"Eldertainment" or functional necessity?: Investigating how virtual agents influence the home lives of people with dementia using the Quality of Life (QOL-AD) scale

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ABSTRACT

A large literature evaluates the impact virtual agents have in the lifestyles of people with dementia by assessing their perceptions of technology. We evaluate the impact of a home virtual agent developed as part of the "Living well with Anne" project on the *quality of life* of elderly people with dementia—rather than focusing on their perception of the technology. This shift from the perception of technology to assessing life is particularly pertinent given the importance of a person's perceived quality of their daily home life and given that positive perception of a technology do not always lead to actual use. We propose an indirect approach to evaluating assistive technology for people with disabilities by assessing impact on users' lives using semi-structured interviews and the QOL-AD scale. We describe a preliminary proof-of-concept study that tests whether perceptions of a virtual agent, actual use of a virtual agent and a participant's quality of life is related, as well as whether a virtual agent improves a participant's quality of life.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; *Interface design prototyping*; *Empirical studies in interaction design*; • **Social and professional topics** → *People with disabilities*; *Seniors*;

KEYWORDS

Dementia, Virtual Agent, Screen Agent, Quality of Life, Focus Group, User Centered Design

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1 VIRTUAL AGENTS FOR DEMENTIA CARE

Over 46 million people worldwide live with dementia—a number estimated to double every 20 years and exceed a global cost of US$1 trillion [25]. Symptoms of dementia include memory loss, confusion with time or place, problems with words in speaking or writing, misplacing things, change in mood or personality and general frustration and uncertainty can greatly impact a person's life [13, 29].

Cognitive assistive technology is an emerging solution to help older adults with dementia remain independent at home for longer[21, 22]. Virtual agents, in particular, have been proposed to have a powerful impact on people's lives (e.g., [17]), perhaps because virtual agents can aid or appear to be aware of a person's needs, wants and demands through conversational speech, emotion and monitoring, which can be important in maintaining a person's dignity. It is therefore unsurprising that virtual agents have previously been used to assist people with dementia in their homes (e.g., [4, 22, 36]).

A key question in research on virtual agents for cognitive assistance is whether and how virtual agents influence people's home lives. Since one research focus is in the design of proof-of-concept prototypes of these virtual agents using such approaches as participatory design, it is not surprising that assessment of the success of these interventions often draw from measures in technology evaluation of human-technology interaction or user experience (e.g., [31, 36]). Although findings from past work may be well suited to deliver clear design guidelines or functional requirements related to trust in and expectations of the technology, it may be less suited to evaluating the impact of technology on people's lives. Literature from dementia research, conversely, has identified concepts and measurement scales that are specifically relevant to the quality of life of dementia patients, and may be particularly meaningful in assessing the influence of technology on their lives. We therefore assess whether and how a virtual agent influences people's home lives using the novel measure of *quality of life* and explore how conventional measures focused on the perception and adoption of a virtual agent relates to its use and its user's quality of life.

2 VIRTUAL AGENTS' INFLUENCE ON HOME LIVES OF PEOPLE WITH DEMENTIA

Past work evaluating virtual agents' influence on the lives of people with dementia has primarily focused on technology perception and acceptance. For example, Yaghoubzadeh et al. [36] conducted exploratory interviews with people with cognitive impairment and found that some participants, particularly younger participants,

were reluctant to use their virtual agent prototype, remarking that the systems were useful for others but not the participants themselves. They also found using a participatory design method influenced acceptance of the resulting prototype. Tsiourti et al. [32] introduced a virtual agent into the homes of 20 older adults for 12 weeks and found that they gave positive ratings of acceptance, perceived usability and usefulness of the agent, although ratings decreased later on due to unmet expectations of the conversational capabilities of the agent. Kramer et al. [18] conducted contextual-inquiry-focused interview and focus group sessions as well as usability evaluation sessions to improve the social acceptability of a virtual agent system. Hanke et al. [15] had 14 seniors and 4 caregivers interact with a conversational agent that provides virtual support and help in daily activities. Participants rated the system's usability as 57 out of 100 using the System Usability Scale (SUS) and reported in post-interaction interviews that the virtual agent could potentially increase the risk of social isolation. Bickmore et al. [3] found that people rated a virtual agent in the role of exercise advisor during a usability study as trustworthy and felt close to it as if it were a friend. Ortiz et al. [23] found that elderly persons both with and without cognitive impairment found a virtual character pleasant to interact with more than text and speech or text only, and had inconclusive results about whether the media type influenced participants' recall of the conversation. Vardoulakis et al. [33] conducted two field studies with a relational virtual agent in older adults' homes and found their satisfaction and acceptance to be above scale midpoints. They also inquired about participants' social ties in their lives and recorded usage times and topics of conversation with the agent, but did not assess the agent's impact on social ties using a standard scale or correlate perceived impact with usage time.

Among works that looked at measures about a person's life (rather than the perception of the technology), Leng et al. [19] found that older adults report better mood and engagement during an iPad-supported activity compared to without the iPad but did not assess life measures apart from mood or longer-term changes in mood and did not employ a virtual agent. As a whole, these works did not explicitly evaluate a virtual agent's influence on a person's quality of life; yet quality of life could be an important benefit of a virtual agent in dementia care as suggested by past works' claims that technology may improve people's lives.

