

Virtual Assistive Companions for Older Adults: Qualitative Field Study and Design Implications

| | | | | |
|---|--|---|--|---|
| Christiana Tsiourti Institute of Services Science University of Geneva Carouge, Switzerland +41 22 379 01 38 Christiana.tsiourti@unige.ch | Emilie Joly VIVA and University of Geneva Petit-Lancy, Switzerland +41 22 379 81 77 Emilie.joly@unige.ch | Cindy Wings Orbis Medisch en Zorgconcern Sittard, The Netherlands +31 6 51 70 90 35 C.wings@orbisconcern.nl | Maher Ben Moussa Institute of Services Science University of Geneva Carouge, Switzerland +41 22 379 00 73 Maher.benmoussa@unige.ch | Katarzyna Wac Institute of Services Science University of Geneva Carouge, Switzerland +41 22 379 02 42 Katarzyna.wac@unige.ch |
|---|--|---|--|---|

ABSTRACT

This paper presents a qualitative study conducted to explore perceptions, attitudes and expectations for a virtual assistive companion designed to supplement human caregiving and facilitate an improved quality of life and long-term health benefits for older adults. The study was conducted adopting a human-centred approach; employing focus groups and individual interviews with older adults, professional caregivers and psychologists specialized in the aging process. Results indicated that users were in favour of a virtual companion and highlighted its potential to assist the accomplishment of daily activities and make more efficient use of human care services. Humanlike communication and behaviour were desirable whereas mixed opinions were expressed about humanlike appearance. The ramifications of the study are discussed in the form of design implications for the development of a virtual assistive companion that possesses the appropriate “social skills” to establish and maintain comfortable and acceptable long-term interaction and offers “useful” support to older adults.

Categories and Subject Descriptors

H.5.1 [Information Interfaces and Representation (HCI)]: Multimedia Information Systems- *Artificial, augmented, and virtual realities*; H.5.2 [Information Interfaces and Representation (HCI)]: User Interfaces - *Interaction styles, User-centred design*.

General Terms

Design, Human Factors, Measurement.

Keywords

Human-centred design, older users, qualitative field study, health promotion, personalization, HCI.

1. INTRODUCTION

The increasing demand for healthcare and quality of life services to support the aging population has inspired researchers worldwide to explore the applicability of new intelligent technologies to support older adults to cope with the challenges of aging, live more independently and make more efficient use of care services. While human caregiving cannot and will not be replaced, assistive technologies have the potential to supplement human caregiving and to improve the quality of life for both older

adults and their caregivers [25]. A range of computer-based techniques has been used in the design of advanced assistive technologies focused on “aging in place”; that is to enable older adults to remain in their homes for longer periods and help those who are in assisted living care facilities to maintain more independence there. Virtual computer-animated characters, also known as Embodied Conversational Agents (ECAs) [12], have attracted a lot of attention over the past years and have been successfully used in health interventions, including several designed specifically for older users [2, 8, 26, 30]. ECAs move beyond the paradigm of computer as a tool and allow for multimodal interaction reflecting natural human-to-human communication. Recent research has shown that ECAs expressing empathetic emotions have the potential to enhance user’s satisfaction, engagement [18] and performance in task achievement [23].

In the scope of the European project *CaMeLi* [10], we investigate the use of ECAs as long-term assistive companions for older adults (aged 65 and above). In this context, we define a successful “virtual assistive companion” as an agent that is seamlessly integrated into the living environment and follows the daily life patterns of its users with the key function to identify and attend to their needs, primarily in the sense of organizing and accomplishing their routine activities and self-managing their care. The companion has to be both “useful”, *i.e.*, able to carry out a variety of tasks in order to assist humans and “socially intelligent”, *i.e.*, to possess social skills in order to interact with people in a believable, comfortable and acceptable manner [14]. An ECA without these functional and social capabilities would not be engaging nor accepted and would thus fail to evolve a long-lasting beneficial relationship with its users.

In order to identify “useful” functionality and to decide which “social skills” are required for an assistive ECA, both the application domain and the nature of interaction with its users need to be analysed in great detail [13]. We address this challenge from a technical and psychological standpoint and conduct a qualitative human-centred study with primary users (*i.e.*, older adults aged 65 and above) and individuals caring for them (*i.e.*, formal care professionals) at home and in assisted living care environments in two different countries, the Netherlands (NL) and Switzerland (CH). Specialists in gerontopsychology provide additional insight into the emotional and cognitive aging processes and propose methods of psychological intervention to improve the everyday care of older adults.

Particularly, we investigate perceptions, attitudes and expectations towards the idea of a virtual assistive companion for older adults and explore the following research questions:

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

PervasiveHealth 2014, May 20-23, Oldenburg, Germany

Copyright © 2014 ICST 978-1-63190-011-2

DOI 10.4108/icst.pervasivehealth.2014.254943

(RQ1) Are ECAs accepted as assistive companions in the living environment (*i.e.*, home or care facility) of older adults?

(RQ2) What are users' expectations towards a "useful" virtual assistive companion; namely which specific tasks should it perform to support older adults accomplish their routine daily activities and make more efficient use of human care services?

(RQ3) What are users' expectations towards a "socially intelligent" virtual assistive companion in terms of "social skills", communication behaviour and character traits?

(RQ4) What are users' expectations towards the appearance (*i.e.*, humanlike, cartoonlike) of a virtual assistive companion?

