Assessing the tolerance of a telepresence robot in users with Mild Cognitive Impairment

– A protocol for studying users' physiological response –

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ABSTRACT

This article describes preliminary work of a research study which supports the use of tele-operated robots for rehabilitation, home care assistance and social interaction. Specifically our idea is to use a telepresence robot, called Giraff, to interact with elderly people suffering from Mild Cognitive Impairment. In order to evaluate the potential implications in the use of Giraff with this specific target of users, a first step has been identified which aims at evaluating the tolerability and safety of the robotic platform. The paper presents a research protocol designed to analyze the emotional response of mild cognitive impaired subjects and their ability to adapt to the robot during repeated interactions. The protocol is based on the analysis of the physiological measures as indicators of the users's emotional reaction to the Giraff experience.

Keywords

Telepresence robot, Mild Cognitive Impairment, physiological response, user evaluation methodology

1. INTRODUCTION

Mild Cognitive Impairment (MCI) is a relatively recent term introduced to define the transition state between normal aging and dementia with the general assumption that people who are evolving towards dementia go through a phase of mild cognitive impairment characterized by cognitive dysfunction of a single cognitive area, namely memory, as core symptoms of Alzheimer dementia [19]. Cognitive impairment without dementia is a common problem in the elderly persons that has negative impact on the performance of everyday activities [20].

Cognitive stimulation interventions have been developed to compensate and in some cases improve memory deficits with the goal of maximizing cognitive functions reducing the risk of cognitive decline [12, 1]. The value of non-pharmacological interventions in preclinical stages of dementia such as MCI is an issue of debate. However, several studies on the effectiveness of cognitive interventions in subjects with MCI show encouraging results. This type of interventions can improve cognitive functioning helping to slow the cognitive decline and delay the onset of Alzheimer. People with MCI can benefit from cognitive training because they retain the cognitive ability to learn new information and apply memorization strategies. According to recent research, stimulation/training programs, both computer-based and non, appear to be promising to improve cognitive abilities in MCI people [2, 7].

In addition to this, it is worth highlighting that social support, leisure activities, physical exercise are also associated with a lower risk of dementia and decrease the occurrence of specific diseases such as cognitive disorders [10]. Some longitudinal studies show that community-dwelling elderly people isolated with poor social networks and support and

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not very physically active have a higher probability of cognitive decline and dementia. In general, there is a strong association between social networks and physical, mental, and emotional health of elderly people [18]. More specifically, social isolation increases the risk of morbidity and mortality [3], psychological distress, depression and suicide [8], and decline in cognitive function [11]. Social role involvement is a factor not only in slowing age-related decline in physical and mental health, but also in reducing risk for disability in activities of daily living [17]. In this respect, it is important to promote social participation of elderly people.

The previous issue have fostered our interest in the promotion of a telepresence system as a support tool for rehabilitative treatment, home care assistance and social participation of people with cognitive/physical disabilities. We are exploring alternative home assistance services for MCIs which integrate the use of a telepresence robot to facilitate remote communication from therapists to patients. This use of telepresence system is also in line with the concept of aging-in-place [9], according to which the majority of elderly people as they age prefers to remain at home rather than go into care or nursing facilities. In this light, telepresence could be exploited to foster aging-in-place, by allowing people staying at home, while enabling them to maintain their relationships with family, friends and health professionals. We are currently exploring the applicative potentiality of a telepresence robot called Giraff,[1] as a means to support rehabilitative interventions, home care assistance, and social participation of mild cognitive impaired persons.

A first step in this direction is represented by an aspect that is usually neglected in robotic research: studying the human tolerance of the robot physical presence. This research is an attempt to suggest and refine objective measures of such an impact. The overall goal is to assess the emotional response of a sample of elderly people with mild cognitive impairment in terms of stress, anxiety, that we can be used to determine the overall *tolerance* of the robotic platform.

In particular, this paper presents a first "brick" in this direction: the definition of a research protocol aimed at analyzing the emotional response of MCI subjects to the robot experience. The protocol consists on a set of steps which guide any assessment of the physiological response of elderly people during repeated interactions with Giraff. The innovative aspect relies in our choice to use an approach which is similar to clinical trials for evaluation of new drugs. It is worth highlighting how the assessment of the level of tolerance of a technological system designed to aid people who have special needs be an indispensable prerequisite to test the potential of these systems in real life contexts.

