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Expert insights for designing conversational user interfaces as virtual assistants and companions for older adults with cognitive impairments ⋆

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Abstract. In this paper, with the overarching goal to make new technologies more useful and usable to older adults, we examine the benefits and shortcoming of conversational user interfaces (CUIs) for older adults, including those with mild cognitive impairment, and dementia-family diseases. We focus on virtual assistants and companions, and approach the question based on in-depth expert interviews we have conducted with eight experts who have first hand insights from working with older adults in varying settings combined with evidence in empirical studies and meta analyses we found in the literature. These rare expert insights suggest that CUIs have considerable merit as virtual assistants and companions, i.e., more advantages than disadvantages for this specific demographic group, but they need to be designed carefully to function. Based on a qualitative evaluation, we outline specific design recommendations we gathered based on the literature and the featured interviews.

Keywords: CUI · chatbots · user acceptance · cognitive training and interventions · dementia · Alzheimer's.

1 Introduction and background

Globally, the number of people over 60 is nearly one billion today [2]. This number has doubled since 1980, and it is predicted to double again in 2050 [2]. These demographic trends are also reflected in the increasing number of cognitive disorders such as in dementia family diseases, i.e., according to the international federation of Alzheimer and dementia associations, "every 3 seconds, someone in the world develops dementia" [1]. Taking these aging and cognition facts along with how rapidly technology evolved in the last decades and continues to evolve, as well as the well-documented age-related accessibility issues to technology solutions [3, 19], a pressing need emerges to optimize technologies for older adults.

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These technologies govern our lives, and making them accessible for older adults would mean helping people function independently as long as possible.

In this paper, we focus on a specific computational solution that is becoming viable in recent years due to the advances in machine learning supported natural language processing (NLP): Conversational user interfaces (CUIs). Boradly, CUIs aspire to mimic human-human interaction by means of adding verbal abilities (text or speech) as an interaction modality when humans interact with machines, often in combination with others such as manual or gesture-based interactions [4, 5]. As most technologies, CUIs are under-studied for older adults and even less so for older adults with cognitive impairments. This is an important research gap: It is well documented that spatial memory is impaired with aging [9], and thus CUIs are promising complementary interaction methods that might compensate against this impairment.

Furthermore, CUIs could potentially provide a sense of companionship to those who suffer from age-related cognitive decline or cognitive impairments because people around them might find it difficult to keep up a conversation with less and less coherence in speech with advancing dementia [8]. In this paper, we focus on the specific question of if CUIs might be particularly useful for older adults, especially those with cognitive impairments, via a concise review of the literature and interviews we conducted with a selected group of experts who work with cognitive aging. Our objective is to obtain and offer a better understanding how to design CUIs, specifically, virtual assistants and companions, especially those on the cognitive impairment spectrum. Our approach is motivated by the fact that those with cognitive impairments might also suffer from poor metacognition, people who work with them (the experts we interviewed) will have important insights that they may not be able to communicate.

1.1 Related work

Even in healthy-aging, humans experience a decline in physical, perceptual, motor and cognitive abilities [9], which are inevitably amplified if the person has a cognitive impairment. These abilities all matter in human computer interaction (HCI) research and applications, but software systems are not always optimized to take the weakening abilities into account. Digital technologies are rarely tested with (or adapted to the needs of) older age groups, even though optimizing technological solutions to cognitive aging is becoming entirely possible: Advances in digital health solutions and availability of personal mobile devices offer exciting new opportunities to assess and *monitor* a person's cognitive state and abilities fairly easily, and even predict cognitive impairment [6, 7]. Once we are able to assess a person's cognitive state reliably, we can optimize interfaces and interactions, and design cognitive interventions accordingly.

It is important to remember that cognitive health interventions for older adults target some of the most vulnerable people. Because these interventions are sensitive, many people are involved in the care pipeline which can be costly, and logistically difficult to deliver. Leveraging digital technologies, especially those based on smartphones which are already relatively commonplace, is an

obvious approach to address this shortfall. However, issues of design effectiveness, particularly in the areas of usability, desirability, and adherence appear to be forming barriers to adoption [10, 17].

