

ORIGINAL RESEARCH ARTICLE

Evaluating the GRACE voice assistant for dementia care among caregivers and healthcare professionals: An interview study.

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Abstract

24

25 **Background:** Considering rising dementia rates, voice assistants are being investigated to support people with
26 dementia (PWD) and reduce the burden on caregivers (CGs). GRACE, an intervention-delivering voice assistant,
27 provides cognitive support and assistance with daily living for people with early-stage dementia. Initial pilot
28 trials showed promising user experience among healthy adults but required further evaluation by care
29 professionals working with PWD as a next reiteration process.

30 **Objective:** This study investigated three main research questions: (1) Which intervention components of
31 GRACE do healthcare professionals (HCPs) and CGs find most valuable for supporting the daily lives of PWD?
32 (2) What key constraints do HCPs and CGs expect when implementing GRACE in dementia care settings? and
33 (3) What changes or additions do HCPs and CGs recommend for optimizing the functionality of GRACE?

34 **Methods:** Twelve semi-structured interviews were conducted (CG: n=4, HCP: n=8). Anonymized transcripts
35 were coded and analyzed thematically to directly answer the research questions.

36 **Results:** Respondents found the onboarding activity and memory exercise to be most valuable, due to its
37 relevance in everyday life. Identified barriers for implementation included practical, technical and ethical
38 challenges. Recommendations for successful implementation and further development of GRACE included
39 improving PWD acceptance and greater AI-supported personalized content. Finally, a list of future exercises for
40 incorporation and other use cases of GRACE beyond dementia care were also identified.

41 **Conclusions:** GRACE has great potential as a complementary tool in dementia care. Ensuring personalization,
42 ease of use, and alignment with care processes will be critical for adoption and long-term success.

43

Keywords

45 Dementia, people with dementia, digital health intervention, digital assistive technology, voice assistant,
46 dementia care, informal caregivers, healthcare professionals, user acceptance, human-robot-interaction,
47 qualitative interview study

48

49 **Introduction**

50 **Background**

51 In recent years, we have seen a rise of digital assistive technologies being used in dementia care with promising
52 potential to support people with dementia (PWD) [1-4]. As the prevalence of dementia continues to grow, it
53 intensifies the demand for individualized and specialized care, placing growing pressure on formal and informal
54 caregiving structures [5]. Dementia contributes significantly to disability and dependency among older adults,
55 presenting complex challenges not only for PWD, but also for healthcare professionals (HCPs), formal or
56 informal caregivers (CGs) who provide daily support [4].

57 The World Health Organization projects a need for approximately 40 million new health and social care jobs by
58 2030 to meet the growing demand for dementia-related services [6]. Unlike other medical conditions, dementia
59 care often requires highly specialized, personalized and adaptive approaches due to the variability of cognitive
60 and functional symptoms across individuals [7-8]. This complexity is compounded by a global shortage of
61 trained professionals [9], as well as family members (who would better understand the needs of PWD) being
62 increasingly less available to provide full-time care.

63 In this context, digital assistive technologies such as voice assistants are being explored as tools to help improve
64 quality of life for PWD while easing caregiving responsibilities [4]. Speech-enabled systems such as smart
65 speakers show potential in supporting daily routines, promoting independence and offering cognitive stimulation
66 [1, 10]. Despite these developments, there remains a lack of in-depth empirical research examining how such
67 technologies are perceived in terms of acceptance, usability and usefulness by those directly involved in
68 dementia care and how they can be meaningfully integrated into real-world care practices [11].

69 **The GRACE voice assistant**

70 One such technology is the GRACE embodied voice assistant, designed to provide lifestyle and cognitive
71 interventions to PWD (early stage) [12]. GRACE aims to go beyond personal assistive robots, and enable
72 individuals to continue aging in place, thus impacting their overall quality of life while also addressing the CG
73 shortage. The current version of GRACE provides various voice-based exercises, which individuals can use in
74 their homes at their own pace. Currently, GRACE has been pilot-tested and reiterated among healthy adults (first
75 with 18-60 years old, then with older adults aged 60 or above), to understand initial technological feasibility and
76 perspectives on its provided interventions [13-15]. The interventions were developed according to Cognitive
77 Stimulation Therapy (CST), an evidence-based non-pharmacological intervention for mild to moderate dementia
78 [16], and delivered through a natural spoken interface with a digital coach (GRACE). Results from these pilot
79 studies showed that users found GRACE to be easy to use, useful, considerate of ethical challenges, and able to
80 form a working alliance (i.e., a collaborative relationship between the user and GRACE) [14-15]. Future studies
81 of GRACE aim to further iterate the technology, including its hardware, infrastructure and design more
82 interventions informed by CST, through focus group studies and pilot studies among PWD. After final iterations,
83 GRACE would be evaluated in a feasibility study with PWD and their CGs at home [17].