The paper is organized as follows: after a brief overview of related work, the main objectives and motivation of the study are described; then the protocol is illustrated by specifying the participants, experimental apparatus and the procedure. A conclusive section summarizes the current status of this activity and the plans for future research.

[1] www.giraff.org

2. TELEPRESENCE ROBOTS

Recent advances in information and communication technologies have stimulated research in telepresence robotics. One of the main feature of telepresence systems is the sense of robot's presence that emerges when humans interact with and via a telepresence robotic system. Spatial presence refers to the "the sense of being physically located somewhere" [16] while social presence refers to "being with others" in a mediated environment [14].

The quality of mobile remote presence robots enable to meet the growing needs of rehabilitation activities also for individual with dementia both in clinical setting and especially in their own home ensuring the safety of the elderly person through a tool that remotely monitor patient's health and maintain contact with the relatives and member of medical staff. Results from a research based on focus groups with healthcare professionals and elderly with disabilities showed that such technologies can (a) improve safety and the sense of security of old patients, (b) help the family health workers to provide medical care, and (c) overcoming social isolation maintaining contacts and improving communication between patients and health professionals [5]. One example of telepresence systems application in medical care field is "Physician-Robot", a telepresence robot allowing physicians to easily and more frequently visit their hospitalized patients. In the evaluation by John Hopkins University, 80% of the patients felt that Physician-Robot increases the interaction between physicians and patients [21].

Care-O-bot is a mobile platform through which the user can control home lighting, heating/air conditioning, in addition the robot works as a video-phone with which to contact the doctor or relatives, and as a system capable to guide elderly person around the house avoiding obstacles via a system of sensors and cameras. The latest prototype Care-O-bot II also has manipulative skills that make an assistant in the tasks of daily living [13]. The platform RP-7 In-Touch Health[2] allows to remotely monitor patients offering ongoing support in terms of primary care and rehabilitation through a telepresence device. Patients can see and hear their doctor in real time through a video-screen and a speaker system. Patients prefer to see their doctor, even if through the robotic platform.

TeCaRob system provides continuous remote physical assistance enhancing independent living and performing tasks such as to transfer and move end-user, to perform tasks in end-user environment, to interact closely with end-user body and to communicate and monitor end-user [15]. TRIC (Telepresence Robot for Interpersonal Communication) is a tool for interpersonal communication that allows older adults to remain in their home environments, while members of family and caregivers are able to maintain a higher level of communication and monitoring via traditional methods [22].

[2] InTouch Health (2004). Advanced technology solutions for healthcare service providers. Retrieved from http://www.intouch-health.com/index.html

In line with these studies we propose to use the Giraff telepresence system as a means to support patients with mild cognitive impairment. To this purpose we describe a preliminary study to evaluate user's level of tolerance and adaptation to spatial and social presence during the interaction with the Giraff system. Tolerance and adaptation are analyzed in terms of affective state through monitoring of physiological responses.

3. A PROTOCOL TO ASSESS THE ROBOT TOLERANCE

This section details the protocol we designed to evaluate the emotional response of mild cognitive impaired user to the interaction with the Giraff telepresence robot. Specifically, the section illustrates the objective of the study, the subjects, the apparatus and experimental settings and finally the different steps of the experimental procedure.

3.1 Motivation and objective

The main motivation underlying this study stems from the need to understand how effective, tolerable and pleasant mobile remote presence robots can be for mild cognitive impaired users in real context of life. To examine the emotional reaction of elderly we rely on the assessment of the patients' physiological response during interaction with Giraff. Objective of the study is to demonstrate that such a response is positive by showing that the "physiological stress" will not increase during the interaction. Assessing the reaction of MCI patients will contribute to have a higher level of awareness of potential problems in the patient-robot interaction that need to be taken into account in view of the overall and long-term use of Giraff as a means to provide rehabilitation and foster social participation of people with MCI.

3.2 Participants

The treatment group will be composed of 5 elderly with MCI for whom an objective memory deficit has been demonstrated by means of neuropsychological tests. The control will consist of old volunteers recruited during their hospitalization at the rehabilitation center (Fondazione Don Carlo Gnocchi [3]) and who give their informed consent to participate in the study.

