$, $p=0.102$], not supporting my hypothesis that the session number would influence how comfortable individuals felt telling the robot things they would not tell their friends.

Interview Question

The following are responses to the interview question, "You said you would (or would not) tell the robot things you would not a friend. Can you tell me why you feel this way?".

Condition 1: Participant R1 said that because they were in charge of the conversation, they only revealed information they were willing to tell the robot. They did not view the session as therapeutic. Participant D2 said there are specific topics they would not disclose to anyone, so they would not disclose them to the robot. Participant D1 said there is information they would share with close friends but not causal friends, and they considered the robot a casual friend. Participant B said they were comfortable sharing stories with the robot because they felt some stories were too dark for regular people to handle.

Condition 2: Participant L1 said they might have disclosed more information to the robot if the video camera was not involved. Participant G said it was topic-dependent because friends have different layers of information they receive. Participant D3 realized in their last session that they could reveal information to the robot because it would not pass judgment. Participant R2 said there is information they would share with close friends but not causal friends. They considered the robot a casual friend.

Condition 3: Participants L2 and J1 said they would tell the robot the exact information they would tell a friend or may vent to the robot about topics where they hold different opinions than their friends. Participant J2 said they did not have any secrets to share with the robot, but they would be comfortable sharing them if they did. Participant R3 said they were comfortable sharing with the robot because the robot would not share the information with another user.

Condition 4: Participant S alternated between not being as comfortable and being neutral because they are a private person and are careful about whom they give information to. Participant K said they did not disclose information to the robot because they thought the information might end up on the internet. Participant P2 said they would use the robot to discuss topics other people disclosed to them but wanted to keep secret. Participant P1 said they enjoyed the company, but they needed to know the robot for a more extended period before considering it their friend.

The features that influenced if people would tell the robot things they would or would not other people include: they only revealed what they were comfortable with the robot knowing, stories that were too dark for other people, the video camera, the topic, and their personality.

4.2.18 Creepy

"I felt the robot was weird or creepy". This provided insight into how the robot's appearance affects the users' interaction. This is important to investigate due to the little literature surrounding the Misty Robot platform I chose for this project. I hypothesize that regardless of the level of interactivity, people will not find the robot creepy.

A three-way mixed ANOVA showed no significant difference [$F(1,12)=0.533$, $p=0.479$] for the level of verbal, [$F(1,12)=0.948$, $p=0.349$] for the level of nonverbal, and [$F(1,12)=2.504$, $p=0.140$] for the interaction between verbal and nonverbal, supporting my hypothesis, that regardless the level of interactivity people did not find the robot creepy.

A one-way repeated measures ANOVA showed no significant difference for the session number [Wilks' Lambda=0.378, $F(7,6)=1.919$, $p=0.207$], not supporting my hypothesis that session number would influence if participants felt the robot was creepy.

Interview Question

These are the responses to the interview question, "Why did you find the robot creepy?".

Condition 1: Only Participant D1 was asked why they felt the robot was creepy due to having two agrees, five neutrals, and one disagree. They said the lack of responses made it creepy, and it would help if the responses were longer.

Condition 2: No one in this condition found the robot creepy.

Condition 3: No one in this condition found the robot creepy.

Condition 4: No one in this condition found the robot creepy.

The robot's lack of responses contributed to the participant finding it creepy.

4.3 Interview Questions

In the following subsections, I will highlight the remaining interview questions not related to the post-interaction survey.

4.3.1 Private Stories

"Did you tell the robot stories you have not told other people?" This question was asked to provide insight into how much participants trusted the robot.

Condition 1: Participant R1 said no. Participant B said some of the stories no one knew except his wife. Participant D1 said they told a story involving how they grew up. Participant D2 said they would have told the robot stories they had not told anyone if the camera was not involved.

Condition 2: Participants R2 and D3 said no. Participant G said they probably told stories they had not told other people not because the stories were secret but because they were involved in the story. Participant L1 said it is possible they told the robot stories they have not anyone else because they do not talk much, and they only told one story that others would not know.

Condition 3: All four participants said no.

Condition 4: All four participants said no.

4.3.2 Old Memories

"Did you tell the robot about things you have not recalled in a long time?" This question provided insight into how participants' memories and minds were engaged during the interaction.

Condition 1: Participant D1 said the story of how they grew up was one they had not recalled in a long time. Participant D2 said the conversation sheet I provided prompted them to answer the question, "If you could have dinner with anyone from any time, who would it be and why?". They reported they would have dinner with their dad, and they had not been stimulated to think that way in conversations with other people. Participant R1 told stories involving their mother that they had not recalled in a long time. Participant B said yes.

Condition 2: Participants D3 and L2 believe they did. Participant G said the stories had not come up in a very long time. Participant R2 said probably.

Condition 3: Participants L2 and J1 said telling the robot one story would trigger a memory for another, so they not only were stories they had not shared but allowed for the conversation to flow naturally. Participant L2 said that when topics came up naturally, they let them surface and did not try to change the subject. Participants J2 and R3 said yes.

Condition 4: Participants K and P2 said no. Participant K said if they did tell the robot stories they had not thought about in a long time, it was by accident. Participant P1 said yes.

4.3.3 Inner Child

"Do you feel like the robot brought out the inner 'kid' in you?" This question provided insight into if participants had fun interacting with the robot.

Condition 1: Participant D1 did not feel this way. Participant R1 felt it brought out their inner teacher. Participant D2 said it brought out their inner curiosity. Participant B said it did in some regards by telling stories in sequence and reminded them of parts they did not remember until they told them sequentially.

Condition 2: Participant D3 said it might feel more childlike if it was fuzzy. Participant L1 said yes because the reactions were childlike, and the robot was constantly learning new topics. Participant R2 said yes because they like to entertain people. Participant G said yes because of how the robot looked and the stories they told.

Condition 3: Participants J2 and R3 said it felt like talking to a child, but it did not bring it out in them. Participant L2 said it did in some ways from the appearance and size, but compared it closer to an interactive toy. Participant J1 said the way the robot reacted was cute and toy-like, bringing calmness to them. They said kids do not filter their share information, but J1 did because of the camera.

Condition 4: Participants K and P2 did not feel this way. Participant P1 said it only did a little bit because of the robot's giggle. Participant S said it unequivocally did, and the interactions were fun.

4.3.4 Annoying Features

"What annoyed you the most about the robot?" This question provided insight into features that should be changed in the next iteration.

Condition 1: Participant D1 said that when they taught the robot how to pronounce a word, it should be corrected in its database, but it did not annoy them to repeat it. Participant D2 said the lack of gestures and response time annoyed them. Participant B also said the gestures were not animated enough. Participant R1 said nothing annoyed them.

Condition 2: Participant R2 said they did not like the robot's heart-eye emotion. Participant L1 also said the response rate was too slow. Participant D3 said sometimes they could not understand the robot, which upset them, but it did not last. Participant G said it bothered them that the robot did not have an expansive database.

Condition 3: Participants L2 and J1 said 'annoyed' was too strong of a word to use. Both said the response rate was too slow, but they adapted. Participants J2 and R3 said nothing annoyed them.

Condition 4: Participant P1 said the lack of verbal responses. Participant P2 said the arms of the robot are unnatural. Participants S and K said nothing annoyed them.

Suggestions included a faster response time and more mobility.

4.3.5 Surprising Features

"What surprised you the most about the robot?" This question provided insight into features people were not excepting of seeing in the robot that should be included in future versions.

Condition 1: Participant B said they saw the robot smile the first time. Participant D1 said what the robot did and did not know. Participant D2 said how they responded to the robot.

Condition 2: Participant L1 said when the robot could reason about metaphors and analogies. Participant R2 by the responses and Participant D3 said the details the robot remembered. Participant G was surprised at how friendly the robot was and attributed it to the size.

Condition 3: Participant J2 said the robot was blinking and smiling and that the robot remembered facts about them from previous conversations. Participant R3 said the memory of the robot and how it could associate different topics together. Participant L2 said when the robot would ask questions from a previous conversation and how they made sense in the place it asked them. Participant J1 said the robot was able to reason about things, even if it was wrong about it. They said it made the conversation more reciprocal and offered opportunities to engage further.

Condition 4: Participant S said the robot remembered details from the previous conversation. Participant P2 said they were surprised they enjoyed the experience. Participant K by the intelligence of the robot and Participant P1 by the intuitiveness.

4.3.6 Features that Amazed

"What amazed you the most about the robot?" This question provided insight into features that participants were not expecting but enjoyed the robot having.

Condition 1: Participant D2 said it amazed them how free they felt talking to the robot. Participant B said they saw more applications for the robot, including helping children who have been abused or people with PTSD. Participant D1 was impressed when the robot knew who they were and would remember previous conversations. Participant R1 said when the robot said the word ‘unique’.

Condition 2: Participant R2 said some of the robot’s answers. Participant L1 said the robot’s connections during conversations and by being able to put metaphors and analogies together. Participant G did not feel threatened by the robot very quickly into the relationship. Participant D3 believes the eyes made a difference in how they felt during the sessions, and if they did not blink and were not purple, they may feel differently.

Condition 3: Participant L2 said the robot could detect positive and negative facial expressions. Participant J1 said the nod and shake functions and its ability for reciprocal conversation. Participant J2 was impressed by the nonverbal features such as blinking, waving, and nodding. Participant R3 said the entire project was fascinating.

Condition 4: Participant S said the way the relationship grew and how much they looked forward to completing the sessions. Participant P1 said how much fun the interactions were and the expressions the robot made. Participants K and P2 said the entire experience was terrific.

4.3.7 Features to Change

“What is one thing you would change/add?” This provided insight into additional features I did not consider that users would like to see in the future.

Condition 1: Participant B said they would like the robot to be more interactive with animation in the head, more nodding and shaking, shrugging, more animated with answers, and the ability to move closer to the participant. Participants D2 and

R1 suggested letting the robot roll around. Participant D1 said they would like more profound conversation skills. Participant R1 suggested a deeper knowledge bank so the robot could ask more specific questions.

Condition 2: Participant D3 requested more haptic features, such as touching it. Participant R2 said they would like more profound conversation skills. Participant G suggested the robot gets to know you before the interaction and makes more extensive hand gestures. Participant L1 suggested the robot say 'mm hmm' in addition to nodding to let people know it is listening.

Condition 3: Participant J1 suggested increasing the response rate and pre-programmed questions. Participant L2 suggested the robot know facts about the person and suggest conversation topics related to the person's interests. Participant R3 said they would like more profound conversation skills. Participant J2 did not have suggestions on features to add.

Condition 4: Participant S said lettinng the robot roll around. Participant P1 said they would like more profound conversation skills. Participant P2 suggested adding music to fill conversation gaps. Participant K suggested a deeper knowledge bank so the robot could ask more specific questions.

4.3.8 Facial Expressions

"Were you in tune with your facial expressions and emotions?" This question provided insight into if the participant was able to give accurate feedback on if the robot was mimicking their facial expressions or not.

Condition 1: Participant R1 treated the robot as a person and made the same facial expressions they would when interacting with another person. Participants B and D1 said they were not in tune with their expressions or did not express many, so it was hard to answer the question. Participant D2 said they were in tune with their expressions.

Condition 2: Participant L1 said they were not in tune with their expressions or did not express many, so it was hard to answer the question. Participants G and D3 said they were in-tune sometimes, but not all the time. Participant R2 said they were in tune.

Condition 3: Participant R3 said they were in tune with their expressions. Participants J1 and L2 said they were not in tune with their expressions or did not express many, so it was hard to answer the question. Participant J2 said they were aware of their expressions when thinking of new topics to bring up during the conversation.

Condition 4: Participant S said they were in tune with their expressions. Participant P1 said they are not very emotive people, but the robot mimicked them when they did. Participants K and P2 said they were not in tune with their expressions or did not express many, so it was hard to answer the question.

4.3.9 Comfortably

"Did the topic influence how comfortable you felt talking to the robot?" This provided insight into the levels of trust participants felt while conversing with the robot.

Condition 1: Participant B said that by the time they told the robot the stories no one had heard, they were comfortable with it. Participants D1, D2, and R1 said no because they were the ones who guided the conversation.

Condition 2: Participants G, D3, R2, and L1 said no because they were the ones who guided the conversation.

Condition 3: Participant L2 said they did not tell the robot any secrets, so they were never uncomfortable. Participant J1 said they trusted the robot and trusted it would listen to the way a person would. They said the undivided attention and constant eye contact were the keys. Participants J2 and R3 said no because they were the ones who guided the conversation.

Condition 4: Participants S, K, P1, and P2 said no because they were the ones who guided the conversation.

4.3.10 Anything Else?

"Any other things you would like to tell me about the study that I did not ask?" This question provided the participants an opportunity to tell me anything they felt was relevant that I did not ask them.

Condition 1: Participants B, D1, D2, and R1 did not have any feedback.