84 **Objectives**

85 The aim of this study is to evaluate the current GRACE prototype (version 2) with respect to its perceived
86 usefulness, usability, and integration potential into dementia care, as viewed by healthcare professionals (HCPs)
87 and caregivers (CGs). Specifically, the study investigates how these stakeholders value different intervention

components, anticipate constraints to implementation, and also envision improvements. PWD were not included as part of this interview study, as we hope to slowly move towards the target population, by completing necessary reiterations of the technology, before finally engaging PWD. Accordingly, the following research questions are addressed:

RQ1. Which intervention components of GRACE do HCPs and CGs find most valuable for supporting the daily lives of PWD?

RQ2. What key constraints do HCPs and CGs expect when implementing GRACE in dementia care settings?

RQ3. What changes or additions do HCPs and CGs recommend for optimizing the functionality of GRACE?

Materials and Methods

Study design

We conducted a qualitative semi-structured interview among participants in the German-speaking region of Switzerland and Germany, to evaluate their perspectives on the GRACE voice assistant. The study was conducted from October 2024 to May 2025. The ethics committee of the University of St. Gallen reviewed the study protocol and checklist and provided an exemption from a formal review on 17 September 2024.

Study participants

Participants were recruited through multiple dimensions: via a study flyer, online dissemination on the study website, institute websites, and LinkedIn, as well as via emails to local organizations and personal networks of the researchers that were identified to be relevant in dementia care. Participants included both CGs who provided care to PWD and HCPs working within dementia care. Individuals were eligible to participate in the study if they: (1) could speak and understand German, (2) professionally or privately care/support PWD, and (3) were able to participate online. All participants received a detailed study information sheet and provided signed informed consent prior to the scheduled interview.

Data collection

The interviews were conducted in German, and took place online via Microsoft Teams, however one interview was in-person and another via telephone due to technical difficulties. All participants provided consent for recording of the interview. An interview guide was developed by all authors, validated by an external expert, and was divided into profiling, content, and concluding sections. Participants were asked questions relating to the use of GRACE, its implementation and optimization. An interview protocol was completed by FW following each interview, reporting any contextual factors, such as disruptions or interview flow.

Data analysis

The semi-structured interviews were audio-recorded and transcribed verbatim. All transcripts were anonymized and replaced with participant codes (i.e., CG# for caregivers and HCP# for healthcare professionals). All recordings were stored on a secure University of Zurich server, available only to the research team and deleted after transcription. Transcription was conducted using noScribe (version 0.5.0b) and manually reviewed by FW to ensure correct translation of Swiss German terms. Data was analyzed using inductive thematic analysis [18]. Transcripts and protocols were coded using ATLAS.ti (version 25.0.1), where initial codes were first generated,

then aggregated into code groups relating to the study's research questions and further categorized into sub-themes. The final codebook was reviewed by FW and RV.

Results

A total of 12 semi-structured interviews were conducted for this study: 4 interviews with CGs and 8 interviews with HCPs who support PWD in their everyday lives. Table 1 displays the characteristics of the study participants. CG4 was conducted with two CGs who wished to participate together. To obtain specific feedback on the current performance and functionality of GRACE, all respondents were sent a short demo video prior to the interview (available on our OSF repository: <https://osf.io/qtxkc>). The video showed an interaction between GRACE and a user, from a previous pilot study. The interaction shown in the video consisted of four parts: 1) an onboarding section in which GRACE and the user briefly introduced themselves; 2) a guessing game exercise in which the user had to match animal sounds to the corresponding animals; 3) a memory exercise in which the user had to remember items on a shopping list and then repeat them; and 4) a final breathing exercise, which GRACE guided the user through. The interviews were then conducted based on this preparatory video.

Table 1. Participant characteristics for this interview study.