Inclusion Criteria. Inclusion criteria for the treatment group recruitment will be the following: age between 65 and 80 years; education>8 years; absence of sensory impairments affecting communication; $26 \leq MMSE \leq 30^4$; good awareness of disease; absence of behavioral disorders (confusion, aggression, hallucinations, motor agitation, etc.)

Exclusion Criteria. Presence of delirium and functional impairments due to cognitive decline or other conditions that compromise cognition such as non-treated or severe current depressive, other psychiatric diseases, unstable significant medical co-morbidity are considered exclusion criteria.

[3] http://www.dongnocchi.it/centri/roma/index.htm
[4] Mini Mental State Examination (MMSE) is a tool used as a screen and in assessing the degree of cognitive dysfunction in patients with diffuse brain disorders.

3.3 Apparatus and experimental settings

The experimental setting involves the use of two rooms: (a) a first room where the patient is located together with the Giraff that can move in the environment, (b) a second room where the experimenter, as a client, can operate the Giraff platform through a PC equipped with special software. The Giraff telepresence Robot is a remotely controlled mobile, human-height physical avatar integrated with a videoconferencing system (including a camera, display, speaker and microphone). It is powered by motors that can propel and turn the device in any direction. An LCD panel is incorporated into the head unit and it represents anthropomorphic element making visible other person's face. The robotic platform is accessed and controlled via a standard computer/laptop using an application over the Internet. From a remote location a person (member of family or healthcare professionals) with no prior computer training teleoperate the robotic platform. In this specific study the Giraff will be operated by the experimenter.

In addition to the robot, other devices will be part of the apparatus, which are used to assess the patients' physiological response as shown in Figure 1: for the recording of muscle activity Surface ElectroMyoGraphy (SEMG) will be used, that is a non-invasive technique for measuring muscle electrical activity that occurs during muscle contraction and relaxation cycles. The SEMG signal generated by the muscle fibers is captured by the electrodes, then amplified and filtered by the sensor before being converted to a digital signal by the encoder. SEMG is commonly used for stress or emotional response to a stimulus assessment with other physiological signals, such as skin conductance and heart rate which will also be assessed in our experiment. A blood pressure monitor will also be employed for measuring resting blood pressure, blood pressure response to stressors and heart rate.

3.4 Outcome measures

Physiological monitoring systems use physiological signals from the subject to extract information about the individual's reaction to given stimuli. Within our experiment we adopt a similar approach and examine the assisted person's physiological responses to the interaction with the Giraff telepresence robot. The overall idea is to have an objective indication of the emotional response of a sample of elderly people with mild cognitive impairment in terms of stress, anxiety, that we can be used to determine the overall *tolerance* of the robotic platform.

The reason for our choice of the physiological measures in combination with some psychological tests relies on their several advantages. More specifically they are more objective than subjective measures and many behavioral measures and additionally they are a continuous measure, so time-varying qualities of presence can be observed. Table 1 shows the physiological outcome measures we have chosen for our study. Our intuition on the use of the Giraff robot is that it will not have a negative impact on person with mild cognitive impairment. More specifically we expect a positive response in terms of affective state/emotional experience, and we hypothesize that Giraff will be judged to be

Table 1: **Physiological measures for assessing MCI elderly people reaction to Giraff**

