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Acceptance and Attitudes Toward a Human-like Socially Assistive Robot by Older Adults

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Recent studies have shown that cognitive and social interventions are crucial to the overall health of older adults including their psychological, cognitive, and physical well-being. However, due to the rapidly growing elderly population of the world, the resources and people to provide these interventions is lacking. Our work focuses on the use of social robotic technologies to provide person-centered cognitive interventions. In this article, we investigate the acceptance and attitudes of older adults toward the human-like expressive socially assistive robot Brian 2.1 in order to determine if the robot's human-like assistive and social characteristics would promote the use of the robot as a cognitive and social interaction tool to aid with activities of daily living. The results of a robot acceptance questionnaire administered during a robot demonstration session with a group of 46 elderly adults showed that the majority of the individuals had positive attitudes toward the socially assistive robot and its intended applications.

Keywords: cognitive and social interventions, older adults, robot acceptance, socially assistive robots

Introduction

The population of the world is aging rapidly. In 2011, 11.2% of the population was aged 60 years and older; by 2050, this number will double to approximately 22% of the population (United Nations, 2011). Population aging is a complex issue that concerns not only the well-being of older adults, but also brings forth severe health, social, and economic problems, as this particular population requires a disproportionately large portion of the available healthcare services (Callahan & Prager, 2008). With aging comes the decline of memory and other cognitive functions (Hedden & Gabrieli, 2004). As the elderly population continues to grow, so too does the number of individuals that will be diagnosed with cognitive impairments including dementia (Jorm, Forten, & Henderson, 1987), resulting in a vulnerable group of individuals who will need assistance in performing personal self-care and independent living activities.

Recent studies have supported the positive effects that cognitive and social interventions can have on the functioning of older adults, including improvements in episodic memory (Belleville et al., 2006), reducing the risk of dementia (Stem & Munn, 2010) and delaying age-related decline in health and mortality (Unger, Johnson, & Marks, 1997). However, implementing such interventions requires considerable resources and people, and trying to sustain them on a long-term basis can be very complex and time-consuming for healthcare professionals. The goal of our research is to develop robotic aids as effective tools for cognitive/social interventions of the elderly. These interventions are aimed to reduce a person's dependence on caregivers, as well as provide him or her with an avenue to interact and socialize during the course of these activities. In particular, we aim to design human-like socially assistive robots capable of providing cognitive assistance, targeted engagement and motivation to promote participation in self-maintenance (i.e., eating, dressing, and grooming; Lawton & Brody, 1969); instrumental (i.e., meal preparation, shopping, and taking transportation; Lawton & Brody, 1969), and enhanced (i.e., cognitively and socially stimulating leisure activities; Rogers, Meyer, Walker, & Fisk, 1998), activities of daily living via expressive verbal and nonverbal communication cues. Our long-term goal is to study how such robots can contribute to therapeutic protocols aimed at improving or maintaining residual social, cognitive, and global functioning of older adults.

In order for robots to be effective assistive technology tools for the elderly, they must be accepted and adopted by the intended user population. Up to one third of all assistive technologies are abandoned within one year of use (Gurley & Norcio, 2009). Additionally, due to time and money constraints assistive technology developers do not always test the technology with people the device is intended for (Gurley & Norcio, 2009). In order to promote adoption of assistive technologies, Kintsch and DePaula

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(2002) proposed a framework for the development, training and use of successful assistive technologies. The framework provides the necessary phases to ensure successful adoption of assistive technologies, including a development phase which requires obtaining feedback from the target population on user preferences, needs and practices that can be used to aid the development of assistive robots.

Measuring Technology Acceptance and Use

A popular questionnaire for measuring target user perceptions of technological systems, with the goal of predicting actual system use, has been the technology acceptance model (TAM; Davis, Bagozzi, & Warshaw, 1989) or the updated TAM2 (Venkatesh & Davis, 2000). TAM measures users' perceived usefulness, perceived ease of use, attitude toward, behavioral intention to use, and actual use of a technological system, as well as interrelations between these categories (Davis et al., 1989). TAM2 is based on TAM, and also includes social influence processes and cognitive instrumental processes (Venkatesh & Davis, 2000). However, the use of the TAM and TAM2 questionnaires with such software systems as office automation tools, email, voicemail, text editors and spreadsheets has shown that both questionnaires only predict 40% of a system's actual use (Legris, Ingham, & Collerette, 2003).

Alternatively, a small number of questionnaires have been developed to directly measure people's perceptions of robotic technologies (e.g. Bartneck, Kulic, Croft, & Zoghbi, 2009; Heerink, Krose, Evers, & Wielinga, 2010; Kamide, Takubo, Ohara, May, & Aria, 2014; Nomura, Kanda, Suzuki, & Kato, 2004). For example, the Godspeed questionnaire was developed to independently measure people's perceptions of anthropomorphism, animacy, likability, intelligence, and safety of a robot (Bartneck et al., 2009). The reliability and validity of these categories have been determined for American university students watching videos of robots and animated characters (Ho & MacDorman, 2010). The Negative Attitudes Toward Robots Scale (NARS) has been developed to measure a person's general attitudes toward robots prior to conducting any robot interaction studies with these individuals (Nomura et al., 2004). The scale is comprised of the three subscales consisting of negative attitudes toward (Nomura et al., 2004): (a) situations of interaction with robots, (b) social influence of robots, and (c) emotions in interaction with robots. NARS has been validated with Japanese university students (Syrdal, Dautenhahn, Koay, & Walters, 2009). The Perception to Humanoid Scale (PERNOD) measures people's perceptions of familiarity, utility, motion, controllability, and toughness of a humanoid robot (Kamide et al., 2014). PERNOD, thus far, has been validated with Japanese university students watching videos of a particular robot.

In addition to the aforementioned scales, the Almere model has been developed to directly measure acceptance and attitudes of older adults toward social robots (Heerink et al., 2010). The Almere model builds upon the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh, Morris, Davis, & Davis, 2003). The UTAUT model predicts the use of technological systems by investigating users' perceptions of performance expectancy, effort expectancy, social influence, and facilitating conditions as well as the moderating factors of gender, age, experience and voluntariness. The Almere model extends the UTAUT model by including the additional constructs of anxiety, attitude toward using the technology, perceived enjoyment, social presence, perceived sociability, trust and perceived adaptability (Heerink et al., 2010). Compared to the abovementioned scales, the Almere model is the only psychological scale designed to measure users', specifically older adults, perceptions of social robots during Human-Robot Interactions (HRI) (Heerink, 2010).

Measuring Technology Acceptance and Use by the Elderly

Presently, there have been several studies that have been conducted to determine acceptance of personal service robots by the elderly. These studies have either consisted of administering questionnaires to older adults to determine which tasks they would accept a robot to do in the home (Beer et al., 2012; Ezer, Fisk, & Rogers, 2009; Smarr et al., 2012) or where they controlled a remote presence robot and then participated in semi-structured interviews to discuss their opinions of the robot (Beer & Takayama, 2011). For example, in Smarr et al. (2012), a robot opinion questionnaire administered to older adults in a group interview setting showed that this group was open to assistance from the PR2 robot in performing home/housekeeping tasks. In Beer and Takayama (2011), older adults participated in two study sessions where they were able to operate a mobile remote presence robot and also interact with another person operating the robot. During subsequent interviews, the older adults expressed positive opinions of the robot. In addition to the aforementioned studies, other studies have specifically investigated attitudes, perceptions, and emotional responses of the elderly toward service robots with human-like features (Swangnetr, Zhu, Kaber, & Taylor, 2010; Zhang et al., 2010). In particular, in Zhang et al. (2010), a study with older participants in a simulated patient room was conducted with a PeopleBot robot that would bring participants a bag of medicine. In each trial, the robot would have one of three different anthropomorphic features: (a) a simple face mask with cameras for eyes, (b) voice capabilities via a speech synthesizer, or (c) a touch display for user interactivity. The results showed that these simple anthropomorphic and interactive features led to perceptions of humanness and positive emotional experiences, especially with increased feature realism.