3 QUALITY OF LIFE AND VIRTUAL AGENTS

Quality of life (QOL) is defined by the World Health Organization Quality of Life (WHOQOL) as: "individuals' perceptions of their position in life in the context of the culture and value systems in which they live in relation to their goals, expectations and concerns" [14] (pp. 1403). Pinto [24] similarly mentions that "QoL reflects an individual perception of satisfaction with life" (pp. 6). Although quality of life and associated phrases like "improving people's lives" are mentioned in literature advocating the use of virtual agents in dementia care (e.g., [17]), the measures researchers use to evaluate those virtual agents tend to assess perceptions of technology rather then the impact on a person's life. Moreover, research in virtual agents for the elderly that discusses the quality of life may not specify the aspects of quality of life that have been presented in the

literature on dementia research. Given the importance of quality of life in dementia literature, and past work demonstrating that virtual agents can have a wide range of benefits extending past the time that people use the technology (cf. [5]), we assess whether a virtual agent in the homes of people with dementia affect their quality of life.

> Hypothesis 1: The Anne virtual agent will improve participants' overall quality of life.

Quality of life is a multidimensional concept that may include psychological, social, physical and other components. Quality of life has been related to concepts such as physical well-being/health, living/living situation, participation and mental well-being (e.g., [20]; for a review, please see [27]). A 2000 inventory of theoretical models and measuring instruments of QoL by the Leo Cahn Foundation (cf. [27]) explicated QoL into a variety of sub-concepts based on the theoretical model and method. Because of the multidimensional nature of quality of life, we ask which dimensions of quality of life a virtual agent will improve.

> Research Question 1: Which dimensions of quality of life will the Anne virtual agent improve?

Past work finds that caregivers tend to rate patients' quality of life as lower than the patients' own self-ratings across five dimensions of quality of life, particularly among caregivers with high levels of burden [26]. We,therefore, hypothesize the same is true in the specific context of a study that involves a virtual agent.

> Hypothesis 2: Caregivers will rate participants' quality of life as lower than the participants' own ratings.

Given that caregivers are critical providers of dementia care who experience some negative effects due to caregiving [12], we also assess whether their quality of life is impacted by a virtual agent.

> Research Question 2: Does the caregiver have the same rating of quality of life as the person they care for?

4 ROLES OF TECHNOLOGY

Meta-research on literature about online tutor agents [10] identifies various types of agents roles, such as social/technical/pedagogical and peripheral/central. Social science literature also identifies roles people take in interpersonal settings [2]. Past work in virtual agents for dementia care often mentions the role of the virtual agent (e.g., [8]) without exploring the implications that the (perhaps unintended) effects of the virtual agent have on its role. We therefore explore how improvements in particular sub-scales of the QOL-AD may be related to the description of the role a virtual agent would have. We collect a list of agent roles from literature and run a design workshop [7] to identify: (1) which roles can be assessed in the QOL-AD questionnaire; and (2) which sub-scales of a QOL-AD questionnaire measure the virtual agent's ability to perform each role.

> Research Question 3: Which QOL-AD items correspond to what roles a virtual agent has?

> Research Question 4: In what roles does a virtual agent influence participants' quality of life?

5 PERCEPTION OF TECHNOLOGY

Perception of technology is a common measure of technology success. Past work on virtual agent systems for dementia has assessed success by measuring the perception of the technology's usefulness, usability and intent to use. Three common measures to assess technology perception are the Technology Acceptance Model (TAM3) [34], the Unified Theory of Acceptance and Use of Technology (UTAUT2) [35] and the Almere Model [16]. The Technology Acceptance Model (TAM3) is a 51-item self-report scale to assess how much participants accept new technology. It consists of the constructs Perceived Usefulness, Perceived Ease of Use, Computer Self-Efficacy, Perceptions of External Control, Computer Playfulness, Computer Anxiety, Perceived Enjoyment, Subjective Norms, Voluntariness, Image, Job Relevance, Output Quality, Result Demonstrability, Behavioral Intention, Use. The UTAUT2 is to study acceptance and use of technology in a consumer context. It consists of the constructs Performance expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Price Value, Habit, Behavioral Intention, Use and has 29 questions. The Almere Model is developed to test the acceptance of assistive social agents by elderly users [16]. It is a 41-item self-report scale and it consists of the constructs Anxiety, Attitude towards Technology, Facilitating conditions, Intention to Use, Perceived Enjoyment, Perceived Ease of Use, Perceived Sociability, Perceived Usefulness, Social Influence, Social Presence, Trust, Use.

Usability studies of virtual agents in dementia care often measure perception of technology without assessing actual use (e.g., [36]). Among field studies that include both measures of actual use and perception of the technology, some do not compare the two measures (e.g., [1]). A notable exception is [28], which found that intention to use but not perceived usefulness correlated with actual use. However, few past works also measure broader potential effects of using virtual agents in dementia care, such as quality of life. Such broader measures could indicate important influences of virtual agents in the home. Therefore, we assess whether the quality of life correlates with the perception of the technology.

