Usability and Acceptance of the Embodied Conversational Agent Anne by People with Dementia and their Caregivers: an exploratory study in home environment settings

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Abstract

Background: Information and Communication Technologies are seen as tools able to support cognitive functions, monitor health and movements, provide reminders to maintain residual memory abilities and promote social support, especially among patients with dementia. Among these technologies, Embodied Conversational Agents (ECAs) are seen as screen-based entities, designed to stimulate human face-to-face conversation skills and thus allow for natural human-machine interaction. Unfortunately, the efficacy of ECA in supporting people affected by dementia and their caregivers is not yet well studied. Therefore, research in this area is essential for the entire scientific community.

Objective: This study aims to evaluate the usability and acceptance of the ECA Anne by seniors affected with dementia. The study is also designed to assess the ability of target users to utilize the system independently and receive valuable information from it.

Methods: A 4-week trial was conducted involving 20 older adults with dementia and 14 family caregivers in home environment settings in Italy. This study used a mixed method approach, balancing quantitative and qualitative instruments to gather data from users. Telemetry data was also collected.

Results: It emerges that older users were particularly engaged in providing significant responses and participated in system improvements. Some of them clearly discussed how technical problems related to speech recognition negatively impacted on the intention to use, adaptiveness, usefulness and trust. Moreover, the usability of the system achieved an encouraging score and the half of the sample recognized a role in the ECA. This study confirms that the quality of automatic speech recognition and synthesis is still a technical issue and has room for improvement, whereas touchscreen modality is almost stable and positively used by patients with dementia.

Conclusions: This specific field of research is novel and poorly discussed in the scientific community. This could be due to its newness, yet there is an urgent need to strengthen data, research and innovation to accelerate the implementation of ECA as a future way to offer non-pharmacological support to community-dwelling persons with dementia.

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Keywords: dementia; older adults with dementia; embodied conversational agent; virtual personal assistant; virtual agent; virtual companion; design for older adults with dementia.
Introduction

The ageing population around the world is growing rapidly and dementia, as an age-dependent condition [1], has become a significant threat to global health. Worldwide, dementia could affect from 47 to 132 million people by 2050, causing high impacts on individuals, families, communities, governments and whole societies [2].

In this scenario, Information and Communication Technologies (ICTs), especially touchscreens, are seen as tools able to support cognitive functions, monitor health and movements, provide reminders to maintain residual memory abilities, promote social support, improve communication with caregivers and provide useful information concerning the health condition [3].

Among these technologies, Embodied Conversational Agents (ECAs) or Personal Virtual Assistants (PVAs) are seen as screen-based entities, designed to stimulate human face-to-face conversation skills and thus allow for natural human-machine interaction [4-5]. Unfortunately, the efficacy of ECA in supporting people affected by dementia and their caregivers is yet to be studied. Therefore, research in this area is essential for the entire scientific community [6]. As a matter of fact, in the last ten years few studies have addressed the use of ECAs among older adults with dementia.

These include a tool for the real-time streaming to a television of a realistic female avatar, previously programmed by a caregiver [7]. This avatar has a realistic voice and the lips are in synchronisation with its speech to ensure that its facial movements appear natural when reminders, notifications and short dialogues with the user are used for supporting patients with dementia (PwD) in their daily activities. In another study, an agent conversation system is shown on a computer screen in the form of an animated face resembling “a five-year-old grandchild” [8]. This system can detect the end of the speech sound of a subject’s reply to a question and begins asking the next question. When the subject speaks, the agent reacts by automatically generating nods, mouth movements, and acknowledgements. In this specific study, the ECA is seen as an alternative way of conversing when no human conversation partner exists. The animation of a female cartoon-like character was used to develop LOUISE [9-11], displayed in an idle pose and moving its lips while speaking on either a computer screen or a television set. This ECA includes attention monitoring and interaction management to automatically determine whether a person wants to communicate. Lastly, a humanoid female character was used to investigate different affective identities found in older care home residents with Alzheimer's disease [12]. The challenges of involving patients with dementia, as well as the possibility of engaging them in a home environment for a significant period of time, are reported in the studies as common limitations and problems.

All the aforementioned examples prove that the ECA research area in the eHealth sector is still immature [13] but this newness can open up opportunities for the future, especially for the challenge of enabling patients with dementia and their caregivers to better manage their life.