Parameter	*Parameter description & assessment*
Heart Rate (HR)	Many things can affect a person's heart rate: stress, fear, exertion, emotion, etc. HR increases when a person is under stress and decreases as one relaxes. Affective valence (positive or negative) of a stimulus also contributes to increase the initial acceleration or deceleration of heart activity [6]: unpleasant stimuli produce a higher initial deceleration, pleasant stimuli produce a higher acceleration heart rate. **We expect that interaction between patient and Giraff will cause an initial greater pick acceleration if the robot is perceived as a pleasant stimulus**
Blood pressure (BP)	A blood pressure for a healthy adult is less than 120/80. Abnormal readings are related to specific cardiovascular disease. In order to truly determine a person's average blood pressure, readings must be taken consistently over time considering individual's blood pressure (hypotension or hypertension). It is a common observation that blood pressure rises as part of the behavioral response to stressful situations. **We expect an absence of high blood pressure if the robot is perceived as pleasant stimulus**
Corrugator and Zygomatic Muscle Activity	Corrugator and zygomatic muscle activity is assessed in this study. Specifically, corrugator muscles are responsible for lowering and contraction of the eyebrows. Significant contractions occur when a stimulus is judged unpleasant. On the contrary, stimuli judged as very pleasant are responsible for a relaxation of these muscles with respect to the baseline case. When viewing neutral stimuli this muscle activity is modest but still above baseline [6]. Activation of the zygomatic muscle is involved in the facial expressions that imply a smile. Its activity increases in response to stimuli rated as pleasant. The activation of this muscle in response to increased activity of the corrugator muscle suggests that some facial grimaces occur in response to negative stimuli [6]. **We expect a relaxation of corrugator muscle and an activity of zygomatic muscle if the robot is perceived as pleasant stimulus**
Skin Conductance (SC)	Skin conductance is a measure of physiological activity. A higher reactivity is associated with an greater physiological arousal. A rapid increase from baseline can be a reliable indicator of an anxiety response [4]. **We expect an absence of high skin conductance if the robot is perceived as pleasant stimulus**

a pleasant stimulus. This general hypothesis corresponds to the expectation on the physiological parameters described in bold in the table. If this hypothesis will be satisfied, then we can conclude that the tolerance of the Giraff robot is satisfactory.

3.5 Procedure

A repeated measures design within subjects is used for the proposed study. Participants and family member are initially briefed on the objective of the study. They are then asked to read and sign an informed consent form. Socio-demographic data are also gathered together with information on participants ability and familiarity with the use of technology.

The protocol is articulated into six main sessions in which participants interact both physically with the human experimenter in the same room and with the experimenter by means of the telepresence Giraff robot (see Figure 2). The experimenter is an unfamiliar person, met for the first time during the experiment and will carry out all the sessions. Physiological measures are monitored during all sessions and specifically in three different moments: at rest, during the sessions (20/25 min.) and at the end of each session. In addition the S-anxiety scale of Spielberg's state-trait anxiety inventory (STAI) is used to measure the intensity of anxiety with respect to the experienced situation. A questionnaire focused on subjective interaction experience with Giraff and its impact on patient satisfaction will be fill out at the end of the sessions.

Session1-2: During the first two sessions the experimenter conducts a simple conversation of ten minutes. The participants are asked to present themselves, to talk about their life (memories, everyday life routine, cognitive difficulties and strategies implemented to overcome them). The experimenter may also ask to patients to make a list of steps required to complete an action (take a shower, put clothes on, make a sandwich, put shoes on).

Session3: During the third session, the experimenter introduces the Giraff robot explaining its basic functionalities also showing an interaction between the experimenter and a doctor of the rehabilitation center. At the end of this session the experimenter announces that in the following sessions the old person will interact with the experimenter through the Giraff.

Session4-6: During the three subsequent sessions, the experimenter by means of Giraff enters the room where the patient is and interacts with him similarly to the previous sessions. Specifically, in the last session in addition to the talk, the patient will also be asked to follow the robot and perform a simple exploration of the room. This specific task aims to evaluate participants' subjective and physiological response to the robot movement.

The participant will meet the experimenter for a final interview again, during which the subjects will be asked tell how they felt about the interaction with the robot in terms of social presence, perceived utility, engagement, privacy, aspect.