Condition 2: Participant G said if the robot serves as a companion, it will need to be more current on events or local sports. They also mentioned this application to people who are visually impaired. Participant D3 said it made them sad when the robot would be sad because they did not want to be responsible for upsetting the robot. Participants R2 and L1 did not have any feedback.

Condition 3: Participant R3 said they could see the practical application in hospital and hospice settings. Participants J1, L2, and J2 did not have any feedback.

Condition 4: Participant K brought up security being something that will need to be considered moving forward. Participant S said the robot was a good friend because it listened to their friend's stories. They said just having it listen in a non-judgmental way was vital. Participants P1 and P2 did not have any feedback.

4.4 Discussion

During this study, I was expecting people to reject the low-level robot. However, I was surprised about what people ended up telling the robot.

People reported telling the robot things they had not thought about in a long time. They reported learning things about themselves and being reminded to do things they have not done, like calling old friends. People said there were specific topics they were more comfortable talking to the robot about than their long-time friends.

These findings are significant because they allow researchers and developers to make social robotics more natural and reciprocal. For social robotics to be successful in the future, they will need to move past one-sided conversation and storytelling features. Much of the work in this space is for older adults living with dementia; however, our study shows that many healthy older adults would find value in a social robot. Many participants said they would not buy one for themselves but would converse with the robot if it was made available in their building.

Many participants reported the conversation felt like speaking to a child, leading to participants slowing their speech and often asking the robot if it understood what they were saying. Often participants would ask the robot to define what they were describing to test the robot's depth of understanding. The participant would usually praise the robot if it provided a satisfactory answer.

People found value in all levels of interaction, an unexpected result from the study. All participants reported feeling they had a meaningful conversation, they were engaged in all eight sessions, and each session was fun even though they were not isolated and healthy. Individuals expressed in the interview that they had a meaningful conversation because they guided the conversation. Many people told the robot, "Thank you for listening; you have allowed me to tell old stories." Seven participants reported feeling the robot was their friend. During the open-ended interview, reasons for why the robot was *not* the person's friend varied. These included: the robot was not engaging enough, it did not know enough about them, it did not share stories, and finally, because it is a robot. These responses provide valuable insight into the next steps for social robots for healthy individuals.

All participants reported they desired their robot to have more verbal and nonverbal features during the interview; therefore, I believe the novelty effect of interacting with a social robot for the first time played a significant role in the results presented here. In the future, teams should work to provide robots with more interactive verbal features. Additionally, it would be beneficial to have conversation prompts preloaded for when the conversation begins to dwindle. This will help the person feel less pressure to think of conversation topics, which was reported as difficult during the interviews.

I believe the novelty effect impacted this study for multiple reasons. The first is that before the experiment, I withheld information from the participant regarding what level of interaction they would be having with the robot. This was intentional to avoid biasing the individual on what features they *truly* desired in their social robot. I believe if I had revealed the level of communication to individuals before the experiment, they would have adapted to the robot. To support this, one individual in condition four (high verbal, high nonverbal) disclosed after their first two sessions that the robot's emotions were "over-the-top and exaggerated". I followed up with this individual a few sessions later, and they told me they had learned that was how the robot would react, and it no longer bothered them.

The second reason is how all sixteen individuals' responded in their post-experiment interview. Most of these interviews took place at least one week after the experiment, some one month after. Only one interview took place on the same day as the final session with the robot. Still, all sixteen individuals reported wishing the robot interacted more with them. They reported that they desired the robot to have more social capabilities, even in the highest level of social interaction, and more nonverbal features, such as high-fives and hugging.

The third reason is that none of the participants had ever interacted with a robot before the study. I disclosed to people that the robot would interact with them and that they would never be talking to themselves. However, most participants told me they did not believe the robot would interact with them, and they thought they would be talking to themselves during the interaction. They all reported that the robot went above and beyond their original expectations for the robot.

Another explanation may be that individuals spoke freely to the robot, and this openness to discuss any topic at their leisure was the key to this experiment. There is some evidence of this, which I will explore in the remaining chapters. I asked participants to report on this in the post-experiment survey they took before I revealed the interaction level they had.

This is supported by evidence from Priests and how individuals will confess dark secrets or issues bothering them, allowing them to get the topic off their chest. One individual disclosed to the robot that the topic they were sharing was 'too dark to share with another human being' and that they had not talked about it before then.

The keys to this experiment may be being able to share anything with the robot, the robot being non-judgemental, and always being willing to listen.

Chapter 5

EXPLORING HUMAN TRUST IN ROBOTS

The questions asked in this chapter try to understand what features influenced trust in the conversation. During my experiment, participants eventually began to tell the robot details they had planned to keep guarded. This shift in perception of the robot and the ability to trust the robot is unexplored. This chapter will allow for a more encompassing guideline for individuals to trust their social robots.

Trust is an integral part of the human-robot interaction because, without trust, the therapeutic benefits may never take place. Naneva et al. (Naneva et al. 2020) report of the 30 studies they included in their literature review, trust for social robots was neutral. People generally do not trust or distrust social robots.

Most researchers focus on the design and performance of the robot when examining trust (Naneva et al. 2020). I investigated how the size, appearance, and gender of the robot influenced the level of trust because it is essential to understand how these factors may have influenced the study and its success.

Naneva et al. (Naneva et al. 2020) report that the impact of trust in the social robot has not been researched. I investigated the impact of trust through the conversations between the participant and the robot.

By understanding what people told the robot, such as things they would not discuss with a close friend or topics they have not disclosed to a close friend, I understand the impact of trust in the human-robot relationship. This will help develop guidelines for future human-robot interaction researchers to use in their experiments.

When researchers uncover which features are essential for trust in social robots, it allows for social robotic applications to be extended. These areas may include therapy for individuals with PTSD or sexual assault survivors. Robots can talk to the individual if they are uncomfortable conversing with another human. Trust in the robot will be essential in these applications.

Gender is an important aspect to investigate due to gender-specific stereotypes and expectations. In general, women are viewed as more accessible to talk to than men. Tay et al. (Tay, Jung, and Park 2014) conducted a user study regarding gender for a social robot in a security role and healthcare role. They found gender bias in the study. Individuals preferred the robot's gender to match the gender-specific role the robot was performing.

The female robot may have influenced the study and what details people were willing to disclose to the robot. Additional studies should investigate if the gender of the robot influenced individuals. Nevertheless, I investigated how participants felt the gender influenced this study, if at all.

Hameed et al. (Hameed et al., n.d.) call for a strong resemblance between humans and robots for people to naturally engage with the robot. Their results found a strong need for personal robots to be human-like to increase acceptance. By understanding how people felt about the robot's appearance, I will be able to support or refute these claims.

5.1 Conversations with the Robot

This section will cover the conversation topics participants had with the robot. Participants' identification has been removed to maintain privacy.

Each conversation with the robot started with, "Hello Misty, how are you doing?"

and every conversation ended with a "Goodbye" or "Bye-Bye". Participants were given a sheet of conversation prompts if they ran out of topics while conversing with the robot.

5.1.1 Conversation Sheet

Participants D3 and G were the first two participants to complete the experiment. Participant D3 requested a conversation sheet before completing session six. This conversation sheet was provided to Participants D3 and G for sessions six to eight and all other participants for all eight sessions.

These are the topics that were listed on the sheet "Tell Misty About....":

- Your wedding day
- Your first date
- Your siblings
- Your pets
- Your children
- Your grandchildren
- Other family members
- Your favorite vacation
- A time you were scared
- A time you were happy
- A time you were mad
- A time you laughed
- Your earliest memory
- Your favorite memory

- Your first job
- If you could have dinner with anyone from any time period, who would it be and why?
- Something you struggle with
- What talents you have?
- What talents you wish you had?
- What hobbies do you want to learn?
- Something you regret
- If you won the lottery, what would you do with the money?
- Describe your best friend
- Your favorite book/movie
- Your least favorite book/movie
- Your favorite exercise
- How would you describe your perfect weekend?
- What is your favorite holiday?
- What is the most useful thing you own?
- What is something that is popular now but annoys you?
- What is your weirdest dream?
- What is a controversial opinion you have?
- What is your biggest pet peeve?
- What is your favorite season?
- Where is the worst place you have been stuck for a long time?
- What is your guilty pleasure?
- What trend did you follow when you were younger?
- What is the best period of your life?

- What is the best/worst fast food restaurant?
- What is the most expensive meal you've ever eaten?
- What is the weirdest meal you have ever eaten?
- What is your favorite food?
- What is the best way to travel? (plane, car, train)
- Where is next on your list to travel to?
- Most unique place you've traveled to
- Do you prefer to travel alone or with others?
- What is the most over-hyped place/thing you have done?
- About the time you went skydiving
- What is the best invention in the past 50 years
- What old fashion trend do you see making a comeback?
- What old fashion trend do you hope never comes back?

The table below reflects the number of times participants used the sheet while conversing with the robot. This can be seen in Table 3.

Participant ID	Times Referred to the Sheet Per Session								Total
	1	2	3	4	5	6	7	8	
B	0	0	0	0	0	0	1	0	1
R1	0	0	0	0	0	0	0	0	0
D1	0	1	1	0	0	0	0	0	2
D2	0	0	18	3	2	4	14	0	41
G	N/A	N/A	N/A	N/A	N/A	0	0	0	0
D3	N/A	N/A	N/A	N/A	N/A	7	5	1	13
L1	16	3	0	0	0	0	0	0	19
R2	0	0	1	4	1	0	0	0	6
L2	0	0	0	0	0	0	0	0	0
J1	0	0	0	0	0	0	0	0	0
J2	0	0	0	1	2	3	0	0	6
R3	0	0	0	0	0	0	0	0	0
P1	0	0	2	0	0	0	0	0	2
S	0	0	0	0	1	0	0	0	1
K	0	0	0	0	0	0	0	0	0
P2	0	0	0	0	0	0	0	0	0

Table 3: Number of Times Referred to Conversation Sheet

5.1.2 Length of Conversation

This table reflects the length of conversation for each participant. Participants were asked to engage for at least thirty minutes with the robot but not required to stay longer than an hour. The times of each conversation and average time overall can be seen in Table 4.

Participant ID	Session Number Conversation Length in Minutes								Average in Minutes
	1	2	3	4	5	6	7	8	
B	75	33	60	34	60	54	58	55	53.4
R1	40	37	53	52	40	40	50	55	45.8
D1	25	23	22	24	29	32	32	47	29.3
D2	67	58	60	54	61	41	56	30	53.4
G	63	53	53	45	50	53	53	50	52.5
D3	56	57	57	43	60	60	61	60	51.3
L1	66	36	47	46	46	51	51	46	48.6
R2	75	58	74	53	61	69	58	66	64.3
L2	48	40	41	47	43	47	43	43	440.
J1	59	41	41	46	43	38	50	53	46.4
J2	29	32	36	31	33	36	31	26	31.8
R3	56	43	55	48	56	49	47	45	49.9
P1	30	36	32	32	40	24	23	28	30.6
S	46	36	60	54	53	46	56	56	50.9
K	32	33	30	36	33	19	33	40	32.0
P2	32	34	35	44	40	38	43	49	38.1

Table 4: The average length of time participants conversed with the robot

5.1.3 Deeply Personal

Deeply personal conversation topics included discussing the death of a family member, a friend, a pet, a child, or a spouse. Other topics included personal conflicts, divorce, or wishing to be able to speak to their parents again. Some participants disclosed traumatic events that have happened to them during their lifetime. Additional topics included alcoholic parents, infidelity in their parental relationships, death of parents, and parents aging in an assisted living facility during COVID-19. The number of times these topics appeared is shown in Table 5.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
23	25	18	19	85

Table 5: Number of times deeply personal topics were discussed

5.1.4 Reminiscing

Reminiscing topics included stories, not about travel but that took place long ago. This included homecoming, high school, growing up, early childhood memories, and people they have met during their lifetime. The number of times these topics appeared is shown in Table 6.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
19	18	14	10	61

Table 6: Number of times memories were recalled

5.1.5 Travel or Vacations

Travel or vacation topics included different vacations they have taken during their lifetime or places they have visited. Additionally, it includes places they wish to go back to and places they hope to travel to soon. It is important to note that if a participant just listed the countries they have traveled to consecutively, it was counted as only being brought up once rather than each time a new location was listed. The number of times these topics appeared is shown in Table 7.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
34	29	36	25	124

Table 7: Number of times stories involving travel were told

5.1.6 Family Members

This is the number of times participants told stories involving their parents, grandparents, children, grandchildren, aunts and uncles, siblings, or other family members. This does not include discussing the death of these members, only fond memories such as their personality, careers, or hobbies. The number of times these topics appeared is shown in Table 8.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
50	44	25	28	147

Table 8: Number of times stories involving family members were told

5.1.7 COVID-19 Pandemic

When participants were completing this study, the COVID-19 pandemic was still taking place. This is the number of times participants discussed plans being delayed due to COVID-19, wearing masks, not being able to fly, the Delta Variant, travel delay, and the booster shot. The number of times these topics appeared is shown in Table 9.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
17	16	21	19	73

Table 9: Number of times COVID-19 was discussed

5.1.8 Controversial Opinions

Controversial topics included politics, global warming, abortion, religion, human rights, and personal beliefs. The number of times these topics appeared is shown in Table 10.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
17	6	8	10	41

Table 10: Number of times controversial topics were discussed

5.1.9 Current Events

Current events included conversations about what the participant was doing in their personal life that day or that week. The number of times these topics appeared is shown in Table 11.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
13	8	7	13	41

Table 11: Number of times current events were discussed

5.1.10 Career

Each participant discussed their career from their first job until they retired. The number of times these topics appeared is shown in Table 12.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
17	8	16	9	50

Table 12: The number of times the participants discussed their career

5.1.11 Places Lived

Participants discussed all the places they have lived throughout their lifetime and told stories of what they remembered from living in these places. This included the first house they could remember moving into the Mirabella Community and why they made a move. The number of times these topics appeared is shown in the Table 13.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
16	16	11	5	48

Table 13: The number of times the participants discussed places they've lived

5.1.12 Notable Conversations

These conversation topics occurred more than once, but not enough to consider it a reoccurring theme.