Even though digital cognitive interventions and training paradigms are subject to much debate with contradictory outcomes [10, 11], this line of thinking has been pursued successfully to some degree with visuospatial interfaces [12–14]. Based on such earlier work, we believe addition of a CUI as virtual assistants of companions can be a scalable solution to engage older adults and patients, which can infer the context and intent of their messages, and provide personalized feedback in a natural way minimizing additional cognitive demands. Computerized cognitive therapies (CCT) are typically provided through structured top-down interfaces, i.e., without a CUI, as evidenced by a lack of studies on CUIs for older adults [29]. However, when CCT are designed and applied properly [11, 17, 20], they are effective, and in some cases could be delivered via a CUI. For example, Khosla and Chu (2013) [15] designed multi-question quizzes to instill a sense of usefulness, increase self-confidence, and build resilience for accepting cognitive decline. A similar approach could be adapted to a CUI. In this vein, for example, Sansen et al (2016) [26] proposed a robotic companion for the older adults to engage them in conversations, Laban et al (2021) [5] similarly discussed social robots for supporting post-traumatic stress disorder, while Ho et al (2018) [16] demonstrated that the emotional response to a CUI can be (depending on the application and design) comparable to interacting with a human, and at times might even be superior to it.

It appears, however, some HCI approaches and design decisions may be overall more usable and desirable, and may lead to higher adherence levels than others in our context with older adults [10, 17]. If a specific design choice leads to higher adherence to physical of cognitive exercises, this can have implications in the context of health and behavioral change; for example, increased adherence may have an even greater impact than improved treatments [18]. Even though new technologies can be challenging to learn and use effectively for older adults [19], it has been shown that chatbots and messaging applications, even in the form of simple text exchanges, are highly effective in encouraging behavioral changes, and especially in increasing treatment adherence [20], where the *framing* of the message is of high importance [21]. The benefits of simple text messaging have been demonstrated in various domains, e.g., antiretroviral treatment for HIV/AIDS [22], and medication after coronary heart disease [23]. It appears that the simplicity and familiarity of messaging platform renders them easier to use than other applications [24]. It is also possible that relatively simple CUIs (as virtual assistants) can help keep track of a patient's medications, motivate them to follow their schedule, inform them about side effects, or simply enable them to search for information that they need.

At the moment, it is clear for technical, medical, and legal reasons that CUIs cannot, and arguably should not, attempt to replace healthcare personnel and real human contact, but they can be of great value in assisting patients, monitoring their vitals (e.g., medication, sleep, diet, etc.) and alert profession-

als when necessary, relieving some of the demands on medical professionals and caregivers [25]. They can also be of value as they can keep company and entertain [15,16], similarly as how humans find engaging online content that fits their own tastes, but delivered in a more proactive, verbally driven manner to those who may not be able to follow the latest trends online.

In sum, CUIs might offer high levels of usability and usefulness for people with cognitive decline or impairments, and given that verbal communication is deeply embedded in human nature, this is not surprising. In this vein, a specific type of conversation, i.e., the solicitation of stories from a user's own life appear to help exercise their speech and memory capabilities, and stands out as an especially promising approach for cognitive interventions [26]. Such an approach, if recorded, also builds knowledge about the individual, thus can eventually afford personalizing the dialog facilitated by a CUI, and, non-verbal communication could be a part of an animated onscreen or augmented reality assistant. However, *how* these CUIs are designed is critically important. Previous research demonstrates that incorporating gamification and personalized interactions can further improve adherence to chatbots, thus to the goals of underlying software, such as a prescribed cognitive training, e.g., by displaying customized reminders, encouraging messages, by enabling chat for keeping the users company, and adding careful use of playfulness to entertain them [27,28]. These measures can go a long way in ensuring user uptake, engagement and retention, and they *can* be provided by artificial intelligence (AI) powered CUIs especially if we can personalize the CUI based on individual observations over time.