In Section 2, we briefly define and describe ECAs and review related work arguing that they are suited for long-term assistive applications for older adults. Section 3 describes the method and instruments used in our qualitative field study. Section 4 presents our key findings supported by results from focus groups and individual interviews with participants. In Section 5, we discuss the ramifications of this study and implications for the design and development of a successful virtual assistive companion, according to the definition presented previously. Finally, Section 6 presents future work and concludes this work.

2. RELATED WORK

2.1. Embodied Conversational Agents (ECAs)

ECAs are computer-animated characters designed to simulate human face-to-face conversation with their users. They are typically represented in the form of human or animal bodies and they are specifically lifelike and believable in the way they behave. Cassell [12] defines ECAs as those virtual characters that have similar properties as humans in face-to-face conversation, including:

- The ability to recognize and respond to verbal and non-verbal input.
- The ability to generate verbal and non-verbal output such as mouth movements, eye movements, head movements, hand gestures, facial expressions, and body posture.
- The ability to deal with conversational functions such as turn taking, feedback, and repair mechanisms.

Research studies suggest that social agents dealing with emotion and affect are capable of capturing the user's attention, engaging them in active tasks and entertaining them [18]. Further, Nijholt [22] claims that affective embodied agents allow the development of affinitive relationships with their human partners. Bickmore [7] introduced and explored the concept of "relational agents", namely ECAs designed to form long-term social-emotional relationships with their users. Relational agents are distinct from other types of social agents in their ability to imitate the way people incrementally get to know and trust each other through conversations [11]. They maintain a memory of specific interactions, with the intention of recalling and referring to them later so as to evolve relationships with their users [7].

2.2. ECAs for Older Adults

Conversation is a primary skill for humans; the ability to engage in face-to-face conversation is an early-learned skill and because the body is so well-equipped to support conversations this ability is often retained by older adults, even when suffering from cognitive impairments [16]. With their ability to recognize and respond to verbal cues, ECAs can serve as powerful ways for

humans to interact with their computers [12]. Simulated face-to-face conversation with an animated character can provide older adults with a familiar and non-threatening interface. Furthermore, when the agent uses relationship-building behaviours users become more engaged over the long term [6]. Based on these assumptions, a variety of ECAs aiming to address the emotional needs, provide companionship and assist older adults in health related domains (*i.e.*, physical exercise, medication adherence) have been developed in the human-computer interaction and Affective Computing communities. We refer to some related examples subsequently.

Ring et al. [26] developed a conversational agent-based system to provide longitudinal social support to isolated older adults by means of empathic feedback. An exploratory short-term pilot study demonstrated significant reductions in loneliness of older adults based on self-reported affective state. With regard to virtual agents envisioned as social companions, Vardoulakis et al. investigated the use of an agent to provide social support and wellness counselling to older adults. Qualitative analysis of interactions with a remote-controlled agent (*i.e.*, Wizard-of-Oz) installed in homes of older adults, identified multiple topics that users liked discussing and showed high acceptance ratings and a positive attitude towards the agent [30]. Several studies by Bickmore and Picard [2, 8] explored "relational agents" for health education and health behaviour change interventions. Results of a two month trial that investigated exercise promotion showed increased physical activity for participants using a virtual exercise coach compared to those using a conventional pedometer [5]. Nevertheless, this effect diminished when the coach was removed, suggesting that further research is needed to cause long-term behaviour change. Bickmore et al. developed a virtual laboratory to explore the longitudinal usage of a virtual exercise coach [9] showing that elderly participants who interacted with an agent using variable dialogue exercised significantly more than those interacting with an ECA with non-variable dialogue.

2.3. Virtual Assistive Companions for Long-term Interaction

Virtual agents that will be used for extended periods of time require special design considerations compared to systems that are either only used for brief interactions or do not engage the user in social interaction [6]. An agent that serves as a long-term companion and assists people in their living environment needs to "do the right things", *i.e.*, it has to be useful and conduct meaningful tasks but also has to "do the things right", *i.e.*, to possess a wide range of "social skills" which will make it acceptable for humans [14]. A number of researchers have explored the design of ECAs that interact with users over multiple conversations, ranging from a handful of interactions to hundreds of interactions spanning months or years [4, 7, 24]. Designing believable and acceptable virtual agents, that maintain user engagement, enjoyment and trust for long-term interaction are important and open research issues.

In our work, we aim to design and develop an ECA to be used by older adults on a daily basis aiming to evolve a long-lasting beneficial relationship based on a companion paradigm: the virtual companion's role is to identify and respond to the user's needs, primarily in the sense of assisting them to accomplish on their own certain daily activities and tasks in their living environment (*i.e.*, home or care facility). The virtual companion will be deployed on a touchscreen computer and will have the ability to recognize verbal and non-verbal input and to respond verbally (*i.e.*, natural language) and non-verbally (*i.e.*, emotional

facial expressions, gestures) with the goal of simulating the way older adults normally interact, collaborate and dialogue with a real human partner to accomplish their daily tasks. In order to motivate and engage the older adults to remain active, the agent should recognize the user's emotions, analyse their behaviour and deliver appropriately tailored empathetic feedback, in a similar way a real-life human companion would do. This will be achieved during the project CaMeLi [10] by using existing and established technologies for emotion recognition [29], dialogue management [21], virtual human simulation [17] etc. These technologies will be adapted to fulfill the user requirements and similarly to previous studies [21] well-defined dialogues for the scenario should increase the accuracy and the fluency of the interaction.