With respect to the field of socially assistive robots, which is still in its infancy, only a handful of studies have investigated the acceptance of these types of robots by the elderly. To date, the majority of outcomes that have been utilized to study socially assistive robots have demonstrated the positive response of elderly individuals to these types of robots, suggesting the potential for such robotic aids. However, these studies were mainly focused toward collecting data on the acceptance and use of animal-like robots (e.g., Heerink, Krose, Evers, & Wielinga, 2006; Nakashima & Fukutome, 2010; Shibata & Wada, 2010;), with one study considering perceptions toward a child-like robot exercise instructor (Fasola & Matarić, 2012). This latter study showed that individuals perceived the robotic exercise system to be intelligent and helpful, however, the study did not explicitly obtain feedback on the robot's human-like attributes.

Uniquely, in this article, we investigate the design of an expressive human-like socially assistive robot in order to determine if the robot's human-like assistive and social characteristics would promote acceptance and positive attitudes toward using the robot as a cognitive tool for carrying out important activities of daily living. Such a study is important early on during the initial development stage of human-like socially assistive robots, in order to ensure the development of robots that meet the needs and wants of our elderly population.

Methods

We are developing the human-like socially assistive robot, Brian 2.1, Figure 1, to provide social interactions and cognitive stimulation to older adults (Allison, Nejat, & Kao, 2009; Chan & Nejat, 2012; Chang, Nejat, & Chen, 2011; McColl, Chan, & Nejat, 2012; Nejat & Ficocelli, 2008). We have chosen to develop an embodied social robot, due to the advantages such robots have over virtual agents such as being more engaging, more influential in decision making and more effective communicators when providing advice and recommendations (Powers, Kiesler, Fussell, & Torrey, 2007; Shinozawa, Naya, Yamato, & Kogure, 2005; Tapus, Tapus, & Mataric, 2009). The current prototype of the robot focuses on assisting individuals with enhanced activities of daily living in order to improve quality of life. Brian 2.1 is able to: (a) learn appropriate assistive behaviors based on the structure of an activity and (b) personalize an interaction based on task compliance and a person's user state during HRI. In this article, we investigate the acceptance and attitudes toward Brian 2.1 by older adults as a technological aid for this intended user population. Our study consists of conducting a robot demonstration session for elderly adults at a seniors association in Canada. Our research team was invited by the association to demonstrate the robot and its capabilities.

Participants

Fifty-four individuals attended a single live robot demonstration session. A robot acceptance questionnaire was given to all attendees to obtain feedback regarding their opinions on Brian 2.1. Forty-six individuals, 37 females and 9 males, ranging in age from 62 to 91 years ($\mu = 76$ and $\sigma = 7.2$), completed

Fig. 1. The socially assistive robot Brian 2.1.

Table 1. Participant experience with computers and robots.

Participants' experience with computers	Participants' experience with robots
No experience: 7 participants	No experience: 32 participants
Beginner (email, use simple programs): 11 participants	Beginner (seen robots at museums/science centers or stores, or have watched shows on real/physical robots): 14 participants
Intermediate (internet, chat): 16 participants	Intermediate (have worked with/used commercial robots): 0 participants
Advanced (editing documents, use complex programs): 12 participants	Advanced (have worked on robot developmental aspects including hardware/software design): 0 participants

and returned the questionnaire. All participants had at least a bachelor's degree. Table 1 summarizes the participants' prior experiences with robots and computers. With respect to previous robotic experience, 32 individuals did not have any experience at all, and the remaining 14 had seen robots before either on television or in museums, science centers, and/or stores. However, the participants had varying computer skills ranging from no experience to advanced, with the majority of them (i.e., 39 participants) being at least at the beginner's level.

The Socially Assistive Robot Brian 2.1

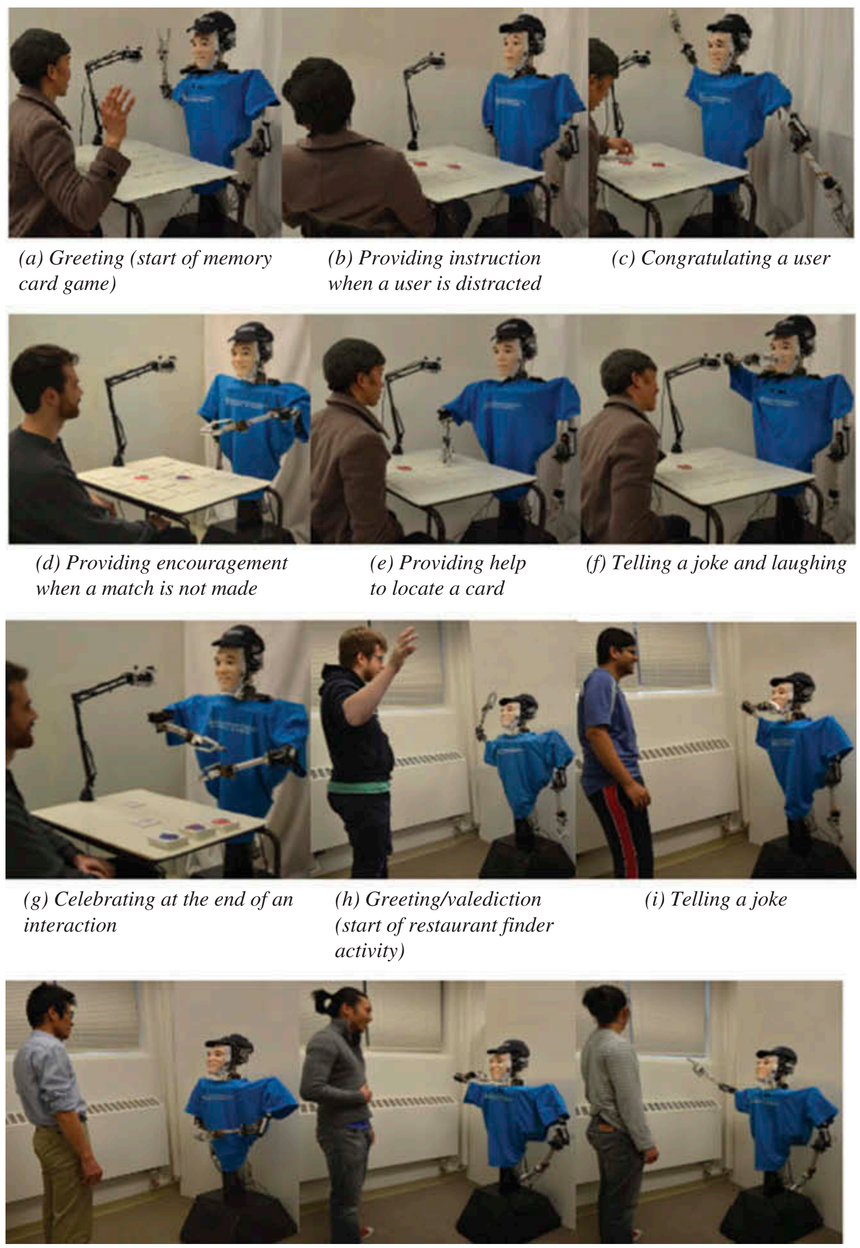
Brian 2.1 has similar functionalities to a person from the waist up. Namely, the robot displays body language, gestures and facial expressions using: (a) a three degrees-of-freedom (DOF) neck capable of head motions such as nodding up and down, cocking from shoulder to shoulder, and shaking from side to side; (b) two arms that have four DOFs each; two DOFs at the shoulder, one at the elbow and one at the wrist; (c) a two DOF waist that allows the robot to turn left and right, and also lean forward and backwards; and (d) a 5 DOF facial muscle system capable of displaying emotions such as happy (i.e., smiling and laughing), neutral, and sad (frowning and droopy eyes). The robot also communicates verbally using speech and vocal intonation via a synthesized male voice.