Given the above, we believe CUIs as virtual assistant/companion apps are promising and viable solutions to make digital health applications more accessible (usable, learnable, and thus desirable) for older adults, and may have value especially for those with age-related cognitive decline or impairments. We specifically focus on mild cognitive impairment (MCI), which can be seen in post-operative cognitive dysfunction (POCD), and/or early stages of dementia-family diseases such as Alzheimer's disease (AD). Although empirical evidence is only accumulating at this point in time, there are promising signs that CUIs may increase adherence (a well-known, unsolved behavioral problem) of older adults to helpful software such as e-coaches and other cognitive and/or physical training interventions, keep them company and entertain them when social interactions are hindered by e.g., cognitive issues, and simply be more usable for older adults. We present more specific arguments and our findings below, after outlining our methodology.

2 Methods

We chose to interview experts instead of the patients themselves, mainly because metacognition also gets difficult with cognitive impairment, therefore it might not be straightforward to interview people in varying brain health conditions. Experts who work with them, and directly observe them, thus, are an extremely valuable source of information. Although we interviewed a small number of peo-

ple (n=8), each of them have years (taken together, 119 years) of experience working with older adults with varying cognitive health conditions. These experts can imagine the implications of placing a CUI in front of a patient in a much more grounded way than most of us who develop software, and thus the interviews provide us with rare and unique insights from their encounters with older adults.

2.1 Participants

We conducted semi-structured interviews with eight aging and cognition experts (age range 25-55) in various domains that represent clinical, day-to-day care, and research perspectives. An overview of the professional expertise (domains, years) of our participants can be found in the Table 1 below.

Table 1. Professional background of the experts we interviewed.

#	*background (experience in years)*
E1	neuroscientist, cognitive training, brain disorders (13)
E2	neuroscientist, brain injuries, geriatric rehabilitation (16)
E3	neuroscientist, cerebrovascular and neurodegenerative markers of AD (9)
E4	psychologist, dynamics of healthy aging (15)
E5	neurologist, brain health and computational biomarkers (21)
E6	developer of computer games for older people (19)
E7	general practitioner, including experience with older patients (20)
E8	nurse with work experience in a dementia ward (6)

2.2 Materials

We conducted the interviews remotely using a video conferencing app (Zoom). An informed consent document was prepared on an online word editing software (Google docs) and delivered electronically by email before the interviews. No other specific software or hardware was needed besides a computer with an Internet connection.

2.3 Procedure and analysis

We recruited the experts from our professional network based on their publications, conference presence and activities in other areas that had a focus on older adults both healthy-aging and those with brain-health issues, and scheduled the sessions by email. An informed consent form was delivered in the same email for them read before joining the session. Once they joined the session, they gave their consent verbally in recorded video. The interview duration was about one hour (50 mins, with a 10 min buffer). Since the interview was semi-structured, we asked all our interviewees the same questions. A selection of these questions are

presented in the Table 2 below. We also allowed them time to offer insights based on what the conversation inspired, or if there were important issues we did not think to ask. Participants were not monetarily compensated, and sessions were recorded based on their consent for internal use. We then transcribed the recordings selectively based on an audio content analysis, i.e., we identified the relevant keywords and themes that were mentioned by the interviewees using an inductive approach. We open-coded the interview data qualitatively broadly following the discourse analysis methods [36]. We analyzed the words, phrases and sentences in the interviews to capture the main messages within the verbal data. We then summarized the feedback into categories in a close-coding session, grouping the open-coded themes. Two researchers from the authoring team were involved in the coding process, which resulted in dozens of codes which was reduced to 30 codes covering the most repeated/emphasized words (role, friend, companion, assistant, caregiver, coach, personality, adaptive, personalized, individual, loneliness, social, patient, comforting, neutral, non-patronizing, agreeable, ACT, empower, animate, encourage, suggest, acceptance, feedback, self-reflect, stories, exercise, dancing, routine, adherence) and grouped under 5 overarching themes (level of expertise, emotional intelligence, personalization, practical features, user acceptance). The analysis was presented and discussed by the authoring team in internal meetings. Below, We detail the most important findings in relation to these themes, embedded with a literature review, in a narrative summary.

Table 2. Example questions used in the interviews. Each category had 3-10 questions some of which involved rating on a 6-point Likert scale. Open comments were always invited. Full list of questions are available upon request.