3. METHODS

To achieve an assistive companion that lives up to its promise, we go beyond traditional technology acceptance models and base our design on a user-centric study developed with older adults in mind and taking into account the social aspects of interaction inspired by human-to-human communication. To determine which functionality is "useful" in the application domain of daily need fulfilment, we analyse the characteristics of the daily living environment of older adults. We use a combination of qualitative data collection methods and direct observation to explore perceptions, attitudes and expectations towards a future virtual assistive companion from older adults, individuals caring for them, and experts in the psychology of the aging process.

3.1. Participant Demographics

The study was conducted in parallel in two fields, The Netherlands and Switzerland. The primary end users were represented by twenty participants both from the "young old" (over 65) and "older old" groups (over 75). All participants were recruited voluntarily based on the following inclusion criteria: (1) indication of interest in the study (2) aged 65 and over (3) with little or no previous computer experience (4) living alone or with their spouse independently or in assisted living facilities (5) being healthy and active (physically, mentally and socially) at the time of the study. Apart from these conditions the selection criteria were not excessively restrictive to explore a broad and diverse set of needs, preferences, attitudes and perspectives. People with physical and sensory impairments (e.g., wheelchair users, visual and hearing impairment) were also included.

A total of twelve care professionals, including occupational therapists, care coordinators and qualified caregivers interacting with older adults on a daily basis in an assisted living facility in the Netherlands participated in the study. Given their close and frequent involvement with older adults, they can provide valuable insights on the kind of assistance that is required and serve as human role models helping to understand how older adults would interact with a virtual assistive companion while carrying out specific tasks. Additionally, the research team included two specialists in neuropsychology and gerontopsychology, members of an association which integrates and valorises elderly people within a local community in Geneva, Switzerland. These experts were involved in the interview sessions and data analysis, to give insight into the emotional and cognitive changes occurring during the aging processes and to propose methods of psychological intervention and cognitive rehabilitation to improve the everyday care of older adults. The key characteristics of all the participants are summarized in Table 1.

Table 1: Description of participants

| Characteristics | The Netherlands Assisted Living Complex | | Switzerland Independent Living |
|--|---|------------------|--|
| Older Adults | | | |
| Age Range | 65-85 | | 65-92 |
| Living Environment | Nursing home | Care apartments | Independent household |
| Total participants | 7 | 4 | 9 |
| Gender: | | | |
| Male | 3 | 2 | 2 |
| Female | 4 | 2 | 7 |
| Social status: | | | |
| Widowed/Divorced | 7 | 4 | 4 |
| Living with spouse | - | - | 5 |
| Care requirements | Daily support | Frequent support | Occasional support |
| Special aid: | | | |
| Hearing aid | - | 2 | 1 |
| Glasses | 4 | 4 | 9 |
| Walker | 4 | 4 | - |
| Wheelchair | 2 | - | - |
| Medication | 7 | 4 | 7 |
| Special diet | - | - | 4 |
| Experience with technology | Low | Medium -High | Medium- High |
| Formal Caregivers and Psychologists | | | |
| Total Participants | 9 | 3 | 2 |
| Expertise | Occupational therapist Care coordinator Qualified caregiver | | Neuropsychologist Gerontopsychologist |
| Working Environment | Nursing home | Care apartments | Local elderly association |

3.2. Instruments and Procedure

The study was divided in three phases and was conducted during a period of four months, between August and November 2013. Older adult participants have been clustered into three homogenous groups according to their living conditions: (1) nursing home residents who receive daily care on a practical, emotional, and physical level; (2) residents of care apartments in an assisted living complex who receive frequent care mainly because of physical deficiencies; (3) older adults living independently alone or with their spouse and receive occasional support for specific tasks. The common or similar experiences among the participants of each group promoted a discussion that better represents their specific care context. Care professionals have been clustered in two groups according to their working environment within the facilities of an assistive living complex: (1) professionals working in a nursing home environment; (2) professionals working in care apartments.

The study sessions were led by at least one facilitator providing instructions and guiding the discussion with the participants and one or two people (based on the size of each group) responsible for taking notes. The facilitators had expertise in the elderly care sector (The Netherlands), neuropsychology and gerontopsychology (Switzerland). All the interviews were conducted in Dutch and French respectively, were audio recorded, transcribed and translated in English for further data analysis. Prior to the beginning of the study, all participants were introduced to the scope of the research. Those who chose to continue signed an informed consent form and had the right to discontinue their participation at any time without any repercussions. In addition to the interviews, detailed field notes were taken by care professionals based on their observation of the daily living of older adults in the assisted living complex.

3.2.1. Semi-structured Focus Group Interviews

The first phase of the study consisted of focus group interviews with older adults and care professionals. Initially, emphasis was set on RQ1, namely to investigate people's acceptance related to the use of a virtual assistive companion that supplements human caregiving to improve the quality of life of older adults and facilitate caregivers. Next to that, the focus groups addressed RQ2, concerning expectations about "useful" assistive tasks for a virtual companion. To expose a variety of opinions, the interviewers tried to construct a holistic view of the multifaceted daily life routine of older adults and discuss the circumstances of their care at home and in assisted living environments. The approach adopted was to ask a set of pre-defined questions and allow the participants to describe and discuss as a group what they would like or not like to have, regardless of the technical feasibility of their ideas.

