

2017

## Real Loneliness and Artificial Companionship: Looking for Social Connections in Technology

Fernando L. Montalvo  
*University of Central Florida*

 Part of the [Cognitive Psychology Commons](#)

Find similar works at: <https://stars.library.ucf.edu/honorstheses>

University of Central Florida Libraries <http://library.ucf.edu>

This Open Access is brought to you for free and open access by the UCF Theses and Dissertations at STARS. It has been accepted for inclusion in Honors Undergraduate Theses by an authorized administrator of STARS. For more information, please contact [STARS@ucf.edu](mailto:STARS@ucf.edu).

---

### Recommended Citation

Montalvo, Fernando L., "Real Loneliness and Artificial Companionship: Looking for Social Connections in Technology" (2017). *Honors Undergraduate Theses*. 186.  
<https://stars.library.ucf.edu/honorstheses/186>



REAL LONELINESS AND ARTIFICIAL COMPANIONSHIP: LOOKING FOR  
SOCIAL CONNECTIONS IN TECHNOLOGY

by

FERNANDO MONTALVO

A thesis submitted in partial fulfillment of the requirements  
for the Honors in the Major program in Psychology  
in the College of Sciences  
and the Burnett Honors College  
at the University of Central Florida  
Orlando, Florida

Spring Term, 2017

Thesis Chair: Dr. Janan A. Smither

© 2017 Fernando L. Montalvo

## **ABSTRACT**

Loneliness among older adults is a problem with severe consequences to individual health, quality of life, cognitive capacity, and life-expectancy. Although approaches towards improving the quality and quantity of social relationships are the prevailing model of therapy, older adults may not always be able to form these relationships due to either personality factors, decreased mobility, or isolation. Intelligent personal assistants (IPAs), virtual agents, and social robotics offer an opportunity for the development of technology that could potentially serve as social companions to older adults. The present study explored whether an IPA could potentially be used as a social companion to older adults feeling lonely. Additionally, the research explored whether the device has the potential to generate social presence among both young and older adults. Results indicate that while the devices do show some social presence, participants rate the device low on some components of social presence, such as emotional contagion. This adversely affects the possibility of a social relationship between an older adult and the device. Analysis reveals ways to improve social presence in these devices.

## **DEDICATION**

For those who feel lonely when they are alone and when they are not, help is only an idea away,

For my faculty mentors, Dr. Janan A. Smither, Dr. Daniel S. McConnell, and Dr. Denise Gammonley, for taking the time to guide and support me through this long project,

For my mother and father who showed me the need to excel and push the limits many years ago,

And to my wife and best friend of 12 years, Itzel, who is always there to support me in my academic endeavors and who is always there to receive my hand as we keep looking for ways to better ourselves.

## ACKNOWLEDGEMENTS

This thesis says one author, but is the result of the support and efforts of more than a few people.

To all of you, you have my eternal and most profound gratitude. Thank you, wife, for leasing your husband out to the UCF Psychology Department, to hold in trust until he gets his Ph.D. degree. My deepest thanks and appreciation to Dr. Janan Smither and Dr. Daniel McConnell for your guidance and for allowing their Technology and Aging Lab undergraduates the freedom to seek out statistical significance in our varied experimental endeavors. Thank you for all the opportunities you have provided me. Thank you, Dr. Denise Gammonley for providing guidance and support to a student from across Memory Mall and for having patience throughout all the delays. My heartfelt appreciation to future Ph.Ds. Jessica Michaelis, Eva Parkhurst, and especially to Michael Rupp, for putting up with the crazy undergrads and always being there to provide assistance and guidance even when you have one thousand things to do. I'm incredibly grateful and indebted to the incredible Melissa Dabydeen, without whom I would still be recruiting older adults; thank you for the huge, interminable pile of things you have done for me and for being someone I look up to. I am also incredibly appreciative and thankful of Victoria Pineda, not just for being all-around awesome (and hilarious), but also for all the transcribing, participant running, proofreading, etc., etc. that you have done for me. To Asmita Devkota, thank you for being participant ninety-X, for all the help offered, and for proofreading this tome. To Daniela Zapata-Ocampo, thank you for the participants ran, for the videos transcribed, and simply for being there. Bijita Devkota, you are our newest member in lab, but thank you as well for helping with proofreading and I cannot wait to see the places you will go. To everyone else... all the friends who have supported me, all the professors who have molded me, and the family that raised me... thank you, thank you, thank you.

## TABLE OF CONTENTS

INTRODUCTION .....	1
LITERATURE REVIEW .....	4
Understanding the Problem: Older Adults, Loneliness, and its Implications.....	4
Technological Interventions as an Approach to Loneliness .....	7
Humans and our Need to Anthropomorphize .....	8
Beyond Ascribing Human Qualities: Can a Non-Human Agent have Social Presence? .....	12
RESEARCH QUESTIONS .....	16
METHOD .....	18
Participants.....	18
Materials & Equipment.....	18
Amazon Echo & Amazon Echo Dot.....	19
Amazon Kindle Fire.....	19
Montreal Cognitive Assessment Test (MOCA).....	20
Demographics and Background Questionnaire. ....	20
UCLA Loneliness Scale.....	20
Amazon Echo Structured Interaction Script and Questionnaire. ....	20
Networked Minds Social Presence Inventory.....	21
Godspeed Anthropomorphic Questionnaire. ....	21
Post-Task Interview Questionnaire.....	22
Procedure .....	22
RESULTS .....	25
Age and Sex Distribution among Conditions. ....	25
Loneliness .....	25
Social Presence .....	28
First Order Social Presence.....	28
Second Order Social Presence. ....	29
Third Order Social Presence. ....	29
Perception of Self.....	30
Perception of the Other. ....	31

Perceived Psychological Engagement. ....	31
Perceived Attentional Engagement. ....	33
Perceived Emotional Contagion. ....	33
Perceived Comprehension. ....	34
Perceived Behavioral Interdependence. ....	34
Anthropomorphism ....	35
Perception of Social Presence ....	35
DISCUSSION ....	37
LIMITATIONS ....	42
APPENDIX A: IRB APPROVAL LETTER ....	43
APPENDIX B: DEMOGRAPHIC AND EXPERIENCE QUESTIONNAIRE ....	46
APPENDIX C: UCLA LONELINESS SCALE ....	49
APPENDIX D: AMAZON ECHO SCRIPTED INTERACTION. ....	52
APPENDIX E: NETWORKED MINDS SOCIAL PRESENCE INVENTORY ....	54
APPENDIX F: GODSPEED ANTHROPOMORPHIC QUESTIONNAIRE ....	56
APPENDIX G: POST-TASK INTERVIEW ....	58
REFERENCES ....	60



## LIST OF FIGURES

Figure 1 Mean NMSPI scores across age-groups in the total scale and subscales. Error Bars SEM. ....	29
Figure 2 Mean Third Order social presence scores. Error bars SEM. ....	30
Figure 3 Mean NMSPI scores between genders in the total scale and subscales. Error Bars SEM. ....	32
Figure 4 Mean NMSPI scores between name conditions in total scale and subscales. Error bars SEM. ....	32
Figure 5 Mean NMSPI scores across visibility conditions in the total scales and subscales. Error bars SEM. ....	33
Figure 6 Percentage of participants who answered favorably to the Amazon Echo as a social companion across conditions. ....	36

## LIST OF TABLES

Table 1 Descriptive characteristics of the sample population (N=84).....	26
Table 2 Percentage of participants in each condition who rated the Amazon Echo favorably as a social companion. ....	36

## INTRODUCTION

In a recent US survey among 3,010 adults 45 years of age and older, the prevalence of chronic loneliness, defined here as loneliness symptoms persisting for longer than one year, was just under 27% (Wilson & Moulton, 2010). Other studies looking at loneliness across both the 50-plus and 80-plus age groups have found similar results, with prevalence rates from 13% to nearly 50% (see Dykstra, 2009 for a summary). With the over 65 years of age population in the US expected to reach 75.5 million people by 2030 (Colby & Ortman, 2015), finding methods to reduce the prevalence of long-term loneliness is crucial. The effects of prolonged loneliness on health, quality of life, and mortality are severe (Donovan et al., 2015; Donovan et al., 2016; Shankar, McMunn, Demakakos, Hamer, & Steptoe, 2017; Shiovitz-Ezra & Ayalon, 2010), highlighting the possibility of an upcoming social and health crisis.

Loneliness is not considered a mental disorder and has no official classification in the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013). Although the debate of whether it should be included as a disorder is outside the scope of this paper, loneliness is a very real experience with both short and long-term consequences. Loneliness is most commonly defined as a subjective feeling of either emotional or social isolation (Cacioppo & Patrick, 2008; Dykstra, 2009). Unlike social isolation, which is an actual quantifiable measure of a person's social network, loneliness is felt by the individual as a mismatch between the social interactions desired and those available (Perlman & Peplau, 1981).

Common therapies and approaches to loneliness seek to increase and improve the quality of social relationships with others (Cacioppo & Patrick, 2008). Unfortunately, this is not always

an easy option for some, forcing them to look for social interaction elsewhere. The human mind is highly developed for social interaction. When we consider the evolution of cranial capacity, size of social groups, and available technology, these interactions have been a crucial part of our ancestors' lives for at least 2 million years, well before the speciation of *Homo sapiens* (Gowlett, Gamble, & Dunbar, 2012). Appropriately, we often use social reasoning and approaches when interacting with non-human elements in our environment by ascribing to them human-like qualities. This tendency to anthropomorphize attempts to make sense of elements in our environment by ascribing to them social qualities that we can more easily understand and relate to (Waytz et al., 2010). Anthropomorphism, the attribution of human characteristics to devices, animals, or objects, is pervasive, affecting not just the qualities we ascribe to these elements, but also how these human-like qualities influence our social selves (Waytz, Cacioppo, & Epley, 2010).

Many pet owners ascribe complex social interactions and emotions to pets, even though their ability to perform complex social interactions is limited (Panksepp, 2004). Dogs and cats have moved from a predominantly utilitarian role, to serving as social agents in our personal environment. As social companions, pets can reduce the likelihood of loneliness in older adults by over a third (Stanley, Conwell, Bowen, & Van Orden, 2014). While pets are widely available and are commonly found in U.S. households, they are not suitable as social companions in every situation. Older adults with reduced mobility, loss of independence, aversion to animals, or cognitive disabilities may find it hard to take care of a pet in their homes.

Fortunately, our innate tendency to anthropomorphize offers other alternatives. The predominant human desire for social companionship, even when others are not around to provide it, is alluded to by robotic movie characters such as the seductive and manipulative Ava in the

movie *Ex Machina* (Bush & Garland, 2015) or the determined BB-8 in *Star Wars: The Force Awakens* (Harper, McGatlin, & Abrams, 2015). These advanced hypothetical robots are years away from reality, but consumer-level social robotics and intelligent virtual agents are beginning to make a push in the mainstream market (Collins, 2016; Jibo, 2016; Softbank, 2016). Could this generation of social robots and devices help reduce feelings of loneliness? This research aims to explore this very possibility.

## **LITERATURE REVIEW**

### Understanding the Problem: Older Adults, Loneliness, and its Implications.

Approaches to exploring the benefits of artificial social interactions on improving the outlook for people with loneliness requires us to understand loneliness itself. Loneliness is a natural part of the human experience. Most people, including introverts, have some degree of desire for the company of others and have negative feelings when this companionship is lacking (Cacioppo & Patrick, 2008; Perlman & Peplau, 1981). Often confounded with depression, loneliness is a separate affective state (Cacioppo et al. 2006). Evolutionary psychologists theorize the possible benefits of loneliness. Thousands of years ago, if we were separated from our group, we ran a much greater risk of harm than solitary individuals do today (Cacioppo & Patrick, 2008). The feeling of loneliness provided a drive for us to return towards the relative safety of our social group. Loneliness serves as a “social pain” indicator in the same way that we feel pain when our fingertips touch the hot surface of an oven. Both mechanisms drive us to remove ourselves from danger and seek safety.

The relationship between loneliness and pain is more than just philosophical. Using fMRI, Eisenberger, Lieberman, and Williams (2003) showed brain regions which activated for physical pain, such as the anterior cingulate cortex (ACC), are also activated when we feel social pain, causing distress. Over the short run, loneliness leads to negative mood, anxiety, and anger, among other emotional states (Cacioppo et al. 2006). If loneliness persists, however, it can be a very dangerous condition with detrimental health effects similar to those of smoking and obesity.