Brian 2.1 uses a noise-cancelling microphone to recognize human verbal actions and two-dimensional cameras to determine the state of both the activity at hand as well as the user during HRI. We define user state to be either engaged in the interaction or distracted by estimating the user's visual focus of attention via head orientation. This approach is similar to other studies that have utilized head orientation to estimate a person's engagement or attention during HRI scenarios (Pitsch et al., 2009; Sidner, Lee, Kidd, Lesh, & Rich, 2005; Stiefelhagen, Yang, & Waibel, 2001; Thomaz et al., 2005). These inputs are then used to determine the robot's assistive behavior which is displayed using a combination of both verbal and nonverbal communication.

Design

The robot demonstration session consisted of a short introduction to the robot, its functionalities and examples of the activities that the robot can assist older adults with. The robot was then physically demonstrated by a member of our research team interacting with it for two different activities: (a) a cognitively stimulating memory card game and (b) a restaurant finding activity. During the activity the robot demonstrated the assistive behaviors that it can provide. Examples of the robot's assistive behaviors during these different interactions are shown in Figure 2 and will be discussed in detail in the following Memory Card Game and Restaurant Finder sub-sections below. In total, the demonstration session was approximately 1.5 hours in length.

The robot's assistive behaviors were developed using guidelines that were presented in Grosch, Medvene, and Wolcott (2008) for person-centered behaviors during geriatric care. These guidelines included: greeting and expressing interest in an individual; orienting an individual to the caregiving task and asking permission to begin; offering choices for completing a task; providing feedback for accomplishing a task; engaging in social conversation; and showing interest and approval of an individual. When caregivers follow these guidelines and engage in these person-centered behaviors it has been shown to reduce



(a) Greeting (start of memory card game) *(b) Providing instruction when a user is distracted* *(c) Congratulating a user*

(d) Providing encouragement when a match is not made *(e) Providing help to locate a card* *(f) Telling a joke and laughing*

(g) Celebrating at the end of an interaction *(h) Greeting/valediction (start of restaurant finder activity)* *(i) Telling a joke*

(j) Information gathering from a user *(k) Providing a suggestion for a restaurant* *(l) Providing directions to a restaurant*

Fig. 2. Example assistive robot behaviors (robot interacting with members of our research team) during the memory card game (a–g) and the restaurant finder activity (h–l).

the resistiveness to care in activities of daily living interactions for elderly residents with dementia in long-term care (Lann-Wolcott & Medvene, 2011), as well as improve the perception of closeness and relationship satisfaction for elderly residents (Coleman & Medvene, 2012). We have also previously validated our socially assistive behaviors in a proof-of-concept study with healthy adult participants and found them effective in engaging individuals in a cognitively stimulating game (Chan & Nejat, 2012).

In our study, after the demonstrations with the robot were completed, a robot acceptance questionnaire was administered to the participants to measure acceptance toward our human-like socially assistive robot. This approach of using rich visual stimuli and a questionnaire allows for measuring broad attitudes and preferences toward less familiar assistive technology (Beach, 2012). Furthermore, questionnaires are one of the methods most commonly used for capturing user perspectives (Ghulam, Shah, & Robinson, 2006). It is very common in assistive technology design to administer questionnaires to initially measure user attitudes, perceptions, and needs, and then as a next step perform usability tests.

As such, the aim of our study was to measure user attitudes, perceptions, and needs, and in the future as a next step we will conduct usability tests with Brian 2.1 based on the feedback of our current study. The administered questionnaire was adapted from the Almere technology acceptance model developed by Heerink et al. (2010), which was designed specifically to test acceptance of an assistive social agent with elderly users. The reliability and validity of the Almere model have been verified through obtaining acceptable Cronbach's alpha values (0.7–0.95) and an acceptable chi-squared goodness-of-fit score (0.96) by conducting numerous social HRI and Human-Computer Interaction (HCI) experiments. These experiments consisted of 188 older adults socially interacting with a robot or virtual agent (Heerink, 2010). The Almere model has commonly been used with visual demonstrations of assistive social agents (Heerink et al., 2010; Xu et al., 2012). The following hypotheses, from the Almere model, were tested with the adapted questionnaire:

Hypothesis 1: A person will perceive Brian 2.1 to be useful if he or she perceives the robot to be easy to use and adaptable and does not cause the person anxiety.
Hypothesis 2: A person will perceive Brian 2.1 to be easy to use if the robot does not cause the person anxiety.
Hypothesis 3: A person will perceive Brian 2.1 to be sociable if he or she trusts it.

In addition to the questionnaire, we also studied whether computer experience had any effect on perceived ease of use of the robot by the elderly. Namely, the additional hypothesis we tested in our study was:

Hypothesis 4: The more experience a person has with computers, the easier he or she will perceive Brian 2.1 is to use.

Memory Card Game

The memory game consists of 16 picture cards being randomly turned face down in a 4 x 4 grid formation in front of a player. The objective for the player is to flip over two cards and match the pictures on the cards. Once a card pair has been matched, the two cards were removed from the game. The game is completed when all cards had been matched appropriately. The robot autonomously provides social stimulation in order to keep a person engaged in the game. We choose the memory card game activity for a human-robot interaction scenario because it is a cognitively stimulating leisure activity that trains a person's visual object memory and the updating function of the central executive component of the working memory (Jeffery, 2008). The pictures of common objects on the cards can also evoke personal memories, and the level of difficulty of the game can be changed to match the cognitive abilities of the user. Additionally, it has been shown that leisure activities, such as card games, can reduce cognitive decline and the risk of dementia (Verghese et al., 2003).

During the course of the game, we demonstrated the robot's ability to act as a social motivator by providing instructions, encouragement, celebration and help. Examples of the robot's behaviors used for the card game interaction are presented in Table 2 and Figures 2a–2g. The instruction behaviors of the robot were implemented in a neutral emotional state. The greeting, celebration, encouragement and end of game interaction behaviors were implemented in a happy emotional state with the robot smiling and speaking in a happy voice (Figures 2a, 2c, 2d, and 2g). A happy voice is characterized by a higher pitch and a faster speaking rate than the robot's neutral voice. Help was provided when the player did not get any matches during three consecutive rounds of the game by the robot providing a hint by asking the

Table 2. Example robot behaviors for card game activity.