3.2.2. Paper Mock-ups

A second round of focus group interviews was conducted to address RQ3 and RQ4. Initially, the discussion addressed the type of "skills" the participants expected to see in a "socially intelligent" companion. Open-ended questions explored human-to-human social interaction between older adults and caregivers and collected information about how users envision the interaction with a virtual companion. Topics included desired communication behaviours (i.e., friendly vs. professional stance) and character traits (i.e., empathic, joyful), aspects the users would like to control, what information they want the virtual companion to communicate, when and how it should be delivered to them (i.e., formal vs. informal communication), etc.

To investigate expectations of older adults and caregivers about the appearance of the virtual companion, high-fidelity mock-ups were presented as colour paper prints (Figure 1). A set of seven graphical emotionally expressive 3D representations were carefully selected to cover a range of different possible looks: different gender and age groups, realistic humanlike look versus cartoonlike look and formal versus informal look. No particular gestures were expressed and all the 3D characters had a neutral facial expression to avoid bias associated with specific emotions. Participants were asked to rate the mock-ups on a 7-point Likert scale, ranging from "not attractive" to "very attractive". Additionally, open-ended questions were used to gain a better understanding of the ratings and to give the respondents the opportunity to express additional thoughts. Finally, the neuropsychologists/gerontopsychologists of our research team contributed their expert opinions about the appearance of the mock-ups from a psychological perspective.

3.2.3. Semi-structured Individual Interviews

The final phase of the study consisted of individual interviews examining more narrow topics to generate a deeper and more nuanced understating of the participants' opinions concerning all our research questions (c.f., Section 1). The individual interviews were deliberately conversational in nature (i.e., open-ended questions) and a semi-structured approach was adopted to allow room for clarification and to have the flexibility to follow interviewee comments in search of additional insight and understanding.

3.3. Qualitative Data Analysis

The qualitative study produced a large amount of data including verbatim notes and transcribed recordings of the group and individual interviews, the interviewer's reflective notes, and detailed field notes of observational investigation made by professional caregivers. Since we are conducting qualitative research we did not seek to quantify data but instead the goal was

to identify the important ideas that repeatedly appeared. We used content analysis [1] and "indexed" textual data in their original form, looking for common structures and themes. Those centred on particular phrases, incidents, or types of behaviour reported by participants during the study. Inductive coding was performed by two persons being present in the study sessions in each country, and the final categorization was validated by an independent researcher. Several themes emerged and developed iteratively, answering our four research questions. The themes were finally refined to the following categories: (1) Acceptance of virtual assistive companions for older adults; (2) "Useful" task performance for a virtual assistive companion; (3) Desired "social skills" and behaviour traits for a virtual companion; (4) Desired appearance for a virtual companion.

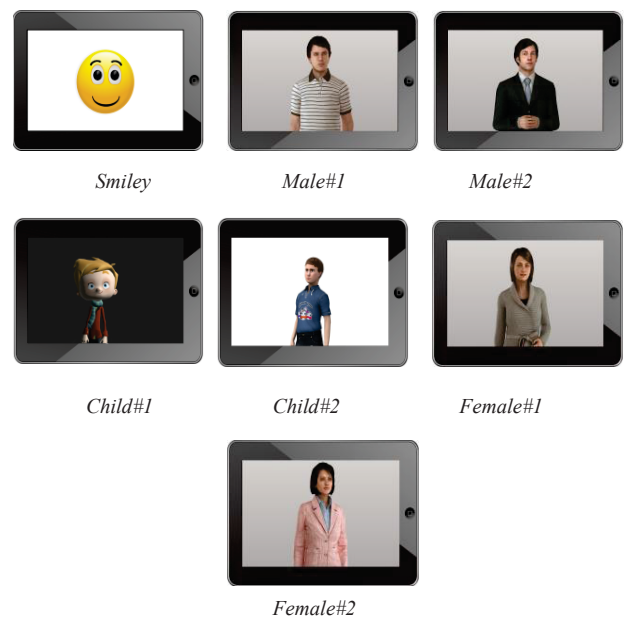


Figure 1: Virtual assistive companion mock-ups. Selected 3D characters from the collections [32] and [19].

4. RESULTS

4.1. Acceptance of Virtual Companions

Responses for acceptance of a virtual assistive companion in the living environment of older adults were positive both from primary users and formal caregivers. After being introduced to the concept, older adults were willing to accept a virtual assistive companion in their daily living context at the present moment and even more in the future, as they expected their needs to increase as they grow older. No significant correlations were found between the acceptance level and gender, age or experience with technology of the participants.

While the overall attitude of the older adults towards the virtual assistive companion was positive, an important outcome was the fact that acceptance is highly correlated with aspects of privacy. Specifically, older adults expressed worries related the use of cameras and uncertainty about whether or not their interactions with the virtual companion would be recorded. One of the Swiss interviewees living independently expressed a categorical refusal of using a device that would be able to "see" what they are doing in the home. While few participants found it convenient to be able to interact with the virtual companion freely at any time, the

majority cautioned that they wanted a sense of control over the interactions and requested the ability to turn the system off, whenever they wished. In summary, older adults specified three acceptable modalities for the virtual companion: (1) a proactive assistant whose actions are time triggered or initiated by the user; (2) a silent observer, set in the background monitoring and safeguarding the user, a task which was an important requirement both for older adults and caregivers; (3) completely deactivated when requested by the user.