Chronic loneliness may arise from various reasons. In younger adults, loneliness is often the result of misperceptions in the quality or quantity of social relationships (Cacioppo & Patrick, 2008). Unable to distinguish between perceived and actual social relationships or acceptance by peers, younger adults may feel isolated, breeding low social self-esteem (Mahon, Yarcheski, Yarcheski, Cannella, & Hanks, 2006). This low self-esteem causes a self-perpetuating cycle, since it can breed further misperception of social acceptance by peers (Vanhalst, Luyckx, Scholte, Engels, & Goossens, 2013). Shyness and chronic depression are also major predictors of loneliness among younger adults (Mahon et al., 2006). As adults continue into midlife, loneliness is driven by our perceived quantity of romantic relationships and intimate friendships (Qualter et al., 2015).

For older adults, loneliness continues to be influenced by misperceptions between perceived and actual social interactions, but loss of friendships or partners to old age and ill-health begins to take its toll (Qualter et al., 2015). This is further compounded by reduced social activities, which are tied to loss of independence. Although the biological underpinnings that create loneliness are poorly understood, problems in the regulation of the hypothalamic-pituitary-adrenocortical axis (HPA-axis) are suspected, with some studies linking decreased cortisol outputs as a possible cause of the health problems we see in lonely older adults (Schutter et al., 2017). Earlier studies also showed that activity in the right ventral prefrontal cortex (RVPFC) has moderating effects on the ACC and may be causing the distress we usually affiliate with loneliness (Eisenberger et al., 2003).

Loneliness affects restorative behaviors such as sleep, with higher incidence of insomnia in those who are lonely (Wilson & Moulton, 2010). Cacioppo et al. (2002) found that lonely people have decreased sleep efficiency, waking up more times during the night, and take longer to fall

asleep both in laboratory conditions and at home. Lower quality of sleep has been associated with poor health (Spiegel, Leproult, & Van Cauter, 1999). Furthermore, lonely people have higher rates of depression and anxiety, as well as emotional instability (Cacioppo et al. 2006; Lambert, Lussier, Sabourin, & Wright, 2007), conditions which are also implicated in poor health. Among adults over the age of 45, lonely people are more likely to abuse drugs and alcohol, as well as to report being in poor health, than those who are not (Wilson & Moulton, 2010).

For older adults—who are at a heightened risk of loneliness due to the loss of social connections, its effects can be even more devastating. Social support is important to our cognitive aging as cognitive abilities are affected by our perceived social network (Gow, Corley, Starr, & Dearly, 2013). Onset of cognitive decline in dementia, such as Alzheimer’s Disease, progresses about 25% faster in those who are lonely (Donovan et al., 2015; Donovan et al., 2016). Longitudinal studies also found that those who are chronically lonely are more likely to have decreased gait performance and increased trouble carrying out activities of daily living, such as bathing, eating, and getting dressed (Shankar et al., 2017). Wilson and Moulton (2010) found that loneliness was a predictor of the total number of diagnosed illnesses a person has. This finding is only compounded by findings that mortality across all major causes is affected by loneliness, with those chronically lonely dying sooner (Shiovitz-Ezra & Ayalon, 2010).

Both due to its impact on the health of older adults and because lonely older adults visit physicians more, regardless of medical condition, the impact of loneliness on health care utilization is considerable and likely amounts to thousands of dollars per person per year (Gerst-Emerson & Jayawardhana, 2015). Current approaches to the treatment of loneliness and its symptoms center around cognitive-behavioral therapy and psychopharmaceutic intervention (Cacioppo & Patrick,



2008; Qualter et al., 2015). Although these therapies have been in place for decades, the increasing percentages of older adults who feel lonely implies that they might not always be suitable. Finding alternative approaches is important to make headways against this increase.

### Technological Interventions as an Approach to Loneliness

In at risk populations, such as physically and cognitively disabled individuals, the adoption of social technology, including mobile devices, can lead to increased social involvement (Darcy, Maxwell, & Green, 2016). Although research into the potential mental health benefits or disadvantages of the social connections provided by these devices has increased in the past decade (i.e. Aarts, Peek, & Wouters, 2014; Naslund, Aschbrenner, Marsch, & Bartels, 2016; Pantic, 2014), additional attention needs to focus not on the social interactions we have *through* technology, but with those we have *with* technology.

With the improvement of voice recognition and production technology in devices such as the Amazon Echo (Amazon, 2017a) and as these devices become more common, we must explore the potential of these technologies to become social agents in themselves. Research should explore, not only the potential of intelligent personal assistants (IPAs; i.e. Amazon's Alexa), robots, and artificial intelligence to become social agents, but also the implications of such a status. The technological developments that have made these devices capable of potentially holding a true conversation, open the door for using these devices in new therapeutic settings. For individuals experiencing loneliness, these devices show promise as social agents which may have a beneficial impact. However, can holding a conversation with a non-human/artificial agent, really reduce feelings of loneliness felt by its users or is it more important to explore how this technology can

better connect us with others? Additionally, while the technology holds potential, it may well be that, for a lonely person, the artificiality of these interactions might be more detrimental than beneficial.

Currently, the most popular social replacement for human to human interaction (HHI) are animals, such as cats and dogs. Feelings of loneliness are highest in older adults who live alone and do not have pets (Stanley et al., 2014). However, ownership of pets may be a response to loneliness, rather than exclusively a method to reduce feelings of loneliness (Pikhartova, Bowling, & Victor, 2014). Regardless, the bond shared between human and their pet means that people can and will seek social engagement outside of HHI. It is this search for social connection in pets which leads us to question whether the same search for social connection could exist when humans interact with socially enabled technologies. Although the features of an IPA may be enough to increase social engagement in older adults, of interest in this study is whether or not current generation IPAs elicit social presence and enough anthropomorphism to become social agents in the lives of the users.

### Humans and our Need to Anthropomorphize

Although it might seem counterintuitive to start with a device that provides the least social cues and abilities, beginning with the most basic IPAs allows us to explore the element of vocal language in our application of a virtual social agent. The results of this study can then guide the direction of further research. Additional features can then be explored and compared, to see how much value they add to the device's social presence amongst users. For a device such as the Amazon Echo (see Methods section for design and specifications), any level of anthropomorphism

garnered from its users must come from its voice interface. Current IPAs are limited by the lack of physical language they communicate. These physical social cues, what we ~~might~~ call body language in humans, help convey information through different channels than those used by spoken language, allowing us to determine with more accuracy the intentions of artificial social agents (Fiore et al., 2013). In other words, what current generation IPAs lack is the visual social cues and signals that improve our ability to form mental representations of our device's social intentions. This potentially presents a barrier to social companionship and limits the device ability to address feelings of loneliness from an interactive angle.

Anthropomorphism, the social power of language, and the social nature of the human brain could be enough to overcome the artificiality of a social interaction with a current generation virtual agent such as Amazon's Alexa. Anthropomorphism is a common human tendency and is even more pronounced on those who report feeling lonely (Epley, Akalis, Waytz, & Cacioppo, 2008). Even at the neural level, neural circuitry often engages human and non-human elements in the same way. Mirror neurons, for example, activate when we execute actions and observe the actions of others, transforming the actions of others into "mental imagery" that our mind can understand as if the movements were our own (Gallese, Keysers, & Rizzolatti, 2004; Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). By mentally imitating the actions of others, mirror neurons may be able to aid our social understanding of our surrounding social actors (Gallese et al., 2004). These neurons, as with other social regions of the brain, do not only activate when other human actors are involved. In a nod to our brain's apparent preference for social reasoning when interacting with other active agents, mirror neuron activation occurs at an equal level whether a

person is watching another person's actions or those of a non-humanoid robot (Gazzola, Rizzolatti, Wicker, & Keysers, 2007).

Theory of mind relates to how we attempt to interpret another person's intentions and thoughts. The very fact that current generation IPAs are controlled by language increases the possibility that we activate the social theory of mind network when addressing the device. After all, language is tied to the development of theory of mind networks (Astington & Baird, 2005). Furthermore, our language is very metaphorical in nature and we often use anthropomorphizing metaphors when speaking about objects. This means that our language itself might transform our objective reasoning about a device into a social reasoning mindset simply from our construction of a socialized situation via metaphorical thinking. Even if the interaction is artificial, there is a true social interaction going on between us and the device.

Key to understanding how anthropomorphic tendencies might influence a person's understanding of the world is to separate the degree of anthropomorphism from its consequences (Waytz et al., 2010). As such, this study seeks to explore people's understanding of their social interaction with a device both congruent with and independent of their score in an anthropomorphic scale. A person might not anthropomorphize a device, but still consider it a social agent. Although this is tied to social presence, discussed below, both anthropomorphism and social presence are perceived to go hand in hand (Harms & Biocca, 2004).

Epley et al. (2007) presented a three-factor model for how non-human elements are anthropomorphized. The first factor, elicited agent knowledge, implies that the knowledge we use when interacting with a non-human agent to think about the agent can influence anthropomorphic

tendencies (Higgins, 1996). Children, for example, readily anthropomorphize teddy bears, pillows, and dolls because their knowledge of what constitutes the self and social reasoning is very limited (Inagaki & Hatano, 1993). For adult users of IPAs or other social technology, knowing the device is a simple software program with predetermined answers to most questions might result in a decrease in anthropomorphism. However, other knowledge structures, such as our use of anthropomorphic metaphors, might subconsciously influence the user to anthropomorphize the device.

A second factor in the model is sociality motivation (Epley et al., 2007), or our tendency to search out social belongingness and connections with others (Baumeister & Leary, 1995). As has been mentioned previously in this paper, the need for social belonging is strong in humans. As such, anything that elicits the possibility of a social interaction can be anthropomorphized. Since IPAs are controlled through voice commands and the interaction resembles a conversation, users, especially those who are lonely, will likely anthropomorphize the devices. In fact, research shows that lonely people are more likely to anthropomorphize animals and devices based on this dimension of the three-factor model (Epley, Akalis, Waytz, & Cacioppo, 2008; Epley, Waytz, Akalis, & Cacioppo, 2008).

The final factor, effectance motivation (White, 1959), implicates our desire to understand our environment as an element of our need to anthropomorphize (Epley et al., 2007). When we come across something we do not understand, we seek to not only make sense of it, but also to become competent agents when interacting with it (White, 1959). We anthropomorphize non-human agents as a way to understand it by relating it to our knowledge of the self (Waytz et al., 2010). In order to understand an object with some sense of agency, our only model of referent is

our ~~own~~ human mind. For users of an IPA, anthropomorphizing the device is an attempt to make sense of any ambiguousness about its functioning and output expectations.

### Beyond Ascribing Human Qualities: Can a Non-Human Agent have Social Presence?

While anthropomorphism dictates the degree of human-like qualities we ascribe to non-human agents, social presence captures the interaction side of the human-device relationship. Social presence describes our degree of “mental closeness” that we subjectively feel between us and a non-human agent; showing how much we believe to be mentally intertwined with another agent (Biocca, Harms, & Burgoon, 2003; Short, Williams, & Christie, 1976). If anthropomorphism can lead us to give an IPA human-like qualities, social presence determines the degree and intimacy of social interaction that we can have with it. In this way, social presence is an increasingly important design consideration in the design of any user interface (Kumar & Benbasat, 2006) and is a key element that should be evaluated in any device meant to address loneliness. If loneliness is a mismatch between a desired social relationship and an actual social relationship, then social presence can be seen as the perceived social relationship in this context. A device must create a sense of social presence in its user if it is to be a social agent in their environment.

For lonely individuals, the quality of a social relationship must match that desired in order for that relationship to reduce loneliness (Cacioppo & Patrick, 2008; Dahlberg, 2007). Otherwise, any relationship that does not meet a lonely person’s expectations is bound to create a stronger sense of loneliness. In terms of IPAs, social presence will assess the quality of the social interaction between a lonely individual and the device. Social presence and anthropomorphism are

interrelated, as it is difficult for people to evaluate a human-like or human-imitating device without using social cognition (Qiu & Benbasat, 2010).