Behavior type	Example behavior
Greeting	"Hi, my name is Brian. I am glad you want to play the memory game with me. Let's start." (Robot smiles and waves)
Instruction	"Let's play a round of the memory game. Please flip over a card." "When you don't pay attention to the game, I get sad. Please flip over a card." (Robot frowns and speaks in a sad tone of voice)
Celebration	"Congratulations, you have gotten a successful match! Please remove the matched cards from the game." (Robot smiles with open arm gestures)
Encouragement	"Those are interesting cards but they are not the same, please flip back the cards and try again. I know you can do this!" (Robot smiles with one arm over the cards)
Help	"Why don't you try flipping over this card." (Robot points to a card location)
Jokes and positive statements	"Why did the cookie go to the doctor? She was feeling crummy." (Robot covers mouth with hand and giggles) "Wow, you are great at this game, I am enjoying playing with you." (Robot smiles)
End of interaction	"Congratulations, you have completed the memory game." (Robot smiles and makes a clapping gesture)

player to flip over a card in a specific location (Figure 2e). The robot also provided jokes and general positive statements to promote the social dimensions of the interaction (Figure 2f). We also demonstrated the robot's ability to detect if someone has become distracted from the game, at which time the robot becomes sad that the person is no longer playing and provides instructions in a sad emotional state (i.e., frowning and speaking with a slow and lower pitch voice; Figure 2b).

Restaurant Finder

The restaurant finder scenario consisted of Brian 2.1 assisting the user in choosing a restaurant to go to for dinner. This interaction involved the robot guiding a user through a series of questions regarding selecting a restaurant and the robot providing a suggestion based on the user's preferences. During the interaction the robot would also make jokes and comment on a user's responses to promote the social dimensions of the interaction. We chose the restaurant finding activity as it has been found that going to restaurants can promote nutrition and social interactions while reducing isolation for the elderly (Richard, Gosselin, Trickey, Robitaille, & Payette, 2000). Furthermore, face-to-face interaction has been found to be the most preferable form of such a type of information retrieval for this population (Barrett, 2000).

Example robot behaviors for this activity are presented in Table 3 and Figures 2h–2l. The robot first greeted the user, explained its objective in finding a desired restaurant for the user and provided a food-related joke (Figures 2h and 2i). The robot then gathered information regarding a user's preference for food type, amount of money to be spent, and a desired location (Figure 2j). Based on the information received, the robot suggested a potential restaurant (Figure 2k). To illustrate the robot's different behaviors, during the demonstration, the user did not accept the first restaurant suggestion, in which case the robot provided an alternative choice. Once a restaurant was chosen, Brian 2.1 would then provide detailed directions to the location of the restaurant from its current location (Figure 2l). When the interaction was completed, the robot smiled, waved and said good-bye. Similar to the memory card game, Brian 2.1 also displayed emotional states during the interaction. Also during the interaction, the verbal responses of the user interacting with the robot were input into the robot's controller by a member of our research team who was not visible to the participants viewing the demonstration. This allowed the robot to choose its appropriate behavior based on the responses of the user while minimizing reliability issues of an automatic speech recognition system at this initial stage of the design. This is a common procedure in HRI research (Lee, Keisler, Forlizzi, & Rybiski, 2012; Shiwa, Kanda, Imai, Ishiguro, & Hagita, 2008).

Table 3. Example robot behaviors for restaurant finder activity.

Behavior type	Example behavior
Greeting	"Hi, I would like to help you find a restaurant to go to for dinner." (Robot waves and smiles)
1. Joke	"Why did the reporter go to the ice-cream shop? To get the scoop!" (Robot covers mouth with hand and giggles)
Information gathering	
1. Food Preference	"Okay, what kind of food would you like to eat?"
	"That sounds really good." (Robot smiles and rubs its tummy)
2. Amount of Money to be Spent	"How much money are you willing to spend? Not very much, a moderate amount, or a lot?"
	"Have a date tonight do we?" (Robot smiles)
	"It is a good idea to save money."
3. Restaurant Location	"Where do you want to go? Downtown in the Entertainment District, North near Yonge St. and Eglington Ave., or closer to where we currently are?"
	"There are a lot of great choices there." (Robot smiles)
Restaurant suggestion	"Have you ever been to Freddy's Bistro before?" (Robot smiles and brings hand to its mouth to mimic eating gesture)
	"Would you like to go there again or should I find somewhere new?"
Providing directions	"Freddy's Bistro is at 432 Fisker Lane. To get there from here, you go 2 blocks east on University St. then turn north onto Charles St. Continue on Charles St. for 4 blocks to reach Fisker Lane. Turn west onto Fisker Lane and the restaurant is at the southwest corner." (Robot points in the direction to first follow)
	"Do you need me to repeat the directions?"
Valediction	"I hope you enjoy your dinner at Freddy's Bistro. Good-bye." (Robot smiles and waves)

Robot Acceptance Questionnaire

The questionnaire included seven constructs (a total of 18 questions). In our study, the participants were asked to indicate their agreement with each statement on the questionnaire using a 5-point Likert scale (i.e., 5 = *strongly agree,* 4 = *somewhat agree,* 3 = *neutral,* 2 = *somewhat disagree,* and 1 = *strongly disagree*). The questions for the constructs are presented in Table 4. The questionnaire also collected demographic information, the participants' previous technology experience with robots and computers. Additional comments on the robot, its behaviors and applications were also solicited on the questionnaire. Participants were asked to identify which specific activities they would like to see the robot perform with them. They were also asked to choose whether they liked or disliked the following four specific robot behavior characteristics: (a) the robot's human-like voice, (b) the robot expressing different emotions through facial expressions and tone of voice, (c) the robot's life-like appearance and demeanor, and (d) the companionship the robot provides by just being there.

Results and Discussion

The descriptive statistics for the constructs of the adapted Almere technology acceptance model are presented in Table 5. In order to verify inter-reliability between statements for the constructs, Cronbach's alpha values were determined for these constructs.

Table 4. Constructs used in Robot Acceptance Questionnaire.

Construct	Statement
Attitude toward using the robot (ATT)	1. I think it's a good idea to use the robot 2. The robot would make my life more interesting 3. It's good to make use of the robot
Perceived sociability (PS)	4. I would find the robot pleasant to interact with 5. I think the robot is nice 6. I find the robot would be a pleasant conversational partner
Perceived usefulness (PU)	7. It would be convenient for me to have the robot 8. I find the behaviors of the robot helpful
Trust (TU)	9. I would trust the robot if it gave me advice 10. I find the robot reliable
Anxiety (ANX)	11. If I should make use of the robot, I would be afraid to make mistakes with it 12. I find the robot intimidating 13. I would feel relaxed interacting with the robot 14. I would feel uneasy if I needed to perform a task for which I had to use the robot
Perceived adaptability (PAD)	15. I think the robot would be adaptive to what I need 16. I think the robot would only do what I need at that particular moment
Perceived ease of use (PEOU)	17. I find the robot would be easy to use 18. I think I could use the robot without any help

Table 5. Cronbach's alpha and descriptive statistics for the constructs.