The formal caregivers recognized potential benefits from the use of a virtual assistive companion in the care environment and were positive towards the idea. Specifically, they expected that assistance to structure their daily routine would bring positive effects for older adults in terms of motivation and self-esteem. Additionally, the virtual companion could potentially enable the care personnel to make more efficient use of their time with older adults by taking care of some trivial tasks. Next to these comments, both care professionals and neuropsychologists/gerontopsychologists emphasized that the ultimate goal for older adults is to remain autonomous for as long as possible. Consequently, they cautioned that an assistive companion should be introduced in the daily living environment with great care:

“The companion could help the elderly but it should not do too much. They have to think for themselves as much as possible.”
[Care professional, NL]

“Be careful with this target group! They cannot be spoiled too much because this is not helpful for their independence.” [Care professional, NL]

4.2. Useful Task Performance

After coding all the participant responses related to the “functional usefulness” of a virtual companion, an exhaustive list of themes was extracted by consensus of the research team. We summarize here the most important tasks that were considered “useful” by older adults and caregivers:

Daily schedule management: Elderly nursing home residents are prone to forgetfulness. To help them accomplish their daily routine activities, the companion can maintain a personal up-to-date daily plan, monitor the execution of activities, and decide about issuing appropriate reminders during the course of her day. Caregivers agreed that elderly would benefit from reminders for basic actions (e.g., wake up, take medication, eat meals) and it could also save valuable time for the care personnel; for example if the people are already awake and prepared to receive their visits.

Agenda Management: All the older adults from the Netherlands and six out of nine older adults from Switzerland (85% of all participants) would like the companion to manage their personal agenda and communicate with them using natural language for creating new entries and reminding events (e.g., social activities, medical appointments). Caregivers cited that this is a basic need since activities written on notes are often lost. The remaining older adults living independently in Switzerland (15% of all participants) stated they do not need an agenda or reminding system since they are already using a smartphone or a paper plan.

Dietary Planning: In Switzerland, six older adults (30% of all participants) living independently at home found it useful if the companion would help them find new recipes based on specific ingredients they have at home. In the Netherlands, nursing home

residents do not cook for themselves but since reading is sometimes difficult, the companion could announce the daily menu and register their selections. Caregivers added that this is a trivial yet time consuming task for the care personnel. Older adults living in care apartments cook for themselves and stated that dietary planning is not a problem for them.

Notifications: The caregivers monitor abnormalities in the daily schedules of older adults. To assist them in this task, the companion could monitor activity in the home and reason about any inconsistencies between what the older adult is supposed to do and what they are doing. In case of discrepancies, it is important to make the right decisions about whether a notification should be sent, how (i.e., via email, phone), when and who is responsible to evaluate the situation. Older adults in the Netherlands proposed a scenario where the companion notifies the appropriate person if they are running late for an appointment.

Safeguarding: Participants living alone in independent homes (Switzerland) were interested in the companion acting as a safety guard that monitors the home and identifies dangerous situations (e.g., loud noises, fall of objects) or accidents (e.g., whether they have fallen down). Older adults living with a spouse did not express great concerns about their safety but acknowledged the fact that some risks exist in the living environment. Caregivers proposed that the companion could learn particular patterns in the routine of older adults and indicate a potential problem if irregular activity is detected. Overall, care professionals caution that safety matters should be handled with great care and placed strong demands for high accuracy and reliability.

Physical and Mental Wellbeing and Socialization: Older adults envisioned that the companion could motivate them to undertake activities that are good for their health such as physical exercises and relaxation exercises or brain training games. Additionally, the companion can suggest and remind them of initiating communication with their social contacts (i.e., family, friends) on a frequent basis. Participants living independently (Switzerland) cited that if the virtual companion knows their personal interests, it could also suggest activities around the city.

4.3. Desired Social Skills

Both older adults and caregivers emphasized the importance of interacting with a supportive companion that expresses a range of pleasant emotions (i.e., joy and happiness). Older adults wanted a companion that is controllable and non-intrusive, specifically one that does not “take over” and execute tasks or request help on their behalf. Similarly, caregivers and psychologists cited that from a clinical perspective it is important that the companion is “guiding” rather than “directing” older adults and that it is oriented on “reminding” them to perform tasks on their own rather than “doing” things for them [27]. When asked what type of behaviour they prefer the virtual companion to have, older adults identified two different personalities depending upon the task at hand. For example, an informal, friendly companion could remind them about their daily appointments and a companion with a more neutral or professional behaviour could deliver medication reminders.

An older adult from the Netherlands and two older adults from Switzerland expressed worries related to emotion recognition:

“It is too intrusive.” [Older adult, NL]

“It is out of the question, from an ethical point of view.” [Older adult, CH]

Participants from the assisted living complex (NL) responded that care professionals monitor their emotional state and emphasized that a human can be of much better help when it comes to emotional difficulties:

“Whenever there is something wrong they (caregivers) come in and sit next to you on the bed and talk.” [Older adult, NL]

On the other hand, older adults from Switzerland were interested in a virtual companion with the ability to recognize emotional states in order to offer psychological motivation:

“If the virtual companion detects the person is feeling sad or anxious it could propose going for a walk calling a friend or a family member.” [Older adult, CH]