Our brains are hardwired for social presence. When a non-human entity displays any sense of agency, we see the activation of regions, such as the anterior paracingulate cortex (APC), tied to social presence in human-human interactions (i.e. Benbasat, Dimoka, Pavlou, & Qiu, 2010). The APC, located in the limbic system, activates when someone starts a conversation with us (Walters et al., 2004), when we are trying to determine the intentions of others (Krueger, McCabe, Moll, Kriegeskorte, & Zahn, 2007), and it predicts how closely we are attached and engaged in a social relationship (Walters et al, 2004; Winston, Strange, O’Doherty, and Dolan, 2002).

Social presence is measured in various orders, as it occurs on a spectrum from low-level engagement to highly symmetric psycho-behavioral interdependence (Harms & Biocca, 2004). Social presence in general is always considering the interaction between the self and the other; as such, measurement of social presence always frames items from both perspectives. The first order of social presence measures ~~simply~~ our level of recognizing that a social other is present (Harms & Biocca, 2004). In relation to an IPA, first order social presence would measure whether a person perceives the virtual agent as a social other. Second order social presence measures whether there is a psychological or behavioral interaction occurring between a person and the second agent (Harms & Biocca, 2004). This is harder for an IPA to attain, since it must show, on a psychological level, an attentional engagement, the sharing of emotions, and mutual comprehension, while displaying on a behavioral level a sense that the actions of one influence the other. In other words, second order social presence measures the depth of the social interaction between a user and an IPA or other social agent. The third order of social presence is perhaps the most important for

loneliness, as it gauges the quality of the social interaction for a user. Third order social presence is a measure of the psychobehavioral symmetry between a person and another social agent (Harms & Biocca, 2004). In terms of an IPA, it measures how much the user believes the IPA “gets” and is in sync with them.

Current generation IPAs face a challenge when trying to elicit social presence. As the technology is still relatively nascent and has many limitations, unsatisfactory user experiences or violation of social expectations may occur regularly. Unfortunately, when it comes to social presence, fMRI studies have shown that strong negative reactions were a stronger predictor of social presence than positive ones (Benbasat, et al., 2010). In other words, bad experiences with the device are likely to outweigh the good experiences if they are even moderately common. An examination of user satisfaction with responses, as well as a record of the positive and negative interactions, should shed some light at the relationship between social presence and negative experiences in this study.

Because social presence exemplifies the presence, quality, and depth of social engagement, any device designed to alleviate the symptoms of loneliness, must attain a high degree of social presence on lonely users. The present study seeks to quantify social presence felt by users of an IPA through both overall and subscale scores.

Loneliness is a highly-socialized affective state. It is not simply bound to the personal experiences of the individual suffering from loneliness, but is highly influenced and informed by the society in which the individual lives (Cacioppo & Patrick, 2008; Dahlberg, 2007). As such, adoption of socially enabled devices, such as intelligent personal assistants (IPAs), is not only



dependent on the perception of the technology by the individual, but also by the perception and opinions of their social network and the society in which they live (see Darcy et al., 2016 for examples). In the United States, where opinions are more negative regarding the social inclusion of robotics as compared to other nations (McDorman, Vasudevan, & Ho, 2009), the use of AI or IPAs to therapeutically reduce loneliness may encounter some resistance. This resistance could, in turn, affect the ability of social interactions with the AI to reduce loneliness in an individual, since the individual may perceive that the use of the AI in this way puts them at odds with the opinion of others and further excludes them socially.

## **RESEARCH QUESTIONS**

The present research seeks to explore the potential of IPAs in reducing loneliness by serving as social companions to elderly adults and other at risk populations. This could be a difficult achievement for IPAs since they lack the visual social cues which could make the devices more likely to convey their intentions and meanings (see Breazeal, 2004; Fiore et al., 2013). However, verbal social cues and repeated interactions with the device could serve as suitable substitutes for this deficiency (see Leite, Martinho, & Paiva, 2013). Particularly, the research seeks to explore the degree of social presence that can be attained by an IPA and the quality and content of the interactions users have with the devices. Loneliness is highly based on the perception of quality in social interactions (Dahlberg, 2007). Therefore, any social interaction with an IPA or robot must have an acceptable level of engagement. However, it is highly probable that the engagement does not have to be at the level of a HHI. This is important since IPAs are not likely to attain high levels of social presence due to their current limitations. Additionally, attitudes towards IPAs and social robots as social companions will be explored.

Anthropomorphism is also an important consideration whenever we are exploring how people interact with technological agents. Measuring the degree to which participants ascribe distinctly human-like characteristics and human-like mental processes to IPAs is important for understanding the perception of a device as an artificial social agent (Waytz, Cacioppo, & Epley, 2010). Assigning anthropomorphic qualities to any device or agent will likely have great impact in how it is perceived as a social companion. Therefore, this study explores the relationship between a user's perception of anthropomorphic qualities and social presence.

This study seeks to explore whether an intelligent personal assistant, such as an Amazon Echo, can serve as a social companion to people suffering from loneliness, especially older adults. To be perceived as an engaging social agent, does a device need to have a high degree of anthropomorphism or social presence? What level of social presence is attained by an IPA and how is it perceived by users? What social interactions do people seek when interacting with an IPA? How can the devices be improved to increase social presence?

This study is exploratory in nature and as, such, no hypotheses will be presented regarding the above questions.

## **METHOD**

### Participants

Ninety-seven participants took part in the study, with some attrition due to those who did not answer in good faith ( $n=7$ ), those whose data was not recorded properly ( $n=1$ ), or those whose interview sound was unintelligible ( $n=5$ ). The final sample consisted of both students at the University of Central Florida ( $n = 40$ ) and volunteer adults recruited from the surrounding community ( $n = 44$ ). Younger adults ranged in age from 18-48 years of age ( $M = 21$ ,  $SD = 5.26$ ) and older adults from 52-87 years of age ( $M = 70$ ,  $SD = 8.59$ ). Older adult volunteers were recruited from an older adult program designed to promote continued learning. University students were recruited through the university's SONA research participation program and received course credit in exchange for their participation. General exclusion criteria included a Montreal Cognitive Assessment (MOCA; Nasreddine et al., 2005) score of 25 or lower, being below 18 years of age, or not understanding English fluently.

The Institutional Review Board examined the research protocol and all study materials before approving the research project. All participants provided informed consent and were debriefed after the study.

### Materials & Equipment

The experiment was conducted using an Acer Aspire E5-575G-53VG 15.6" Laptop running Windows 10 64-bit. Depending on the experimental condition, participants interacted either with an Amazon Echo placed approximately 5" behind and to the right of the laptop or an Amazon Echo Dot placed approximately 46" to the right of the participant and hidden from view

behind a computer monitor. The Amazon Echo Dot was wirelessly connected via Bluetooth to a Jawbone Jambox portable speaker placed 5” behind and to the right of the laptop. Although the MOCA was administered by paper copy, all other measures, surveys, and questionnaires were completed through Qualtrics online research participation software. An Amazon Kindle Fire 7” tablet was provided to participants in order to use the Alexa application.

#### *Amazon Echo & Amazon Echo Dot.*

The Amazon Echo used for this study was operated hands-free by interacting with the intelligent personal assistant software named Alexa (Amazon, 2017a). The system includes an array of seven speakers which allow for determining location of the user (a blue light ring on the top of the cylinder points towards the user). An internal speaker delivers sound. The Amazon Echo Dot used in this study is a black and smaller, disc-like version of the Amazon Echo (Amazon, 2017b). It has a small internal speaker for voice interaction, but no speaker output for music or other advanced functions. In this study, it was connected via Bluetooth to a speaker, which provided audio to the participant.

#### *Amazon Kindle Fire.*

The Amazon Kindle Fire is a 7” tablet with a 171 ppi, 1024 × 600 IPS display (Amazon, 2017c.. For study purposes, participants were required to interact with the Amazon Alexa app, which allows for control of the Amazon Echo or Echo Dot. Current interactions between users and Alexa are shown on the tablet’s lock-screen and the application, although the application provides additional information. Participants were also encouraged to access Skills (similar to applications) available for the Echo through the tablet.

### *Montreal Cognitive Assessment Test (MOCA).*

The Montreal Cognitive Assessment, version 7.3 – Alternate Version (Nasreddine et al., 2005), was used to assess cognitive impairment in any participants over 50 years of age. The MOCA consists of various cognitive tasks, mostly relating to executive function. The test was administered in paper form. A score of 25 or below is indicative of possible cognitive decline.

### *Demographics and Background Questionnaire.*

A short demographics and background questionnaire asked participants their age, ethnicity or race, highest degree of school completed, living situation (alone or with others), ownership of pets, number of children, religiousness, and previous experience with intelligent personal assistants. A total of 13 questions were used to assess these items.

### *UCLA Loneliness Scale.*

The UCLA Loneliness scale (Revised Version – 3/1996; Russell, 1996) was used to assess loneliness by self-report. It is a 20-item measure in which participants must answer on a 4-point Likert scale, with answers ranging from “I often feel this way” to “I never feel this way”. A score of 40 or above is generally considered to indicate a lonely individual and was used as the determining criteria for this study.

### *Amazon Echo Structured Interaction Script and Questionnaire.*

A 20-item script was provided to participants consisting of 10 socially oriented interactions (i.e. “Alexa, can you tell me a joke?”) and 10 non-social interactions (i.e. “Alexa, what is traffic like?”). Participants were required to say the interaction prompted on the script and then rate each

interaction on a 4-point scale from “Yes! It did exactly as requested.” to “It did not do what I wanted it to do.”. The scale was intended to measure participant satisfaction with Alexa’s output.

*Networked Minds Social Presence Inventory.*

The Networked Minds Social Presence Inventory (NMSPI, Version 1.2 2004; Harms & Biocca, 2004) is a 34-item scale that measures, through self-report, three orders of social presence, including co-presence, psycho-behavioral interaction, and a third order consisting of interpersonal symmetry. Subscales measure perceived behavioral interdependence, perceived psychological engagement, perception of self, perception of the other, perceived attentional engagement, perceived emotional contagion, and perceived comprehension. The first and second orders of social presence are measured through scoring on the respective sections of the measure, while the third order of social presence is calculated through correlation between the subscales (Harms & Biocca, 2004).

*Godspeed Anthropomorphic Questionnaire.*

The 4-item subscale of the Godspeed Anthropomorphic Questionnaire (Bartneck, Reichenbach, & Carpenter, 2006) was used to assess the degree to which participants anthropomorphized the Amazon Echo or Echo Dot. The questionnaire asks participants to rate, in a 5-point Likert scale, whether they perceive the virtual agent to have human, conscious, or lifelike qualities.

### *Post-Task Interview Questionnaire.*

A 10-item post-task interview questionnaire was verbally administered and assessed participants' opinion of the Amazon Echo and their interactions with the Echo. The questionnaire allowed participants to offer more information than could be provided by the above measures. Questions also addressed participants' attitudes toward the Amazon Echo as a social companion, what additional features the Echo should have, and how they felt about social robotics. A final question explored each participant's understanding of the concept of loneliness by asking them to define the word "loneliness".

### Procedure

Participants were randomly assigned to one of four experimental conditions in a  $2 \times 2$  experimental, between-subjects design (device visible or not-visible  $\times$  referring to device as Alexa or Amazon Echo). This allowed researchers to explore any effect of the device's physical presence, as well as the language used to refer to the device, on social presence and anthropomorphism. The first independent variable tests whether the physical presence of the device being talked to is required for social presence or anthropomorphism. The second variable tests whether assigning a human name to a device and addressing it as if it were a female person affects participants' perception of social presence and anthropomorphism.

After providing informed consent, older participants (50 years of age or older) were screened for cognitive decline using the MOCA test (Nasreddine et al., 2005). No participants failed this assessment. Next, participants read a short introduction into the study and began the



online portion by completing demographics and background questionnaire. This was followed by the UCLA Loneliness Scale (Russell, 1996).

Participants then received instructions on how to interact with the Amazon Echo or Echo Dot. Researchers provided examples of how to start an interaction, reply to prompts by Alexa, and use the Amazon Kindle Fire's Alexa application. Participants were then instructed to continue with the online prompts, which instructed participants to complete the Amazon Echo Structured Interaction Script and Questionnaire. This portion served as practice for the unstructured interaction that followed and as exposure to the different kinds of interactions available for Alexa. Participants also rated whether they believed Alexa was providing satisfactory answers.