Introduction, briefing	Interviewee's domains of expertise, experience with CUIs, inviting them to think about their interactions with MCI patients
Potential and usefulness of CUIs	Do you think a CUI would be of use for a patient with MCI? [yes/no, why]
Personality of the CUI	What characteristics should the 'personality' of the CUI possess, particularly with regard to the target population (seniors, POCD/MCI/AD patients)?
Capabilities of the CUI	On what topics should the user be able to chat with the CUI? What should the CUI NOT do? (actions or topics to be avoided)
Habit building	What type messages would foster good habits? (specific examples) What should the CUI NOT do? (actions or topics to be avoided)
Usability, UX, user acceptance	What interaction paradigms would enhance the CUI's usability? What features might help that the patient will enjoy or look forward to using the app without getting bored or too "stressed"?
MCI, POCD, AD patients	Problems for POCD/MCI/AD patients that a CUI could help? Requirements that are specific to this group?
Wrap up final comments	If you were designing a CUI assistant/companion app, functionalities and content would you prioritize? Can you recap your vision of a personal assistant for MCI patients?

3 Results: Pros and cons of CUIs for older adults

Although CUIs as virtual coaches or cognitive training apps are shown to help increase human well-being different domains and might be more usable for older adults than other interfaces [24,29], there are also valid arguments against them. Some of these arguments focus on technological factors e.g., limits in a CUI's operational capacity, others on psychological matters e.g., lack of user acceptance. Below we highlight concerns as well as opportunities pointed out in previous research and in our expert interviews, based a narrative that contains our own position embedded in it.

3.1 CUI's level of expertise

Even though there is evidence that AI can outperform physicians in certain tasks (e.g., diagnostics benefit quantitatively comparing large data), people trust human counterparts more than digital solutions [30]. Our experts [E1-8] observed that current CUIs can come off unnatural as they cannot properly interpret emotional and non-verbal components of human interactions. Importantly, the domain is loaded with ethical and legal questions which are still mostly open. For example, should humans always be aware that they are talking to a machine? Who would be responsible for the mistakes an algorithm would make? An in-depth treatment of these questions are beyond the scope of this paper, however, a carefully designed *helper* CUI, i.e., an assistant or companion, can provide a relatively uncomplicated and cost-effective solution with unique strengths. Several experts [E3, E7] commented that due to its constant availability, a CUI can continuously monitor and analyze conversation content, thus pick up subtle changes much earlier than a physician using traditional methods capturing patient data at a particular moment in time, and the data produced by a CUI may be considerably richer than other that of other apps if it improves adherence.

3.2 CUI's emotional intelligence / importance of personalization

Many current CUIs are based on decision tree models, and thus can only interact with the user based on predefined questions and answers. Those can be perceived as incompetent, boring, rigid, impersonal, and can frustrate users. However, there may be a positive side to this simplicity [E7]: A structured, somewhat predictable conversation can support patients with cognitive issues such as mild cognitive impairment (MCI), Alzheimer's disease (AD) or post-operative cognitive dysfunction (POCD), as structure and repetition can make them feel secure. For example, E7 said:

> *"Structure is exactly what people need. They like to hold on to structure [...] I can imagine that even someone with [only] slight cognitive deficits would like structure, because structure means security [...], what you ultimately strive for. So I see a benefit."*

Also importantly, our expert interviews revealed that many older adults with cognitive issues might be embarrassed by their condition, and may be more willing to ask and accept help from an anonymous, machine-like device than from a human. It has indeed been demonstrated that in some cases (e.g., depressive disorder), the use of chatbots result in a higher rating of therapeutic alliance between patient-and-chatbot than between patient and clinician [31]. Future CUIs based on machine learning (ML) and AI will be smarter than their counterparts today, especially given the unprecedented progress in natural language processing (NLP). These next generation CUIs will understand a user's context, behavior patterns and preferences, thus can tailor content and timing of prescribed interventions or necessary assistance in a personalized manner. An ideal CUI should be configured to be discreet and respect user's privacy, automatically adapt to the user's needs and mood (e.g., through sentiment detection) as this might give a stronger feeling of being understood and increase adherence [E2], *and* offer options to manually adjust settings. This would enable both user-driven personalization (i.e., user configured) and an AI-driven one (i.e., AI learns and proposes or imposes adaptive changes). Personalization is also relevant to caregivers and family members (not only the older adults and MCI/AD patients) as the CUI can be configured to facilitate the communication in a customized manner as well as learn the communication patterns of the caregivers and family members with the older adults around them and lead to insights into a patient's experience. In our interviews, experts expressed contrasting views on what level of personal rapport between patient and chatbot is desired: some believe that emotional connection strengthens adherence to interventions [E4], while others expressed concerns about emotionally loaded conversations, as a machine is likely not able to respond to human emotions appropriately, which can lead to frustration and other negative emotions in the human counterpart [E6, E7, E8]. This is also an ethical quagmire in terms of human connection. For example, one of the experts said:

> *"[...] when you talk about a caregiver and friend, an emotional and social component comes into the game, the chatbot cannot do that. It would even be pathological if someone said "The chatbot is my friend". It must never become a friend, it would already draw or entail a part of the social isolation." [E7].*

Similarly, E6 stated that:

> *"From an ethical perspective, chatbot should not pretend to be a human, it has to be clear that the user is interacting with a computer [...] user should agree if he/she wants to get "manipulated/deceived" with such a device as long as he/she can still decide for themselves" [E6].*

3.3 Most promising CUI features as expressed by experts

In our expert interviews, functionalities such as *encouraging* patients, *reminding* them of tasks such as following prescriptions and exercises, and *animating* or

nudging them to engage in activities stood out as the most promising features. Below we elaborate on a few of these.

First and foremost, *encouraging patients*, and *rewarding* them for their efforts was mentioned by all experts. It is crucial though that messages are not too repetitive nor patronizing, and a variety of sincere and specific motivational messages and compliments are configured, worded to reassure and foster a sense of self-efficacy. Similarly, acceptance commitment therapy (ACT) messages have great potential, which have improved treatment outcomes in various chronic conditions [32], and lend themselves well for digital interventions. **Secondly**, several experts [E2, E3, E6, E8] mentioned integrating *social features* as human interactions can feel much more authentic and rewarding than e.g., a compliment given by a chatbot. Also, psychological mechanisms involved in interaction with machines can be complex; e.g., a simple algorithmic rewards in computer games can be addictive (as in gambling), and people can 'humanize' robots and software, and feel affection or attachment for them. The key is designing an *appropriate* reward system, and for that, it is important to understand what motivates the individual user [33]. Additionally, for many chronic health issues, adherence to prescribed protocols (e.g., medication, exercise, nutrition, cognitive interventions) appears to be a difficult problem. In the context of older adults' adherence to digital interventions, we must also consider memory lapses. Experts expressed that even the simple, customizable *reminder* functionalities aligned to a patient's daily routines (to support building new habits) bear great potential. It is important that the user does not feel *controlled* by the bot in general, nor this feature in particular, as negative feelings can lead to a decline in user acceptance. The **third** highly recommended CUI feature is to *animate* or *nudge* patients (plus caregivers, family members) to e.g., contact others, play an active game, go for a walk or initiate dancing. Such prompts could be aligned to some predefined targets (e.g., social engagement, cognitive training, physical activities) and the degree of challenge should adapt to the user's current social, mental and physical fitness level, context and capabilities. Combining physical and cognitive exercises (as in exergames and multi-domain training) have positive effects as well [34], and experts posited that adding social components in such interventions may have an even greater effect [E3, E6]. Plus, explaining why a particular activity is beneficial also increases adherence [E4, E5, E8]. These insights overlap substantially with a recent meta analysis study [29].

3.4 Factors of user acceptance

User acceptance of CUIs surfaced as an important theme in our interviews, for which practical, social and psychological reasons were mentioned. Several experts mentioned the technology acceptance models (TAM) [35]. Specifically, a *senior* TAM (STAM) adaptation [37] (see Figure 1), which specifies similar variables and system characteristics, e.g., facilitating conditions and social influence impact perceived usefulness and ease of use, and lead to user acceptance (or rejection). On the practical side, adoption of new technologies, including smartphones, is generally lower in older adults [19]. User interfaces are not customized

to the specific needs of this demographic group, making operation of applications and devices unnecessarily difficult for older adults, especially for those with cognitive impairments. CUIs aimed at older adults should be subjected to high usability standards, and tested in carefully designed experiments.