4.4. Desired Appearance

Older adults’ opinions about the appearance, behaviour and mode of communication of the virtual companion were diverse. Unsurprisingly, all participants emphasized the importance of interacting with a friendly face and voice. They wanted the virtual companion to communicate in a humanlike manner, namely using natural language and synchronized nonverbal conversational behaviour (*i.e.*, facial expressions). Participants from the Netherlands preferred a realistic humanlike avatar, which could even resemble a familiar person (*i.e.*, relative, caregiver *etc.*). According to the results of the mock-up ranking (7-point Likert scale) by older adults and caregivers in the Netherlands, the most wanted character was a female with informal look (Female#1, Figure 1); the male character with formal look (Male#2, Figure 1) had the worst overall ranking. Older adults stated they wanted to feel comfortable and “*attracted*” to the companion and the most important requirement was that the 3D character looks realistic:

“I want to be able to look the avatar in the eyes”. [Older adult, NL]

On the other hand, humanlike behaviour and appearance were less popular among older adults from Switzerland. Specifically, six out of nine participants preferred a fictitious cartoonlike character (Smiley, Figure 1). The second most popular character was once again Female#1:

“The humanlike avatars are too impersonal, too serious, maybe depressing after a while.” [Older adult, CH]

Both older adults and care professionals emphasized that the user should be able to tailor certain aspects of the agent’s appearance and behaviour:

“Just like a computer game, you can choose your own figure, looks of the figure voice, etc.” [Care professional, NL]

5. DISCUSSION: DESIGN IMPLICATIONS

5.1. Decoupling Requirements and Personalization

A virtual companion is an entity that is envisaged to share the home of an older adult for an extended period of time. In the beginning of this paper, we argue that the success of its deployment depends on two key factors: “*usefulness*”, *i.e.*, performing assistive tasks and holding task-oriented conversations and “*social intelligence*”, *i.e.*, showing personality traits, social skills and emotional aspects of face-to-face interaction that are comfortable and socially acceptable, considering the particular needs of the user. The study participants reacted differently to these aspects. Although there were many common topics, diverse

needs and mixed wishes lead to high inter-individual variability in preferences about “*useful*” tasks. The variation can be attributed mainly to the different profiles, care requirements and living conditions of the older adults (*i.e.*, assisted living versus independent living environment). Similarly, opinions about the humanlike appearance and behaviour of the virtual companion were somewhat mixed, yet all participants highlighted the requirement of being able to tailor certain aspects of appearance and behaviour. These findings, brought together, clearly indicate the need to decouple all requirements and develop functionality that will allow users to select which features match their particular needs, preferences, as well as social and physical context. The virtual companion should be personalized taking into consideration the human’s likes and dislikes and adapting its behaviour accordingly. At this stage, we cannot rule out that part of the variation in the findings also reflects a cultural phenomenon; it is worth studying these particular aspects in further user studies in different countries.

5.2. Humanlike Appearance and Behaviour

Mixed opinions were expressed about humanlike versus cartoonlike appearance of the virtual companion. The high ranking of Female#1 (Figure 1) can be explained by the fact that it resembles familiar faces: caregivers are usually women. The preference of Female#1 over Female#2 and the low ranking of Male#2 can also be explained by this phenomenon: a casual clothing style is more usual for care workers compared to the rather business style of Female#2 and Male#2.

People generally expect virtual characters to have a behaviour fitting their appearance and will often be disturbed by discrepancies between the two. It is a known fact that a virtual character that closely resembles a human in appearance but does not behave like one generally provokes discomfort and there is the danger of the interaction breaking down. This situation could even lead to feelings of revulsion against the character, as in the “*Uncanny Valley*” hypothesis presented by Mori [20]. Participants in our study were shown static mock-ups of high-fidelity humanlike 3D characters, without getting a chance to interact with them. Statements made by participants (*c.f.*, Section 4) reflect the fact that lack of expression had a negative impact on the perceived communication with a virtual character. This might justify the preference of some older adults towards a cartoonlike character. Additionally, a familiar character like the Smiley (Figure 1) makes affective facial expressions easier to understand.

Overall, fifteen out of twenty older adults (75%) stated that a head will do and they do not need to view gestures or the whole body of the 3D character. Nevertheless, a disadvantage could occur when animating the character. Non-verbal cues carry a great deal of social meaning and the lack of a human body would mean losing a rich set of communication cues.

Further investigation with interactive virtual characters is needed before concluding about users’ preferences for the appearance of virtual companion.

5.3. Supplementing Vs. Replacing Self-Care and Human Caregiving

Overcoming health constraints and maintaining a sense of control over one’s life decisions is a great accomplishment that boosts the self-esteem of the elderly [28]. The findings of this study confirm that older adults want to manage their care and maintain their autonomy for as long as possible. As they cited, when they need assistance from others, they like to “*ask for it using their own*

mouth”, instead of having the virtual companion do so for them. Similarly, experts emphasized that older adults need to “*think and act for themselves*” as much as possible. Evidently, it is important to avoid making older adults overly reliant on the virtual companion; this would have the effect of undermining rather than increasing their self-confidence and independence.

While discussing the ability of the virtual companion to recognize the user’s emotional state, some older adults expressed the negative perception of having a “*machine*” attempting to substitute roles and tasks, which only a human is able to perform. This emphasizes the importance of personal contact and emotional support in the daily life of older adults. Clearly, a virtual companion cannot and will not replace human caregiving; it will merely supplement it by taking care of trivial tasks that consume valuable time of the care personnel. This time could be spent for more effective and supportive interaction with older adults.