Participant Code	Role	Intensity of contact with PWD	Experience using technology in care	Previously known to the interviewer
CG 1	Relative of PWD	high	none-low	yes
CG 2	Relative of PWD	high	high	yes
CG 3	Relative of PWD	medium	none-low	no
CG 4	Relatives of PWD (dual interview)	high	none-low	yes
HCP 1	Professional care worker	high	none-low	distantly
HCP 2	Former therapist	high	none-low	no
HCP 3	Professional care worker	high	medium	distantly
HCP 4	Psychiatrist and psychotherapist	medium	medium	no
HCP 5	Excluded in analysis due to poor quality			
HCP 6	Advanced Practice Nurse (APN)	medium	medium	no
HCP 7	Nursing professional	high	medium	no
HCP 8	Nursing professional	high	none-low	no
HCP 9	Neuropsychologist	medium	medium	no

Note: CG – caregiver; PWD – person with dementia; HCP – healthcare professional. Intensity of contact with PWD was assigned as follows: low (approximately once per week or less), medium (several times per week), high (daily contact). Experience using technology in care was assigned as follows: none-low (no use of modern assistive technologies or only occasional use of long-established consumer devices such as radio), medium (use of technology for individual cases or specific purposes such as entertainment or monitoring purposes), high (regular and diverse use of technologies across multiple care activities). These levels were subjectively assigned by the interviewer following manual review of transcripts and post-interview protocols and are intended as descriptive indicators for sample characterization rather than as validated quantitative measures.

In the first part of the interview, the respondents' initial impressions of GRACE were gathered. All respondents had watched the GRACE video immediately before or during the interview (in the case of HCP1), enabling them to provide detailed feedback on the current GRACE exercises. Both the CGs and the HCPs were generally open and interested in GRACE. When asked directly, all respondents said they were interested in trying out GRACE themselves in the future and possibly using it. The general openness to use it was therefore very high. As for

initial reactions to GRACE, the respondents expressed a mixture of appreciation, curiosity, skepticism, and constructive criticism. Many were impressed by the assistant's friendly demeanor, especially in the onboarding, where GRACE introduces herself and asks a few personal questions. Participants found this initial interaction particularly valuable for reducing tension and building trust. In addition, initial reactions to the appearance of GRACE were mainly positive as well. Here, the visual design of GRACE was perceived as accessible and friendly by most respondents - an important factor when interacting with PWD according to the respondents.

Evaluation of the onboarding activity

The onboarding activity, where GRACE briefly introduces itself and asks the user a few personal questions, was rated particularly positively by participants. Almost half the participants (n=5, 41.6%) said that this personal introduction made initial contact much easier and helped build trust between GRACE and the user. However, some of GRACE's statements during the introduction were perceived as rather unnatural by the respondents. For example, when the user in the demonstration video answered that she had no siblings, GRACE replied with "I'm sorry." Several respondents found this answer irritating, as it did not correspond to the social norms they were accustomed to. It was therefore noted that GRACE's responses to such topics should be made even more natural in the future. Despite such constructive criticism, however, the onboarding was generally seen as a good starting point for interaction between GRACE and the conversation partner. Some of the respondents also noted that, ideally, this phase should be extended/expanded in the future to enable an even more natural, interesting and easy start to the interaction.

Evaluation of GRACE's exercises

Overall, the memory exercise received the best ratings. Five of the respondents even rated this exercise as the best so far. In contrast, only two respondents named the breathing exercise and none of the respondents named the guessing exercise as the best exercise. To better understand these assessments, detailed questions were then asked about each exercise to gather both positive and critical feedback on the current functionalities of GRACE. This feedback is summarized below for each exercise, noting that respondents focused their comments on the exercises they had the most to say about. Furthermore, it should be noted that at no point were respondents asked to name the best and worst exercises; they were simply asked where they saw the greatest potential for GRACE to support PWD, CGs, and HCPs in everyday life. This part was therefore designed to be relatively open-ended to capture the honest opinions of respondents as realistically as possible.

Memory exercise

Table 2 summarizes the feedback received relating to the memory exercise intervention component. Participants provided both positive and negative feedback, as well as suggestions for further improvement to the current memory exercise.

Table 2. Feedback of the memory exercise delivered by GRACE.

Feedback	Mentioned by
Positive feedback	
Rated as the best exercise.	CG2, CG3, CG4, HCP2, HCP8
Appreciated its ability to activate and cognitively stimulate PWD.	CG2, CG3, CG4
Thematic relevance for everyday life of PWD.	CG1, HCP1, HCP9
Shopping list theme was praised for its simplicity and suitability for everyday use.	CG1, HCP1, HCP9

Appreciated increasing level of difficulty over time.	HCP9
Negative feedback	
Found the level of difficulty too high.	HCP3, HCP7
Criticized the corrective feedback from GRACE when the user forgot an item on the list, finding it harsh, and potentially causing discomfort to the PWD, or make them feel like they were being tested.	HCP3, HCP7, HCP9
Recommendations for improvement	
Replacing closed-ended questions with more open-ended questions.	CG2, CG3, HCP3, HCP4, HCP9
Exchanging direct corrections with hints.	HCP9
The topic (shopping list) could be expanding and personalized according to individual interests of the PWD. Topic recommendations included seasonal topics (Christmas, Easter) or personal hobbies (travel, history, geography).	HCP4, HCP7, HCP9
Incorporating more praise.	HCP4, HCP9
Simplifying and shortening instructions.	HCP7
Communicating the progress of PWD over time.	CG1

184

185 Direct participant quotes were translated by the authors using DeepL, and some have been selected to represent
186 the feedback summarized in Table 1.