To bridge this gap, therefore, this paper discusses the main findings emerging after 4 weeks’ usage of the ECA “Anne” by 20 older adults with dementia and 14 family caregivers, in home environment settings in Italy.

Material and Method

This study aims to evaluate the usability and acceptance of the ECA Anne by seniors affected with dementia. The study is also designed to assess the ability of target users to utilize the system independently and receive valuable information from it.

At first, Anne was developed along the MyLifeMyWay project (http://www.mylifemyway-aal.eu/) to enable seniors to live at home independently for as long as possible. The system was
then adapted for seniors suffering from forgetfulness, as is typical at the beginning of dementia, during the Living Well with Anne Project (http://livingwellwithanne.eu/).

The virtual character works on a Surface Pro tablet under the Microsoft Windows 10 operating system. The following languages are currently available: Dutch, English, German, Italian and French. Anne can support people with dementia (PwD) in all aspects of daily life: communication with the outside world, keeping track of items on the personal calendar, daily structure, medication, reading the news and relaxation (games and music). All these functionalities and features were developed following the user-driven approach [14], with the engagement of a multidisciplinary team and the involvement of users in the requirements definition process [15-16].

**Fig. 1.** Screenshots of current available modules showing an example layout. The layout can be different, or the module hidden or disabled, depending on user abilities. Copyright Virtask B.V.

**Fig. 2.** Home screenshots. Copyright Virtask B.V.

The user can interact with Anne through two channels: 1) visual/haptic: via a Material-UI graphical user interface (looking at the screen and touching the screen); 2) acoustical: via a
voice user interface (listening to the avatar's voice and speaking to the avatar). Anne’s voice user interface consists in automated speech recognition and text-to-speech functions. The user can always select which channel to use, i.e. all commands must be accessible through touch and speech.

**Subjects**

20 volunteers diagnosed with dementia were enrolled in the study. Inclusion criteria were:
- Age of 65 years or older,
- Living independently,
- Mini-Mental Status Examination (MMSE) [17] score between 24 and 27,
- Ability to understand and sign the written informed consent.

The presence of at least one of the following criteria excluded the user from enrollment:
- Lack of written informed consent,
- Presence of an unstable chronic condition, a Mini Mental Status Examination lower than 24,
- Presence of severe physical illness or disabilities that could be aggravated through the use of Anne.

14 family caregivers (e.g. 9 spouse and 5 son) were involved in the study. This study was approved by the local ethical committee and all subjects provided their informed written consent.

**Study Design**

The field trial ran for 4 weeks in participants’ homes. The whole study was managed by skilled personnel and researchers who ensured the supervision of tests and technical assistance during the period of interaction with the system. Each enrolled subject was introduced to Anne, received general training on its correct use and returned home with a printed user manual with step-by-step instructions and a dedicated phone number to call in case of technical problems or doubts.

This study used a mixed method approach, balancing quantitative and qualitative instruments to gather data from users.

Users responded to the following tests at the beginning and end of the four weeks of usage:

1. **Quality of Life in Older Adults with Cognitive Impairment (QOL-AD) questionnaire [18-19]**. The questionnaire has 13 items covering physical health, energy, mood, living situations, memory, family, marriage, friends, chores, fun, money, self and life as a whole. The assessment is scored on a 4-point Likert Scale ranging from 1 (poor) to 4 (excellent) with total scores ranging from 13 to 52.

2. **The Almere model [20]**, which is a Likert Scale-based questionnaire designed primarily to measure older adults’ acceptance of socially assistive robots. The questionnaire focuses on the following 12 constructs: (1) anxiety (ANX), (2) attitude toward technology (ATT), (3) facilitating conditions (FC), (4) intention to use (ITU), (5) perceived adaptiveness (PAD), (6) perceived enjoyment (PENJ), (7) perceived ease of use (PEOU), (8) perceived sociability (PS), (9) perceived usefulness (PU), (10) social presence (SP) and (11) trust (TR).

At the end of the period, users also responded to:

3. **The System Usability Scale [21]**, which is a questionnaire providing a quantitative measure of how usable a system is based on a ten statement 5-Likert Scale scored from 0-100, with 100 indicating perfect usability.