5.4. Behaviour Traits for Long-Term Interaction

A fundamental goal of the virtual assistive companion in *CaMeLi* is to evolve a long-lasting beneficial relationship with its users. Studies have shown the importance of “*working alliance*” for maximizing outcomes in long-term helping situations [31]. In order to achieve this goal, older adults have to trust and care for their virtual companion and feel cared for in return. The results of this study confirm the importance of behaviour traits such as being non-intrusive, considerate, proactive and possessing “*smooth*” communicative skills in order to engage in successful long-term interaction with older adults. Additionally, to work towards a relationship of trust with its user, the companion should be designed to gather information during the interaction, for example by asking questions, and to remember past events and conversations. Researchers have explored the use of virtual agents able to create episodic memories [17] making them able to respond more adequately and adapt to the user’s specific needs across time. The *CaMeLi* virtual companion will build upon the foundations of this research.

5.5. Ethical and Privacy Considerations

There are several ethical issues that are commonly raised regarding the use of humanlike “*socially intelligent*” virtual agents in general and related to the use of these agents particularly for the sensitive population of older adults. Research results indicate that if humans are expected to interact with virtual agents similarly to the way they interact with human companions, they have to invest in engaging in emotional and physiological activities [14]. Therefore, an important concern is “*Whether it is ethically justifiable to aim to create virtual companions that older adults bond with*”. Bickmore addressed some of the most common criticisms of this type of research [3]. It is essential that older adults are not deceived into thinking they are interacting with a real “*person*”. On the contrary, it must be clarified that the virtual companion is merely a computer-driven character with limited capabilities.

In terms of privacy, after careful consideration of the concerns raised by older adults and care professionals we conclude that a virtual assistive companion can be said to be respecting the older adults’ rights as long as: (1) the user is free to decide whether to enable and interact with the virtual companion or not; (2) the processing of multimodal data streams is done “*on-the-fly*” and no records of the interaction between the user and the virtual companion are stored or transmitted; (3) the companion respects the autonomy of the user who is free to decide whether to follow

its recommendations or not; (4) the role of the virtual companion is primarily to “*motivate*” and “*remind*” the user rather than “*execute*” tasks for them; and (5) the virtual companion can take autonomous decisions only if there is a probability of an emergency situation related to the user’s safety.

6. CONCLUSION AND FUTURE WORK

Loss of autonomy is a major cause for older adults to make a transition from independent living and residential care to nursing homes. In many cases, due to age related impairments or a catastrophic event, such as an accident or the passing of a spouse, older adults need support, including monitoring, planning and reminding to complete daily routine activities of self-care, physical and mental wellbeing and social interaction. Recent research has proven that ECAs provide several inherent advantages that make them especially useful for building systems to supplement human caregiving and address the needs of older adults in the spectrum of daily need fulfilment [2, 26, 30]. Nonetheless, to develop autonomous social agents capable of forming long-term assistive relationships with older adults and staying at their care facilities and homes, we need to understand the motivations of the users and the process by which they come to accept or reject this technology.

Traditional technology acceptance models do not take into account social aspects of interaction with ECAs nor are these models developed with older adults in mind [15]. Our qualitative field study has contributed new global insights about what “*having a virtual assistive companion in the living environment*” means for older adults, formal caregivers and psychologists specialized in the aging process. Based on their preferences, requirements and possible challenges in terms of functional and social characteristics and the desired appearance of a virtual agent, we extract a set of implications to inform the design of a “*successful virtual companion*” that simulates natural human-to-human interaction and collaboration to support older adults accomplish daily activities.

To conclude, we would like to highlight that since it is practically and methodologically impossible to investigate all possibly relevant factors that might influence people’s acceptance, attitudes and desires (*i.e.*, discuss all possible agent appearances, behaviours, and assistive tasks) a lot of issues still remain open for examination. Our next step will be the development of a functional prototype of the virtual assistive companion, taking into account the documented design implications about “*social skills*”, appearance and “*useful*” functionality. Placing the companion in the living environment and testing it with older adults in the two countries of the study will be the final future challenge. We aim to explore different types of interaction and tasks that might occur in a home in order to gain a greater understanding of the possible capabilities and limitations of a virtual companion. A profound understanding of the way different factors influence older adults’ views and acceptance in the long-term will enable us to improve the design and development of successful virtual assistive companions to promote better quality of life and long-term health benefits. Hence, another further aim is to use longitudinal experimental paradigms which will allow us to measure and determine whether perceptions and attitudes towards a virtual companion change over time, as the abilities and behaviour of the agent evolve and the familiarity with the user increases.

7. ACKNOWLEDGMENTS

This work was supported by the European projects CaMeLi (AAL-2012-5-030) and My Guardian (AAL-010000-2012-16). We like to express our gratitude to the staff as well as the study participants at Orbis (Orbis Medisch en Zorgconcern) and VIVA (Valoriser et Intégrer pour Vieillir Autrement) for their cooperation.