Construct	Min	Max	Mean	Std. Dev.
ATT ($alpha = 0.6$)	1	5	4.22	0.80
PS ($alpha = 0.0$)	1	5	3.30	0.86
PU ($alpha = 0.2$)	1	5	3.41	0.97
TU ($alpha = 0.3$)	1	5	3.33	0.85
ANX ($alpha = 0.7$)	1	5	2.51	1.20
PAD ($alpha = 0.2$)	1	5	3.63	0.90
PEOU ($alpha = 0.8$)	1	5	3.27	1.05

A statement analysis was also performed to remove statistically weak statements to improve reliability of the constructs (Field, 2009). Namely, for the latter we determined whether deleting individual statements in a construct would improve the overall reliability of the construct. The alpha values for the constructs are presented in Table 5. In general, alpha values of at least 0.6 are considered acceptable for short instruments with constructs with a small number of items (Bergström et al., 1998; Moss et al., 1998; Petrick & Backman, 2002; Shin, Collier, & Wilson, 2000; Sturmey, Newton, Cowley, Bouras, & Holt, 2005; van der Horst et al., 2007). The ATT, ANX and PEOU constructs had acceptable alpha values of 0.6 or greater. However, the PS, PU, TU, and PAD constructs had low alpha values and were removed from further analysis. For the PU, TU, and PAD constructs, the low values could be a result of having only two questions for these constructs. Similar statement analysis procedures have been applied in Birch and Irvine (2009), Curtis and Payne (2008), and McLeod, Pippin, and Mason (2009) for studies using the UTAUT model, from which the Almere technology acceptance model is derived. Below we discuss the results for the ATT, ANX, and PEOU constructs in more detail. For these discussions, the Likert scale results are categorized with respect to positive, negative, and neutral responses.

Attitude toward using Brian 2.1 was positive ($\mu = 4.22$, $\sigma = 0.80$) and the robot was well received. These positive attitudes were further expressed by participants making specific comments about the robot, such as "I love the idea of the robot and its applications" and the robot is "fascinating" and "very interesting with regard to assisting the elderly where necessary." In general, older adults do not use technology to the same extent as younger adults do (Mitzner et al., 2010). Younger adults have more access and a greater ability to use new technologies than those that have spent the majority of their lives without such technology. Several factors affect the acceptance of technology by older adults including their fear to use something new, not seeing the need, lack of training or advice on how to use the technology, and the technology not being user friendly (Tacken, Marcellini, Mollenkopf, Ruoppila, & Szeman, 2005). However, level of acceptance can increase when this population receives adequate training and clearly understands the benefits of use (Oppenauer, Preschl, Kalteis, & Kryspin-Exner, 2007). Within this context, we emphasized the functionalities of Brian 2.1 for assistance with enhanced activities of daily living during our live demonstration session. We postulate that this is one of the main reasons why the elderly individuals generally had positive attitudes toward the robot. Furthermore, in our study, all participants had at least a bachelor's degree which can provide another potential reason why the elderly demographic we studied had positive attitudes toward the robot. Individuals with a higher education level (attended high school, or graduated high school, and also have a university degree) have been found to be less likely to express negative attitudes toward a robot than those with a lower education level (Scopelliti, Guiliani, & Fornara, 2005).

There was minimal anxiety toward the robot itself or interacting with it ($\mu = 2.51$, $\sigma = 1.2$). Anxiety toward robots is an important consideration when designing robots intended to be used in everyday lives. Surveys conducted with elderly adults have shown that they express more negativity and anxiety toward the notion of having a robot assistant, especially in a home environment, over young people (Scopelliti, Guiliani, D'Amico, & Fornara, 2004). However, the more concerned older adults are about personal cognitive weakening, the more positive they feel about the cognitive support and help a robot can provide in everyday life (Cesta et al., 2007). The overall perceived ease of use of the robot was neutral ($\mu = 3.27$, $\sigma = 1.05$). This result could be attributed to the participants not having a chance to personally interact with the robot, and, of course, an indication that one demonstration session may not be considered to be enough training for using the robot; stressing the importance of providing adequate training as mentioned above.

Table 6. Summary of liked robot characteristics.

Ranking	Robot characteristics
1 (74% of participants)	The robot's human-like voice
2 (70% of participants)	The companionship the robot provides by just being there
3 (65% of participants)	The robot expressing different emotions through facial expressions and different tones of voice
4 (33% of participants)	The robot's life-like appearance and demeanor

Adapted Almere Model Hypotheses Tests

As a result of the low Cronbach alpha values for the constructs PU and PS, we were unable to test Hypotheses 1 or 3. However, we were able to test hypothesis H2 using regression analysis: A person will perceive Brian 2.1 to be easy to use if the robot does not cause the person anxiety. The results of the analysis indicated that when a participant felt less anxious toward Brian 2.1, he/she perceived the robot as easier to use, (Beta $= -0.35$, $t = -2.518$, $p < 0.05$). A study by Heerink et al. (2010) also tested Hypothesis 2 with two different experimental conditions and found a significant inverse relationship between the ANX and PEOU constructs for elderly users that: (a) interacted with the cat-like iCat robot during a one-on-one social interaction and (b) watched a video of the Robocare domestic mobile robot, which had a human avatar displayed on a screen, assisting an elderly person by monitoring the environment and reminding him/her to take medication. Such a negative relationship between technology anxiety and perceived ease of use has also been identified in several prior studies with respect to computers (e.g. Venkatesh, 2000) including with the elderly (Phang et al., 2006), as well as elderly users and mobile health services (Guo, Sun, Wang, Peng, & Yan, 2013).

Characteristics of Brian 2.1

As we aimed to design Brian 2.1 to resemble a human in both communication capabilities and behaviors, we asked individuals to state whether they liked or disliked certain robot behavior characteristics. The behavior characteristics of the robot were then ranked in order from most liked to least liked based on the responses of the participants, Table 6, to investigate if there was any overall preference with respect to the robot's human-like attributes. Seventy percent liked the overall companionship that the robot could provide, while 65% liked that the robot had the ability to express different emotions through facial expressions and tone of voice, and 33% liked the robot's life-like appearance and demeanor. Our results are similar to the findings in Zhang et al. (2010), which found that elderly adults preferred when a medicine delivery robot had a pre-recorded human voice and a simple human-like face mask over an obvious electronic voice and an mechanical abstract face (e.g., just having cameras for eyes).

Participants commented on how Brian 2.1's voice was "amazingly clear" and also had "fabulous intonation." Comments regarding the facial expressions were also positive, with several individuals stating that the expressions worked very well and were believable. The results here show that human-like communication was preferred over human-like appearance by the elderly participants. In Dautenhahn et al. (2005), human-like communication was also found to be desirable for a robot companion over human-like appearance by students, faculty members and researchers recruited from a university. The results from both our study and the one presented in Dautenhahn et al. (2005) suggested that such a preference may not be age-related.

It is also interesting to note that there were no direct comments regarding the male gender of Brian 2.1. Furthermore, the responses to the questionnaire for the male robot were similar for both the male and female participants in our study. Our results are similar to a number of other studies that have also favorably investigated the use and perceptions of male socially assistive robots by older adults (Fasola & Mataric, 2012; Kuo et al., 2009).