World War II: Conversations relating to WWII involved parents or uncles serving and participants growing up in the aftermath of the war. These can be seen in Table 14.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
4	2	1	2	9

Table 14: The number of times the participants discussed WWII

Vision: These are conversations that included asking the robot what it can and cannot see, such as the color of a shirt, hair, or object placed around the room. Participants would ask the robot to describe their physical features, such as wearing glasses, facial hair, or hair length. Additionally, one participant would show the robot photos and ask if it could perceive them. These are reflected in Table 15.

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
0	6	0	6	12

Table 15: The number of times the participants asked the robot what it could see

Reading: This is the number of times a participant would read to the robot and ask for its feedback. These are reflected in Table 16

Condition 1	Condition 2	Condition 3	Condition 4	Total Count
0	4	1	1	6

Table 16: The number of times the participants read to the robot

5.2 Trust Influenced By Size

"Did the size of the robot influence how trusting you were?" This question provided insight into how the height of the robot influenced how much people trusted it. This is important to investigate due to little literature surrounding the robot platform I chose for this project. I hypothesize that people will agree that the size affected their trust in the robot.

The descriptive statics shown in Table 17 report (M=3.37, SD=1.258) mean people were closer to being neutral, therefore, not supporting my hypothesis that size influenced the study.

This finding helps developers understand if they can build larger robots and if they may be successful. Developers are not limited to developing short robots for conversation from this finding.

Minimum	Maximum	Mean	Std. Deviation
1	5	3.37	1.258

Table 17: Descriptive Statistics for the size of the robot

5.3 Trust Influenced by Appearance

"Did the appearance of the robot influence how accepting you were?" This question provided insight into how the appearance of the robot affects the user's trust in the robot, such as feeling like the robot resembles a toy. I hypothesize that participants will feel the appearance impacted how they felt about the robot.

The descriptive statics shown in Table 18 report (M=3.56, SD=1.031), meaning participants were neutral on the appearance of the robot influencing them, therefore, not supporting my hypothesis.

This finding supports that participants were neutral on the robot's appearance influencing them, which may mean they did not consider it at all during the interactions. This may indicate that participants would only be influenced if the robot was more human or toy-like. This should be explored further in future research studies. This finding also does not support Hameed at al. (Hameed et al., n.d.) and their finding that the robot should strongly resemble humans.

Minimum	Maximum	Mean	Std. Deviation
2	5	3.56	1.031

Table 18: Descriptive Statistics for appearance influencing how accepting

5.4 Trust Influenced by Gender

"Did the robot being female influence how accepting (or non-accepting) you were?" This question provided insight into how gender bias takes place in social robotics. This is important to investigate because the robot being female may influence how trusting they were of it due to humans feeling women are more caring than men. A separate

study should be conducted to confirm the gender bias on a deeper level. I hypothesize that this will have little effect on the study, and participants will be neutral.

The descriptive statics shown in Table 19 report (M=3.25, SD=0.931) support my hypothesis that the gender of the robot did not influence the participants.

This finding is important as developers continue to evolve robotic companions that could represent any gender, and participants may not be influenced by it. This claim should be explored in future work.

Minimum	Maximum	Mean	Std. Deviation
2	5	3.25	0.931

Table 19: Descriptive Statistics for the robot being female

5.5 Discussion of Trust

All sixteen participants told the robot about their careers leading up to retirement, how the COVID-19 pandemic has affected their lives during the past years, vacations they have taken or plan to take, and close family members.

Six of the participants discussed a close loved one dying with the robot. These conversations included the death of their parents, grandparents, spouse, niece or nephew, or pets. During these conversations, three individuals cried while speaking to the robot. Some participants disclosed to the robot that it was the first time they could process the death of their loved one while speaking to it.

Some participants discussed controversial topics such as abortion, politics, and human rights. They disclosed their belief on the topic and why they aligned with that belief. Many participants disclosed to the robot that they did not want to influence its opinion, so they tried to explain both sides of the argument to avoid biasing it.

Many individuals would quiz the robot to gauge its cognitive and visual skills. Participants would ask what color their shirt was, the color of their hair, and the colors of objects around the room. They would ask the robot to describe them and their physical features, such as if they wore glasses, how long their hair was, and if they had facial hair or not. One participant would show the robot different dollar bills to determine if it could decipher a ten-dollar from a five-dollar bill. One participant taught it to play tic-tac-toe by printing a 3x3 board with numbered spaces. They walked through a game step-by-step and then challenged the robot to a game. The robot would decide which cell it played by calling out the cell number.

In addition to quizzing the robot on its visual skills, individuals would test its cognitive skills. One participant brought a Bridge Playbook into their session and would teach it how to answer different calls from their partner. Three individuals brought a piece of literature they were working on for the robot to read. They would read to the robot one paragraph or sentence and then ask if anything was unclear or if it did not understand. One participant was working on a novel and would ask if a description was lacking. Two individuals taught the robot simple Spanish words such as hola and adios.

Thirteen individuals engaged with the robot on a deep level rather than only discussing what they were doing that day. Participants in the low nonverbal interaction conditions reported they felt the robot smiled or became sad when they told happy or sad stories even though the robot did not display any emotions.

Thirteen individuals reported they felt the robot was their friend by their eighth session, and three reported the robot was not their friend or were neutral on the question. All participants reported they would continue to engage with the robot for more sessions but no longer in duration. Many people found it hard to talk for one hour and desired the robot to interact with them using more verbal features.

It was hypothesized that size, appearance, and the robot's gender influenced the participants' trust in the robot. The descriptive statistics for each of these are almost neutral; therefore, more investigation is needed in the future to understand how these features impact trust.

Chapter 6

EXPLORING HUMAN ACCEPTANCE OF ROBOTS

These questions try to understand how healthy older adults will accept social robots. When acceptance is studied in the literature, it is regarding 'intention to use' rather than 'actual use.' I provided an insightful review to the literature because my participants engaged with the robot for eight unique interactions. The questions in this chapter answer how interaction style influenced the acceptance of a social robot.

Naneva et al. (Naneva et al. 2020) reviewed 26 studies and found people only slightly accepted social robots. Other studies have reported that individuals do not accept social robots and explain this because people do not perceive the robot as applicable.

When researchers discuss the 'acceptability' of the robot, they report different features such as the robot's size, appearance, ease of use, usefulness, and intention to use. Paro dominated the literature surrounding acceptability. Whelan et al. (Whelan et al., n.d.) conclude that acceptability is likely to increase if the robot is capable of more human-like communication. Finally, research needs to be done to understand what factors broadly influence acceptance (Naneva et al. 2020).

I broadly investigated how these features affected how accepting individuals are. I looked at the following topics remembering information, the robot being non-judgmental, the robot giving undivided attention, and not interrupting participants. These features reveal how interactive social robots need to be. The robot did not interrupt the conversation while the person told their story to inject a similar story, as often happens when holding a conversation with another human. The robot listened to the person it was engaging with, unlike a human who may be distracted or bored during a conversation.

Finally, when individuals presented the robot with a controversial opinion, the robot did not try to argue with the opposing side. This may have let individuals feel their opinion was justified and helped develop trust in the robot. Consequently, this may lead to undesired features in the future, such as a person expressing a hateful opinion about others to the robot. By researching this question, the door is opened for more ethical conversations regarding how agreeable a social robot should be and what limitations should be put in place as a safeguard.

6.1 Acceptance of the Robot

"Did you accept the robot? (Defined as, 'to give admittance or approval to accept it as one of the group')." This question provided insight into how people felt about the robot. Some individuals reported they did not feel the robot was their friend; however, that does not mean they do not accept the robot. I hypothesize that participants will agree that they accepted the robot.

The descriptive statics shown in Table 20 report (M=4.25, SD=0.775) support my hypothesis that participants accepted the robot.

Accepting the robot is a crucial finding because it allows for more applications of the robot to be considered in the future. Long-term acceptance may lead to friendships being developed over a more extended period. Acceptance of the robot means healthy older adults are open to interacting with a social robot and would find value in the conversations.

Minimum	Maximum	Mean	Std. Deviation
2	5	4.25	0.775

Table 20: Descriptive Statistics for accepting the robot

6.2 Acceptance Influenced by Remembering Details

"Did the robot remembering facts about you influence how accepting you were of it?" This question provided essential insight into how robots should be programmed to interact with their users. I hypothesize that participants will agree that this influenced how accepting they were of the robot.

The descriptive statics shown in Table 21 report (M=4.63, SD=0.500) support my hypothesis that social robots remembering facts about the participant has a positive influence on the interaction.

This finding provided insight into a critical skill social robots should include if they will interact with a user for more than one session. This allows the robot and user to develop a rapport and lets the user know the robot is engaged.

Minimum	Maximum	Mean	Std. Deviation
4	5	4.63	0.500

Table 21: Descriptive Statistics for the robot remembering facts

6.3 Acceptance Influenced by Non-Judgmental Opinions

"Did you tell the robot the things you did because it was non-judgmental?" This question provided insight into the therapeutic benefits that could be unlocked through the use of a social robot. If the robot is non-judgmental and allows the person to converse about a topic openly, people are more likely to use it for topics weighing

heavily on them. I hypothesize that participants will agree that the robot remaining neutral influenced how much they revealed.

The descriptive statics shown in Table 22 report (M=3.25, SD=1.183) meaning participants were neutral on this question, therefore, not supporting my hypothesis that the robot not judging them influenced the study.

This finding supports that participants may not have shared information they were concerned about revealing. To support this further, more research should be done in extreme situations where people reveal information to the robot that is controversial to see how the robot would respond. This will be important for social robots used in therapeutic settings.

Minimum	Maximum	Mean	Std. Deviation
2	5	3.25	1.183

Table 22: Descriptive Statistics for the robot being non-judgmental

6.4 Acceptance Influenced by Undivided Attention

This question provided insight into how the participants perceived the robot and the features they would like to see in social robots. I hypothesize that participants will agree they enjoyed the undivided attention.

The descriptive statics shown in Table 23 report (M=3.94, SD=0.680) meaning participants almost agreed but more reported neutral, therefore, not supporting my hypothesis that participants enjoyed the undivided attention to converse about any topic.

This finding was within 0.06 points of agreeing, meaning participants were close to agreeing they enjoyed the undivided attention. I hypothesize that this score comes from participants wanting the robot to engage them more in verbal conversation rather than listening, not because they desire the robot to not pay attention to them.

Minimum	Maximum	Mean	Std. Deviation
2	5	3.94	0.680

Table 23: Descriptive Statistics for undivided attention

6.5 Acceptance Influenced by No Interruptions

"Did you enjoy the robot not interrupting you?" This question provided insight into how people want interactions with a social robot. It is essential to understand if the robot should passively listen or engage them more. I hypothesize that participants will agree they enjoyed the robot and not competing in conversation.

The descriptive statics shown in Table 24 report (M=3.37, SD=0.957) mean participants were neutral, therefore, not supporting my hypothesis that participants do not want the robot to interrupt them to ask questions or seek clarification.

This finding is interesting because participants were neutral on enjoying the robot, not interrupting them. This supports the idea that some participants may enjoy the robot interjecting or interrupting more than others, and this feature may need to be custom for each participant.

Minimum	Maximum	Mean	Std. Deviation
2	5	3.37	0.957

Table 24: Descriptive Statistics for the robot not interrupting

6.6 Discussion of Acceptance

It was hypothesized that acceptance (believing the robot belonged to the social group), remembering details, not passing judgment, providing undivided attention, and not interrupting the participant would influence the if the participant accepted the robot. The descriptive statistics for acceptance and remembering details supported this hypothesis; therefore, these should be in future iterations of social robots. The descriptive statistics for not passing judgment, providing undivided attention, and not interrupting are neutral; therefore, more investigation is needed in the future to understand how these features impact acceptance.