8. REFERENCES

- [1] Babbie, E. 2013. *The practice of social research*. Wadsworth Cengage Learning.
- [2] Bickmore et al. 2005. Establishing the computer-patient working alliance in automated health behavior change interventions. *Patient education and counseling*. 59, 1 (Oct. 2005), 21–30.
- [3] Bickmore, T. 2005. Ethical Issues in Using Relational Agents for Older Adults. *Proceedings of the AAAI Fall Symposium on Caring Machiness: AI in Eldercare* (Washington, DC, 2005).
- [4] Bickmore, T. et al. 2010. Maintaining Engagement in Long-term Interventions with Relational Agents. *Applied artificial intelligence : AAI*. 24, 6 (Jul. 2010), 648–666.
- [5] Bickmore, T.W. et al. 2013. A randomized controlled trial of an automated exercise coach for older adults. *Journal of the American Geriatrics Society*. 61, 10 (Oct. 2013), 1676–83.
- [6] Bickmore, T.W. et al. 2005. “It’s just like you talk to a friend’ relational agents for older adults. *Interacting with Computers*. 17, 6 (Dec. 2005), 711–735.
- [7] Bickmore, T.W. 2003. *Relational Agents : Effecting Change through Human-Computer Relationships*. Massachusetts Institute of Technology.
- [8] Bickmore, T.W. and Picard, R.W. 2005. Establishing and Maintaining Long-Term Human-Computer Relationships. *ACM Transactions on Computer Human Interaction*. 12, (2005), 293–327.
- [9] Bickmore, T.W. and Schulman, D. 2009. A Virtual Laboratory for Studying Long-term Relationships between Humans and Virtual Agents. *Proceedings of the 8th International Conference on Autonomous Agents and Multiagent Systems* (2009), 297–304.
- [10] CaMeLi : Care Me for Life: <http://www.cameli.eu/site/>.
- [11] Campbell, R.H. et al. 2009. Relational Agents: A Critical Review. *The Open Virtual Reality Journal*. 1, 1 (Apr. 2009), 1–7.
- [12] Cassell, J. 2000. More Than Just Another Pretty Face: Embodied Conversational Interface Agents. *Communications of the ACM*. 43, (2000), 70–78.
- [13] Dautenhahn, K. 2003. Roles and functions of robots in human society: implications from research in autism therapy. *Robotica*. 21, 4 (Aug. 2003), 443–452.
- [14] Dautenhahn, K. 2007. Socially intelligent robots: dimensions of human-robot interaction. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*. 362, 1480 (Apr. 2007), 679–704.
- [15] Heerink, M. et al. 2010. Assessing Acceptance of Assistive Social Agent Technology by Older Adults: the Almere Model. *International Journal of Social Robotics*. 2, 4 (Sep. 2010), 361–375.
- [16] Horn, J. 1982. The Theory of Fluid and Crystallized Intelligence in Relation to Concepts of Cognitive Psychology and Aging in Adulthood. *Aging and Cognitive Processes SE - 14*. F.I.M. Craik and S. Trehub, eds. Springer US. 237–278.
- [17] Kasap, Z. et al. 2009. Making Them Remember—Emotional Virtual Characters with Memory. *IEEE Computer Graphics and Applications*. 29, 2 (Mar. 2009), 20–29.
- [18] Klein, J. et al. 1999. This computer responds to user frustration- Theory, Design, Results and Implications. *Proceedings of CHI ’99 Extended Abstracts on Human Factors in Computing Systems* (Pittsburgh, USA, May 1999), 242.
- [19] Mixamo Character Collection: <http://www.mixamo.com/c/3d-characters>.
- [20] Mori, M. et al. 2012. The Uncanny Valley. *IEEE Robotics & Automation Magazine*. 19, 2 (Jun. 2012), 98–100.
- [21] Moussa, M. Ben and Magnenat-Thalmann, N. 2013. Toward socially responsible agents: Integrating attachment and learning in emotional decision-making. *Computer Animation and Virtual Worlds*. 24, 3-4 (May 2013), 327–334.
- [22] Nijholt, A. 2003. Disappearing computers, social actors and embodied agents. *Proceedings of the International Conference on Cyberworlds* (2003), 128–134.
- [23] Partala, T. and Surakka, V. 2004. The effects of affective interventions in human–computer interaction. *Interacting with Computers*. 16, 2 (2004), 295–309.
- [24] Pinto, H. et al. 2008. The senior companion multiagent dialogue system. *Proceedings of the 7th international joint conference on Autonomous agents and multiagent systems* (May 2008), 1245–1248.
- [25] Pollack, M.E. 2005. Intelligent Technology for an Aging Population: The Use of AI to Assist Elders With Cognitive Impairment. *AI Magazine*. 26, 2 (2005), 9–24.
- [26] Ring, L. et al. 2013. Addressing Loneliness and Isolation in Older Adults. *Affective Computing and Intelligent Interaction* (Geneva, 2013).
- [27] Shumaker, S.A. et al. 2008. *The Handbook of Health Behavior Change*. Springer.
- [28] Taft, L.B. 1985. Self-esteem in later life: A nursing perspective. *Advances in nursing science*. 8, 1 (Oct. 1985), 77–84.
- [29] Den Uyl, M.J. and Van Kuilenburg, H. *The FaceReader: Online facial expression recognition*.
- [30] Vardoulakis, L.P. et al. 2012. Designing relational agents as long term social companions for older adults. *Proceedings of the 12th international conference on Intelligent Virtual Agents* (Heidelberg, Sep. 2012), 289–302.
- [31] Williams, S.L. et al. 2007. The therapeutic effects of the physician-older patient relationship: effective communication with vulnerable older patients. *Clinical interventions in aging*. 2, 3 (Jan. 2007), 453–467.
- [32] WorldViz : Vizard: <http://www.worldviz.com/products/vizard/index.html>. Accessed: 2012-03-05.