4. **The closeness scale [22]**, which is a measure of self-other inclusion and relationship.
closeness. It was used to evaluate the closeness with the avatar at the end of the usage period.

5. Some unstructured short questions which were asked to users in order to record the general impression of the system (i.e. role of Anne as virtual assistant, if Anne could have an impact on their wellbeing) and the major discomfort issues perceived during the period of usage.

Except for the closeness scale, family caregivers responded at the same scales. Each instrument was verbally administered in a face-to-face session by a trained psychologist who entered the response on a paper version of each instrument. During the 4 weeks of usage, telemetry data was collected to track every event caused by an activity of the user on the tablet. These activities include clicks on the touchscreen or voice interaction. Moreover, the used feature types such as games or medication reminders were also recorded. All these activities were timestamped and therefore enabled a comprehensive analysis of the user’s behaviour over time. Compared to surveys, this usage data is especially suited to detect problems and evaluate the status quo [23].

**Statistical Analysis**

Continuous variables were reported as mean and standard deviation while categorical variables were expressed as absolute number and percentage. The Almere model [20] was used as the main instrument of acquiring quantitative acceptance data. Negative questions were recoded (ANX question 1, 2, 3 and 4, PENJ question 20, PEOU question 21, 24 and 25, SP question 36). The questions and constructs of the Almere model are shown in Multimedia Appendix 1.

Changing of the acceptance level from pre-test to post-test for both users and caregiver were reported as means and standard deviation of each item of the Almere model. Paired-samples t-tests were conducted to compare acceptance of Anne by older adults and caregivers through time (pretest and posttest). Closeness and perceived relation were reported as absolute numbers and percentage. Finally usability was measured with the SUS [21]: item values were reported as mean and SD.

**Results**

Recruitment began in October 2019 and the trial started in December 2019. Enrolment was completed in January 2020. The sample of older adults was composed of 20 users (age; mean=75.5 ±4.2) where 30% were male and 70% were female. A large percentage were married (85%) with a medium/high level of education. Only 6 participants had previous experience in using tablets for leisure activities. The caregivers (age; mean=66.4 ±12.6) were equally male and female and with a medium/high level of education. The general quality of life was in between the fair and good perception and it maintained this level during the 4 weeks of the study. Light positive differences were observed in the delta difference between pre- and post-tests (delta QoL, M=0.4) among older adults. To the contrary, worse situations emerged at the post-test stage (delta QoL, M=-1.5) in the case of family caregivers.

Table 1. Older Adults and caregivers’ characteristics. Values are presented as n (%) or mean±SD

|                  | Older Adults N=20 | Caregivers N=14 |
|------------------|-------------------|-----------------|
| Age, mean±SD     | 75.5±4.2          | 66.4±12.6       |

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| Gender, n(%)          |        |        |
|----------------------|--------|--------|
| Male                 | 6(30.0)| 6(42.9)|
| Female               | 14(70.0)| 8(57.1)|
| Marital status, n(%) |        |        |
| Married              | 17(85.0)| 11(78.6)|
| Full time relationship| 0(0.0)| 1(7.1)|
| Separated            | 0(0.0)| 0(0.0)|
| Divorced             | 1(5.0)| 0(0.0)|
| Single               | 1(5.0)| 2(14.3)|
| Widowed              | 1(5.0)| 0(0.0)|
| Education, n(%)      |        |        |
| No education         | 0(0.0)| 0(0.0)|
| Primary              | 7(35.0)| 2(14.3)|
| Secondary            | 4(20.0)| 5(35.7)|
| Tertiary             | 9(45.0)| 7(50.0)|
| MMSE, mean±SD        | 25.2±1.3| -     |
| QoL pre-test, mean±SD| 28.5±6.6| 35.5±5.7|
| QoL post-test, mean±SD| 28.9±7.8| 34.0±7.6|
| delta Qol, mean±SD   | 0.4±4.6| -1.5±3.8|

**Acceptance**

As reported in Multimedia Appendix 1, results show that older adults became less anxious (ANX, p=0.07) during the 4-weeks of use. Positive changes among constructs are observed for perceived enjoyment (PENJ, p=0.41), social presence (SP, p=0.0). Other constructs such as attitude (ATT), perceived adaptiveness (PAD) and facilitating facilities (FC) did not change or nearly changed during the time of use. On the contrary, intention to use (ITU, p=0.17), perceived usefulness (PU, p=0.23) and trust (TU) registered a negative change during the time of use.