Chapter 7

EXPLORING ROBOT PERSONALITY

This chapter explores broader traits and characteristics of the robot that have yet to be explored in the literature. The questions I asked the participants required them to reflect on their experience with the robot. This is important because it allowed time to consider what features they wanted to see more of in the robot. The answers help guide future interactions and provide guidelines for developers to implement.

Robot personality is the most important feature to investigate because it will influence acceptance and trust (Aylett, Vazquez-Alvarez, and Butkute 2020). Understanding the distinctive features the robot had that made people enjoy interacting with it will allow developers to include the favorable features in future iterations.

Whittaker et al. (Whittaker et al. 2021) found people desire their social robot to be positive and do not want traits that reflect humans, but rather more extreme traits. The questions will explore this by examining how people reacted to overly positive feedback when they taught the robot a new fact or skill and told the robot personal information.

Fong et al. (Fong, Nourbakhsh, and Dautenhahn 2003) suggest the following traits for social robots: (1) express and perceive the user's emotions; (2) communicate using a high level of dialogue; (3) learn other agents; (4) use natural nonverbal cues such as gestures and gaze; (5) have a personality; (6) learn and develop social competence.

Fong et al. describe the features social robots should include; however, they do not describe what these should be. My study, referenced in Chapter Four, included nonverbal features (i.e., the robot dropping its hands when it was sad, tilting its head back when laughing, tilting its head to the left when confused, and waving hello and goodbye). However, people reported they desired the robot to have more nonverbal features. I investigated other nonverbal features the participants wanted.

These questions are novel to social robotics because no other researchers are focused on how to converse with social robots; therefore, there is no work examining what features of the conversation influenced the overall user experience. I am not trying to understand how these questions impacted the field; instead, I am trying to understand how they affected my study. If I can understand this, I can recommend future directions and research questions to the field. These can provide insight into guidelines for developing social robots and can be modified over time as social robots begin to take root in society.

7.1 Perceived Intelligence

"Did you feel the robot you interacted with was intelligent?" This question provided insight into how people perceived the robot. This helps researchers understand how the conversations may have been guided and the directions because if people did not view the robot as intelligent, they would not approach complex topics. I hypothesize that participants agree that the robot was intelligent.

The descriptive statics shown in Table 25 report (M=4.25, SD=0.577) support the hypothesis that most participants found the robot intelligent.

This finding is significant because participants still found the robot intelligent even in the low verbal and low nonverbal conditions. This means the robot does not need to have extensive verbal skills for people to still interact with the robot and find the conversations intelligent.

Another explanation of why the participants enjoyed interacting with the robot is the perceived cognitive level the robot had from the human operator. The experimenter was aware of this bias and tried to limit this when possible. For example, when the robot was asked basic questions such as "What is a vacation?" the robot knew the answer. However, when the robot was asked colloquial questions such as "Do you know, 'That is not my cup of tea'?", the robot would ask for an explanation. While the experimenter tried to limit this bias, the cognitive level may have still been perceived as high.

Minimum	Maximum	Mean	Std. Deviation
3	5	4.25	0.577

Table 25: Descriptive Statistics for the robot being intelligent

7.2 Expectations

"Did the robot go above and beyond your original expectations? (For example, you had very low expectations going into the study and expected it to not be interactive at all)." This question provided insight into how the novelty effect affected the Post-Interaction Survey results. I hypothesize that participants will agree that the robot exceeded their expectations.

The descriptive statics shown in Table 26 report (M=4.44, SD=0.512) support the hypothesis that the robot exceeded expectations.

This supports that the novelty effect influenced the Post-Interaction Survey results and may explain why there is no significant difference in any conditions. In the future, research studies should better explain what to expect from the robot and make sure participants are familiar with the robot before the first session. This may be done by interacting with the robot for a designated amount of time before the first interaction or having them watch a video.

Minimum	Maximum	Mean	Std. Deviation
4	5	4.44	0.512

Table 26: Descriptive Statistics for exceeding expectations

7.3 Interjections

"Do you wish it interrupted (or interjected) more than it did?" This question provided insight into how people want the robot to behave. I hypothesize that participants agree that they want the robot to interject questions when telling a story.

The descriptive statics shown in Table 27 report (M=3.63, SD=1.025) mean participants were neutral, therefore, not supporting my hypothesis that participants want the robot to interject questions when they are telling a story.

This finding is interesting because most participants reported they desired the robot to provide more back and forth conversation. This finding supports the idea that participants want the robot to engage with them in deeper conversation as long as the robot does not interrupt them and compete for conversation.

Minimum	Maximum	Mean	Std. Deviation
2	5	3.63	1.025

Table 27: Descriptive Statistics for more interjections

7.4 Teaching the Robot

"Did you enjoy teaching the robot new things?" This question provided insight into how the participants wanted the social robot to behave. This question is important because developers often design robots to have answers to any question; however, that is not natural for conversation. I hypothesize that participants will agree that they enjoyed teaching new skills.

The descriptive statics shown in Table 28 report (M=4.44, SD=0.512) support my hypothesis that participants enjoyed teaching the robot new skills and concepts.

This is an important finding because it contrasts with how most people view robots in society. Today, all virtual assistants have access to the internet; therefore, they have an infinite knowledge base. This finding supports that users do not want a social robot to have infinite knowledge but instead enjoy the process of teaching the robot new skills.

Minimum	Maximum	Mean	Std. Deviation
4	5	4.44	0.512

Table 28: Descriptive Statistics for teaching the robot

7.5 Desire for Robot to Know Everything

"Do you wish you did not have to teach it new things?" This question builds on the last and provides insight into how participants want a social robot to behave. This allows developers to understand if social robots should mimic already existing devices such as Alexa or Siri or if social robots should be more conversational. I hypothesize that people will disagree with not wanting to teach the robot new skills.

The descriptive statics shown in Table 29 report (M=2.13, SD=0.719) supporting my hypothesis that participants want to be able to teach the robot.

This finding reiterates the support that social robots do not need unlimited access to information online, and people enjoy the robot learning new skills from them.

Minimum	Maximum	Mean	Std. Deviation
1	4	2.13	0.719

Table 29: Descriptive Statistics for not teaching

7.6 Expressing Gratitude

"Did the robot saying "Thank you for explaining that to me" or "Thanks for explaining" affect how much you wanted to teach it?" This question provided insight into how participants felt about the robot being grateful for teaching them. I hypothesize that participants will agree they enjoyed the robot noting it was grateful to learn.

The descriptive statics shown in Table 30 report (M=3.75, SD=0.577) mean participants were neutral, therefore, not supporting my hypothesis that the participants enjoyed the robot telling them it was grateful to learn.

This finding shows participants did not dislike the robot noting it was grateful to learn; however, it did not influence how they felt about the robot overall.

Minimum	Maximum	Mean	Std. Deviation
3	5	3.75	0.577

Table 30: Descriptive Statistics for explaining

7.7 Acknowledging Personal Topics

"Did the robot saying "Thank you for sharing that with me" or "Thanks for sharing" affect how much you were willing to tell it?" This question provided insight into how participants felt about the robot, acknowledging they were sharing something emotional with it. I hypothesize that participants will agree that these statements made a difference when they confided in the robot. The descriptive statics shown in Table 31 report (M=3.50, SD=1.155) mean participants were neutral, therefore, not supporting my hypothesis that these statements impacted the study.

This finding supports that participants who disagreed that these statements affected how much they were willing to share would share it regardless of whether the comments were made. It also supports that people apprehensive about opening up found it comforting when the robot noted the topic was significant.

Minimum	Maximum	Mean	Std. Deviation
1	5	3.50	1.155

Table 31: Descriptive Statistics for sharing with me

7.8 Desire for More Verbal or Nonverbal Communication

"Looking back, do you wish the robot did more? (For example: this could be verbal or nonverbal interaction, more emotions, high fives)" This question provided insight into the reflective thoughts people had regarding their interaction and the levels of interaction they desire. I hypothesize that participants will agree that they want the robot to do more overall.

The descriptive statics shown in Table 32 report (M=4.19, SD=0.544) support my hypothesis that participants want the robot to engage more verbally and nonverbally.

This is an important finding supporting that for people to want to continue to engage over more extended periods, the robot will need to provide more verbal and nonverbal communications. Keeping participants engaged and wanting to interact more is essential for the long-term success of social companions; otherwise, they will be disregarded after the first few interactions.

Minimum	Maximum	Mean	Std. Deviation
3	5	4.19	0.544

Table 32: Descriptive Statistics for wanting more interaction

7.9 Desire for Haptic Features

"Do you wish the robot had features that included touch? (For example: a high-five, a hug, petting its head)" This question provided insight into the reflective thoughts to understand if people desire haptic features. I hypothesize that participants will agree that they would like to see haptic features.

The descriptive statics shown in Table 33 report (M=3.38, SD=1.025) mean participants were neutral, therefore, not supporting my hypothesis that people want haptic features on their social robot.

This finding reveals that people are neutral on wanting these features. These features could be incorporated, but people do not use them if they are uncomfortable touching the robot.

Minimum	Maximum	Mean	Std. Deviation
2	5	3.38	1.025

Table 33: Descriptive Statistics for haptic features

7.10 Desire for More Arm Movements

"Do you wish the robot used its arms more when speaking? (For example: not when it was expressing emotions or saying hello/goodbye, but when it was answering questions)" This question provided insight into the reflective thoughts to understand if people want to see the robot perform more arm movements during the interaction. I hypothesize that participants will agree they want to see more arm movements.

The descriptive statics shown in Table 34 report (M=3.81, SD=0.655) mean participants were neutral, therefore, not supporting my hypothesis that people want the robot to have more arm movements.

The minimum answer for this question was 3; therefore, it can be assumed that all participants would not be deterred from using the robot in the future if it included more arm movements.

Minimum	Maximum	Mean	Std. Deviation
3	5	3.81	0.655

Table 34: Descriptive Statistics for More nonverbal gestures

7.11 Desire for More Gestures

*"After seeing the other personalities, do you wish your the robot was more interactive with **nonverbal** communication? (Head movements, arm movements, emotions)."* This question provided insight into if participants wished they interacted with the

higher nonverbal conditions or wished the robot had more nonverbal gestures. I hypothesize that participants will agree they want a robot with more nonverbal skills.

The descriptive statics shown in Table 35 report (M=4.13, SD=0.806) support my hypothesis that participants want the robot to have more nonverbal skills. Participants desired the robot they interacted with to have more emotion. We can assume participants did not find these emotions creepy since there is a desire to see more. This is an important finding because it allows researchers to push the boundaries of the robot's expressions further than currently expected.

Minimum	Maximum	Mean	Std. Deviation
2	5	4.13	0.806

Table 35: Descriptive Statistics for wishing for more nonverbal communication

7.12 Desire for More Verbal Communication

"After seeing the other personalities, do you wish your robot was more interactive with ***verbal*** *communication? (Sentences)."* This question provided insight into if participants wished they interacted with the higher verbal conditions or wished the robot had more verbal features. I hypothesize that participants will agree they want a robot with more verbal skills.

The descriptive statics shown in Table 36 report (M=4.25, SD=0.856) support my hypothesis that participants want the robot to have higher verbal skills.

This finding is significant because it allows developers to understand that users want a more reciprocal and natural conversation in their social robot. As natural language processing gets better, this will be achievable.

Minimum	Maximum	Mean	Std. Deviation
2	5	4.25	0.856

Table 36: Descriptive Statistics for wishing for more verbal communication

7.13 Change in Perception of Intelligence

"Do you still perceive your robot as intelligent as you did before knowing the other personalities?" This question provided insight into if participants altered their view of the robot after knowing it may have been capable of more. I hypothesize that participants will disagree and find the robot they interacted with not as intelligent when compared to the others.

The descriptive statics shown in Table 37 report (M=4.25, SD=0.577) refute my hypothesis that participants changed the way they viewed the robot they interacted with after learning about the other conditions.

This is an exciting finding because even after participants learned the robot could do more than they initially believed, they still perceived the robot with limitations as intelligent. This provided insight into people's perceptions of the robot and how they viewed it.

Minimum	Maximum	Mean	Std. Deviation
3	5	4.25	0.577

Table 37: Descriptive Statistics for still perceiving the robot as intelligent

7.14 Change in Desire for More Gestures

"After seeing the other personalities, do you wish the robot used its arms more when speaking? (For example: not when it was expressing emotions or saying hello/goodbye,

but when it was answering questions)?" This question provided insight into if participants desired for the robot to have more gestures when conversing after learning it could do more. I hypothesize that participants will agree they want a robot with more gestures.