Upon completion of the structured interactions, participants were instructed by the researcher that they would remain alone for 15 minutes, during which time they could interact with the Amazon Echo in any way they desired. Participants were also directed towards the Skills section of the Alexa app and shown how to find, activate, and use the skills. The only limitations placed on participants was to keep the volume at its present level and not to purchase anything through its services. Upon delivering the instructions, the researcher would turn on a video camera that was only being used for audio recording purposes. At this point, the researcher would note and announce the current time, as well as indicate when they would return to the room.

The recorded audio from the interaction between the participant and Alexa was analyzed for number of interactions, type of interactions, and whether or not Alexa's reply was successful. Additionally, assessment of the quantity of socially presented queries was carried out, as well.

At the end of the 15-minute unscripted interaction, participants continued the online measures, completing the NMSPI (Harms & Biocca, 2004) and the Godspeed Anthropomorphism Scale (Bartneck et al., 2006). After this point, participants were instructed to direct their attention to the researcher, who proceeded to administer the post-task interview questionnaire. The questionnaire sought to assess common themes between participants relating to their interaction with the Amazon Echo, including additional elements they desired, but were not available, and participants' opinions of how to improve social presence. Two questions address whether the participant saw the device as a social agent. The interview also explored participants attitudes toward social robotics. Finally, the questionnaire attempted to identify how each participant understood loneliness by asking them to define the word "loneliness".

At the conclusion of the study, participants were fully debriefed on their participation and any participation credit due to student participants was awarded.

## RESULTS

Please refer to Table 1 for a descriptive summary of characteristics for the study sample. In regards to sample characteristics, age, gender, and loneliness are discussed further below.

### Age and Sex Distribution among Conditions.

There were a total of 84 participants in our final sample with the following distribution throughout the conditions: 23 participants ( $n_{Younger}=11$ ,  $n_{Older}=12$ ;  $n_{Male}=10$ ,  $n_{Female}=13$ ) in the Amazon Echo visible condition, 20 ( $n_{Younger}=10$ ,  $n_{Older}=10$ ;  $n_{Male}=8$ ,  $n_{Female}=12$ ) in the Amazon Echo hidden condition, 20 ( $n_{Younger}=10$ ,  $n_{Older}=10$ ;  $n_{Male}=6$ ,  $n_{Female}=14$ ) in the Alexa visible condition, and 21 ( $n_{Younger}=9$ ,  $n_{Older}=12$ ;  $n_{Male}=4$ ,  $n_{Female}=17$ ) in the Alexa hidden condition. No significant differences in age,  $F(3, 80)=0.32$ ,  $p=.81$ , were found between experimental conditions, between the ages of younger participants in each condition,  $F(3, 36)=0.92$ ,  $p=.44$ , or between the ages of older adult participants in each condition,  $F(3, 40)=1.66$ ,  $p=.19$ . Differences in the distribution of male and female participants within each group were present, with all conditions showing more female participants and one condition showing almost twice the number of female than male participants.

### Loneliness

Only 3 participants, or 3.6% of the sample, scored in the lonely range, considered any score over 40 on the UCLA Loneliness Scale (Russell, 1996). The median loneliness score was 14.50 ( $M=15.86$ ,  $SD=10.13$ ). The three lonely participants, as measured by the UCLA Loneliness Scale, included two in the Amazon Echo visible condition and one in the Amazon Echo hidden condition.

Table 1 Descriptive characteristics of the sample population (N=84).

Characteristic	Adults 18-48 (n=40)	Adults 52-87 (n=44)	Overall
Sex			
Female (%)	26 (65.0)	30 (68.2)	56 (66.7)
Male (%)	14 (35.0)	14 (31.8)	28 (33.3)
Mean age in years ( <i>SD</i> )	20.85 (5.30)	70.32 (8.60)	46.76 (25.87)
Ethnicity/Race			
White (%)	24 (60.0)	40 (90.9)	64 (76.2)
Black or African American (%)	6 (15.0)	2 (4.5)	8 (9.5)
Asian (%)	6 (15.0)	1 (2.3)	7 (8.3)
Other (%)	4 (10.0)	1 (2.3)	5 (5.6)
Hispanic <sup>a</sup> (%)	7 (17.5)	2 (4.5)	9 (10.7)
Education			
Some High School (%)	1 (2.5)	0 (0.0)	1(0.1)
High School (%)	29 (72.5)	8 (18.2)	37 (44.0)
Associates Degree or Equivalent (%)	5 (12.5)	2 (4.5)	7 (8.3)
Bachelor's Degree (%)	5 (12.5)	13 (29.5)	18 (21.4)
Master's Degree (%)	0 (0.0)	15 (34.1)	15 (17.9)
Professional or Doctorate Degree (%)	0 (0.0)	6 (13.6)	6 (7.1)
Living Alone (%)	1 (2.5)	13 (29.5)	14 (16.7)
Living with Pets (%)	21 (52.5)	19 (43.2)	40 (47.6)
In a Romantic Relationship (%)	29 (72.5)	29 (65.9)	58 (69.0)
Have Children (%)	1 (2.5)	30 (68.2)	31 (36.9)
Religious (%)	20 (50.0)	25 (29.76)	55 (65.4)
Previous IPA Use (%)	29 (72.5)	20 (45.5)	49 (58.3)

<sup>a</sup> Participants were asked if they were Hispanic or not independent of the Ethnicity/Race question.

Results indicated that most of the study participants were low on the loneliness scale. Although previous studies have shown that older adults are particularly susceptible to loneliness (Qualter et al., 2015; Schutter et al., 2017; Shankar et al., 2016; Wilson & Moulton, 2010), our sample indicated a low rate of loneliness among the older adults. Age had a negative weak correlation with the UCLA loneliness score,  $r = -.24$ ,  $p = .03$ . This was mainly due to higher

loneliness scores among the younger adult group ( $M = 17.78$ ,  $SD = 11.20$ ), as compared to the older adult group ( $M = 14.11$ ,  $SD = 8.81$ ). Within the younger adult group, age was still weakly and negatively correlated with the UCLA score,  $r = -.34$ ,  $p = .03$ , but no relationship between variables was present in the older adult group.

No significant differences in UCLA scores existed between sexes,  $t(82) = 0.64$ ,  $p = .53$ , experimental conditions,  $F(3,80) = 0.64$ ,  $p = .59$ , ethnicity or race,  $F(3,80) = 1.15$ ,  $p = .34$ , living arrangement,  $t(82) = 0.37$ ,  $p = .71$ , having pets,  $t(82) = 1.56$ ,  $p = .12$ , romantic relationships,  $t(82) = 0.31$ ,  $p = .76$ , and religion,  $t(82) = -1.88$ ,  $p = .06$ .

Significant differences in UCLA score were present across highest education achieved,  $F(4,78) = 3.42$ ,  $p = .01$ . This analysis, which excluded the one participant who had not completed high school, shows that participants who completed high school and/or completed some college (no degree) are significantly lonelier ( $M = 19.05$ ,  $SD = 11.43$ ) than participants who have already obtained a bachelor's degree ( $M = 10.56$ ,  $SD = 7.25$ ). However, this analysis is confounded by a correlation between age and UCLA scores described above as there are more younger adults in the high school and/or some college group and more older adults in the bachelor's degree group.

Similarly, significant differences were present in UCLA score between participants with children and those without,  $t(81.89) = -2.44$ ,  $p = .02$  ( $M_{DIFF} = -4.84$ ,  $SE_{DIFF} = 1.98$ ). Participants with children were less lonely ( $M = 12.81$ ,  $SD = 6.83$ ) than those without ( $M = 17.64$ ,  $SD = 11.31$ ). Again, this is confounded by the distribution of ages across these groups.

### Social Presence

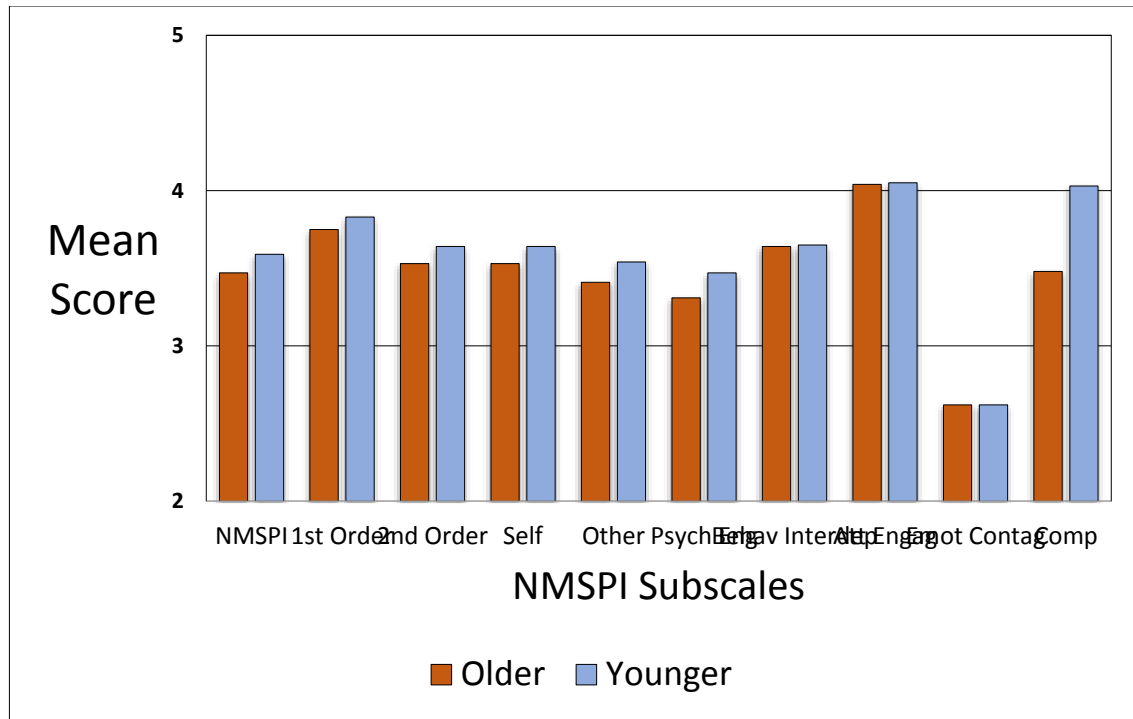
Overall, participants rated the Amazon Echo's IPA as eliciting a weak sense of social presence ( $M = 3.53$ ,  $SD = 0.39$ ). No significant differences were observed in total NMSPI scores between the Amazon Echo and Alexa conditions,  $F(1,80) = 1.81$ ,  $p = .18$ , or between Visible and Hidden conditions,  $F(1,80) = 1.15$ ,  $p = .34$ . Additionally, no interaction was observed,  $F(1,80) = 0.21$ ,  $p = .65$ .

While there are no differences in social presence between our younger and older adult groups as defined, differences in NMSPI total score are found when we compare adults over 65 years of age with everyone else,  $t(81.71) = -2.05$ ,  $p = .04$ . Over 65-years of age adults scored lower ( $M = 3.43$ ,  $SD = 0.28$ ) than younger ages ( $M = 3.59$ ,  $SD = 0.44$ ).

Participants' tendencies to anthropomorphize Alexa were significantly and positively correlated with total NMSPI score,  $r = .29$ ,  $p = .01$ , perception of others,  $r = .35$ ,  $p = .001$ , first order social presence,  $r = .24$ ,  $p = .03$ , second order social presence,  $r = .24$ ,  $p = .03$ , perceived psychological engagement,  $r = .35$ ,  $p = .001$ , and perceived emotional contagion,  $r = .36$ ,  $p = .001$ .

#### *First Order Social Presence.*

Participants perception of co-presence with the Amazon Echo was rated as moderate ( $M = 3.79$ ,  $SD = 0.70$ ). First order social presence measured the perception that the agent was present in the room and that the participant was there with the agent.