The potential use of a male socially assistive robot such as Brian 2.1 is also motivated by results of past studies that have explicitly investigated the influence of robot gender on (both female and male) users' perceptions of social robots (Crowell, Villanoy, Scheutzz, & Schermerhornz, 2009; Powers & Kiesler, 2006; Broadbent et al., 2012; Tapus, Tapus, & Mataric, 2008). These studies have found that human-like male robots can be: (a) more preferred than female robots (Tapus et al., 2008), (b) perceived to be more reliable (Crowell et al., 2009), and (c) considered to be both knowledgeable and social, and therefore users will follow the advice of such robots (Powers & Kiesler, 2006). In addition, focus groups with residents of a retirement village have also found that the residents think a male voice for healthcare robots would be easier to hear than a female voice (Broadbent et al., 2012).

Robot Tasks

With respect to the specific activities that the participants would like the robot to perform, examples of other cognitively stimulating activities such as additional interactive games, sing-alongs, or the robot reading out loud or telling a story were provided. One participant stated that the robot could also be an instructor for exercise routines. Individuals liked the idea that the robot could potentially provide cognitive support, and hence, a few suggestions were made to have the robot provide older adults with reminders (i.e., for medication and appointments), and instructions and prompts (i.e., for eating).

Computer Experience and Acceptance of the Robot

In our study, we conducted an analysis using Spearman ρ to determine if a correlation existed between computer experience and perceived ease of use of Brian 2.1. Participant computer experience was defined on an ordinal scale from the lowest level representing no computer experience to the highest level representing advanced computer experience. We found no significant correlation between these two factors for our user group, ($\rho = -0.03$, $p = 0.831$). Our results differ from a similar study conducted by Heerink (2011), which consisted of showing a video of the domestic Robocare robot to older adults. In Heerink (2011), it was found that males, and probably also females with more computer experience, will perceive the robot as a more easy to use technology. The differences between our two studies could be attributed to our distinct study procedures. Namely, we presented a single live demonstration to all participants at once while the Robocare study presented video demonstrations to participants individually. Furthermore, our study promoted the social dimensions of interacting with Brian 2.1 for both our activity scenarios, while the Robocare robot abilities to monitor, provide reminders and information were more emphasized in (Heerink, 2011). The physical presence of Brian 2.1 in addition to its use of natural communication which included both verbal and nonverbal modes could also be a reason why we did not find any correlation between computer experience and the perceived ease of use of Brian 2.1.

Conclusion

In this article, we presented a study with the human-like socially assistive robot Brian 2.1 in order to investigate the acceptance and attitudes toward the robot by older adults as an assistive technology for providing cognitive and social interventions for activities of daily living. The robot was presented to a potential user group for two different interaction scenarios where the robot assisted with the following enhanced activities of daily living: (a) a memory card game activity and (b) a restaurant finding activity. Results of a robot acceptance questionnaire showed that, in general, the older adult participants had positive attitudes and minimal anxiety toward the robot. They also did not perceive the robot as difficult to use. In addition, we found that when a person felt less anxious toward Brian 2.1, he or she perceived that the robot would be easier to use. Similar results have been found when introducing new technology to users, which suggests that prior training with the robot may be beneficial to reduce anxiety and improve user perceptions of a robot with respect to ease of use when introducing such new technology. In the future, one-on-one interactions between a user and the robot could also be monitored using physiological indices, as we have done in our previous work (Chan & Nejat, 2012), in order to further evaluate anxiety during the interactions themselves.

Although none of the participants in our study had any real prior experience with robots, the majority did not perceive that the robot would be difficult to use. The perceived ease of use of the robot was also not related to prior computer experience. These results suggest that human-like communicative social capabilities in a robot may encourage adoption of this new technology by elderly users of varying technological backgrounds, even by those without prior technological experience. As such, this motivates the future investigation and design of socially assistive robots with such capabilities. Technological experience has in the past been a barrier to acceptance of assistive technologies by older adults, and in order to overcome this barrier, designers of assistive robots should design robots that will be perceived as easy to use by elderly individuals with different technological experiences.

The majority of participants especially liked the robot's human-like voice and the potential companionship it could provide. They also liked the robot's emotional communication abilities such as its facial expressions and different tones of voice. Similar results have been found in studies with service robots that have investigated human-like features. Our findings have indicated the importance of including human-like and emotional communication capabilities in a socially assistive robot for the elderly.

In conclusion, our study has investigated important design considerations for the acceptance of socially assistive robots for the elderly. Overall, the results of this study have shown promise and motivate further development and pilot testing of Brian 2.1 and similar human-like robots as social and cognitive interaction tools for older adults to aid with activities of daily living.

Future work will comprise of performing one-on-one interaction studies comparing Brian 2.1 to a human caregiver with respect to acceptance and use. These interaction studies will investigate various activities such as the restaurant finder and memory game activities in addition to activities suggested by the participants, such as reading stories, instructing exercise routines and giving reminders. Future work will also include investigating older adults' long-term use and perceptions of Brian 2.1 to determine the predictive validity of the adapted Almere model utilized in this study.

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References

Allison, B., Nejat, G., & Kao, E. (2009). The Design of an Expressive Human-like Socially Assistive Robot. *ASME Journal on Mechanisms and Robotics*, *1*(1), 1–8.

Barrett, J. (2000). *The information needs of elderly, disabled elderly people, and their carers*. Oxford, UK: Disability Information Trust.

Bartneck, C., Kulić, D., Croft, E., & Zoghbi, S. (2009). Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. *International Journal of Social Robotics*, *1*(1), 71–81.

Beach, S. R. (2012). Assessing needs, preferences, and attitudes using survey methods. *Quality of Life Technology*, *3*, 65–85.

Beer, J. M., & Takayama, L. (2011). Mobile remote presence systems for older adults: Acceptance, benefits, and concerns. *ACM/IEEE International Conference on Human-Robot Interaction*, 19–26.

Beer, J. M., Smarr, C., Chen, T. L., Prakash, A., Mitzner, T. L., Kemp, C. C., & Rogers, W. A. (2012). The Domesticated Robot: Design Guidelines for Assisting Older Adults to Age in Place. *ACM/IEEE International Conference on Human-Robot Interaction*, 335–342.

Belleville, S., Gilbert, B., Fontaine, F., Gagnon, L., Ménard, E., & Gauthier, S. (2006). Improvement of episodic memory in persons with mild cognitive impairment and healthy older adults: Evidence from a cognitive intervention program. *Journal of Dementia and Geriatric Cognitive Disorders*, *22*, 486–499.

Bergström, G., Jensen, I. B., Bodin, L., Linton, S. J., Nygren, Å. L., & Carlsson, S. G. (1998). Reliability and factor structure of the Multidimensional Pain Inventory–Swedish Language version (MPI-S). *Pain*, *75*(1), 101–110.

Birch, A., & Irvine, V. (2009). Preservice teachers' acceptance of ICT integration in the classroom: applying the UTAUT model. *Educational Media International*, *64*, 295–315.

Broadbent, E., Tamagawa, R., Patience, A., Knock, B., Kerse, N., Day, K., & MacDonald, B. A. (2012). Attitudes towards health-care robots in a retirement village. *Australasian Journal on Ageing*, *31*, 115–120.