187 *“I also like the memory task with the shopping list. It's something that's very relevant to them,*
188 *something that's very close to them. (..) I can imagine that they will respond well to it because they feel*
189 *that they can do it and want to do it themselves.” (HCP9)*

190 *“I think (...) the memory exercise is quite good. But I have to say (...) that there are people (...) who*
191 *don't learn anything because it's like a test. I hear this from our patients too when you do these tests,*
192 *these memory tests, or when you do exercises where you have to repeat a word or remember what the*
193 *other person said, or something like that. (...) Some people really find it unpleasant because it's like an*
194 *exam, like a test where they also realize that they don't do so well there.” (HCP7)*

195 Regarding recommendations for improvement to the memory exercise, participants suggested that GRACE could
196 instead ask first “What do you need for breakfast?” or “What usually goes on a shopping list?”. In terms of the
197 feedback provided for missing recall items, it was also suggested for GRACE to instead provide hints such as
198 “The item that is still missing is spread on bread in the morning” instead of “You forgot the butter”.

199 **Breathing exercise**

200 Table 3 summarizes the feedback received for the slow-paced breathing exercise, with an immersive
201 environment. Participants shared a mix of positive and negative feedback, along with recommendations for
202 enhancing the current breathing exercise.

203 **Table 3. Feedback of the breathing exercise delivered by GRACE.**

Feedback	Mentioned by
Positive feedback	
Rated as the best exercise.	HCP3, HCP7
Found it good as an initial exercise (e.g. for its potential to relieve initial tension).	HCP2

Instructions are easy to follow.	HCP7
Useful when the PWD is open to participation.	CG3, CG4, HCP9
Negative feedback	
Effectiveness greatly depends on the openness of the PWD to this type of exercise.	HCP4, HCP8
Questioned the added value of the exercise.	HCP6
Recommendations for improvement	
Use of Familiar Voices in Breathing Guidance	HCP7
Simplification of Breathing Instructions	HCP1

A selected direct quote relating to this exercise, which nicely summarizes the feedback from Table 3 is:

“I personally think the breathing exercises are great. I'm a fan of these exercises. My mother would probably find it completely silly. Why should I breathe now? It's very difficult. It probably really depends on the patient. But it's a good idea. Anything that activates makes sense. You just have to try a lot and see what works and what doesn't.” (CG3)

Guessing exercise

Similar to the memory and breathing exercises, Table 4 summarizes the feedback obtained for the animal guessing exercise. Participants provided both positive and negative feedback, as well as recommendations for improvement.

Table 4. Feedback of the animal guessing exercise delivered by GRACE.

Feedback	Mentioned by
Positive feedback	
Found it useful for PWD.	HCP4, HCP6, HCP9
Found the simplicity as particularly positive.	HCP4
Negative feedback	
Found it too childish.	CG1, CG3
Questioned its overall usefulness.	HCP8
Recommendations for improvement	
To expand the range of topics and sounds to reflect the interests and life experiences of PWD to make it more interesting and fun.	CG1, CG2, HCP1, HCP4, HCP7, HCP9
More praise and positively framed feedback on the PWD's progress should be incorporated.	CG1, HCP2

Additionally, some participants also mentioned the involvement of family members or CGs in this exercise as a way to provide/improve personalization. One participant also imagined scenarios in which former farmers could hear milking sounds via GRACE, however also noted the technical complexity:

“There's a lot of potential there. But that would probably require a lot (...) of development” (HCP7)

General impressions of GRACE

In addition to feedback on specific exercises, other general impressions of GRACE's current appearance and functions were collected, these have been summarized in Table 5.

223 **Table 5. Feedback on the general impressions of GRACE.**

Feedback	Mentioned by
General perceptions of GRACE	
Found it helpful for freeing up caregiver and HCP time.	CG2, CG4, HCP2, HCP7, HCP8, HCP9
Found it useful for keeping PWD engaged independently.	HCP2, HCP7, HCP8, HCP9
Saw potential and value in further testing.	HCP1, HCP8, HCP9
Found it more suitable for home than clinical use.	HCP1, HCP6
Found it easy to use.	CG4, HCP1, HCP9
Emphasized that it should support, not replace, human care.	HCP4, HCP8, HCP9
Felt it should not be used for diagnostics.	HCP4, HCP9
Perceived its appearance as “toy-like”.	HCP4
Found usability good, with room for improvement.	CG1, HCP4, HCP6, HCP8
General positive feedback	
Found interaction cognitively stimulating.	HCP8
Saw potential for a “wow-effect” on PWD.	HCP8
Found GRACE to be sympathetic.	HCP9
Found the facial design pleasant.	HCP1
Found the voice pleasant.	HCP1, HCP9
General negative feedback	
Found the color too bright or irritating.	HCP2, HCP7
Found facial expressions unnatural.	HCP7, HCP9
Felt talking to GRACE could isolate PWD.	HCP6
Found the voice lacking empathy.	HCP2