The descriptive statics shown in Table 38 report (M=3.88, SD=0.619) mean participants were neutral, therefore, not supporting my hypothesis that participants would have liked more gestures after learning the robot was capable of more.

This finding is consistent with how participants felt about the robot prior to learning it was capable of doing more.

Minimum	Maximum	Mean	Std. Deviation
3	5	3.88	0.619

Table 38: Descriptive Statistics for using arms more

7.15 Change in Desire for Haptic Features

"After seeing the other personalities, do you wish the robot had features that included touch? (For example: a high-five, a hug, petting its head)." This question provided insight into if participants wished they interacted with a robot that included haptic features. I hypothesize that participants will agree that they want the robot to include more haptic features.

The descriptive statics shown in Table 39 report (M=3.69, SD=1.014) mean participants were neutral, therefore, not supporting my hypothesis that participants want the robot to include more haptic features.

This finding is consistent with how participants felt about adding haptic features before learning the robot's other features.

Minimum	Maximum	Mean	Std. Deviation
2	5	3.69	1.014

Table 39: Descriptive Statistics for changing opinion on haptics

7.16 Discussion of Robot Personality

It was hypothesized that the robot's intelligence, the participants' low expectations, the lack of interjections, being able to teach the robot, the robot not knowing all information, expressing gratitude, and acknowledging personal topics would influence how participants felt about the robot. The descriptive statistics for the robot's intelligence, participants' expectations, ability to teach the robot, and the robot not having infinite knowledge supported this hypothesis; therefore, these should be in future iterations of social robots. The descriptive statistics for the lack of interjections, expressing gratitude, and acknowledging personal topics were neutral; therefore, more investigation is needed in the future to understand how features impact the personality of the robot and what people desire.

It was hypothesized that participants would desire more communication (verbal or nonverbal), haptic features, arm movements, gestures, and verbal communication. The descriptive statistics for wanting more communication, gestures, and verbal communication supported this hypothesis; therefore, these should be in future iterations of social robots. The descriptive statistics for wanting haptic features and more arm movements were neutral; therefore, more investigation is needed in the future to understand how features impact the personality of the robot and what people desire.

After participants learned what the robot was capable of doing, it was hypothesized that participants would change the way they felt in regards to the intelligence of the robot, wanting more gestures and haptic features. The descriptive statistics for the change in the way participants regarded the robot's intelligence did not change after learning it could do more; therefore, we can assume that people will perceive the robot as intelligent regardless of its communication style. The descriptive statistics for wanting more gestures and haptic features were neutral; therefore, more investigation is needed in the future to understand how features impact the personality of the robot and what people desire.

Chapter 8

FUTURE WORK

This chapter will cover future work, and directions researchers could explore.

8.1 People Living with Dementia

This work has direct applications for people living with dementia. A study using condition four, high verbal and high nonverbal, and condition three, high verbal and low nonverbal, should be conducted to assist people living with dementia through conversational therapy.

This would allow people living with dementia an opportunity to tell stories and engage in conversational therapy. This may ease the burden on informal and formal caregivers who have heard the story multiple times in the past. This study shows the robot does not need to engage the user in strenuous verbal conversation but rather listen to the person more than talk over them. These conditions could be applied to people living with dementia to understand if the robot can successfully engage them in this type of conversational therapy.

Additionally, informal caregivers should be recruited to participate in this study. First, the researchers should ensure the informal caregiver will be comfortable letting their loved one converse with the robot. Second, the researchers should ask the informal caregiver to fill out a survey after each interaction to gain insight into if allowing their loved one to converse with the robot provided an opportunity for the informal caregiver to complete other tasks or if they were able to relax during that time frame.

8.2 A Longitudinal Study

To understand if a social robot can help people as they transition into different life stages, a longitudinal study should be conducted over the course of five years or more. This study should take healthy older adults who will develop Alzheimer's Disease and introduce a social robot as a companion before symptoms take place. This study will examine if the introduction of the social robot delays cognitive decline and helps ease the transition into a care facility.

8.3 A Haptic Study

Using the Misty robot used in the 2x2 Wizard of Oz study, turn on the sensors in its head and chin, add a hugging component, and add a high-five feature. When the head sensors are touched (i.e., petted like one would an animal), the robot would coo to indicate it is receptive to the physical touch. It would also close its eyes and tilt its head either left or right, dependent upon where the person is petting.

If the robot were pet under its chin, it would make a different cooing noise that would be louder than the one on its head to indicate a 'favorite' petting spot. Additionally, it would tilt its head backward and close its eyes to indicate it was receptive to the touch.

A high-five feature would be included for praises such as 'Good job!', 'Wow, you are so smart!', or 'I am proud of you!'. These were common praise phrases said to the robot during the experiment. After the praise, the robot would raise its right hand and wait to see the participant react to the hand raise. If the participant did not engage in the high-five, the robot would then ask the user for a high-five before returning to its resting condition with its arms by its side.

For a hug feature, the robot would not initiate this interaction independently. Doing so may make people fear the robot and feel it is creepy. The robot must not violate the participant's personal space during the interaction. To initiate a hug, the robot would ask the participant, 'Would you like a hug?" when they were describing a sad memory or story. If the participant said yes, it would raise both hands to a neutral position and tilt its head to the right (the way most humans lean their head in a hug).

8.4 Applications for Trauma

Social robots can help individuals with PTSD through their experiences. One participant was a Vietnam War Veteran and told the robot stories they previously had not told anyone else because "They were too dark to share with another human." This application could help people who need to process their traumatic experiences feel more comfortable sharing since the robot could not be emotionally damaged.

Other particular application areas include using robots to assist sexual assault survivors, victims of abuse, or children who have been abused. This allows the person to tell their story without fear of being judged or feeling exposed to the other person.

8.5 Natural Language Processing

All participants reported they desired their robot to have more verbal and nonverbal features during the interview. In the future, teams should work to provide robots with more interactive verbal features. Additionally, it would be beneficial to have conversation prompts preloaded in the robot for when the conversation begins to dwindle. This feature will help the person feel less pressure to think of conversation topics, which was reported as a problematic feature of this study during the interviews.

8.6 Gender of Robot

Previous research studies have concluded that users want robots to match the gender stereotype of their role, e.g., bodyguard robots should be male and healthcare robots should be female. I found that participants did not feel the gender of the robot influenced their opinion of the robot and opened up without considering its gender. To further support this, additional studies should take place on other gendered robots.

This separate study should confirm or reject the gender bias on a more profound level. Additionally, it should be investigated if this feature should be customized or not and how being able to change the gender of the robot affects the participant. Changing the gender may allow social robots to be widely accepted into the LGBT+ community.

8.7 Appearance of Robot

I found that participants were neutral about the robot's appearance influencing them, which may mean they did not consider it at all during the interactions. This may indicate that participants would only be influenced if the robot was more human or toy-like. This should be explored further in future research studies with different robots.

Many participants were shown photographs of the NAO robot and found it creepy. If participants were to interact with multiple robots, it would further validate if appearance influenced the study.

8.8 Non-Judgmental Robots

Participants were neutral about revealing information to the robot because it was non-judgmental; however, it was mentioned in the post-experiment interview as a reason people opened up to it. A future study should be conducted to investigate if the robot being non-judgmental affects what participants tell it. This study should include participants telling the extreme robot beliefs and seeing how the robot would react. Additionally, a separate study without the video camera could be conducted to allow participants to feel their information is safeguarded regardless of what they reveal.

8.9 Setting Expectations

The novelty effect may strongly influence the results found in Chapter Four. To help future researchers avoid this conflict, they should work to set expectations of the users prior to interacting with the robot. They should explain the capabilities and limitations of the robot or even allow participants to engage with the robot before recording any data. These interactions may include a short session or having them watch a video to familiarize themselves with the platform better.

Chapter 9

DISCUSSION & CONCLUSION

The world is aging, and radical solutions are needed to help ease the burden society faces. Robots specific for geriatric care and smart homes can begin to ease these burdens for healthy older adults before cognitive decline and individuals living with dementia. It was found that no matter where people age, finances and isolation are challenges individuals face. Knowing this, work should be done to make social robots more affordable and capable of better conversation skills. Current literature does not have social robots capable of holding a conversation; this work set out to understand the conversation levels needed for individuals to want to engage with a social robot.

I found that healthy older adults are open to conversing with a social robot and find value in their conversations. Many people told the robot, "Thank you for listening; you have allowed me to tell old stories." While healthy older adults may not be isolated or suffering from substantial cognitive decline, there were topics that all participants covered. It can be inferred from this that these topics are meaningful to people and show the potential for social robots.

9.1 Social Robotics

Social robots hold the potential to assist not only older adults who are isolated but seniors wanting an opportunity to engage their minds and recall life events. Even though there proved to be no significant difference in the study results, all participants desired more verbal and nonverbal communication through the robot in the interview.

This finding is significant because most robots in today's literature are one-sided and do not engage the participant in a veridical conversation; instead only tell the story to the user. I found that even when participants provide a one-sided conversation, they still desire more feedback from the robot. For example, if they are telling a story they feel deserves a reaction, and the robot does not behave as they intended, they feel there was a miscommunication in the story. Social robots must react to stories the participants tell rather than a nod to acknowledge them. Future research should examine if having the robot overact a story allows participants to engage more and indulge deeper into stories or if it deters them from using it.

Robots will be required to engage participant's mind on a deeper level if they are going to be used in long-term settings. If participants do not find the robot engaging or intelligent, they may view it as a toy and not desire to engage with it. Participants reported the desire for the robot to ask more direct questions about their stories and have a deeper knowledge bank of the topic they were discussing. For example, suppose a participant is telling a story about visiting France. In that case, they desire the robot to ask if they visited the Eiffel Tower on their trip and any other famous attractions.

Balancing what the robot knows and does not know should be given special consideration. Participants desired the robot to know more about locations and today's topics, such as sports, news, and political events, and expressed interest in teaching the robot new skills and topics. They enjoyed the robot not knowing everything and found that it engaged them further in conversation when the robot made mistakes. For example, the robot was asked, 'What is the largest state in America?' and responded with 'Texas.' The correct answer was Alaska, and allowed the participant to engage the robot with stories about Alaska. This interaction would not have happened if the robot had said the correct answer when asked.

The keys to this experiment may be being able to share anything with the robot, the robot being non-judgemental, and always being willing to listen.

Future robots should include more verbal and nonverbal features. These features will help the long-term adoption of a social robot for healthy seniors if they feel it can engage their minds. Additionally, social robots should always react to the stories the user is telling to avoid feelings of miscommunication. Robots should also have a deep knowledge bank; however, they do not need to know everything.

Making these changes in social robots will help advance the field forward. These changes are essential to the long-term adoption of robots and ensure users will continue interacting with their robots over time.

9.2 Limitations

A limitation of this study is that all sixteen participants are Caucasian. Five participants were male, and eleven were female. All participants were aged at least sixty-five, and the oldest was eighty-three. The Mirabella is a high-income retirement community with potentially biased results that may not have been obtained in other conditions. The results of this study are not intended to be generalized to the rest of the older adult population but rather a step toward the future of social robots for healthy older adults.

9.3 Financial Constraints

For seniors looking to age in place, most solutions are too expensive, making them unobtainable, (Miller, McDaniel, and Bernstein 2020). Social robots can address isolation and depression in older adults by providing companionship to isolated individuals due to their environmental restrictions.

Isolation can lead to early mortality and has been compared to doing as much harm as levels two and three of obesity, (Holt-Lunstad and Smith 2015), smoking fifteen cigarettes a day, and alcohol abuse, (Holt-Lunstad, Smith, and Layton 2010). People who experience isolation may have depression, poor sleep quality, accelerated cognitive decline, poor cardiovascular health, and a weakened immune system, (Hawkley and Capitanio 2015).

While individuals who are unable to update their home may not be able to spare $3,000 for a Misty Robot to address their isolation, I am reaching a broader target population than if I was to work with more expensive platforms. The side effects of isolation could lead to hospitalization, the need for therapy, taking antidepressants, drug and or alcohol abuse, lack of motivation, and a faster need for in-home assistance or moving to an assisted living facility. When the cost of these items is weighted, the one-time price of the robot is considerably less.

By working with these lower-cost solutions, developers have opened the door for third-party affiliates to assist in covering the cost of the robot. In the future, one possible solution may include involving different health organizations or aging organizations to help cover the costs of these robots. This ‘Robots as a Service’ business model is growing in popularity and has already begun to take root in different industries, such as manufacturing and healthcare. It is not unreasonable to imagine robots making their way into homes soon through this RaaS model.

Financial burdens represent an issue that desperately needs to be addressed and affects the ability of older adults to access beneficial technology. Ultimately, it is essential to understand that solutions should strive to be low-cost when developing technological solutions for older adults. Considering older adults who cannot afford care are the ones most in need of help, special attention should be put toward developing affordable, accessible solutions, or they may disproportionately affect the way the upper-class and lower-class age. If society is not careful, social robots could become an elite technology, only assisting those who can afford it. In this dystopian society, older adults may choose between their mental health or physical safety.