For informal caregivers, the constructs anxiety (ANX), facilitating condition (FC), social presence (SP) and perceived ease of use (PEOU) did not change or nearly changed during the time of interaction with Anne. The constructs that registered negative changes were: attitude (ATT, p=0.15), intention to use (ITU, p=0.6), perceived adaptiveness (PAD, p=0.15) perceived enjoyment (PENJ, p=0.05), perceived sociability (PS, p=0.05), perceived usefulness (PU, p=0.0), and trust (TR, p=0.12).

**Closeness scale**

The aim of the closeness scale was to assess the perceived relationship by asking respondents to evaluate their relationship with Anne. They had to select one of seven pairs of increasingly overlapping circles that best described their relationship with Anne. In each pair of circles, one circle referred to the respondent and the other circle to Anne. A larger overlap indicated a closer relationship. For the analysis, visualisation was numbered as follows: 1= no overlap; 2= little overlap; 3= some overlap; 4= equal overlap; 5= strong overlap; 6= very strong overlap; 7= almost total overlap.
Older adults visualized their relationship with Anne with some overlaps (42.1%) or no overlap (26.3%). Minor percentages are attributed to strong, equal or little overlaps (10.5%).

**Figure 3.** The seven pairs of increasingly overlapping circles describing the relationship between the older users and Anne

**Figure 4.** Older adults’ perceived relationship with Anne (percentage)

**Usability**

All participants successfully completed the SUS. The SUS is scored out of 100, with a higher score indicating greater perceived usability. Anne received a mean score of 67.1 among older adults and 71.4 among caregivers. Both scores were compared to what is considered an acceptable score in terms of usability [24]. Given that Anne is a TRL 7 – System prototype demonstration in operational environment, it reached a positive result even if below the average acceptable score of 68 in the case of seniors who are Anne’s primary users. From the analysis of the single items reported in Table 2, seniors and their caregivers perceived Anne as
easy-to-use and well-integrated, thus instilling confidence during usage and the idea that people could quickly learn her major functionalities.

**Table 2.** Mean (SD) of the SUS Score among participants

| SUS Items                                           | Older Adults | Caregivers |
|-----------------------------------------------------|--------------|------------|
| SUS_1 I think that I would like to use this system frequently | 3.8±1.3     | 3.2±1.0    |
| SUS_2 I found the system unnecessary complex        | 1.8±1.0     | 1.5±0.9    |
| SUS_3 I thought the system was easy to use          | 4.1±1.2     | 4.2±0.9    |
| SUS_4 I think that I would need the support of a technical person | 2.9±1.5     | 2.2±1.4    |
| SUS_5 I found the various functions well integrated | 3.7±0.9     | 3.6±0.9    |
| SUS_6 I thought there was too much inconsistency    | 2.4±1.3     | 2.1±1.4    |
| SUS_7 I would imagine that most people would learn quickly | 3.9±0.9 | 3.8±0.7    |
| SUS_8 I found the system very cumbersome           | 2±1.1       | 1.6±0.9    |
| SUS_9 I felt very confident using the system        | 3.3±1.5     | 3.2±1.0    |
| SUS_10 I needed to learn a lot of things before I could get going | 2.9±1.3     | 1.9±0.9    |
| **SUS_Score**                                       | **67.1±23.3**| **71.4±17.6**|

**General impression of the system and major discomforts**

From the unstructured short questions asked to users, some discomfort issues were pointed out namely related to the speech command “The speech command does not work well. Sometimes Anne answers other questions and this is very frustrating, making me feel insecure. Maybe this is because of me as I have no tech skills”, and news service “Anne’s speech is poor, does not stop for punctuation when reading, always the same monotonous tone. Moreover, Anne only reads the title and it is not possible to listen to the full article”.

Medication and gaming functions were the most successful services: “I often take it at the wrong time. I was very precise in my medicine intake thanks to Anna”, “I think that having an assistant who reminds me is a great help”, “The games help me keep my mind active”, “I used to play memory games and puzzles every night. I think it is perfect to stimulate my memory”, “Games helped me feel less lonely”. In addition, caregivers also really appreciated these functions: “I was glad to see my mother-in-law doing something new during the day”. The general impression was good among older users: “Anne kept me company when I was bored or alone”, “I enjoy talking to Anna. Every day I say ‘good morning, Anne’”, “When I was lonely, I used to talk to Anna”.