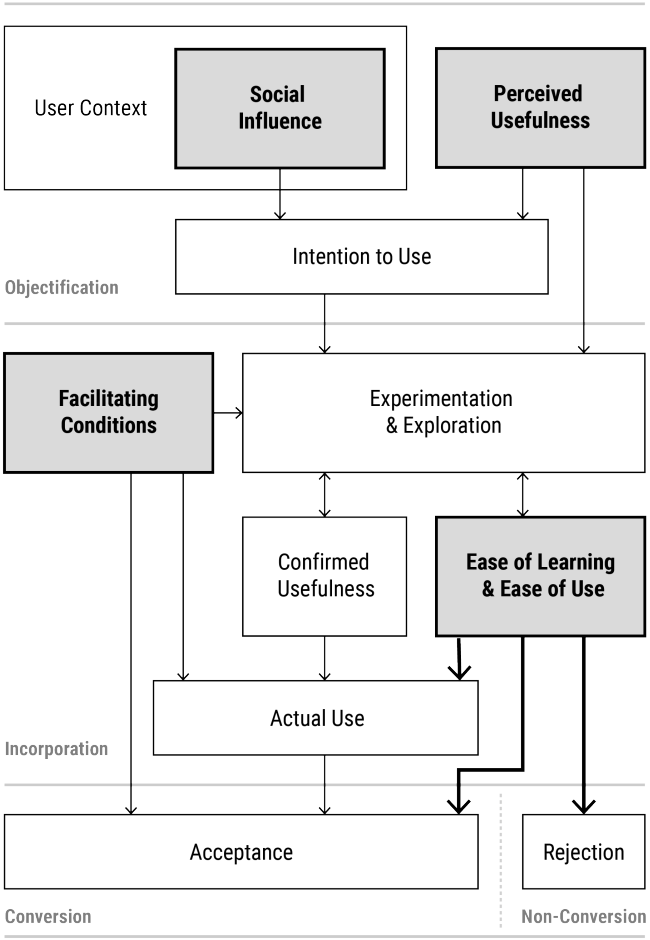

Fig. 1. Senior Technology Acceptance & Adoption Model (STAM) by Renaud and Van Biljon [37]. Figure redrawn and emphasis added by the authors.

Privacy and security issues may also require special attention with older adults to prevent exploitation, specifically of people in more vulnerable states (e.g., MCI, AD, POCD). Less tech-savvy users may not feel confident about configuring a device listening to them, and speech can contain sensitive information. Evidently, there are large individual differences in technology competence depending on e.g., level of education [38]), type of technology [20], incentive [39],

or if it enhances engagement with family [E2]. Furthermore, social context and subjective norms are important aspects for older adults' acceptance of CUIs as assistants of companions. Many questions are raised in this context from various social and cultural groups: Is it respectful and dignified that a patient is cared for or treated by a CUI? To what degree can a chatbot help against the issue of loneliness that many older adults experience? Is it (un)ethical if the chatbot would provide a (fake) sense of companionship to a patient? While some resist such technology-driven solutions due to their potentially deceptive nature, others, who are more optimistic about technology, may encourage its use and be early adopters themselves. Linked to these issues, some experts consider loneliness as one of the biggest problems of MCI patents [E3, E8], for which CUIs *can* help, i.e., they might not only assist and entertain, but also reinforce social contact with other humans.