Callahan, D., & Prager, K. (2008). Medical care for the elderly: Should limits be set? *American Medical Association Journal of Ethics*, *10*, 404–410.

Cesta, A., Cortellessa, G., Giuliani, M.V., Pecora, F., Scopelliti, M., & Tiberio, L. (2007). Psychological implications of domestic assistive technology for the elderly. *PsychNology Journal*, *5*, 229–252.

Chan, J., Nejat, G., & Chen, J. (2011). Designing socially assistive robots as effective tools for cognitive interventions. *International Journal of Humanoid Robotics*, *8*(1), 103–126.

Chan, J., & Nejat, G. (2012). Social intelligence for a robot engaging people in cognitive training activities. *International Journal of Advanced Robotic Systems: Human Robot Interaction*, *9*(113), 1–13.

Coleman, C. K., & Medvene, L. J. (2012). A person-centered care intervention for geriatric certified nursing assistants. *The Gerontologist*, *52*(6), 1–12.

Crowell, C. R., Villanoy, M., Scheutzz, M., & Schermerhornz, P. (2009). Gendered voice and robot entities: perceptions and reactions of male and female subjects. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 3735–3741.

Curtis, M. B., & Payne, E. A. (2008). An examination of contextual factors and individual characteristics affecting technology implementation decisions in auditing. *International Journal of Accounting Information Systems*, *9*, 104–121.

Dautenhahn, K., Woods, S., Kaouri, C., Walters, M., Koay, K. & Werry, I. (2005). What is a robot companion—Friend, assistant, or butler? *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 1488–1493.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management science*, *35*, 982–1003.

Ezer, N., Fisk, A. D., & Rogers, W. A. (2009). More than a servant: Self-reported willingness of younger and older adults to having a robot perform interactive and critical tasks in the home. *Human Factors and Ergonomics Society Annual Meeting*, *53*, 136–140.

Fasola, J., & Mataric, M. (2012). Using socially assistive human-robot interaction to motivate physical exercise for older adults. *Proceedings of the IEEE*, *100*(8), 2512–2526.

Field, A. (2009). *Discovering statistics using SPSS*. London, UK: Sage Publications.

Ghulam, S., Shah, S., & Robinson, I. (2006). User involvement in healthcare technology development and assessment. *International Journal of Health Care Quality Assurance*, *19*, 500–515.

Grosch, K., Medvene, L., & Wolcott, H. (2008). Person-centered caregiving instruction for geriatric nursing assistant students. *Journal of Gerontological Nursing*, *34*(8), 23–31.

Guo, X., Sun, Y., Wang, N., Peng, Z., & Yan, Z. (2013). The dark side of elderly acceptance of preventive mobile health services in China. *Electronic Markets*, 23(1), 49–61.

Gurley, K., & Norcio, A. F. (2009). A systematic review of technologies designed to improve and assist cognitive decline for both the current and future aging populations. In N. Aykin (Ed.), *Internationalization, design and global development* (pp. 156–163). Berlin: Springer.

Hedden, T., & Gabrieli, J. D. E. (2004). Insights into the ageing mind: A view from cognitive neuroscience. *Neuroscience*, *5*, 87–96.

Heerink, M., Krose, B., Evers, V., & Wielinga, B. (2006). The Influence of a Robot's Social Abilities on Acceptance by Elderly Users. *IEEE International Symposium on Robot and Human Interactive Communication*, 521–526.

Heerink, M. (2010) Assessing acceptance of assistive social robots by aging adults (Doctoral dissertation). University of Amsterdam, Amsterdam, the Netherlands.

Heerink, M. (2011). Exploring the influence of age, gender, education, and computer experience on robot acceptance by older adults. *ACM/IEEE International Conference on Human-robot Interaction*, 147–148.

Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2010). Assessing acceptance of assistive social agent technology by older adults: The Almere Model. *International Journal of Social Robotics*, *2*, 361–375.

Ho, C. C., & MacDorman, K. F. (2010). Revisiting the uncanny valley theory: Developing and validating an alternative to the Godspeed indices. *Computers in Human Behavior*, *26*, 1508–1518.

Jeffery, S. (2008). Cognitive stimulation technique may prevent decline in healthy elderly. *Medscape Medical News*. Retrieved from http://www.medscape.com/viewarticle/577373

Jorm, A. F., Korten, A. E., & Henderson, A. S. (1987). The prevalence of dementia: A quantitative integration of the literature. *Acta Psychiatrica Scandinavica*, *76*, 465–479.

Kamide, H., Takubo, T., Ohara, K., Mae, Y., & Arai, T. (2014). Impressions of humanoids: The development of a measure for evaluating a humanoid. *International Journal of Social Robotics*, *6*, 33–44.

Kintsch, A., & DePaula, R. (2002). A framework for the adoption of assistive technology. *State Wide Assistive Technology, Augmentative and Alternative Communication, SWAAAC: Supporting Learning Through Assistive Technology*, 1–10.

Kuo, I., Rabindran, J., Broadbent, E., Lee, Y. I., Kerse, N., Stafford, R. M. Q., & Macdonald, B. A. (2009) Age and gender factors in user acceptance of healthcare robots. *IEEE International Symposium on Robot and Human Interaction*, 214–219.

Lann-Wolcott, H., & Medvene, J. L. (2011). Measuring the person-centeredness of caregivers working with nursing home residents with dementia. *Behavior Therapy*, *42*, 89–99.

Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*, *9*, 179–186.

Lee, M. K., Kiesler, S., Forlizzi, J., & Rybski, P. (2012). Ripple effects of an embedded social agent: a field study of a social robot in the workplace. *ACM annual conference on Human Factors in Computing Systems*, 695–704.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management*, *40*, 191–204.

McColl, D., Chan, J., & Nejat, G. (2012). A socially assistive robot for mealtime cognitive interventions. *Journal of Medical Devices–Transactions of the ASME*, *6*(1), 017559.

McLeod, A., Pippin, S., & Mason, R. (2009). Individual taxpayer intention to use tax preparation software: examining experience, trust, and perceived risk. *Journal of Information Science and Technology*, *6*(1), 26–44.

Mitzner, T. L., Boron, J. B., Fausset, C. B., Adams, A. E., Charness, N., Czaja, S. J., . . . Sharit, J. (2010). Older adults talk technology: Technology usage and attitudes. *Computers in Human Behavior*, *26*, 1710–1721.

Moss, S., Prosser, H., Costello, H., Simpson, N., Patel, P., Rowe, S., Turner, S., & Hatton, C. (1998). Reliability and validity of the PAS-ADD Checklist for detecting psychiatric disorders in adults with intellectual disability. *Journal of Intellectual Disability Research*, *42*, 173–183.

Nakashima, T., & Fukutome, G. (2010). Healing Effects of Pet Robots at an Elderly-Care Facility. *IEEE International Conference on Computer and Information Science*, 407–412.

Nejat, G., & Ficocelli, M. (2008). Can I be of assistance? The intelligence behind an assistive robot. *International Conference on Robotics and Automation*, 3564–3569.

Nomura, T., Kanda, T., Suzuki, T., & Kato, K. (2004). Psychology in human-robot communication: An attempt through investigation of negative attitudes and anxiety toward robots. *IEEE International Workshop on Robot and Human Interactive Communication*, 35–40.