The majority of the older adults perceived Anne as a friend (40%) or did not perceive any role to attribute (30%). The remaining 30% perceived the ECA as an assistant (15%) and secretary (15%).
At the question if Anne was seen as a way to improve their wellbeing, seniors responded positively (70%), with a slight difference detected between male (66.7%) and female (71.4%) users. Among these, the sense of well-being was related to the match with memory (30%), ability to do things for fun (15%) and mood (10%). Female users mostly associated the match with memory, whereas males identified the match with mood. The remaining 30% did not find any connection between Quality of Life and Anne.

**Telemetry Data**

Two distinct classes of events were established in order to meaningfully analyse telemetry data. *Transition events* describing events for navigating through Anne which are mostly the events caused by clicking on the device and, *target events* which include the usage of Anne's actual features such as reading the news and listening to the radio. For example, a user clicks ten times on the touchscreen before being able to read the news which was the actual intention. This gives an event path of ten transition events followed by the target event originating from reading the news. As we can see from this example, the distinction of transition and target events helps us to assess usability and the learning effects of handling Anne.

During the observed trial period, the 20 users actively performed an overall 93,299 events. The most popular feature was games (52,008 events), followed by medication (2,205 events), news and radio (with 931 and 881 events, respectively). The high amount of events for games is due to Anne’s design. A new event is created every time a user starts, quits and restarts a game. These user actions are rather common in a game and, consequently, game events were very common. Nevertheless, as previously mentioned, games are a very popular feature.

From a telemetry point of view, the number of touchscreen clicks before a target event can be seen as a measure of usability. Struggling users intuitively require a lot of clicks because they try many different possibilities and hence, purposeful and quick handling is not possible. 80% of the sample, i.e. 16 users, only required one click on average for their target event. Thus, users seem to handle Anne very well.

Usability also has an impact on user behaviour over time. In the beginning, a user using a new
device is in an exploratory period, trying out the many features and not knowing how to handle the device very well. After some time, a user masters usage and knows exactly how to handle the device. Hence, actions become very efficient and purposeful and the efficiency in handling the device results in an increase in meaningful usage. This user journey was also detected in the case of Anne.

As previously defined, transition events mainly consist of touchscreen clicks, but also on comments provided by Anne. Thus, a large number of transition events indicate problems with handling Anne, whereas a large number of target events show actual increased purposeful activity and interest. In order to capture user behaviour, we decomposed the active field trial time range into four periods. The first starting from day one to six, the second from seven to thirteen, the fourth from day fourteen to day twenty and the final period from day twenty-one to day twenty-seven. We then analysed the number of target and transition events in these periods. Since the number of users varies over these periods, the number of target and transition events was adjusted according to the respective number of users. The corresponding visualisation is given in Figure 6.

In the first and second period, the number of transition events is 767 and 639, respectively, while the number of target events is 562 and 928. In these periods, the number of transition events is comparatively high whereas the number of target events is rather low. Consequently, user exploration takes place in the first two periods. This is in contrast to the two subsequent periods. In the third and fourth period, the number of target events is 1,098 and 1,140, respectively, while the number of transition events is 404 and 444, respectively. Thus, we detected a sharp increase in target events and a decrease in transition events over time. Here, the users efficiently handled Anne and had many meaningful interactions, i.e. target events.

Using similar measures, weekly reports were automatically generated to summarize the usage and detect potential technical problems of users with Anne. For example, if a user stopped using Anne because he was overwhelmed. Caregivers could respond to these problems with suitable assistance and thus prevent users to get frustrated with Anne. This was especially helpful for the typology of users involved in this study.

Voice interaction was also measured. Compared to 853 successful voice interactions, users still very prefer in 55'442 cases the touchscreen to realize their purposes. Within voice interactions, users primarily prefer the features news in 342 cases followed by medication with 175 cases. Touchscreen interactions are dominantly used for the game feature with 52'008 cases.
For example, playing a puzzle or card really requires touchscreen interactions. In this context, voice interactions are not efficient and would also be very unintuitive. As game is the most popular feature by far, this makes a great impact in favor of touchscreen interactions. Another possible reason of the prevalence of touchscreen interaction could be that users may not be natively familiar with such a new and innovative technology. Especially, if we take into account the advanced age of the users.