224

225 In summary, the evaluation of the current exercises provided detailed insights into the strengths, weaknesses, and
226 optimization potential of GRACE, as a direct response to RQ1. The onboarding was highly praised for its trust-
227 building and tension-reducing effect, but minor improvements such as optimizing GRACE's unnatural responses
228 were suggested. The memory exercise received the most positive overall ratings and was appreciated for its
229 potential to stimulate the brain and its suitability for everyday use. However, the corrective feedback and its
230 “test-like” atmosphere was criticized. Recommendations included replacing corrections with hints and making it
231 more open-ended and better tailored to the interests of PWD. The breathing exercise was generally found to be
232 helpful for reducing tension, but it was noted that its effectiveness strongly depends on the openness of PWD to
233 use it, suggesting possible barriers to acceptance. The guessing game exercise was praised for its simplicity but
234 also criticized as too childish. An important suggestion was to expand the content and adapt it to the individual
235 interests of PWD. Beyond the individual exercises, general impressions of GRACE showed mixed reactions to
236 its appearance: some praised the friendly design and potential to reduce the workload of caregivers, while others
237 rated the appearance and voice negatively. Ultimately it was emphasized that GRACE should serve as a
238 complementary tool for CGs and HCPs instead of a replacement.

239 **Potential barriers to using GRACE**

240 In addition to initial impressions, the interviews also explored potential challenges and barriers to the practical
241 introduction and use of GRACE, in order to answer RQ2 (key implementation constraints). The findings focused

on the willingness of CGs, HCPs and the expected willingness of PWD to interact with GRACE, its integration into workflows, and existing ethical concerns among the respondents (see Table 6).

Table 6. General adoption and ethical challenges as reported by respondents.

Feedback	Mentioned by
<i>On the part of the PWD</i>	
Lack of motivation to use GRACE.	CG1, CG2, CG3, CG4, HCP1, HCP3, HCP7, HCP8, HCP9
Limited technological familiarity or openness.	CG1, CG2, CG3, CG4, HCP1, HCP2, HCP3, HCP4, HCP6, HCP7, HCP9
May trigger negative or aggressive emotional reactions.	CG1, HCP1, HCP4, HCP6, HCP7
Reduced usability as dementia progresses.	CG2, CG3, HCP1, HCP7
<i>On the part of CGs & HCPs</i>	
Unpredictability of PWD reaction due to individual differences.	HCP2, HCP3, HCP7, HCP8, HCP9
General uncertainty about added value of GRACE in comparison to other activities.	CG1, HCP1, HCP4
Potentially requires additional effort.	HCP4, HCP7
Time constraints in professional care settings.	HCP1, HCP4
<i>Technological challenges that are to be solved first</i>	
GRACE needs to recognize unclear or low-volume speech and be able to adapt to it (e.g. incoherent or inaudible conversations).	CG3, CG4, HCP3, HCP4, HCP8
GRACE needs to adapt to unpredictable user behavior.	HCP8
GRACE needs to accommodate vision and hearing impairments.	CG2, HCP4, HCP6
<i>Ethical concerns regarding the use of GRACE</i>	
Fear of replacing human caregivers with robotic alternatives.	CG4, HCP1, HCP4, HCP6, HCP8, HCP9
Concern about the trade-off between personal data use and actual benefit.	CG1, CG3, CG4
Concern about people with dementia forming emotional bonds with a robot.	HCP8
Need for reliable deletion of personal data after use.	CG2
Importance of obtaining informed consent for use of personal data.	HCP9
Concerns about data security and risk of unauthorized access.	CG3, CG4
Potential risk of deception of PWD through personalized interaction (e.g. when personalized topics are discussed or familiar sounds / voices are used).	HCP7, HCP9
Concern about forced use and lack of user autonomy (e.g. GRACE should always be a voluntary option and never imposed on PWD).	HCP1, HCP2
Fear of increased isolation due to reduced face-to-face contact.	HCP6
Privacy concerns around passive listening in on background conversations in shared environments.	CG1
Concern that GRACE may reduce joyful caregiver-PWD interactions.	HCP9
Belief that all available tools should be tried if they help PWD.	HCP3