Another dimension of user acceptance of any technology is its perceived usefulness. In the case of CUIs for people with cognitive deficiencies, this starts with psychological aspects, notably that patients must first of all *accept* their need for support [E8]. Some patients try to mask the cognitive decline and reject interventions, others (mainly advanced AD) may not be aware of their condition and thus may not cooperate. CUIs (or machines in general) offer great potential in these situations as they can support patients in an unobtrusive manner, bypassing some of the social anxieties cognitive impairments can cause. If patients feel empowered through the CUI, if it increases their independence and if it helps them to better achieve their goals, acceptance will certainly increase. Experts recommend framing interventions around one's personal well-being [E1], patients should be explained why CUIs in general and specific exercises in particular are beneficial for them [E4, E5, E8]. Also feedback mechanisms add value, as this supports self-reflection and offers a sense availability to the patient. Also, CUIs do not get impatient, they are never tired or under stress, which brings up the question of how the 'personality' of a CUI should be designed to increase user acceptance. In response to this question, experts mentioned attributes such as *friendly, helpful, patient, empathetic, comforting, reassuring, encouraging*, and *motivating*, but all emphasized the importance of personalization, and fine-tuning for cultural differences.

If patients *like* the personality of the CUI, they are likely to feel more comfortable than if they did not, and their anxiety levels might thus be reduced [E3]. This is extremely important, as anxiety can have negative impacts on treatment outcomes. Empathetic CUIs that display a positive tenor can increase adherence [40], however, CUI's messaging should not downplay severeness of a patient's condition [E3], rather, CUI should offer coping strategies that support the patient as well as the caregivers and family members in dealing with the condition. Last but not least, we cannot overstate the importance of usability when designing CUIs for this target group. Aging can come with reduced visual ability, hearing difficulties, decrease of fine motor skills, attention and memory glitches and consequently, a decline in learning speed. All experts emphasized

carefully considering structure, language, UI and interaction design (Table 3), which also appear in related literature [41].

Table 3. Practical advice by our experts concerning ease of use of CUI/chatbot.

Content and Structure	To accelerate adaptation, the CUI must be clearly structured and self explanatory, not overloaded with many features or sensory stimuli, and should not intimidate the user.
Language	Messages must be simple and unambiguous, complex syntax should be avoided and the wording should never make the patient feel 'talked down' or unintelligent.
Interface and Interaction Design	Beyond the obvious (e.g., large font and target size, high contrast), the application should be characterized by high fault tolerance (for touch and voice interaction).
Voice	Although voice interaction causes less friction than a visuospatial interface, a combination of text and voice might increase intelligibility for patients with visual or hearing impairments.

While CUIs are considered more intuitive and manageable than visuospatial interfaces by many, it is important to remember that e.g., voice interfaces have their own unique usability challenges. For example, privacy issues arise when other people can hear the conversation, thus, an option to switch to headphones and to another interaction modality should be provided. Also, patients might speak a lesser-studied language or dialect, use or pronounce words in unexpected ways, have a soft voice, and as such, the CUI needs to be trained for the individual user's speech patterns. Another issue is that the speech might be directed to someone else, thus unintended conversations might be initiated and generate confusion. More pragmatically, if the patients *depend* on the CUI and do have have access to it because they lost their device or forget to charge it etc.,it is important have built-in monitoring functions and prompts that prevent serious negative side effects. All these concerns requires that the CUI should be able to learn and adapt, otherwise they will not live up to their potential.

4 Discussion and conclusions

Given that there are signs of promising digital cognitive assessments running on a smartphone or a tablet that enable precise, sensitive and long-term monitoring of human cognitive health [6, 7], it is more imaginable now than ever that we can deliver timely digital interventions that might help ease patients' troubles, keep them company and possibly protect their cognitive reserve. Such digital interventions, however, seem to be out of reach for many older adults due to a new form of digital divide [42] ignited by lack of usability stemming from an awareness and understanding of barriers to technology adoption among older age groups. Motivated by filling this gap, specifically, the current lack of understanding and awareness of the needs of patients with cognitive impairments, and to eventually

find ways to optimize technology solutions for them and their caregivers / family members, we interviewed eight experts who worked with older patients, each in a different capacity.