Discussion

Overall, the sample involved in this study demonstrated a positive approach to Anne: after the 4 weeks of usage, they were less anxious in the usage, more skilled in the basic functionalities and half of them perceived a role for the ECA. None of the participants withdrew from the trial and they all provided useful feedback to facilitate the understanding of data gathered - even if family caregivers seemed to be more sceptical, especially as regards acceptance. Based on these findings, it emerges that older users were particularly engaged in providing significant responses and participated in improving the system. Some of them clearly discussed how technical problems related to speech recognition negatively impacted on intention to use, adaptiveness, usefulness and trust. This impact is evident from data gathered, based on the acceptance and usability tests [20, 21]. The innovative aspect of Anne, as well as of other ECAs, is that users could interact with the system through voice and by stimulating a more human-like interaction rather than just navigating with the touchscreen. Unfortunately, our study confirms that the quality of automatic speech recognition and synthesis is still a technical issue and has room for improvement [7-11], whereas touchscreen modality is almost stable and positively used by PwD [3, 25-26]. The use of voice could also be relevant for older users in general and even more so for those who, for example, have motor skill impairments such as Parkinson’s disease. Moreover, it could also reduce the feeling of loneliness which is one of the public health concerns affecting our ageing society globally [27].
Despite this issue, the closeness scale [22] analysis shows that Anne was perceived as a companion able to support memory and enjoyment needs. Anne served as a source of entertainment and as a way to handle adherence to medication plans. This is evident from telemetry data insights which enable a user-centric design (UCD) analysis of Anne. For instance, it opens the idea for further development actions to improve game and medication features, as well as setting new incentives for less-used features. In spite of these results, the data have raised authors’ awareness to the fact that ECAs could be a promising way to cope with the health and well-being of seniors with dementia if they are designed, developed, and assessed around and with the patient. The first challenge is to target the disease process from its earliest stages and to follow the person throughout the journey in order to foster healthy ageing and improve the lives of older people, their families and the whole community.

In our study, we recruited twenty users in the early stages of dementia with a range of MMSE [17] of between 24 and 27, since the main objectives were to assess users’ acceptance, usability and feasibility to operate the system. In this stage, users used devices independently or, in the case of those with poor digital experience, they were still able to manage routine changes, such as introducing a new device into their daily life. Within this study, users also benefited from general training on the correct use of the system, a printed user manual with step-by-step instructions and a dedicated phone number to call for assistance in the case of technical problems or doubts. For seniors with dementia all novelties can become extremely distressing and disorientating. Therefore, becoming familiar with the technology at an early stage is fundamental, as is providing users with continuous support.

It is well known that the abilities and needs of people with dementia and those who provide care for them change along the path defined by the progression of symptoms, as does the ability to cope with them. These changing needs also mean that some technologies will be more appropriate or effective at the different stages of dementia [28]. Most of the interventions targeting people in the early stages of dementia and their carers aim to support people’s memory and their ability to live independently. Examples of technologies falling into this category are GPS, communication devices and other technologies that can help mitigate memory problems (such as medication reminders, locators, voice cues to help perform daily activities and ‘dementia-friendly’ versions of household gadgets), as well as tools promoting the self-management of health [29]. For people with moderate to severe stages of dementia (for example with an MMSE score of between 20 to 9) the largest set of technologies are those that enhance safety (i.e. fall detectors, motion sensitive lights, sensors measuring room temperature and raising alarms when it gets too warm or too cold, as well as cooker or smoke alarms). At this stage of dementia, active use of safety technology tends to shift to the carer, while the person with dementia often becomes a less active user [ref]. Moreover, examining feedback from the point of view of family caregivers, as in our study, or other carers (i.e. nurses, health care professionals or care workers who work with PwD), could build more awareness on how to develop effective technologies.