Some key quotes that highlighted a fear of contact with technology and low acceptance rate among PWD:

246 “My mom wasn’t very familiar with it [referring to a smartphone]. We tried to teach her, especially in
247 the early stages, also to communicate via the internet, to get information via the internet. She didn’t
248 want any of that” (CG4)

249 “If they can’t understand or grasp something, or aren’t properly attuned to it, then it tends to make them
250 aggressive.” (HCP6)

251 Regarding ethical considerations, participants mentioned different aspects of data protection, where some could
252 also weigh its risks against the benefits of using services like GRACE:

253 “It must be clearly regulated which data goes where (...) I have the feeling that I would have given a lot
254 of information. In the end, it’s about the health and safety of a relative” (CG3)

255 “(...) how much does GRACE learn about my grandmother over time and how much is then stored in the
256 background. But I don’t know, for some reason I’m less concerned about that, I’d be less concerned in
257 that case. Well, I think the benefits would outweigh the problems” (CG4)

258 In summary, while respondents were generally open to GRACE, they emphasized that it is critical to address
259 such challenges and ethical concerns to ensure that GRACE is used safely, beneficially, and voluntarily on an
260 ongoing basis.

261 **Recommendations for the implementation and further development of GRACE**

262 In addition to answering RQ2, respondents were also asked for recommendations on how to improve GRACE in
263 the future, how to facilitate its introduction into practice and how to ensure user acceptance among all
264 stakeholders involved. Table 7 summarizes feedback obtained regarding strategies for improving acceptance
265 among PWD, implementation and familiarization, as well as integration into the workflows of CGs and HCPs.

266 **Table 7. Recommendations for successful implementation and acceptance of GRACE as reported by respondents.**

Feedback	Mentioned by
Strategies to Improve PWD Acceptance	
Encouraging PWD engagement through more motivation and praise.	CG1, HCP4
Increasing acceptance through collaborative use of GRACE.	CG1, CG4, HCP2, HCP3, HCP6, HCP9
Ensuring GRACE interactions are fun and entertaining.	CG1, CG2, CG4, HCP1
Fostering positive early experiences with GRACE.	CG1
Sparking interest by positioning GRACE as a personalized “friend”.	CG2, HCP3
Initial Implementation and Familiarization	
Boosting engagement through joint trial sessions with caregivers.	HCP1, HCP2, HCP6, HCP7, HCP9
Improving acceptance through repeated exposure.	HCP1, HCP2, HCP3
Motivating use by helping PWD recognize personal benefits.	CG1, HCP7
Introducing GRACE with the help of younger caregivers (e.g., grandchildren).	HCP9
Integration into Workflows and Ease of Use	
Making integration easier through collaborative use.	CG1
Providing enough familiarization time before full adoption to ease the learning curve.	CG4, HCP1, HCP3

Facilitating adoption by helping caregivers understand GRACE's functions.	HCP1, HCP8
Identifying the right physical placement for GRACE.	HCP6, HCP7
Ensuring GRACE is intuitive and easy to use (e.g. 1-2 buttons at max.).	HCP1, HCP7
General Implementation and Integration Advice	
Enhance human-likeness through expressive facial features and natural interaction.	CG1, CG2, HCP1, HCP2, HCP7
Ensure GRACE is intuitive, comes with a manual, and requires minimal setup.	CG4, HCP1, HCP8, HCP9
Test GRACE in real-world settings with PWD before finalizing features.	HCP7
Place GRACE at eye level in a consistent and visible spot to support interaction.	HCP2, HCP4
Simplify choices and reduce decision-making demands for PWD.	CG1, HCP1, HCP2

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268 For successful initial implementation, two critical factors emerged: joint use with PWD and thorough preparation
 269 of CGs and HCPs. The concept of familiarization was paramount, emphasizing that PWD, CGs as well as HCPs
 270 need to gradually acclimate to GRACE's presence and interaction. This process involves trying GRACE together
 271 with PWD multiple times and doing so in an empathetic manner. Simultaneously, comprehensive introductions
 272 and training for CGs and HCPs on GRACE's functions and benefits were named as important ingredients for a
 273 successful initial implementation. This could be promoted, for example, by making user manuals available and
 274 ensuring that setup is very simple and intuitive. In addition, to significantly boost PWD acceptance and
 275 motivation to use GRACE, respondents considered shared use with CGs and HCPs as crucial, as this could foster
 276 an enjoyable and engaging experience. Furthermore, they expressed that incorporating fun elements and praise
 277 into GRACE's interactions could increase long-term engagement. Finally, making GRACE more human-like
 278 through natural facial expressions and speech patterns was also suggested. However, there were also some
 279 comments that viewed such humanization as rather negative, as it could potentially cause confusion among
 280 PWD.