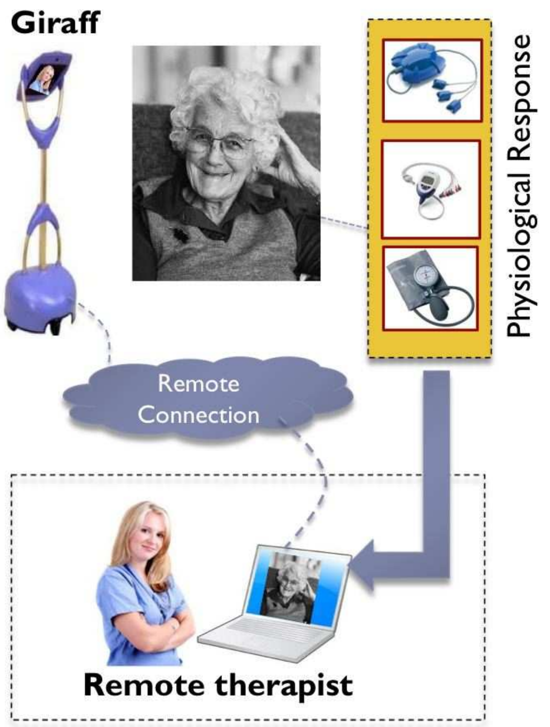

Figure 1: Experimental settings

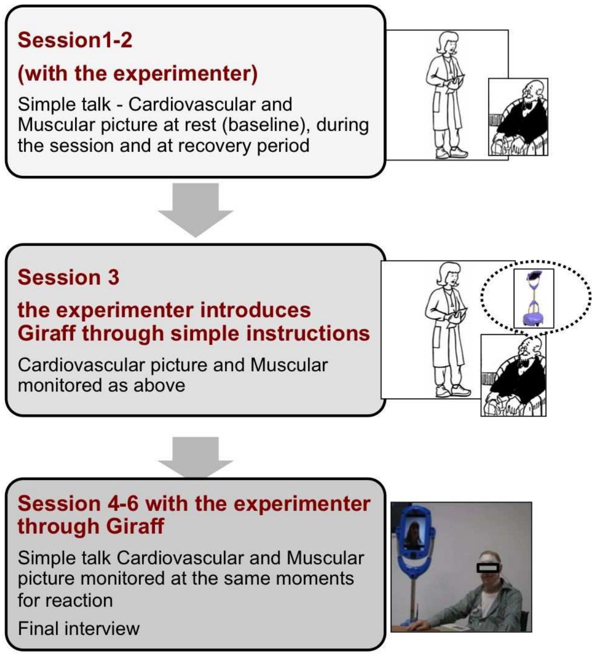

Figure 2: Timeline of the experiment

4. CONCLUSIONS

This paper describes a preliminary study which is part of a research effort that evaluates the potential application of a telepresence prototype, called Giraff, as a devise to support rehabilitation interventions, home care assistance and social participation of elderly people with a MCI diagnosis. Although dementia is not curable, there are now non-pharmacological and pharmacological therapies to control symptoms, improve quality of life and delay the time of admission. Telepresence robotics may offer its contribution in the management and treatment of the person who has the early symptoms of dementia. We believe that robots like Giraff have a potential to support both elderly persons with special needs to maintain independence longer in their home environments and their careers to be closer and more in touch with them.

In our opinion Giraff could be an effective tool to organize non-pharmacological treatment such as rehabilitative and cognitive stimulation interventions, to monitor over time patients with MCI and progression of their disease by a continuous homecare assistance. However, a first essential step in this direction is to understand the patient emotional response to the telepresence system.

In our work we adopt physiological signals as indicators of individuals' reaction to technology and their emotional experience. Similarly to a clinical trial, this paper describes a research protocol aimed to assess the safety and tolerability of Giraff in patient with MCI in order to monitor the patients' stress level during the interaction. Currently recruitment of subjects of both the experimental and control group is ongoing (see Figure 2). The results of this preliminary work will provide guidance for the next stages that will evaluate Giraff as a possible tool of rehabilitation, home care assistance and social participation of patients with special needs.

As a conclusive remark we would like to summarize the main idea underlying this paper. In order to assess the perceived safety and tolerability of an assistive technology, such as telepresence systems by people with special needs, it is necessary to have a confirmation that the presence of the robot in a person's life does not cause serious adverse effects. The idea presented in this paper consists in the proposal to use analysis focused on human-robot interaction which adopt a typical approach of clinical trials for evaluation of new drugs. As in these trials, our proposed protocol aims is to evaluate the perceived safety and tolerability of the robot by means of a first phase of the study which is carried out before the subsequent studies that will validate the system as an aid for rehabilitation, homecare assistance and social participation.

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5. REFERENCES

[1] A. Acevedo and D. A. Loewenstein. Non-pharmacological cognitive interventions in aging and dementia. *Journal of Geriatric Psychiatry and Neurology*, 20(4):239–249, 2007.

[2] S. Belleville. Cognitive training for persons with mild

cognitive impairment. *International Psychogeriatric*, 20(1):57–66, 2008.

[3] L. F. Berkman and T. Glass. *Social Epidemiology*, chapter Social integration, social networks, social support and health. New York: Oxford University Press, 2000.