**Figure 1** Mean NMSPI scores across age-groups in the total scale and subscales. Error Bars SEM.

#### *Second Order Social Presence.*

Participants NMSPI scores for second-order social presence, or perceived psych-behavioral interaction, indicated a weaker perception of social presence than in first order ( $M = 3.45$ ,  $SD = 0.39$ ). First order social presence was significantly higher,  $t(83) = 4.80$ ,  $p < .001$  indicating that Alexa was better at generating feelings of co-presence than psycho-behavioral interaction. Psychobehavioral interaction implies that participants felt there was a communication of psychological data between them and the echo, including emotions and intentions.

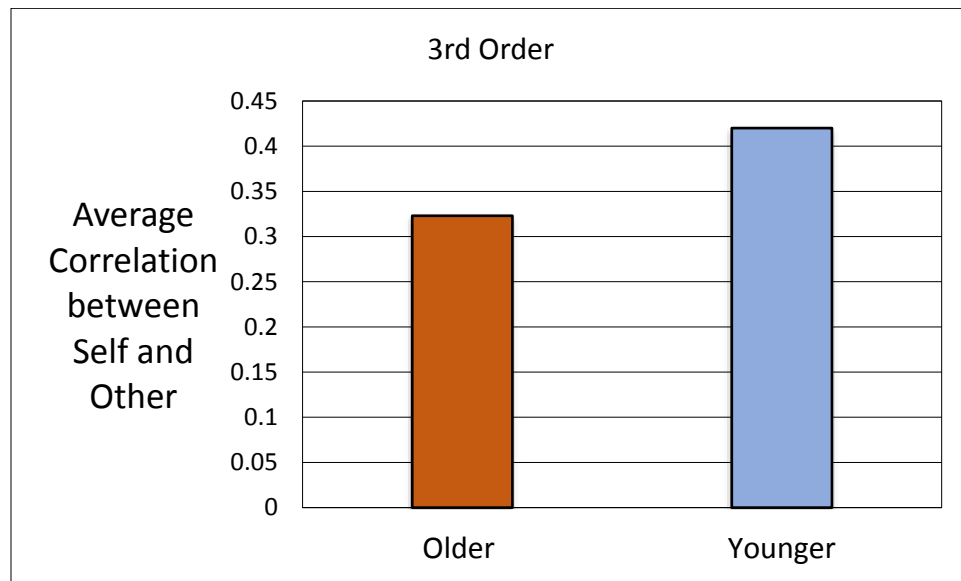
#### *Third Order Social Presence.*

Significant differences were present between the hidden and visible conditions in third order social presence,  $F(1,80) = 5.70$ ,  $p = .02$ ,  $\eta_p^2 = .07$ . Third order social presence measured the

degree of social connection or social symmetry between the agent and the participant. Participants who could see the Amazon Echo scored higher in subjective symmetry ( $M = 0.43$ ,  $SD = 0.22$ ) than those who could not see the device ( $M = 0.30$ ,  $SD = 0.27$ ).

Additionally, age is weakly and negatively correlated with third order social presence,  $r = -.24$ ,  $p = .03$ . However, no significant differences exist between age groups in third order social presence.

Significant differences existed in pet ownership,  $t(82) = 2.22$ ,  $p = .03$ , with those who owned pets having a higher score for third-order social presence, ( $M = 0.43$ ,  $SD = 0.26$ ), than those who did not ( $M = 0.31$ ,  $SD = 0.23$ ).



**Figure 2** Mean Third Order social presence scores. Error bars SEM.

#### *Perception of Self.*

Participants scores on perception of self were on average 3.58 ( $SD = 0.42$ ). Significant differences were present between the Amazon Echo and Alexa conditions in regards to perception



of self,  $F(1,80) = 4.38, p = .04, \eta_p^2 = .05$ . Participants in the Amazon Echo condition scored higher ( $M = 3.68, SD = 0.36$ ) than participants in the Alexa condition ( $M = 3.48, SD = 0.46$ ), indicating that those in the Amazon Echo condition rated higher in scale items relating to the perception of their own mental states, intentions, and how these affected the social interaction.

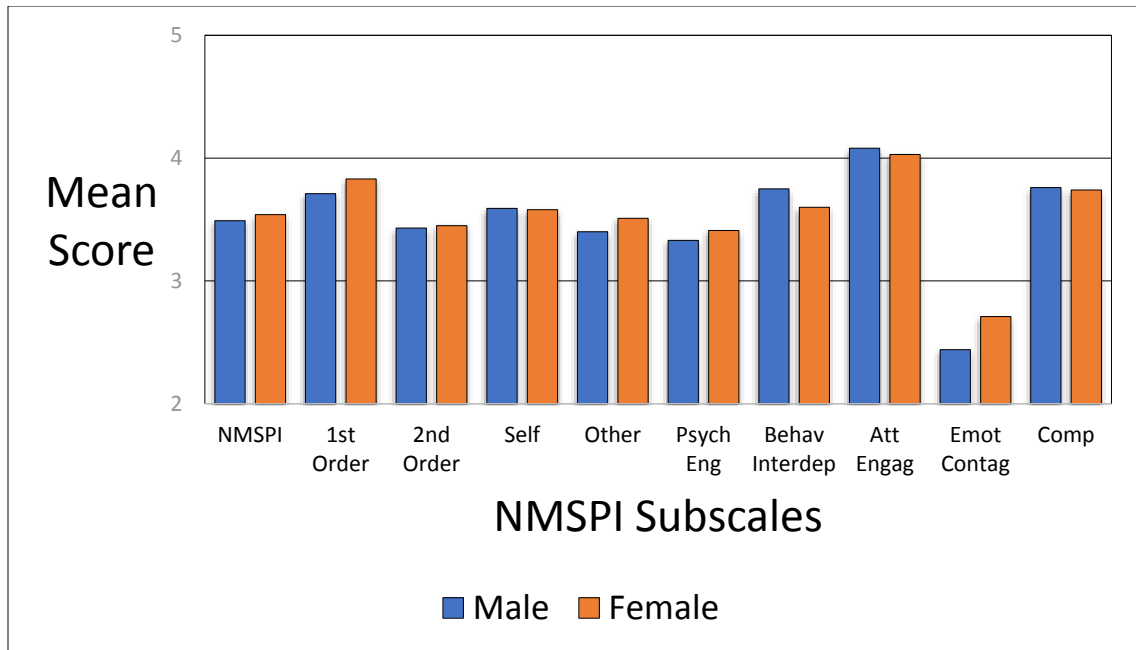
#### *Perception of the Other.*

Participant scores on perceptions of other were on average 3.47 ( $SD = 0.42$ ). Significant differences were present between the perception of self and perception of other subscales,  $t(83) = 3.11, p = .003$ , with perception of self-scoring higher. Perception of other related to participants' perception of the Echo's "mental" state, intentions, and how these affected the social interaction.

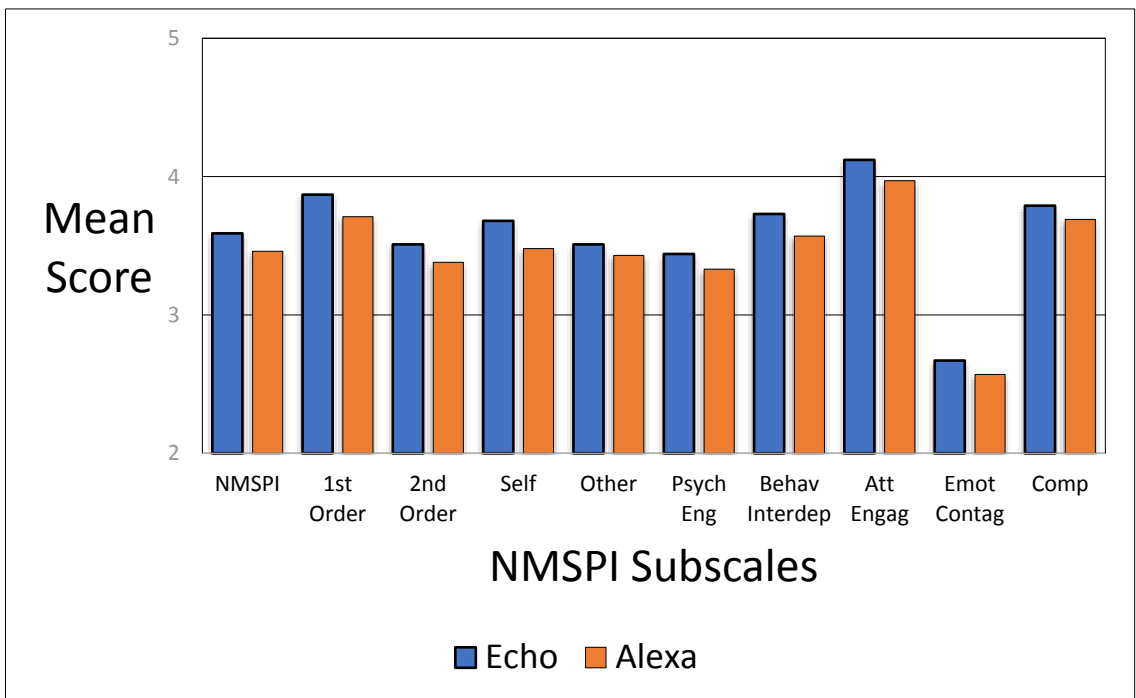
Additionally, significant differences in perception of the other are found when we compare adults over 65 years of age with other ages,  $t(80.23) = -2.23, p = .03$ . Over 65-years of age adults scored lower ( $M = 3.35, SD = 0.33$ ) than younger ages ( $M = 3.55, SD = 0.46$ ).

#### *Perceived Psychological Engagement.*

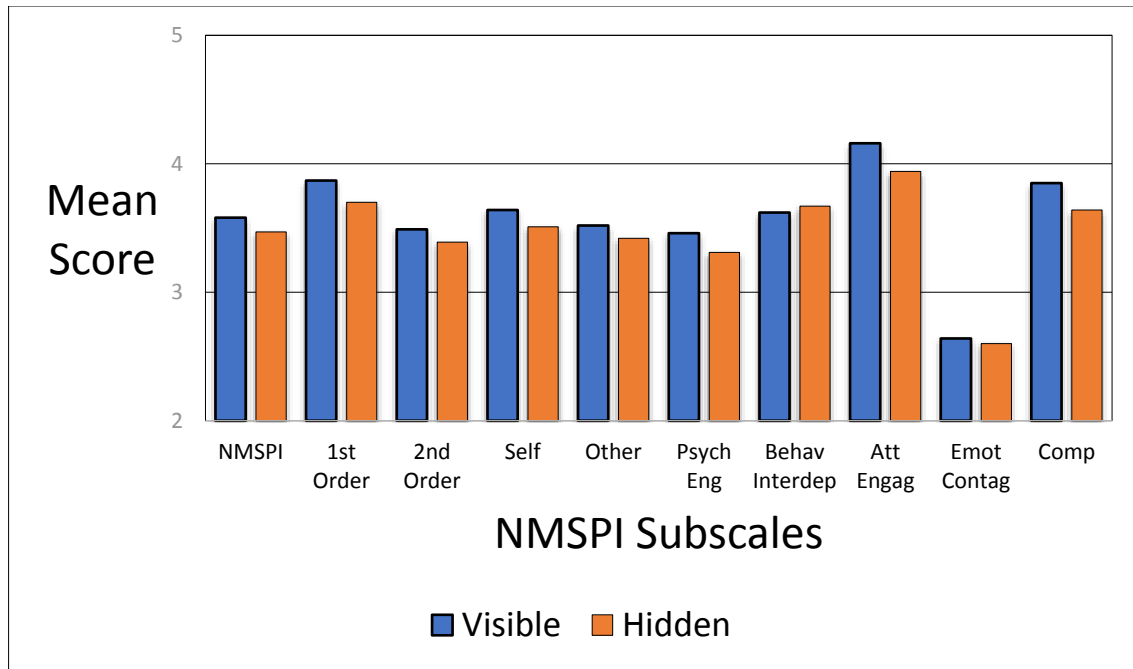
Mean scores for perceived psychological engagement were 3.39 ( $SD = 0.43$ ). Age was weakly and negatively correlated with perceived psychological engagement,  $r = -.22, p = .04$ . This indicates that older adults rate the communication of psychobehavioral information, including emotional states, between themselves as the device with a lower score. We do see a significant difference between adults over 65 years of age and other ages in perceived psychological engagement,  $t(82) = -2.17, p = .03$ ; with those over 65 scoring lower ( $M = 3.27, SD = 0.33$ ) than those of younger ages ( $M = 3.46, SD = 0.41$ ).