Oppenauer, C., Preschl, B., Kalteis, K., & Kryspin-Exner, I. (2007). Technology in old age from a psychological point of view. *HCI and Usability for Medicine and Health Care, Lecture Notes in Computer Science*, *4799*, 133–142.

Petrick, J. F., & Backman, S. J. (2002). An examination of the construct of perceived value for the prediction of golf travelers' intentions to revisit. *Journal of Travel Research*, *41*(1), 38–45.

Phang, C., Sutanto, J., Kankanhalli, A., Li, Y., Tan, B. C., & Teo, H. (2006). Senior citizens' acceptance of information systems: A study in the context of e-government services. *IEEE Transactions on Engineering Management*, *53*, 555–569.

Pitsch, K., Kuzuoka, H., Suzuki, Y., Sussenbach, L., Luff, P., & Heath, C. (2009). "The first five seconds": Contingent stepwise entry into an interaction as a means to secure sustained engagement in HRI. *IEEE International Symposium on Robot and Human Interactive Communication*, 985–991.

Powers, A., & Kiesler, S. (2006). The advisor robot: tracing people's mental model from a robot's physical attributes. *ACM SIGCHI/SIGART Conference on Human-robot Interaction*, 218–225.

Powers, A., Kiesler, S., Fussell, S., & Torrey, C. (2007). Comparing a computer agent with a humanoid robot. *ACM/IEEE International Conference on Human-Robot Interaction*, 145–152.

Richard, L., Gosselin, C., Trickey, F., Robitaille, C., & Payette, H. (2000). "Outings to your taste": A nutrition program for the elderly. *The Gerontologist*, *40*, 612–617.

Rogers, W. A., Meyer, B., Walker, N., & Fisk, A. D. (1998). Functional limitations to daily living tasks in the aged: A focus group analysis. *Human Factors*, *40*(1), 111–125.

Scopelliti, M., Giuliani, M. V., D'Amico, A. M., & Fornara, F. (2004). If I had a robot at home. Peoples' representation of domestic robots. In S. Keates, J. Clarkson, P. Langdon, & P. Robinson (Eds.), *Designing a more inclusive world* (pp. 257–266). London, England: Springer.

Scopelliti, M., Giuliani, M. V., & Fornara, F. (2005). Robots in a domestic setting: a psychological approach. *Universal Access in the Information Society*, *4*, 146–155.

Shibata, S., & Wada, K. (2010). Robot therapy-a new approach for mental healthcare of the elderly. *Gerontology*, *57*, 378–386.

Shin, H., Collier, D. A., & Wilson, D. D. (2000). Supply management orientation and supplier/buyer performance. *Journal of Operations Management*, *18*, 317–333.

Shinozawa, K., Naya, F., Yamato, J., & Kogure, K. (2005). Differences in effect of robot and screen agent recommendations on human decision-making. *International Journal of Human-Computer Studies*, *62*, 267–279.

Shiwa, T., Kanda, T., Imai, M., Ishiguro, H., & Hagita, N. (2008). How quickly should communication robots respond? *ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 153–160.

Sidner, C. L., Lee, C., Kidd, C. D., Lesh, N., & Rich, C. (2005). Explorations in engagement for humans and robots. *Artificial Intelligence*, *166*(1), 140–164.

Smarr, C., Prakash, A., Beer, J. M., Mitzner, T. L., Kemp, C. C., & Rogers, W. A. (2012). Older Adult's Preferences for and Acceptance of Robot Assistance for Everyday Living Tasks. *Human Factors and Ergonomics Society Annual Meeting*, *56*(1), 153–157.

Stem, C., & Munn, Z. (2010). Cognitive leisure activities and their role in preventing dementia: A systematic review. *International Journal of Evidence-Based Healthcare*, *8*(1), 2–17.

Stiefelhagen, R., Yang, J., & Waibel, A. (2001). Tracking focus of attention for human-robot communication. *IEEE-RAS International Conference on Humanoid Robots*, 343–350.

Sturmey, P., Newton, J. T., Cowley, A., Bouras, N., & Holt, G. (2005). The PAS–ADD Checklist: independent replication of its psychometric properties in a community sample. *The British Journal of Psychiatry*, *186*, 319–323.

Swangnetr, M., Zhu, B., Kaber, D., & Taylor, K. (2010). Meta-analysis of user age and service robot configuration effects on human-robot interaction in a healthcare application. *AAAI Fall Symposium Series*, 121–126.

Syrdal, D. S., Dautenhahn, K., Koay, K. L., & Walters, M. L. (2009). The negative attitudes towards robots scale and reactions to robot behaviour in a live human-robot interaction study. *Adaptive and Emergent Behaviour and Complex Systems: Convention of the Society for the Study of Artificial Intelligence and Simulation of Behaviour*, 109–115.

Tacken, M., Marcellini, F., Mollenkopf, H., Ruoppila, I., & Széman, Z. (2005). Use and acceptance of new technology by older people. Findings of the international MOBILATE survey: 'Enhancing mobility in later life.' *Gerontechnology*, *3*, 126–137.

Tapus, A., Ţăpuş, C., & Matarić, M. J. (2008). User—robot personality matching and assistive robot behavior adaptation for post-stroke rehabilitation therapy. *Intelligent Service Robotics*, *1*, 169–183.

Tapus, A., Tapus, C. & Mataric, M. J. (2009). The Role of Physical Embodiment of a Therapist Robot for Individuals with Cognitive Impairments. *IEEE International Symposium on Robot and Human Interactive Communication*, 103–107.

Thomaz, A. L., Berlin, M., & Breazeal, C. (2005). An embodied computational model of social referencing. *IEEE International Workshop on Robot and Human Interactive Communication*, 591–598.

Unger, J., Johnson, C., & Marks, G. (1997). Functional decline in the elderly: Evidence for direct and stress-buffering protective effects of social interactions and physical activity. *Journal of Annals of Behavioural Medicine*, *19*, 152–160.

United Nations. (2011). World population prospects the 2010 revision. In *Vol II: Demographic profiles*. New York:United Nations.

van der Horst, K., Kremers, S., Ferreira, I., Singh, A., Oenema, A., & Brug, J. (2007). Perceived parenting style and practices and the consumption of sugar-sweetened beverages by adolescents. *Health Education Research*, *22*, 295–304.

Venkatesh, V. (2000). Determinants of perceived ease of use: integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research*, *11*, 342–365.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*, 186–204.

Venkatesh, V., Morris, M.G., Davis, F. D., & Davis, G.B. (2003) User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*, 425–478.

Verghese, J., Lipton, R. B., Katz, M. J., Hall, C. B., Derby, C. A., Kuslansky, G., . . . Buschke, H. (2003). Leisure activities and the risk of dementia in the elderly. *New England Journal of Medicine*, *348*(25), 2508–2516.

Xu, Q., Ng, J. S. L., Cheong, Y. L., Tan, O. Y., Wong, J. B., Tay, B. T. C., & Park, T. (2012). Effect of scenario media on human-robot interaction evaluation. *ACM/IEEE International Conference on Human-Robot Interaction*, 275–276.

Zhang, T., Kaber, D. B., Zhu, B., Swangnetr, M., Hodge, L. & Mosaly, P. (2010). Service robot feature design effects on user perceptions and emotional responses. *International Journal of Intelligent Service Robotics*, *3*, 73–88.