[4] M. Birket-Smith, N. Hasle, and H. H. Jensen. Electrodermal activity in anxiety disorders. *Acta Psychiatrica Scandinavica*, 88:350–355, 1993.

[5] P. Boissy, H. Corriveau, F. Michaud, D. Labonte, and M. A. Royer. A qualitative study of in-home robotic telepresence for home care of community-living elderly subjects. *Journal of Telemedicine and Telecare*, 13:79–84, 2007.

[6] M. M. Bradley and P. J. Lang. *Handbook of psychophysiology*, chapter Emotion and motivation, pages 581–607. New York: Cambridge University Press, 2007.

[7] P. S. Brum, O. V. Forlenza, and M. S. Yassuda. Cognitive training in older adults with mild cognitive impairment: impact on cognitive and functional performance. *Dementia & Neuropsychologia*, 3(2):124–131, 2009.

[8] J. T. Cacioppo, L. C. Hawkley, E. Crawford, J. M. Ernst, M. H. Burleson, M. A. Kowaleski, W. B. Malarkey, E. Van Cauter, and G. Berntson. Loneliness and Health: Potential Mechanisms. *Psychosomatic Medicine*, 64:407–417, 2002.

[9] M. Cutchin. The process of mediated aging-in-place: a theoretically and empirically based model. *Social Science and Medicine*, 57(6):1077–1090, 2003.

[10] L. Fratiglioni, S. Paillard-Borg, and B. Winblad. An active and socially integrated lifestyle in late life might protect against dementia. *The Lancet Neurology*, 3(6):343–353, 2004.

[11] L. Fratiglioni, H. X. Wang, K. Ericson, M. Maytan, and B. Winbland. Influence of social network on occurrence of dementia: A community based longitudinal study. *Lancet*, 355(9212), 2000.

[12] S. Gauthier, B. Reisberg, M. Zaudig, R. C. Petersen, K. Ritchie, K. Broich, S. Belleville, H. Brodaty, D. Bennett, H. Chertkow, J. L. Cummings, M. de Leon, H. Feldman, M. Ganguli, H. Hampel, P. Scheltens, M. C. Tierney, P. Whitehouse, and B. Winblad. Mild cognitive impairment. *Lancet*, 367(9518):1262–1270, 2006.

[13] B. Graf, M. Hans, and R. D. Schraft. Care-o-bot ii-development of a next generation robotic home assistant. *Autonomous Robots*, 16(2):193–205, 2004.

[14] C. Heeter. Being there: the subjective experience of presence. *Presence: Teleoperators and Virtual Environments*, 1(2):262–271, 1992.

[15] A. Helal and B. Abdulrazak. TeCaRob: Tele-Care using Telepresence and Robotic Technology for Assisting People with Special Needs. *International Journal of Assistive Robotics and Mechatronics*, 7(3):46–53, 2006.

[16] W. A. IJsselsteijn, H. de Ridder, J. Freeman, and S. Avons. Presence: Concept, determinants and measurement. In *Proceedings of the SPIE*, pages 520–529. TeX Users Group, March 2000.

[17] C. Mendes de Leon, T. Glass, L. Beckett, T. Seeman, D. Evans, and L. Berkman. Social Networks and Disability Transitions Across Eight Intervals of Yearly Data in the New Haven. *J Gerontology B Psychological Sciences and Social Sciences*, 54(3):S162–S171, 1999.

[18] J. L. Moren-Cross and N. Lin. *Handbook of Aging and the Social Sciences (6th ed.)*, chapter Social networks and health. New York: Elsevier, 2006.

[19] R. Petersen. Normal aging, mild cognitive impairment, and early alzheimer's disease. *Neurologist*, 1:326–344, 1995.

[20] K. Ritchie and J. Touchon. Mild cognitive impairment: conceptual basis and current nosological status. *Lancet*, 355(9199):225–228, 2000.

[21] P. D. Thacker. Physician-robot makes the rounds. *Journal of Telemedicine and Telecare*, 293(2):150, 2005.

[22] T. C. Tsai, Y. L. Hsu, A. I. Ma, T. King, and C. H. Wu. Developing a telepresence robot for interpersonal communication with the elderly in a home environment. *Telemedicine and e-Health*, 13(4):407–424, 2007.