**Figure 3** Mean NMSPI scores between genders in the total scale and subscales. Error Bars SEM.



**Figure 4** Mean NMSPI scores between name conditions in total scale and subscales. Error bars SEM.



**Figure 5** Mean NMSPI scores across visibility conditions in the total scales and subscales. Error bars SEM.

#### *Perceived Attentional Engagement.*

Scores for attentional engagement were not normally distributed and were negatively skewed. Mean scores were 4.05 ( $Mdn = 4.17$ ,  $SD = 0.58$ ), showing a moderate level of perceived attentional engagement. This subscale measured whether participants felt the Echo was paying attention and if they were paying attention in turn.

#### *Perceived Emotional Contagion.*

Scores for perceived emotional engagement were not normally distributed and were negatively skewed. Mean scores were 2.62 ( $Mdn = 2.75$ ,  $SD = 0.67$ ), indicating low perceived attentional engagement. Nonparametric tests (Wilcoxon Signed Rank Test) show significant differences between perceived emotional contagion and attentional engagement,  $p < .001$ , with

participants rating perceived attentional engagement higher. Emotional contagion related to the transmission of emotional information.

#### *Perceived Comprehension.*

The mean score for perceived comprehension was 3.74 ( $SD = 0.68$ ). Age was moderately and negatively correlated with perceived comprehension,  $r = -.40$ ,  $p < .001$ . Furthermore, significant differences existed between age groups in perceived comprehension,  $t(82) = 3.96$ ,  $p < .001$ . Older adults rated the ability to understand the device, as well as their ability to be understood by the device, lower ( $M = 3.48$ ,  $SD = 0.61$ ) than younger adults ( $M = 4.03$ ,  $SD = 0.65$ ). This could potentially indicate a usability issue, as older adults may be having more trouble giving the Amazon Echo verbal commands and understanding its output. A full analysis of IPA usability is outside the scope of this paper.

Non-parametric tests showed that perceived comprehension was significantly different to both perceived emotional contagion,  $p < .001$ , and attentional engagement,  $p = .003$ . Scores for attentional engagement were higher and those for emotional contagion were lower.

#### *Perceived Behavioral Interdependence.*

Mean scores for perceived behavioral interdependence were 3.65 ( $SD = 0.74$ ). Significant differences were present between perceived behavioral interdependence and perceived psychological engagement,  $t(83) = -3.28$ ,  $p = .002$ . Participants scored higher in perceived behavioral interdependence. This subscale measured participants feelings of their behavior affecting the Echo and vice versa.

### Anthropomorphism

No significant differences were found between anthropomorphism scores in experimental groups.

Significant differences in loneliness were present between the low and high UCLA scores split along the median,  $t(82) = 3.88$ ,  $p < .001$ . Participants who were least lonely anthropomorphized the Amazon Echo more ( $M = 14.07$ ,  $SD = 3.72$ ) than those who were most lonely ( $M = 12.33$ ,  $SD = 3.50$ ).

### Perception of Social Presence

Interview responses indicated that most participants, 65.4%, did not see the Amazon Echo, in its current iteration, as a social companion. When asked whether they viewed an enhanced Amazon Echo or advanced social robotics as possibilities for social companionship, responses were more evenly split, with 52.7% having a favorable attitude and 47.3% seeing it in a negative light.

Male participants viewed Alexa, in its current version, more negatively, 71.4% “No”, than female participants, 55.4%. However, male participants viewed an enhanced Alexa or advanced social robotics more favorably, 39.3% “No”, than female participants, 42.9%.

Across experimental conditions (see Table 2), participants who could see the Amazon Echo rated the device as a social companion favorably less often than participants who could not see the device. Calling the IPA Amazon Echo or device in the visible condition resulted in a

greater percentage of participants rating the device favorably as compared to Alexa than in the hidden condition, which had an opposite effect.

**Table 2** Percentage of participants in each condition who rated the Amazon Echo favorably as a social companion.

Name of Device	Visibility of Device	
	Visible	Hidden
Amazon Echo	31.82%	45.00%
Alexa	14.29%	42.85%



**Figure 6** Percentage of participants who answered favorably to the Amazon Echo as a social companion across conditions.

## **DISCUSSION**

The goal of this study was to investigate whether a consumer-level IPA, specifically the Amazon Echo and its voice-controlled software Alexa, could be perceived as a social agent for older adults and whether this attribution allowed it to be used as a social companion to older adults feeling loneliness. To be perceived as a social agent, the study sought to examine what degree of social presence and anthropomorphism was needed, as well as any differences, among both older and younger adults. Additionally, the study sought to identify further exploratory routes into further improvement of social presence in the design of IPA features.

Unfortunately, our sample contained too few people rated as lonely by the UCLA Loneliness scale for statistical comparison. Trends in loneliness were explored through correlation and by splitting UCLA Loneliness scores across the median. However, since people that are high on loneliness may exhibit impaired executive control (Baumeister, Twenge, & Nuss, 2002; Cacioppo et al., 2000), decreased self-regulation (Baumeister, DeWall, Ciarocco, & Twenge, 2005), increased friendship seeking, increased need to make a positive impression on unfamiliar others (Maner, DeWall, Baumeister, & Schaller, 2007), increased negative feelings towards social mismatch (Twenge, Baumeister, Tice, & Stucke, 1994), unhealthy diets (Hawkley & Cacioppo, 2007), and increased self-defeating behavior (Twenge, Catanese, & Baumeister, 2002), generalizing conclusions from three participants is inadequate. Although loneliness trends and significance is discussed in the results, any discussion of loneliness here is limited to comparisons with previous studies.

Although approximately evenly split, a slight majority of participants were favorable towards an enhanced IPA or advanced social robotics serving as social companion. This relative ambivalence contrasts with participants' perception of the current generation Amazon Echo as a social companion, which is a lot clearer. Interview data suggests that most participants felt Alexa was not suitable as a social companion. However, participants who did feel that Alexa was suitable as a social companion rated higher in overall NMSPI score, but not higher in anthropomorphism. A trend towards more anthropomorphism existed, but was not significant. Interestingly, participants considered a visible intelligent personal assistant as less likely to be a social companion than one that was hidden. This could potentially be attributed to recognition that a visible device is a device and hence, decreases a user's sense that it can be a social agent. Visibly realizing something is not human may lower our sense of social interaction with the device. Since a hidden device is perceived as simply a (mostly) human voice talking through a speaker, it may be easier to ideate as a social companion. A voice does not violate societal norms of what should be a social companion as much as a cylindrical device does.

This may be somewhat supported by the effect we see with how we refer to the device. As mentioned in Results, referring to the Amazon Echo as an Echo or device in the visible condition resulted a greater ratio of participants rating Alexa favorably as a social companion than in the hidden condition, where the trend was reversed. The lower proportion of participants rating the Echo favorably when in the Alexa and visible condition may indicate a violation of expected social schemas. By referring to a device as she or Alexa, participants may feel as if there is a violation of semantic knowledge when they can see the device. When it is hidden, since the voice can potentially be someone, there is no such violation of expectations.



Although language has previously been tied to anthropomorphic tendencies, this may not carry through to an effect on our sense of social presence or our perception of a social agent. Calling something by a human name does not necessarily make it a social agent. As with participants' interview responses, NMSPI scores show lower social presence scores for the Alexa condition. Again, calling something Alexa when it is a device may violate our social schemas. A further possibility is that calling something by the name Alexa heightens our expectations of what we would expect from it as a social agent, garnering higher social presence expectations, which are then violated, leading to lower scores.

In contrast with the interview, the NMSPI scores showed higher means for the visible condition, although they were not significantly different from the hidden.

Overall, Alexa's ability to generate social presence could be considered as low to moderate across the complete NMSPI scale and its subscales, with the exception of perceived emotional contagion which was rated as having very low social presence. This is somewhat expected as the Amazon Echo is limited in the complexity of social interactions, has no physical anthropomorphic qualities, and lacks body language. The last two elements could assist in the expression of emotion if present (i.e. a "smile" in an LED light display might let us know the device is happy or support verbal indications of happiness).

Differences in the scores among the NMSPI subscales hint at the elements that participants found most deficient, as well as which ones garnered high social presence. First order social presence, or co-presence, received higher scores than second order social presence, or psycho-behavioral interaction. Of course, first order social presence simply measures if another social self

and the participant are present in the same space and notice each other. However, second order social presence includes interactions and emotional engagements that are beyond the current capabilities of the Amazon Echo. Most participants (85.71%), for example, expressed that the Amazon Echo was unable to express emotions (fake or real) and that its tone of voice appeared flat and emotionless. As such, participants received very little emotional information from the Amazon Echo, which limited the sharing of emotions between the two agents.

Although not always statistically significant, older adults rated the device as having less social presence than younger adults did and this was significantly prevalent when comparing adults over 65 years of age against the rest of participants. Overall, to improve social presence for older adults, improvements throughout various social domains should be made, but the biggest problem stems from comprehension. Hinting at a usability issue, older adults rated the ability of the Echo to understand them and for them to understand the Echo much lower than younger adults.

Based on the results of the NMSPI, improving Alexa's chances as a social companion to older adults requires first and foremost usability studies to explore what difficulties in use and comprehension could be driving the lower Perceived Comprehension scores among older adults. Although the Amazon Echo is controlled by "natural language", the phrasing of the questions and limitations in ability must be learned by the participant in order to successfully engage with the device. Overall across both age groups, improving emotional contagion should improve social engagement and social presence. The difficulty here is finding the perfect balance between proper emotional simulation and a too emotional device, especially considering that the user knows that the interactions are not real. A too emotional device might cross into the uncanny valley and be seen with discomfort by users. However, adding body language elements (i.e. smiling "screen"

face or expressions of care and concern) may help spread emotional contagion. The relationship between higher NMSPI scores and participants' likelihood of considering Alexa a social companion indicates that improvements in the scale components may lead to higher companionship acceptability.

## **LIMITATIONS**

Several limitations impacted the study. The most predominant limitation was the lack of lonely older adults in our sample. Many of our older adult participants were recruited from an educational program for older adults. The low loneliness scores found among these older adults might indicate the success of these programs at forming strong social relationships between members. However, it could also be an indication of another variable influencing social interaction in this population. Regardless, the fact that only one older adult was lonely, as scored on the UCLA loneliness scale, keeps us from being able to generalize the findings of this study to the overall older adult population that might be experiencing long-term loneliness.

An additional limitation that may have affected a subscale of the social presence scores was the location of the Amazon Echo Dot for the hidden condition. In this condition, the device was hidden from view and farther from the participant. While still well within the sound detection range of the Dot (Amazon, 2017b), the hidden location may have led to problems with sound detection due to obstructions between the participant and the device. From examining recorded video of participants interacting with the Dot, we do not feel that this was a major concern. However, it is possible that the Hidden condition's lower Perceived Comprehension score (see Figure 5) might be a result, in part, of this obstructed location.

Finally, as with all interviews performed by differing researchers, there may have been some differences in the exact wording of questions by each researcher. However, examination of the distributions of participant answers for each researcher shows no significant differences.

## **APPENDIX A: IRB APPROVAL LETTER**



University of Central Florida Institutional Review Board  
Office of Research & Commercialization  
12201 Research Parkway, Suite 501  
Orlando, Florida 32826-3246  
Telephone: 407-823-2901 or 407-882-2276  
[www.research.ucf.edu/compliance/irb.html](http://www.research.ucf.edu/compliance/irb.html)

## Approval of Human Research

From: UCF Institutional Review Board #1  
FWA00000351, IRB00001138

To: Janan A. Smither and Co-PIs: Daniel S. McConnell & Fernando Montalvo

Date: November 22, 2016

Dear Researcher:

On 11/22/2016 the IRB approved the following human participant research until 11/21/2017 inclusive:

Type of Review: UCF Initial Review Submission Form  
Expedited Review

Project Title: Examining individual attitudes towards virtual agents as social companions.

Investigator: Janan A. Smither

IRB Number: SBE-16-12471

Funding Agency:

Grant Title:

Research ID: N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30 days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form cannot be used to extend the approval period of a study. All forms may be completed and submitted online at <https://iris.research.ucf.edu>.