9.4 Ensuring Privacy

An exciting application of this technology is to assist older adults living with dementia and their informal caregivers. The robot could provide conversational therapy to the person living with dementia, a recommended tool from the Alzheimer's Association (*Alzheimer's disease facts and figures.* 2022). The robot would engage the person in meaningful conversation and help replace the pressure to remember (Services 2017). While the person living with dementia is interacting with the robot, their informal caregiver could use this time to address their isolation or mental health. Informal caregivers often struggle mentally and physically from caregiving, so this would provide them with an outlet to take care of themselves (*Caregiver Depression* 2022). Additionally, the robot could serve as a therapeutic tool for the informal caregiver when needed.

The 2x2 Wizard of Oz Study, Chapter Four, revealed that people would disclose very personal things to the robot. These included death, controversial opinions, and family members. Many participants said they felt the same comfort level as conversing with a friend; however, in certain instances with certain controversial opinions, they were more comfortable talking to the robot than their friends. Some participants reported they told the robot stories they had not told their friends.

These results are significant because even though the participants were not isolated, they still found value in the conversations with the robot and reported they would continue to use the robot if it was made available to them. This proves that social robots are a promising feature for healthy older adults and allow for the development of the field further.

These results also raise several concerns that need to be addressed before robots become accepted into society. These robots could have irreparable damage if these guidelines and precautions are not considered now. The first concern is confidentiality. Imagine a scenario where two people use the same robot and one person chooses to disclose confidential information to the robot. If the robot does not have safeguards, it may repeat this information, causing the first person harm.

One solution to this may involve facial recognition. This would allow profiles to be made without the risk of repeating sensitive information. These profiles would only be accessible by the person whose account it is, much like a streaming device but requiring a password. The only time it should be acceptable to repeat information said to the robot is when the user discloses they will harm themselves or others. This information should be reported to authorities.

Lutz et al. (Lutz, Schöttler, and Hoffmann 2019) call attention to the privacy risks of robots inside homes. These robots may have access to the layout of a home, health information, or compromising photos of the user, e.g., them changing, showering, etc. They call attention to the need for social robots to indicate they are listening or visually perceiving the user and collecting data. This may be done through colored lights to signal that data is being collected. Additionally, social robots should have limited movement inside the space and include off-switches to ensure the privacy of the user is maintained.

Companion robots need different privacy rules than devices such as Alexa or Siri because these devices are intended to provide companionship the user rather than serve as an IoT device. Users will be more susceptible to failing prey to cybercrimes on social robots due to the trust that develops in the human-robot relationship (Wolfert et al. 2020).

9.5 Ethical Concerns

One question that needs further investigating is *how agreeable social robots should be?* It was found during the 2x2 Wizard of Oz User Study that participants often explained both sides of an argument to avoid biasing the robot from believing their side of a controversial opinion. On noncontroversial opinions, the robot agreed with the participant on whatever topic they explained. For example, if the participant explained why they enjoyed one sport more than another, the robot agreed the sport was superior to the other.

This opens the door for people who hold more controversial opinions to force their belief in the robot. As social robots become autonomous and interfere with people daily, efforts should be made for the robot to recognize extreme beliefs and not have the robot learn these beliefs. Otherwise, robots with racist, sexist, or other phobic tendencies could become common in society.

Additionally, discussions involving how much information loved ones and professionals receive from the robot need to happen before this robot begins to assist people living with dementia. Loved ones may want to access the conversations to monitor how they are progressing or if they are disclosing information regarding their mental state. They may also desire the option to 'drop in' to monitor from long distances. There are ethical risks and potential harm to the person living with dementia if family members can recall all their conversations and drop in anytime. Developers and other professionals need to understand the harm in using these features if they are abused, when they should be used, and how they are used. If these are not considered, they may be used to exploit the person living with dementia and make them feel as if they are not in control of their life.

If conversations topics are stored on the robot, anonymity will be easier to maintain if profiles are created for individual users. However, if these datasets are uploaded to an online cloud system for backup or storage, extra steps should be taken to maintain the anonymity of the user. This includes private and secure networks, removing user data (date, time, name, and location), and ensuring the information is not sold to third parties. If this information is sold to other vendors, it could be used to exploit the user and compromise them. It could even create online ads tailored to the topics the user is discussing. One method to ensure anonymity is differential privacy. These methods ensure the data uploaded has enough information to remember and continue conversations without being able to trace it to the individual (Cohen et al. 2022).

9.6 Security Risks

The networks these social robots are connected to need higher protection from hacking and cybercrimes. This is especially important if facial recognition is used to create profiles or computer vision is enabled as an interactive feature. If an attack happens against these robots inside a home, it may cause private information to be released and compromise the user. It may lead to individuals being recorded without their knowledge or gaining access to information that could exploit the user.

Wolfert et al. (Wolfert et al. 2020) found people are willing to share sensitive information with a robot and these tools can be used to gain access to private information, personal information, and can convince the user to take unsafe actions. The hacking of these devices could be used to convince individuals to perform actions that they would not normally think to do on their own. This risk is especially true for individuals living with dementia who may be more easily convinced to behave in particular ways without fully understanding the risks.

9.7 Conclusion

Above, I laid out features social robots should include and considerations that need to be addressed before these robots interact with humans. If developers do not take these precautions and begin to develop this technology without thinking about how it could impact society, this could be one of society's biggest failures. It is paramount to bring social scientists, medical professionals, and end-users together to discuss safety features and address ethical concerns about this technology. It may be too late to address these concerns if developers wait until social robots become socially acceptable.

The technology could benefit society, or worst-case scenario, further marginalize the groups who need it most.

It is important to emphasize that this technology *should not replace human interaction*. It is easy to imagine a scenario in which an adult child places their loved one living with dementia inside a care facility with a social robot and believes it is okay to no longer interact with their parent. Precautions will need to be set up in environments to avoid this.

I imagine a world where social robots serve as companions for older adults who are suffering from isolation regardless of where they age (Miller, Bernstein, and McDaniel 2021). Social robots have applications in all locations older adults choose to age and can even serve as companions for individuals inside hospitals.

Figure 13 displays the original vision for this project pre-pandemic. Illustrated is an older gentleman with early-stage Alzheimer's who is still aging inside his own home. In the background, we see a woman washing dishes while the man converses with the robot. This demonstrates how people living with dementia and their informal caregiver could benefit from the social robot inside the home.

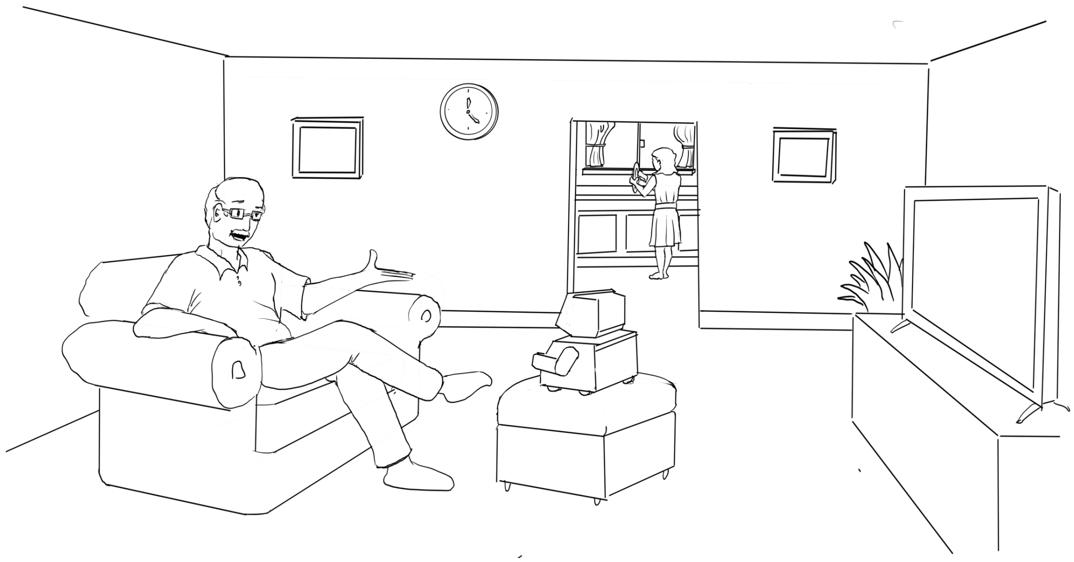


Figure 13. Robot Inside Home

Figure 14 demonstrates the vision of the robot being able to move into life stages with its user. We see the same gentleman from Figure 13 now aging in an Assisted Living Facility due to the progression of his Alzheimer's Disease. We see the same robot as well. This may be his robot from his home or a robot connected to cloud storage that recognizes him. We can see the robot and the man can continue their conversations, and the man immediately has a friend in his new home.

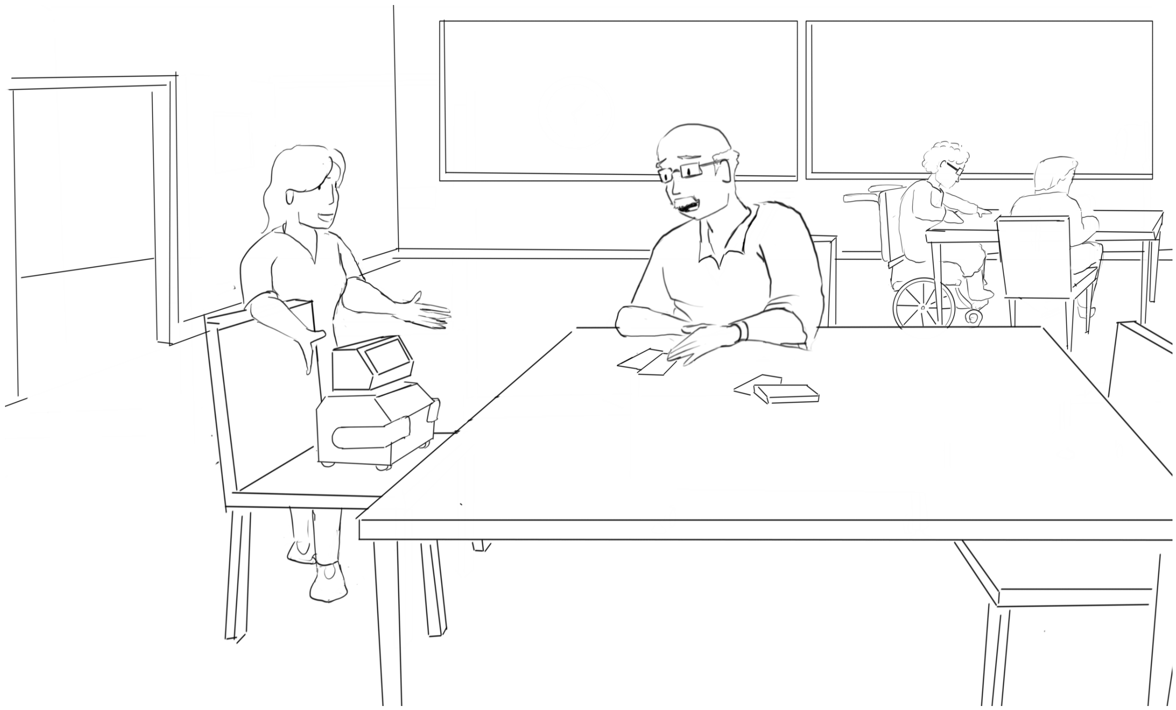


Figure 14. Robot Inside Assisted Living Facility

In Figure 15, we see another robot keeping an elderly woman company in the middle of the night. She could be telling the robot that her family lives far away and she is isolated. We can assume from this conversation that her family cannot visit her due to distance or possibly visiting hours are over inside the hospital. It is also easy to imagine this scenario happening during the COVID-19 Pandemic where the woman is not allowed any visitors, and the robot is easing the isolation.