281 To answer RQ3 (functional optimization), respondents provided several recommendations for improving and
 282 expanding GRACE's general and technical functionalities (see Table 8).

283 **Table 8. Recommendations for enhancing GRACE's technical and general functional domains.**

284

Feedback	Mentioned by
Technical Improvement	
Adding a screen or visual elements (e.g., for showing pictures).	CG2, CG3, HCP4
Including headphone support for clearer audio.	HCP4
Enabling connection to smart-home features (e.g., lighting control).	CG2
Supporting behavior-based interaction for personalized responses.	CG2
Making GRACE wireless to improve mobility and ease of use.	HCP7
Ensuring GRACE is easy and intuitive to charge.	HCP4
User Experience & Interface Improvement	
Avoiding distress caused by unexpected movement (e.g., sensors).	HCP1
Offering customization options for GRACE's look and feel.	CG2, HCP1, HCP 7, HCP8
Providing different physical form options (e.g., radio, TV, puppet).	CG2, HCP1

Keeping GRACE's interactions very simple and straightforward.	HCP1, HCP2
Making interactions more friendly, motivating, and engaging.	CG1, CG2, CG4, HCP2, HCP3, HCP4
Focusing on helpful content rather than excessive compliments.	CG2
Simplifying physical controls (1-2 buttons max.) and ensuring clear on/off feedback.	HCP2, HCP4, HCP7, HCP9
Using slower, simpler language in GRACE's spoken interactions.	HCP1, HCP2, HCP7, HCP8, HCP9
Functional improvement recommendations for supporting PWD	
Improving interaction through behavior-based tracking	CG1
Adding more language and dialect options.	CG1, HCP4, HCP6, HCP7
Personalizing interaction through user-specific preferences and topics. Potentially by using generative AI.	CG1, CG2, HCP1, HCP2, HCP3, HCP7, HCP8, HCP9
Providing a calling function for emergencies.	CG1, CG2, CG3, CG4, HCP6, HCP8
Helping maintain contact when phone PIN is forgotten.	CG3
Offering mnemonic aids and reminder functions.	CG1, CG2, CG3, HCP3, HCP6
Playing music tailored to the PWD's preferences.	HCP1, HCP2, HCP3, HCP7
Functional improvement recommendations for supporting CGs & HCPs	
Providing entertainment and conversation support for PWD.	HCP2, HCP4, HCP9
Including a translation function for multilingual communication.	HCP6
Supporting caregivers with task recommendations and checklists.	CG2, CG3
Integrating a medication dispenser for easier daily care.	CG2
Enabling early-stage disease diagnostics.	CG2, CG3, HCP9
Supporting disease progression tracking.	CG1, CG2, CG3, HCP9
Implementing intelligent emergency notifications.	CG2, HCP6, HCP8
Tracking and monitoring PWD location and daily activities.	CG1, CG2, CG3, HCP8

285

286 The interviews also yielded numerous suggestions for new exercises in the areas of cognition, physical activity,
287 creativity, and social interaction (see Figure 1), with open-ended questions and discussions about personal
288 memories emerging as a particularly strong desire, underscoring the desire for more natural conversation
289 opportunities.