If continuing review approval is not granted before the expiration date of 11/21/2017, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in IRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the [Investigator Manual](#).

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Kamille Chap

Signature applied by Kamille Chaparro on 11/22/2016 08:21:00 AM EST

IRB Coordinator

## **APPENDIX B: DEMOGRAPHIC AND EXPERIENCE QUESTIONNAIRE**



Demographics Survey:

1) What is your age?

\_\_\_\_\_

2) What is your ethnicity/race (If Hispanic, indicate “yes” in the next survey question)?

- a. White
- b. Black or African American
- c. Native American or American Indian
- d. Asian; Please indicate your Asian country of origin/identity: \_\_\_\_\_.
- e. Pacific Islander
- f. Other (Please use this if you do not identify as any of the above or wish to specify it further): \_\_\_\_\_.

3) Are you Hispanic?

- a. Yes:
  - i. Please indicate your (or your family’s) country of origin: \_\_\_\_\_.
- b. No.

4) What is the highest degree of school you have completed? *If currently enrolled, highest degree received.*

- a. No schooling completed.
- b. Pre-K/Nursery School to 8<sup>th</sup> Grade
- c. Some high school/no diploma.
- d. High school graduate diploma, diploma, or the equivalent (i.e. GED).
- e. Some college credit, no degree. (First year/Freshmen students – do not select).
- f. Trade/Technical/Vocational Training.
- g. Associate Degree.
- h. Bachelor’s Degree
- i. Master’s Degree.
- j. Professional Degree.
- k. Doctorate Degree.

5) Do you live alone or with others (roommates, family, wife/husband, kids, etc.)?

- a. Yes.
- b. No.

- 6) Do you have any pets?
- a. Yes (Please specify type of pet): \_\_\_\_\_
  - b. No.
- 7) Relationship Status:
- a. Single, never married.
  - b. Have boyfriend/girlfriend.
  - c. Married, Long-term romantic cohabitation, or domestic partnership.
  - d. Widowed.
  - e. Divorced.
  - f. Separated.
- 8) Do you have children?
- a. Yes.
  - b. No.
- 9) Do you consider yourself a religious person?
- a. Yes.
  - b. No.
- 10) Do you have experience using an intelligent personal assistant, such as the Amazon Echo, Apple Siri, Google Home, Microsoft Cortana, etc.
- a. No.
  - b. I've used one once.
  - c. I've occasionally used one.
  - d. I frequently use one.
  - e. I'm an avid user.
- 11) Which intelligent personal assistants have you used? \_\_\_\_\_

## **APPENDIX C: UCLA LONELINESS SCALE**

### **UCLA-California Loneliness scale**

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

O indicates "I often feel this way"

S indicates "I sometimes feel this way"

R indicates "I rarely feel this way"

N indicates "I never feel this way"

1. I am unhappy doing so many things alone

O S R N

2. I have nobody to talk to

O S R N

3. I cannot tolerate being so alone

O S R N

4. I lack companionship

O S R N

5. I feel as if nobody really understands me

O S R N

6. I find myself waiting for people to call or write

O S R N

7. There is no one I can turn to

O S R N

8. I am no longer close to anyone

O S R N

9. My interests and ideas are not shared by those around me

O S R N

10. I feel left out

O S R N

11. I feel completely alone

O S R N

12. I am unable to reach out and communicate with those around me

O S R N

13. My social relationships are superficial

O S R N

14. I feel starved for company

O S R N

15. No one really knows me well

O S R N

16. I feel isolated from others

O S R N

17. I am unhappy being so withdrawn

O S R N

18. It is difficult for me to make friends

O S R N

19. I feel shut out and excluded by others

O S R N

20. People are around me but not with me

O S R N

## **APPENDIX D: AMAZON ECHO SCRIPTED INTERACTION**

*YOU WILL NOW COMPLETE A SERIES OF TASKS WITH THE AMAZON ECHO. WHEN TALKING TO THE AMAZON ECHO, PLEASE SAY THE WORDS EXACTLY AS THEY ARE DEPICTED IN THIS SCRIPT. AFTER EACH INTERACTION WITH THE DEVICE, PLEASE COMPLETE THE QUESTION BELOW EACH INTERACTION.*

- 1) Say: "Alexa, can you tell me a joke?"

[Participants will see the following question after this and all other interactions.]

- a. Did the Amazon Echo complete the task as desired?
  - i. Yes, it did exactly as I requested.
  - ii. For the most part, but I needed a little bit more.
  - iii. It did some of what I wanted, but left a lot to be desired.
  - iv. It did not do what I wanted it to do.
- 2) Say: "Alexa, what is traffic like?"
- 3) Say: "Alexa, how are you?"
- 4) Say: "Alexa, how is traffic?"
- 5) Say: "Alexa, are you a robot?"
- 6) Say: "Alexa, what is the weather like?"
- 7) Say: "Alexa, I'm feeling sad."
- 8) Say: "Alexa, on what day is the 4<sup>th</sup> of July next year?"
- 9) Say: "Alexa, what is your favorite movie?"
- 10) Say: "Alexa, at what time is Star Trek (or another current movie) playing at the Oviedo movie theater?"
- 11) Say: "Alexa, can you rap?"
- 12) Say: "Alexa can you read me Game of Thrones?" (Answer the questions below while the audiobook plays.) After answering the questions, say "Alexa, stop."
- 13) Say: "Alexa, can you sing?"
- 14) Say: "Alexa, can you play the song Happy." After answering the questions, say "Alexa, stop."
- 15) Say: "Alexa, where were you born?"
- 16) Say: "Alexa, what is today's date?"
- 17) Say: "Alexa, why are you called Alexa?"
- 18) Say, "Alexa, can you give me some news?". After answering the questions below, say "Alexa, stop."
- 19) Say, "Alexa, when is your birthday?"
- 20) Say, "Alexa, Wikipedia cognitive psychology."

## **APPENDIX E: NETWORKED MINDS SOCIAL PRESENCE INVENTORY**



## Networked Minds Social Presence Inventory

\*\* Answers to the questions below will be presented after each question in a 5 point Likert scale. The scale will begin at (1) Completely Disagree and end at (5) Completely Agree. \*\*

- 1) I often felt as if Alexa and I were in the same room together.
- 2) I paid close attention to Alexa.
- 3) I was able to communicate my intentions clearly to Alexa.
- 4) My actions were often dependent on Alexa's actions.
- 5) I was often aware of Alexa in the room.
- 6) I was easily distracted from Alexa when other things were going on.
- 7) I was sometimes influenced by Alexa's moods.
- 8) My thoughts were clear to Alexa.
- 9) My behavior was often in direct response to Alexa's behavior.
- 10) I hardly noticed Alexa in the room.
- 11) I tended to ignore Alexa.
- 12) When I was happy, Alexa tended to be happy.
- 13) I was able to understand what Alexa meant.
- 14) What I did often affected what Alexa did.
- 15) I think Alexa often felt like we were in the same room together.
- 16) Alexa paid close attention to me.
- 17) When I was feeling sad, Alexa also seemed to be down.
- 18) Alexa was able to communicate her intentions to me.
- 19) Alexa's actions were often dependent on my actions.
- 20) Alexa was often aware of me in the room.
- 21) Alexa was easily distracted from me when other things were going on.
- 22) When I was feeling nervous, Alexa also seemed to be nervous.
- 23) Alexa's thoughts were clear to me.
- 24) The behavior of Alexa was often in direct response to my behavior.
- 25) Alexa didn't notice me in the room.
- 26) Alexa tended to ignore me.
- 27) Alexa was sometimes influenced by my moods.
- 28) Alexa can explain how I felt.
- 29) Alexa was able to understand what I meant.
- 30) What Alexa did often affected what I did.
- 31) I think Alexa often felt as if we were in different places rather than together in the same room.
- 32) When Alexa was happy, I tended to be happy.
- 33) I often felt as if we were in different places rather than together in the same room.
- 34) When Alexa was feeling sad, I tended to be sad.
- 35) When Alexa was feeling nervous, I tended to be nervous.
- 36) I can easily explain how Alexa felt.

## **APPENDIX F: GODSPEED ANTHROPOMORPHIC QUESTIONNAIRE**

## Godspeed Anthropomorphic Questionnaire

Please rate your impression of the Amazon Echo on these scales.

1) The Amazon Echo was...

Fake 1 2 3 4 5 Natural

2) The Amazon Echo was...

Machinelike 1 2 3 4 5 Human-like

3) The Amazon Echo was...

Unconscious 1 2 3 4 5 Conscious

4) The Amazon Echo was...

Artificial 1 2 3 4 5 Lifelike

## **APPENDIX G: POST-TASK INTERVIEW**

(The following questions will be asked by the researcher)

Script: *“You have completed all the online surveys. Now, we will do a short interview about your experience with the Amazon Echo. Please answer the questions as honestly as possible.”*

- 1) What did you think of Alexa?
- 2) For you personally, when thinking of an agent such as Alexa, would you refer to it as an artificial intelligence, software, personal assistant, or another term? What other term would you use?
- 3) At any moment, did you find yourself thinking of Alexa as if you were thinking of a person?
- 4) Did Alexa elicit any emotions from you (i.e. happiness, sadness, frustration)? Which emotions?
- 5) At any point, did you think Alexa conveyed its own emotions?
- 6) Do you think agents such as Alexa will ever be advanced enough to feel like a social companion?
- 7) What are some things that you would have liked her to do?
- 8) Would you ever consider the Alexa as a social companion?
- 9) How would you feel about having an artificial friend (i.e. a robot friend)? [If no...] How would you feel about having an artificial pet (i.e. a robot pet)?
- 10) What to you is loneliness?

## REFERENCES

- Aarts, S., Peek, S.T.M., & Wouters, E.J.M. (2014). The relation between social network site usage and loneliness and mental health in community-dwelling older adults. *International Journal of Geriatric Psychiatry*, 30. 942-949.
- Amazon. (2017a). Amazon Echo – Black [Online Product Page]. Retrieved from <https://www.amazon.com/Amazon-Echo-Bluetooth-Speaker-with-WiFi-Alexa/>
- Amazon. (2017b). Echo Dot – 2<sup>nd</sup> Generation [Online Product Page]. Retrieved from <https://www.amazon.com/dp/B01DFKC2SO/>
- Amazon. (2017c). Kindle Fire Tablet with Alexa 7” [Online Product Page]. Retrieved from <https://www.amazon.com/dp/B00TSUGXKE/>
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders*. Washington DC: American Psychiatric Pub.
- Astington, J. W., & Baird, J. A. (Eds.). (2005). *Why language matters for theory of mind*. Oxford University Press.
- Bartneck, C., Croft, E., & Kulic, D. (2008, March). Measuring the anthropomorphism, animacy, likeability, perceived intelligence and perceived safety of robots. In *Metrics for HRI workshop, technical report* (Vol. 471, pp. 37-44).
- Baumeister, R. F., DeWall, C. N., Ciarocco, N. J., & Twenge, J. M. (2005). Social exclusion impairs self-regulation. *Journal of personality and social psychology*, 88(4), 589.

- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological bulletin*, 117(3), 497.
- Baumeister, R. F., Twenge, J. M., & Nuss, C. K. (2002). Effects of social exclusion on cognitive processes: anticipated aloneness reduces intelligent thought. *Journal of personality and social psychology*, 83(4), 817.
- Benbasat, I., Dimoka, A., Pavlou, P. A., & Qiu, L. (2010, December). Incorporating Social Presence in the Design of the Anthropomorphic Interface of Recommendation Agents: Insights from an fMRI Study. In *International Conference of Information Systems 2010 Proceedings* (p. 228).
- Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators and virtual environments*, 12(5), 456-480.
- Breazeal, C. (2004). Social interactions in HRI: the robot view. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, 34(2), 181-186.
- Bush, E. (Producer) & Garland, A. (Director). (2015). *Ex Machina* [Motion Picture]. UK: Universal Pictures International.
- Cacioppo, J. T., Ernst, J. M., Burleson, M. H., McClintock, M. K., Malarkey, W. B., Hawkley, L. C., ... & Spiegel, D. (2000). Lonely traits and concomitant physiological processes: the MacArthur social neuroscience studies. *International Journal of Psychophysiology*, 35(2), 143-154.