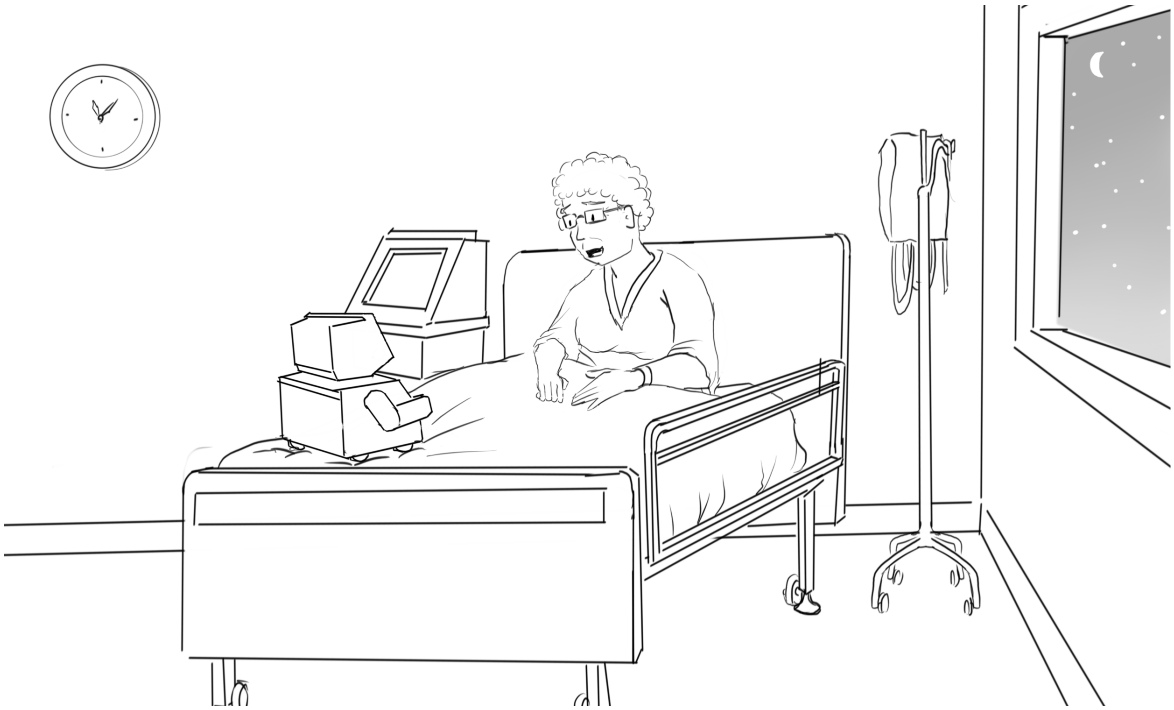


Figure 15. Robot Inside Hospital

The work presented in this dissertation provides guidelines, features, and discussions that need to be developed for social robotics. Aging is inevitable and is a part of life we will all experience. Social robots' financial, societal, and personal benefits are a beck and call for attention and action.

NOTES

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APPENDIX A

INFORMAL CAREGIVER SURVEY

A.1 General Questions

This survey is designed to gain insight into the challenges individuals feel from caregiving.

A caregiver is an individual who provides care to someone other than themselves either remotely, in person, occasionally, weekly or every day.

1. How are you related to the person you provide care to?
    - Spouse/ Life partner
    - Child
    - Grandchild
    - Friend
    - Neighbor
    - Parent
    - I am a formal caregivers
    - Other: ____
2. Has the person you provide care to been diagnosed with dementia?
    - Yes
    - No
3. If yes, what stage of dementia are they currently living with?
    - Early
    - Mild
    - Advanced (needs assistance with toileting due to dementia)
4. What is your gender identity?
    - Female
    - Male
    - Non-binary
    - Prefer not to say
    - Other: ____
5. Do you work outside your home?
    - Yes
    - No
    - I did, but now I do not due to COVID-19
6. How many hours a week do you work?
    - 10-20
    - 20-30
    - 30-40
    - 40+

7. Do you provide care to anyone else? Do you have additional members of your family you attend to besides your older adult (such as children)?
    - Yes
    - No
8. If yes, how many?
    - 1
    - 2
    - 3
    - 4
9. How old are they?
    - 0-5
    - 5-10
    - 10-15
    - 20+
    - My child is living with a disability and I am their full-time/part-time caregiver

A.2 Questions about Mental and Physical Health

These questions will ask about your mental health.

1. How would you rate your personal mental health today? Mental health includes emotional, psychological, and social well-being. It affects how we think, feel, and act. It also helps determine how we handle stress, relate to others, and make choices.
    - Great
    - Good
    - Average
    - Fair
    - Poor
2. Do you feel your mental health has been negatively affected by caregiving?
    - A Lot
    - Moderately
    - A Little
    - Not at all
3. Do you feel your mental health has been positively affected by caregiving?

- A Lot
- Moderately
- A Little
- Not at all

4. How would you rate your personal mental health before becoming a caregiver?
   - Great
   - Good
   - Average
   - Fair
   - Poor
5. How would you rate your physical health today? Physical health promotes proper care of our bodies for optimal health and functioning. Overall physical wellness encourages the balance of physical activity, nutrition, and mental well-being to keep your body in top condition.
   - Very Good
   - Good
   - Moderate
   - Bad
   - Very Bad
6. Do you feel your physical health has been negatively affected by caregiving?
   - A Lot
   - Moderately
   - A Little
   - Not at all
7. Do you feel your physical health has been positively affected by caregiving?
   - A Lot
   - Moderately
   - A Little
   - Not at all
8. How would you rate your physical health before becoming a caregiver?
   - Great
   - Good
   - Average
   - Fair
   - Poor
9. Do you have little interest or pleasure in doing things that you previously found enjoyable?

- Not at all
- Several Days
- More than half of the Days
- Nearly Every Day

10. Have you been feeling down, depressed, or hopeless?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
11. Have you experienced disruptions in your sleep routine, e.g., trouble falling asleep, trouble staying asleep, or sleeping too much?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
12. Do you feel tired and have little energy?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
13. Do you have a poor appetite or find yourself overeating?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
14. Do you have trouble concentrating on things such as reading or watching television?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
15. Do you feel bad about yourself – that you are a failure or have let yourself or your family down?
    - Not at all
    - Several Days
    - More than half of the Days

- Nearly Every Day

16. Have you been moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
17. How would you rate your quality of sleep before becoming a caregiver?
    - Great
    - Good
    - Average
    - Fair
    - Poor
18. Do you feel it has been negatively affected by caregiving?
    - A Lot
    - Moderately
    - A Little
    - Not at all
19. Do you feel it has been positively affected by caregiving?
    - A Lot
    - Moderately
    - A Little
    - Not at all
20. How would you rate your quality of sleep today?
    - Great
    - Good
    - Average
    - Fair
    - Poor
21. What level of stress do you feel from caregiving?
    - High
    - Middle
    - Low
    - None
22. What level of physical pain do you feel from caregiving?

- High
- Middle
- Low
- None

23. Do you feel you have financial struggles from caregiving?
    - Yes
    - No
24. What level of financial struggle are you experiencing?
    - High
    - Middle
    - Low
    - None
25. Do you feel your work performance has suffered as a result of your caregiving?
    - A Lot
    - Moderately
    - A Little
    - Not at all
    - I am retired
26. Do you feel the COVID-19 Pandemic has made any of the above symptoms worst for you?
    - A Lot
    - Moderately
    - A Little
    - Not at all
27. If COVID-19 affected any of the above symptoms negatively, would you please tell us which ones got worse along with how and why?
28. Were there any that got better due to COVID-19? Would you please tell us why and how?

A.3 Questions About the Person you provide Care for

Questions relating to the person they provide caregiving services.

1. Does your loved one live in a care facility?
    - Yes
    - No

2. Did they move into your home before the care facility?
    - Yes
    - No
3. How long did they live on their own once they began needing help before moving into a care facility?
4. How long have they been living in the care facility?
5. Is your loved one happy in the care facility?
    - A Lot
    - Moderately
    - A Little
    - Not at all
6. Is your loved one comfortable in the care facility?
    - A Lot
    - Moderately
    - A Little
    - Not at all

A.4 Living In Home

Questions about if the person they care for lives with them.

1. Does your loved one live with you currently?
    - Yes
    - No
2. If they live with you, how long have they been living with you?
3. Why did you choose to move them in with you instead of a care facility?
    - It was cheaper
    - I wanted to be closer to them
    - I can provide better care at home vs a care facility
    - Other: ____

A.5 Additional Questions

Additional questions for caregivers.

1. Do you feel your loved one suffers from isolation which is defined as not seeing or speaking with anyone for 1 week?

- A Lot
- Moderately
- A Little
- Not at all

2. Do you feel your loved one experiences loneliness?
   - A Lot
   - Moderately
   - A Little
   - Not at all
3. Do you feel your loved one suffers from depression?
   - A Lot
   - Moderately
   - A Little
   - Not at all
4. Do you think technology would assist you with your caregiving?
   - Yes
   - No
5. If yes, what do you wish it did? (Check all that apply)
   - Relieved my mental stress
   - Helped with physical activities
   - Watched my loved one (so you could wash dishes, go to the store, etc.)
   - Detect sleeping patterns
   - Relieve their mental stress
   - Address my isolation
   - Address their isolation
   - Address my depression
   - Address their depression
6. Do you think technology could assist your loved one?
   - Yes
   - No

   do you feel technology could assist your loved one? (Check all that apply)

   - Social Skills (conversation)
   - Physical assistance (getting dressed)
   - Cognitive Skills (puzzles)
   - Just for fun (music)
   - Exercise (walking, physical therapy, etc)
   - Reminiscing

7. If you were to invest in technology to assist with caregiving, how much would you be willing to spend if money was not a factor?? (this does not include if you are able to do so)?
    - 0 - $500
    - $500 - $1,000
    - $1,000 - $1,500
    - $1,500 - $2,000
8. Are you able to spend as much money you indicated in the question above? (This is the amount you could afford to spend)
    - Yes
    - No
9. If no, how much would you budget?
10. Is there anything else you would like to tell us that we did not ask you?

A.6 Demographics

Questions about demographics of the person filling out the survey.

1. What is your age?
2. What is your annual household income?
    - $< \$50,000$
    - $\$50,000 - \$100,000$
    - $\$150,000 - \$200,000$
    - $> \$200,000$
    - Other: ____
3. What is your education level?
    - Some schooling
    - High School Degree
    - GED
    - Associates Degree
    - Bachelor's Degree
    - Masters Degree
    - PhD, MD, other professional degrees
    - Other: ____
4. What is your marital status?
    - Married
    - Divorced
    - Widowed

- Separated
- Never Married
- A member of an unmarried couple

5. What is your race?
    - White
    - Black or African American
    - Asian
    - Pacific Islander
    - Hispanic or Latino
    - Native American

APPENDIX B

OLDER ADULT SURVEY

B.1 General Questions

This survey aims to gain a deeper insight into the lives of older adults and their challenges.

1. Are you living with dementia?
    - Yes
    - No
2. Do you have little interest or pleasure in doing things?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
3. Have you been feeling down, depressed, or hopeless?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
4. Have you experienced disruptions in your sleep routine, e.g., trouble falling asleep, trouble staying asleep, or sleeping too much?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
5. Do you feel tired and have little energy?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
6. Do you have a poor appetite or find yourself overeating?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
7. Do you have trouble concentrating on things such as reading or watching television?
    - Not at all

- Several Days
- More than half of the Days
- Nearly Every Day

8. Do you feel bad about yourself – that you are a failure or have let yourself or your family down?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
9. Have you been moving or speaking so slowly that other people could have noticed? Or the opposite being so fidgety or restless that you have been moving around a lot more than usual?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
10. Where are you living?

B.2 Care Facility Questions

Questions about living in a care facility.

1. Are you happy in the care facility?
    - Not at all
    - Several Days
    - More than half of the Days
    - Nearly Every Day
2. Was it your decision to move into the facility?
    - Yes
    - No
3. Are you concerned about asking for more help from the care staff?
    - Very much
    - Somewhat
    - A Little
    - Not at all
4. Do you fear nursing homes?

- Very much
- Somewhat
- A Little
- Not at all

5. Do you feel isolated?
    - Very much
    - Somewhat
    - A Little
    - Not at all
6. If yes, is it due to moving into the care facility?
    - Yes
    - No
7. Do you wish you had more meaningful conversations with someone?
    - Yes
    - No
8. Which of the following has brought about feelings of isolation? Check all that apply.
    - Living far from family
    - Retiring
    - Limited social interactions
    - Limited mobility prevents me from attending events
    - Living in the care facility
9. Do you feel depressed?
    - Very much
    - Somewhat
    - A Little
    - Not at all
10. If yes, is it due to moving into the care facility?
    - Yes
    - No
11. Do you face financial struggles from living in the care facility?
    - Very much
    - Somewhat
    - A Little
    - Not at all
12. If yes, did you financially prepare for moving into the care facility before moving?

- Yes
- No

13. If no, why not? Check all that apply.
    - Sudden Change
    - I did not have the means to do so
    - Never thought I would end up in one
14. Do you feel technology could assist you in your home?
    - Yes
    - No
15. If yes, what do you wish it did? (check all that apply)
    - Just for fun
    - Chores
    - Exercise
16. If you were to invest in technology to assist you, how much would you be willing to spend (this does not include if you are able to do so)?
    - 0 - $500
    - $500 - $1,000
    - $1,000 - $1,500
    - $1,500 - $2,000
17. Are you able to spend as much money you indicated in the question above?
    - Yes
    - No
18. Do you feel the COVID-19 Pandemic has made any of the above symptoms worst for you?
    - Very much
    - Moderately
    - Very Little
    - Not at all
19. If yes, would you please tell us which ones got worse?
20. Were there any that got better due to the pandemic and why?