We cannot achieve the challenge of targeting the disease process from its earliest stages without changing the way of thinking, feeling and acting towards people living with dementia and their complex needs. Thus, the second challenge is to support people affected by this terrible illness in doing what they need and decide, recognising their purpose, identity and independence. The key point is to avoid any kinds of stereotypes about the experience of living with dementia and the opportunities that ECA could offer to really address individuals’ medical, cognitive, psychological, environmental, cultural, and social needs [30]. According to the World Health Organization (WHO) global strategy on ageing and health [31-33], such action could give value to the person’s functions and needs. This means that technologies must continue to monitor health and safety as primary needs, but it is necessary to support and
maintain physical and mental capacity throughout the life-course by providing opportunities for leisure and social activities to facilitate inclusion, participation and thus reduce loneliness and social isolation [34]. Supporting higher level needs such as belonging, self-esteem, identity and self-actualization [35] is the aim of the next generation of technologies. Older adults are bearers of value for the design of technologies, and the beneficiaries of such systems. If the meaningful engagement of patients with dementia is essential for setting the future of ECAs, the two challenges depend on how much researchers, medical scientists, technology developers and social and business innovators are ready to agree on a common vision concerning healthy ageing as the way of developing and maintaining functional ability enabling well-being in older age [34-36]. In this study, the connectivity between ICT sectors, clinical staff and research fields was ensured through the adoption of the User-Centric Design approach [14] enabling Anne’s original version to be adapted to the specificities of PwD. Design for older adults is typically a multi-dimensional process involving significant time and cost in thinking, problem-solving research, iterative testing and re-design to meet the needs, capabilities and limitations of users [37]. However, there are still great opportunities to be discussed and learned from the untold stories of implementing UCD to create more efficient, effective, and sustainable e-Health solutions [38].

Comparison with prior works and limitations

To our best knowledge, this is one of the few studies on the use of ECA among seniors with dementia and their caregivers. This research focused on 4 weeks of interaction between 20 seniors with dementia and the agent Anne in a home setting. This framework is rare in ECA research, mostly consisting of studies on short-term interaction in a controlled environment [13] and with the enrollment of a smaller sample size [7-12]. Despite these strengths, 4 weeks were not enough to evaluate significant level of acceptance and usability even in the light of the technical discomfort related to the automatic speech recognition. Longer trial are needed to measure changes in user experience and familiarity with the system. Moreover, the specific Italian national context and culture could be seen as a bias and a significant limitation that do not allow for the generalization of results. Nevertheless, conducting methodologically sound scientific research in the dementia care and support community is an urgent step forward. Specifically, the possibility of running Randomized Control Trials (RCTs), enrolling a bigger sample and gathering data pre- and post-longer interventions through robust methods, remain key challenges for the whole sector of innovation technologies. Another key step that could move forward the sector could be the further study those user characteristics that match the positive acceptance of such systems and consent to better profile future customers.

Conclusion

This study focused on Embodied Conversational Agents (ECAs) as future e-Health systems able to address the basic and higher-level needs of people living with dementia. This specific field of research is novel and poorly discussed in the scientific community. This could be due to its newness, yet there is an urgent need to strengthen data, research and innovation to accelerate the implementation of ECA as a future way to offer non-pharmacological support to community-dwelling persons with dementia. In our vision, this primarily means collaboration between interdisciplinary research networks, medical scientists, technology developers and social and business innovators and the direct engagement of older adults and their formal and informal caregivers. Secondly, sharing the strengths and weaknesses of research is fundamental for building common knowledge from previous studies. In the midst of the coronavirus disease (COVID-19), these key points could prove significant to improve healthcare services. E-Health
technologies have huge challenges to overcome but the opportunity to increase quality of services and access to health information for users can really make a difference in these times of the pandemic.

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Conflicts of Interest

None declared.

Abbreviations

PWD(s): Patient(s) With Dementia
ECAs: Embodied Conversational Agent(s)
PVAs: Personal Virtual Assistant(s)
MMSE: Mini-Mental State Examination
SUS: System Usability Scale
ANX: anxiety
ATT: attitude toward technology
FC: facilitating conditions
ITU: intention to use
PAD: perceived adaptiveness
PENJ: perceived enjoyment
PEOU: perceived ease of use
PS: perceived sociability
PU: perceived usefulness
SP: social presence
TR: trust
WHO: World Health Organization
RCT: randomized controlled trial
UCD: User Centered Design

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Supplementary Files
Multimedia Appendixes

Almere model constructs and items.
URL: https://asset.jmir.pub/assets/b4903863ac8c76e878c37eb683eb8fb0.docx