Usability concerns when designing for older adults are discussed in related research communities, however, arguably, not much of this knowledge is implemented in practice given the low levels of technology adoption among older adults. Importantly, psychological aspects, for example, embarrassment people feel about having a cognitive impairment is rarely taken into account. Such feelings are very common due to stigma around dementia, and affect people's behavior deeply. When software are designed by technologists without psychological insights, important mishaps can occur, e.g., a CUI might make the patient uncomfortable because it would have the wrong tone, reveal too much to others, or might create high cognitive load, preventing technology acceptance and use. In this vein, a key finding in our interviews was that CUIs can be desirable for people with cognitive impairments given that they might allow bypassing social anxieties (feeling embarrassed about the condition), if *message framing* is right. Message framing appears to be of utmost importance not only to prevent a CUI from belittling or patronizing the users; but to reduce anxiety, motivate, encourage and reward them. While personalized and sophisticated systems can increase benefits in monitoring and managing the disease, even simple text based solutions, if message framing is right, offer important benefits and should be exploited. For this ACT messaging seems to be a promising concrete lead to explore. On the other hand, for CUI apps aiming at behavior change, details matter: CUI should encourage the patient but should not mislead them, it should offer rewards but do not overdo it not to lead a negative, addiction-like behavior, it should explain the user why and exactly how the suggested behaviors will improve their lives. As such, these observations stimulate dozens of new research questions to find the right message framing both those that are generalizable, and those that are personalized for individual cases with the help of AI-based solutions. Another important insight, also well documented in the literature, is that in connection to feeling the stigma as well as struggling with processing information, people with cognitive impairments tend to withdraw, and loneliness is a major issue. Such social isolation leads to much needed stimulation for the brain and affects people's motivation to fight the disease, creating a negative loop: they withdraw because of the disease, disease gets worse because they withdraw. This line of thinking brings up the companion apps. Virtual companions that provide (proactive) stimulation -from simply entertaining the user to prompting / nudging towards social behavior- may have much value in protecting cognitive reserve. A successful CUI, however, must present the right 'personality. It appears that the level of realism creates a host of issues. If the CUI is too mechanical, people may be reluctant to trust it (humans still trust humans more than machines), but if it is too realistic, it might generate a false sense of friendship which does not exist. If the patient perceives the CUI as a friend (to replace a real friend), it might have negative consequences in terms of already impoverished human connections, and it might upset the user when

the friend does not come through. Thus, the level of realism is a very important factor and must be delicately designed, specifically challenging to get it right for people with cognitive impairments not to add further to their confusion. Perhaps a solution to this is to enable social features integrated within the CUI app to ensure connections to other humans are regularly provided. Similarly as the behavior change related notes above, the companion apps are also in their early days and more experiments are needed to find the most effective solutions that pose no harm to the patients. Simpler CUIs, i.e., the assistants rather than companions, are less complicated as they would most likely increase effectiveness of people in following any prescribed medical procedure, e.g., before and after surgery, following an exercise plan at home, or taking one's medication timely, and in the right doses, etc. In all cases, even in the simplest for of assistance, though it is necessary to remember that speech can contain sensitive, private information and there is not only a risk of making people uncomfortable but can open up a risk of exploitation. Security and privacy, again, especially given the vulnerabilities of this group, should be taken very seriously.

We believe this qualitative evaluation, coupled with quantitative evidence in literature from empirical studies gives us unique insights in designing CUIs, especially for older adults. Based on consolidating results from the literature and the expert interviews, we are convinced that CUIs –given that they are designed with a user-centric approach, personalized as much as possible, and any hearing loss issues are accounted for– may be a very good interaction alternative that is well suited for older adults, especially for those with cognitive impairments such as MCI, POCD or AD. Whether as assistants or companions, carefully designed CUIs that are adjusted to users' context and needs are useful, and can become effective means to increase adherence to cognitive training and lifestyle interventions for this demographic group. However, we believe that user acceptance of a CUI will increase, only if the design is adjusted specifically for this demographic groups (healthy-aging adults, MCI, POCD and AD patients), making the benefits of the CUI apparent for the user, and as the interface is personalized over time, we expect that a CUI will be easier to use than a visuospatial interface for this age group. While the messages we take from these interviews are largely positive with specific design recommendations, it is important to remember that a qualitative interview with only eight experts might not reflect the global reality. Our observations in this paper thus should be taken as a starting point for design recommendations and be validated with the target user group for the goals of each CUI implementation. Similarly, we plan to follow the key ideas in this paper with a series of CUI prototypes, and user experiments for better understanding the limitations of CUIs and specific CUI designs.

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