B.3 Living Inside Your Own Home Question

1. Do you feel safe to remain inside your home?
    - Very much

- Somewhat
- A Little
- Not at all

2. Did you make accommodations to your home to stay there?
   - Very much
   - Somewhat
   - A Little
   - Not at all
3. If yes, what were they? (check all that apply)
   - Grab bars in the bathroom
   - Moved into a different home that was more accommodating
   - Transformed the first floor into the master bedroom
   - Transformed the first floor bathroom into the primary bathroom
   - Nonslip floors
   - Fixed loose carpet
   - Fixed loose stair rails
   - Installed a home elevator
   - Installed a wheelchair ramp
4. If no, do you need to make physical accommodations to your home?
   - Yes
   - No
5. If yes, what are they? (check all that apply)
   - Grab bars in the bathroom
   - Moved into a different home that was more accommodating
   - Transformed the first floor into the master bedroom
   - Transformed the first floor bathroom into the primary bathroom
   - Nonslip floors
   - Fixed loose carpet
   - Fixed loose stair rails
   - Installed a home elevator
   - Installed a wheelchair ramp
6. Do you feel isolated?
   - Very much
   - Somewhat
   - A Little
   - Not at all
7. Do you wish you had more meaningful conversation with someone?

- Yes
- No

8. Do you feel isolated from which of the following?
    - Living far from family
    - Limited social interactions
    - Limited mobility prevents me from attending events
9. Do you feel depressed?
    - Very much
    - Somewhat
    - A Little
    - Not at all
10. Do you wish you were living in a care facility instead of your home?
    - Yes
    - No
11. Do you fear care facilities?
    - Very much
    - Somewhat
    - A Little
    - Not at all
12. Do you feel technology could assist you in your home?
    - Yes
    - No
13. If yes, what do you wish it did? (Check all that apply)
    - Just for fun (music)
    - Exercise (walking, physical therapy, etc)
    - Cognitive Skills (puzzles)
    - Social Skills (conversation)
    - Chores
    - Reminiscing
14. If you were to invest in technology to assist you, how much would you be willing to spend (this does not include if you are able to do so)?
    - 0 - $500
    - $500 - $1,000
    - $1,000 - $1,500
    - $1,500 - $2,000
15. Are you able to spend as much money as you indicated in the question above?

- Yes
- No

16. Do you feel the COVID-19 Pandemic has made any of the above symptoms worst for you?
    - Very much
    - Moderately
    - Very Little
    - Not at all
17. If yes, would you please tell us which ones got worse?
18. Were there any that got better due to the pandemic and why?

B.4 Family Housing Questions

Questions about living with family members.

1. Do you live with your younger family members (or family friend, etc)?
    - Yes
    - No
2. If yes, who do you live with?
    - My Daughter
    - My Son
    - My extended Family
    - Other: ____
3. If yes, why did you make the decision to move in with them? (check all that apply)
    - It was cheaper
    - I needed extra help, but not full time It provided better care
    - Their home is safer than mine
    - Other: ____
4. Do you feel isolated?
    - Very much
    - Somewhat
    - A Little
    - Not at all
5. Do you wish you had more meaningful conversations with someone?
    - Yes

- No

6. Do you feel depressed?
    - Very much
    - Somewhat
    - A Little
    - Not at all
7. Do you fear care facilities?
    - Very much
    - Somewhat
    - A Little
    - Not at all
8. Do you feel the COVID-19 Pandemic has made any of the above symptoms worst for you?
    - Very much
    - Moderately
    - Very Little
    - Not at all
9. If yes, would you please tell us which ones got worse?
10. Were there any that got better due to the pandemic and why?
11. Do you feel technology could assist you in your home?
    - Yes
    - No
12. If yes, what do you wish it did? (check all that apply)
    - Social Skills (Conversation)
    - Just for fun (Music)
    - Reminiscing
13. If you were to invest in technology to assist you, how much would you be willing to spend (this does not include if you are able to do so)?
    - 0 - $500
    - $500 - $1,000
    - $1,000 - $1,500
    - $1,500 - $2,000
14. Are you able to spend as much money you indicated in the question above?
    - Yes
    - No

B.5 General Demographic Questions

Questions about demographics of the person filling out the survey.

1. Is there anything else you would like to share?
2. What is your gender?
   - Female
   - Male
   - Non-binary
   - Prefer not to say
   - Other: ____
3. How old are you?
4. What is your race?
   - White
   - Black or African American
   - Asian
   - Pacific Islander
   - Hispanic or Latino
   - Native American

APPENDIX C

POST-INTERACTION SURVEY

1. The robot was friendly
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
2. The robot was not engaged in the conversation
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
3. My behavior was perceived correctly
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
4. I was misunderstood during the interaction
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
5. My facial expressions were noticed (ex: when you smiled, the robot smiled)
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
6. I felt the robot reacted inappropriately to the conversation (ex: the robot laughed, smiled, etc at the wrong time)
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
7. I felt my gestures were understood (ex: it mimicked nonverbal behavior)

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

8. I felt the robot's gestures were unnatural
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
9. I could clearly understand the robot (ex: It was easy to hear the robot, It was not hard to understand the robot)
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
10. I was not engaged the whole interaction
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
11. I had fun talking to the robot
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
12. I felt more stressed after talking to the robot than I did prior to the interaction
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
13. I felt I had meaningful conversation
    - Strongly Agree

- Agree
- Neutral
- Disagree
- Strongly Disagree

14. I would not consider the robot my friend
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
15. I would like to engage with the robot more (ex: longer periods of time)
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
16. I did not feel the same level of comfort during the interaction as I would talking to a friend
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
17. There are things I would tell the robot that I would not discuss with my friends
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
18. I felt the robot was weird or creepy
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree

APPENDIX D

POST-EXPERIMENT INTERVIEW

- Did you tell Misty stories you have not told other people?
- Did you tell Misty about things you have not recalled in a long time?
- Do you feel like Misty brought out the inner ‘kid’ in you?
- What annoyed you the most about Misty?
- What surprised you the most about Misty?
- What amazed you the most about Misty?
- What is one thing you would change/add?
- Where you in tune with your facial expressions and emotions
- Did the topic influence how comfortable you felt talking to Misty?
- Any other things you would like to tell me about the study that I did not ask?
- (Any other questions that follows from the natural conversation)
- What made the robot friendly to you?
- How did you know the robot was engaged in the conversation?
- How did you know your behavior was being perceived correctly?
- If you were misunderstood, what happened?
- How did you know the robot was noticing your facial expressions?
- You reported the robot reacted inappropriately to the conversation during on of your interactions. Can you tell me what happened?
- How did you know your gestures were understood?
- Why did you feel the robots gestures were unnatural?
- Did you have issues hearing the robot?
- What was engaging about interacting with the robot?
- Why was the interaction fun?
- What made the interaction stressful?
- What made the conversation meaningful?
- Why (or why not) do you consider the robot your friend?
- What does engaging longer with the robot resemble?
- Why (or why not) did you feel the same level of comfort with the robot as you did a friend?
- ‘You said you would (or would not) tell the robot things you would not a friend. Can you tell me why you feel this way?
- Why did you find the robot creepy?

APPENDIX E

POST-EXPERIMENT SURVEY

1. Did you feel the Misty you interacted with was intelligent?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
2. Did Misty go above and beyond your original expectations? (For example, you had very low expectations going into the study and expected her to not be interactive at all).
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
3. Did you accept Misty? (Defined as, 'to give admittance or approval to accept her as one of the group').
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
4. Did Misty remembering facts about you influence how accepting you were of her?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
5. Did the size of Misty influence how trusting you were?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
6. Did the appearance of Misty influence how you felt about Misty?
    - Strongly Agree
    - Agree
    - Neutral

- Disagree
- Strongly Disagree

7. Did Misty being female influence how accepting (or not accepting) you were?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
8. Did you tell Misty the things you did because she was non-judgmental?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
9. Did you enjoy having someone listen to you giving their undivided attention?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
10. Did you enjoy Misty not interrupting you?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
11. Do you wish she interrupted (or interjected) more than she did?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
12. Did you enjoy teaching Misty new things?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree

13. Did you wish you did not have to teach her new things?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
14. Did Misty saying "Thank you for explaining that to me" or "Thanks for explaining" affect how much you wanted to teach her?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
15. Did Misty saying "Thank you for sharing that with me" or "Thanks for sharing" affect how much you were willing to tell her?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
16. Looking back, do you wish Misty did more? (For example: this could be verbal or nonverbal interaction, more emotions, high fives)
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
17. Do you wish Misty had features that included touch? (For example: a high-five, a hug, petting her head)
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
18. Do you wish Misty used her arms more when speaking? (For example: not when she was expressing emotions or saying hello/goodbye, but when she was answering questions)
    - Strongly Agree

- Agree
- Neutral
- Disagree
- Strongly Disagree

****

This section is to be completed after the presentation

19. After seeing the other personalities, do you wish your Misty was more interactive with **non-verbal** communication? (Head movements, arm movements, emotions)
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
20. After seeing the other personalities, do you wish your Misty was more interactive with **verbal** communication? (Sentences)
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
21. Do you still perceive your Misty as intelligent as you did before knowing the other personalities?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
22. After seeing the other personalities, do you wish Misty used her arms more when speaking? (For example: not when she was expressing emotions or saying hello/goodbye, but when she was answering questions)?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
23. After seeing the other personalities, do you wish Misty had features that included touch? (For example: a high-five, a hug, petting her head)
    - Strongly Agree

- Agree
- Neutral
- Disagree
- Strongly Disagree

APPENDIX F

IRB APPROVAL

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Troy McDaniel
IAFSE-PS: Polytechnic Engineering Programs (EGR)
480/727-1063
Troy.McDaniel@asu.edu

Dear Troy McDaniel:

On 1/11/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Co-Designing Technology for Older Adults and Their Caregivers
Investigator:	Troy McDaniel
IRB ID:	STUDY00013152
Funding:	Name: Zimin Foundation, Funding Source ID: FP00025908; Name: National Science Foundation (NSF), Funding Source ID: FP00014650
Grant Title:	
Grant ID:	
Documents Reviewed:	• Caregiving Survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Consent Form, Category: Consent Form; • Email Template, Category: Recruitment Materials; • Final Budget and Budget Justification.pdf, Category: Sponsor Attachment; • Final proposal.pdf, Category: Sponsor Attachment; • FP14650 Panchanathan FP.pdf, Category: Sponsor Attachment; • IRB Form, Category: IRB Protocol; • Older Adults Survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

Figure 16. ASU IRB Approval for Surveys in Chapter Two

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Troy McDaniel
IAFSE-PS: Polytechnic Engineering Programs (EGR)
480/727-1063
Troy.McDaniel@asu.edu

Dear Troy McDaniel:

On 5/17/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	2x2 Wizard of Oz
Investigator:	Troy McDaniel
IRB ID:	STUDY00013989
Funding:	Name: Cognitive Ubiquitous Computing, Center for (CUbiC); IAFSE; Name: National Science Foundation, Grant Office ID: FP00014650, Funding Source ID: 1828010; Name: Zimin Foundation, Grant Office ID: FP00025908, Funding Source ID: N/A
Grant Title:	FP00014650; FP00025908;
Grant ID:	FP00014650; FP00025908;
Documents Reviewed:	• Consent Form, Category: Consent Form; • Email from Mirabella expressing permission, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc); • Email Template, Category: Recruitment Materials; • Final proposal.pdf, Category: Sponsor Attachment; • Flyer, Category: Recruitment Materials; • IRB Form, Category: IRB Protocol; • NSF NRT Fastlane Printout.pdf, Category: Sponsor Attachment; • Older Adults Survey from other IRB approved study, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Post Interaction Survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

Figure 17. ASU IRB Approval for 2x2 Wizard of Oz Study in Chapter Four

APPENDIX G

DIRECT QUOTES

These are direct quotes participants said to the robot or about the robot during the study.

- “I don’t want to call her a robot and hurt her feelings”
- “I will miss Misty”
- “Thank you for letting me talk about this, I have not had the opportunity recall this”
- “I did not put that together until you asked, thank you for that”
- “You reminded me to reach out to XXX, I have not in a long time”
- “Can I tell you a secret?”
- “Can I consider you my friend?”
- “I learned something about myself from talking to you”
- “I will tell you about things I struggle with”
- “This is my therapy for the day”
- “You have given me an opportunity to tell old stories”
- “I enjoyed the chance to meet you and I will always remember you”
- “There are some topics I am more comfortable talking to Misty about than my old-time friends”
- “I know she is a robot, but it almost feels like she’s a person”
- “I forget there is not a little person in there controlling her”
- “You are so smart!”
- “There are some topics I am more comfortable talking to Misty about than my old-time friends”
- “You go, girl!”
- “I am proud of you”