- Cacioppo, J. T., Hawkley, L. C., Berntson, G. G., Ernst, J. M., Gibbs, A. C., Stickgold, R., & Hobson, J. A. (2002). Do Lonely Days Invade the Nights? Potential Social Modulation of Sleep Efficiency. *Psychological Science*, 13(4), 384-387.
- Cacioppo, J. T., Hawkley, L. C., Ernst, J. M., Burleson, M., Berntson, G. G., Nouriani, B., & Spiegel, D. (2006). Loneliness within a nomological net: An evolutionary perspective. *Journal of research in personality*, 40(6), 1054-1085.
- Cacioppo, J.T. & Patrick, W. (2008) *Loneliness: Human nature and the need for social connection*. New York, NY: WW Norton & Company.
- Colby, S. L., & Ortman, J. M. (2015). Projections of the size and composition of the US population: 2014 to 2060. *Current Population Reports*, (P25-1143).
- Collins, K. (2016). *Man seeking robot: One inventor's quest to cure loneliness*. C Net. Retrieved from <http://www.cnet.com/news/man-seeking-robot-one-inventors-quest-to-cure-loneliness/>
- Csordas, T. J. (2008). Intersubjectivity and intercorporeality. *Subjectivity*, 22(1), 110-121.
- Dahlberg, K. (2007) The enigmatic phenomenon of loneliness. *International Journal of Qualitative Studies on Health and Well-being*. 2(4), 195-207.
- Darcy, S., Maxwell, H., & Green, J. (2016). Disability citizenship and independence through mobile technology? A study exploring adoption and use of a mobile technology platform. *Disability & Society*. 31(4), 497-519, DOI: 10.1080/09687599.2016.1179172



- Donovan, N.J. Wu, Q., Rentz, D.M., Sperling, R.A., Marshall, G.A., & Glymour, M.M. (2010). Reciprocal relations of loneliness and cognitive function in older U.S. adults. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*, 11(7), 201-202, doi: 10.1016/j.jalz.2015.07.194
- Donovan, N. J., Wu, Q., Rentz, D. M., Sperling, R. A., Marshall, G. A., & Glymour, M. M. (2016). Loneliness, depression and cognitive function in older U.S. adults. *International Journal of Geriatric Psychiatry*, 1-10. doi:10.1002/gps.4495
- Dykstra, P.A. (2009). Older adult loneliness: myths and realities. *European Journal of Ageing*. 6(2): 91-100.
- Eisenberger, N. I., Lieberman, M. D., & Williams, K. D. (2003). Does rejection hurt? An fMRI study of social exclusion. *Science*, 302(5643), 290-292.
- Epley, N., Akalis, S., Waytz, A., & Cacioppo, J. T. (2008). Creating social connection through inferential reproduction loneliness and perceived agency in gadgets, gods, and greyhounds. *Psychological Science*, 19(2), 114-120.
- Epley, N., Waytz, A., Akalis, S., & Cacioppo, J. T. (2008). When we need a human: Motivational determinants of anthropomorphism. *Social cognition*, 26(2), 143-155.
- Epley, N., Waytz, A., & Cacioppo, J. T. (2007). On seeing human: a three-factor theory of anthropomorphism. *Psychological review*, 114(4), 864.

- Fiore, S.M., Wiltshire, T.J., Lobato, E.J.C., Jentsch, F.G., Huang, W.H., & Axelrod, B. (2013). Toward understanding social cues and signals in human-robot interaction: effects of robot gaze and proxemic behavior. *Frontiers in Psychology*, 4, 859, 1-15.
- Gallese, V., Keysers, C., & Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends in Cognitive Sciences*, 8(9), 396-403.
- Gazzola, V., Rizzolatti, G., Wicker, B., & Keysers, C. (2007). The anthropomorphic brain: the mirror neuron system responds to human and robotic actions. *Neuroimage*, 35(4), 1674-1684.
- Gerst-Emerson, K. & Jayawardhana, J. (2015). Research and Practice: Loneliness as a public health issue: The impact of loneliness on health care utilization among older adults. *American Journal of Public Health*, 105(5), 1013-1019.
- Gow, A. J., Corley, J., Starr, J. M., & Deary, I. J. (2013). Which social network or support factors are associated with cognitive abilities in old age? *Gerontology*, 59(5), 454-463.
- Gowlett, J., Gamble, C., Dunbar, R. (2012). Human evolution and the archaeology of the social brain. *Current Anthropology*, 53(6), 693-722.
- Harms, C., & Biocca, F. (2004). Internal consistency and reliability of the networked minds measure of social presence. In M. Alcaniz and B. Rey [Eds.], *Seventh Annual International Workshop: Presence 2004*. Valencia: Universidad Politecnica de Valencia.
- Harper, T. (Producer), McGatlin, J. (Producer), & Abrams, J.J (Director and Producer). (2015). *Star Wars: The Force Awakens* [Motion Picture]. United States: Lucasfilm.

- Hawkey, L. C., & Cacioppo, J. T. (2007). Aging and loneliness: Downhill quickly?. *Current Directions in Psychological Science*, 16(4), 187-191.
- Higgins, E. T. (1996). Knowledge activation: Accessibility, applicability, and salience. In E.T. Higgins & A.W. Kruglanski (Eds.), *Social Psychology: Handbook of basic principles* (pp. 133-168). New York, NY: Guilford Press.
- Inagaki, K., & Hatano, G. (1993). Young children's understanding of the mind-body distinction. *Child development*, 64(5), 1534-1549.
- Jibo. (2015). *Jibo: Meet the world's first social robot*. Jibo. Retrieved from <https://www.jibo.com/>.
- Krueger, F., McCabe, K., Moll, J., Kriegeskorte, N., Zahn, R., Strenziok, M., ... & Grafman, J. (2007). Neural correlates of trust. *Proceedings of the National Academy of Sciences*, 104(50), 20084-20089.
- Kumar, N., & Benbasat, I. (2006). Research note: the influence of recommendations and consumer reviews on evaluations of websites. *Information Systems Research*, 17(4), 425-439.
- Lambert, V., Lussier, Y., Sabourin, S., & Wright, J. (2007). Attachment, Solitude, Psychological Distress in Young-Adults. *International Journal of Psychology*, 30(1), 109-131.
- Leite, I., Martinho, C., & Paiva, A. (2013). Social robots for long-term interaction: a survey. *International Journal of Social Robotics*, 5(2), 291-308.
- Mahon, N., Yarcheski, A., Yarcheski, T., Cannella, B., & Hanks, M. (2006). A meta-analytic study of predictors for loneliness during adolescence. *Nursing Research*, 55(5), 308-315.

- MacDorman, K. F., Vasudevan, S. K., & Ho, C. C. (2009). Does Japan really have robot mania? Comparing attitudes by implicit and explicit measures. *AI & society*, 23(4), 485-510.
- Maner, J. K., DeWall, C. N., Baumeister, R. F., & Schaller, M. (2007). Does social exclusion motivate interpersonal reconnection? Resolving the "porcupine problem.". *Journal of personality and social psychology*, 92(1), 42.
- Mukamel, R., Ekstrom, A.D., Kaplan, J., Iacoboni, M., & Fried, I. (2010). Single-neuron responses in humans during execution and observation of actions. *Current Biology*. 20(8), 750-756.
- Naslund, J. A., Aschbrenner, K. A., Marsch, L. A., & Bartels, S. J. (2016). The future of mental health care: Peer-to-peer support and social media. *Epidemiology and Psychiatric Sciences*, 25(2), 113-122. doi:10.1017/S2045796015001067
- Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., ... & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, 53(4), 695-699.
- Panksepp, J. (2004). *Affective neuroscience: The foundations of human and animal emotions*. Oxford: Oxford University Press.
- Pantic, I. (2014). Online social networking and mental health. *Cyberpsychology, Behavior, and Social Networking*. 17(10), 652-657. DOI: 10.1089/cyber.2014.0070
- Perlman, D., & Peplau, L. A. (1981). Toward a social psychology of loneliness. In S. Duck & R. Gilmour (Eds.), *Personal relationships in disorder*. (pp. 31-56). London: Academic Press.

- Pikhartova, J., Bowling, A., & Victor, C. (2014). Does owning a pet protect older people against loneliness?. *BMC geriatrics*, 14(1), 106.
- Qualter, P., Vanhalst, J., Harris, R., Van Roekel, E., Lodder, G., Bangee, M., ... & Verhagen, M. (2015). Loneliness across the life span. *Perspectives on Psychological Science*, 10(2), 250-264.
- Qiu, L., & Benbasat, I. (2010). A study of demographic embodiments of product recommendation agents in electronic commerce. *International Journal of Human-Computer Studies*, 68(10), 669-688.
- Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, validity, and factor structure. *Journal of personality assessment*, 66(1), 20-40.
- Schutter, N., Holwerda, T.J., Stek, M.L., Dekker, J.J.M., Rhebergen, D., & Comijs, H.C. (2017). Loneliness in older adults is associated with diminished cortisol output. *Journal of Psychosomatic Research*. 95(2017), 19-25.
- Shankar, A., McMunn, A., Demakakos, P., Hamer, M., & Steptoe, A. (2017). Social isolation and loneliness: Prospective associations with functional status in older adults. *Health Psychology*. 36(2), 179-187.
- Shiovitz-Ezra, S., and Ayalon, L. (2010) Situational versus chronic loneliness as risk factors for all-cause mortality. *International Psychogeriatrics*, 22(3). 455-462.
- Short, J., Williams, E., & Christie, B. (1976). The social psychology of telecommunications. New York: John Wiley.

- Softbank Robotics. (2016). *Cool Robots*. Retrieved from <https://www.ald.softbankrobotics.com/en/cool-robots>.
- Spiegel, K., Leproult, R., & Van Cauter, E. (1999). Impact of sleep debt on metabolic and endocrine function. *The Lancet*, 354(9188), 1435-1439.
- Stanley, I.H., Conwell, Y., Bowen, C., Van Orden, K.A. (2014) Pet ownership may attenuate loneliness among older adult primary care patients who live alone. *Aging & Mental Health*, 18(3), 394-399.
- Twenge, J. M., Baumeister, R. F., Tice, D. M., & Stucke, T. S. (2001). If you can't join them, beat them: effects of social exclusion on aggressive behavior. *Journal of personality and social psychology*, 81(6), 1058.
- Twenge, J. M., Catanese, K. R., & Baumeister, R. F. (2002). Social exclusion causes self-defeating behavior. *Journal of personality and social psychology*, 83(3), 606-615.
- Vanhalst, J., Luyckx, K., Scholte, R. H., Engels, R. C., & Goossens, L. (2013). Low self-esteem as a risk factor for loneliness in adolescence: Perceived-but not actual-social acceptance as an underlying mechanism. *Journal of abnormal child psychology*, 41(7), 1067-1081.
- Walter, H., Adenzato, M., Ciaramidaro, A., Enrici, I., Pia, L., & Bara, B. G. (2004). Understanding intentions in social interaction: the role of the anterior paracingulate cortex. *Journal of cognitive neuroscience*, 16(10), 1854-1863.

- Waytz, A., Cacioppo, J., & Epley, N. (2010). Who sees human? The stability and importance of individual differences in anthropomorphism. *Perspectives on Psychological Science*, 5(3), 219-232.
- Waytz, A., Morewedge, C. K., Epley, N., Monteleone, G., Gao, J. H., & Cacioppo, J. T. (2010). Making sense by making sentient: effectance motivation increases anthropomorphism. *Journal of personality and social psychology*, 99(3), 410.
- White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological review*, 66(5), 297.
- Wilson, C., & Moulton, B. (2010). *Loneliness among older adults: A national survey of adults 45+*. Prepared by Knowledge Networks and Insight Policy Research, Washington DC: AARP. Retrieved from: [http://assets.aarp.org/rgcenter/general/loneliness\\_2010.pdf](http://assets.aarp.org/rgcenter/general/loneliness_2010.pdf).
- Winston, J. S., Strange, B. A., O'Doherty, J., & Dolan, R. J. (2002). Automatic and intentional brain responses during evaluation of trustworthiness of faces. *Nature neuroscience*, 5(3), 277-283.