> Research Question 5: Does participants' quality of life correlate with their perception of the technology?

6 CURRENT STUDY

We plan to conduct an in-home field study to evaluate whether a virtual agent affects the quality of life experienced by people with cognitive disabilities and their carers.

7 METHOD

7.1 Virtual Agent System: The Living Well with Anne Project

Anne (see Figure 1) is a virtual agent designed to support elderly with cognitive impairments with the following features: agenda (personal and medication), news and video calling. Anne's features are designed to aid with memory loss and cognitive impairment. Anne is the agent-based user interface that allows the user to access features by speech and touch (screen). Anne expresses emotions and uses natural language to give information and emotional feedback to people with dementia and their caregivers.

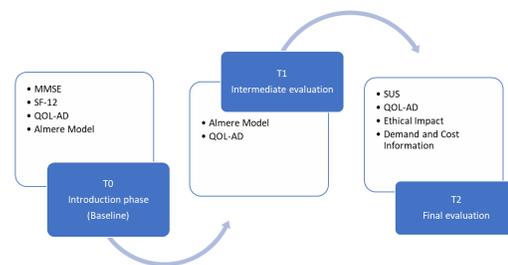**Figure 1: Virtual agent Anne (one of the possible avatars)**

Figure 2: Research-based approach

The system design is the result of the project researchers' past work in assisted living as well as a comprehensive participatory design approach following ISO 9241-210, in which potential users are involved in all stages of development. In the first design iteration [9], professional and informal caregivers participated in a series of focus groups to gather user requirements. In the second, elderly with dementia did small tasks with a prototype version of the Anne virtual agent. In the third, we will conduct exploratory field-research with 20 people with either cognitive impairment or dementia in each of the Netherlands, Italy and Luxembourg.

7.2 Measures

We use the QOL-AD [20, 30] (both caregiver and self-report versions) to measure quality of life of the participant. Over 1000 known scales of quality of life exist (cf. [30]. The QOL-AD is a brief, dementia-specific scale [20, 30] that can be used as a self-report scale by people with dementia or as a caregiver-reported scale of either the caregiver's or the patient's quality of life. The QOL-AD contains 29 questions in 13 dimensions: physical health, energy, mood, living situation, memory, family, marriage, friends, self as a whole, ability to do chores around the house, ability to do things for fun, money, life as a whole. It was developed by a literature review on dementia and has been validated cross-culturally including the UK, US, Korea and Brazil and is widely used [6].

A QOL-AD pre-test will be delivered prior to the introduction of the system and a post-test at the conclusion of the study (please see Figure 2 for an overview). We use the Almere Model [16] to measure technology perception at the conclusion of the study. We use data tracking of the system functions to measure actual use of the system. The last session of the study will include a semi-structured interview to assess how the virtual agent's presence or characteristics may have influenced the person's reported quality of life, after all other measures.

7.3 Analysis

Quality of life will be assessed using paired t-test of the pre- and post-intervention quality of life questionnaire, with correction for multiple comparisons. The relationship between technology perception, actual use and overall quality of life will be analyzed using Pearson's correlation. Interview results will be qualitatively analyzed using grounded theory to identify open-ended reasons for any changes in quality of life that are observed.

8 DISCUSSION AND LIMITATIONS

People tend to attribute agents that have demonstrated one positive quality as having other positive qualities despite those qualities not being demonstrated (i.e., the halo effect). Although the halo effect is typically related to judgments about the same agent, rather than a judgment about the agent influencing a judgment about a person's life, it may still apply in this work since participants may believe that the questions about their life are about how the agent influences their life. We attempt to mitigate this by using open-ended questions about quality of life not necessarily directed at the technology itself, by probing further using interview questions to evaluate whether changes in quality of life may be due to factors other than the virtual agent and by measuring actual system use for comparison.

We do not explore other measures of quality of life, such as behavioral measures (e.g., how often a person exercises or results from physical examination). Although it is possible that other measures may be influenced by a virtual agent, we first assess self-reported and caregiver-reported measures as an initial "direct" measure of whether a virtual agent can improve people's lives. Although the QOL-AD has been validated, it may be subject to biases in self-reporting that could be avoided using more objective measures, which is left as future work.

We do not conduct an extensive review of quality of life definitions, instead of using sub-scales of the QOL-AD scale. However, future research can better define and categorize quality of life in the context of additional work such as Droes et al.[11], which proposes that quality of life consists of affect, self-esteem/self-image, attachment, social contact, enjoyment of activities, sense of aesthetics in living environment, physical and mental health, financial situation, security and privacy, self-determination and freedom, being useful or giving meaning to life and spirituality.

Moreover, we do not general specific hypotheses about sub-scale concepts of quality of life, instead conceptualizing it as a single concept and correcting for multiple comparisons of sub-scales in analysis. Since this runs the risk of failing to detect meaningful effects, and doesn't take into considering how the functions of a

particular virtual agent may influence the categories of quality of life that it influences, we consider the current work as exploratory and plan further hypothesis development as future work.

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