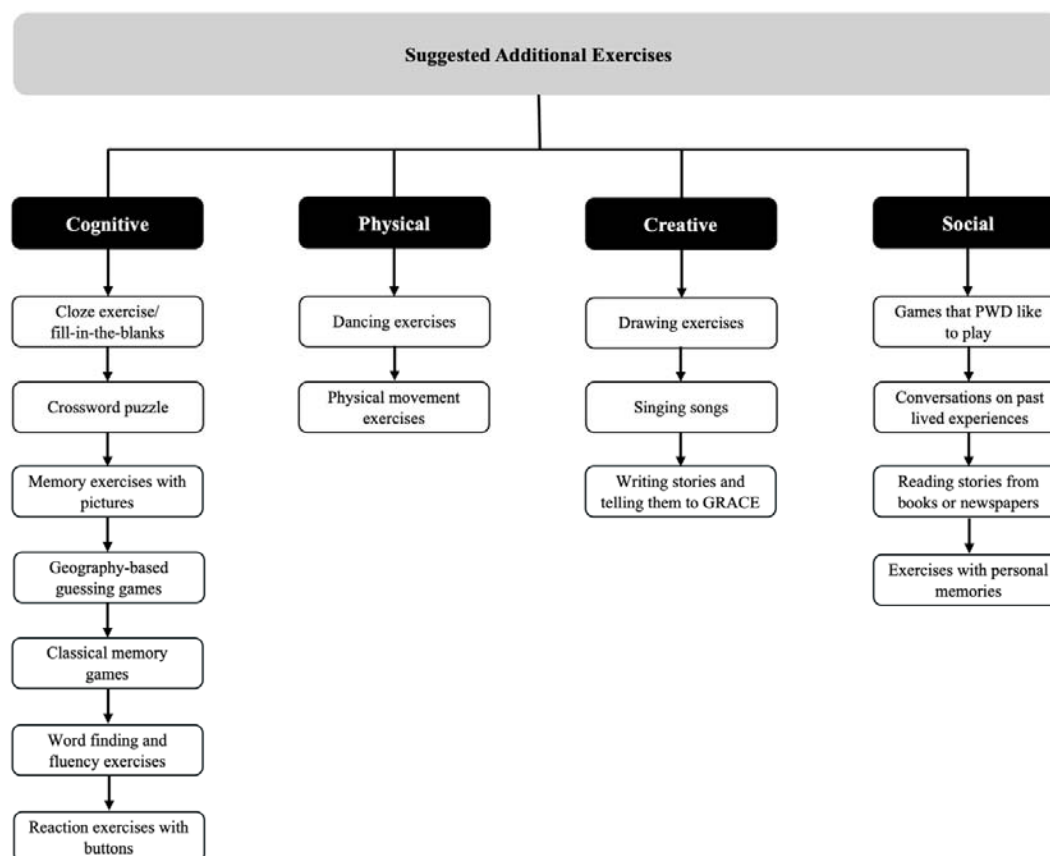


Figure 1. Additional activities suggested by respondents for GRACE, categorized by cognitive, physical, creative and social domains.

Beyond its current functionalities, respondents identified several additional potential applications for GRACE within dementia care that have been summarized in Table 9 (also contributing to RQ3).

Table 9. Potential future areas of application for GRACE.

Feedback	Mentioned by
Technological Advancements and AI Integration	
Development of GRACE into an AI-driven learning system.	CG1, CG2, CG3, CG4
Integration into a smart home system for assisted living.	CG2, CG3
Integration into a classical robotics platform.	CG2
Social and Psychological Support for PWD	
As a companion to reduce aspects of loneliness among PWD.	CG1, CG4, HCP1, HCP2, HCP3, HCP4, HCP5, HCP6, HCP7, HCP8
As an interaction replacement when PWD are alone.	CG1, HCP1, HCP2, HCP4, HCP5
Emotional support for coping with memory loss.	HCP3, HCP7
Tool for social interaction among PWD.	HCP8
Expanded Use Cases in Dementia Care	
General personal assistant for PWD, CGs and HCPs in daily life.	CG2, CG3, HCP1, HCP3,

	HCP6, HCP8
As an early warning system for cognitive decline.	CG2, HCP8, HCP9
Tool for activation therapy.	HCP8, HCP9
For individuals with early/young onset dementia.	HCP1
In collaboration with memory clinics for enhanced care.	CG3
Tool for dementia prevention.	HCP7
Decision-support tool for assessing PWD participation in assisted dying services.	CG3
Broader Applications beyond Dementia Care	
Expansion into childcare.	CG2

The most frequently suggested broader role for GRACE was as a companion to reduce loneliness among PWD (CG1, CG4, HCP1, HCP2, HCP3, HCP4, HCP5, HCP6, HCP7, HCP8), and also as a general personal assistant for PWD, CGs and HCPs in their daily routines (CG2, CG3, HCP1, HCP3, HCP6, HCP8). Examples mentioned included assistance with household tasks, facilitating communication and coordination among HCPs, monitoring PWD's condition, and aiding with various other daily responsibilities. Respondents also proposed that GRACE could include more AI-supported, personalized content and features (CG1, CG2, CG3, CG4), where it may also be possible to adapt to the PWD's stage of dementia, potentially empowering PWD to remain in their homes longer (GC2, GC3, HCP1, HCP3, HCP6, HCP8), thereby enhancing their independence. Further suggested applications included utilizing GRACE as an early warning system for cognitive decline prior to a dementia diagnosis (CG2, HCP8, HCP9), and as a tool for activation therapies in clinical environments (HCP8, HCP9).

Discussion

This qualitative evaluation of the voice assistant GRACE among HCPs and CGs provides both practical insights and guidance for future development for assistive technologies in this field of application, thus significantly contributing to filling the current gap in well-founded empirical research on how such technologies are perceived by those directly involved in dementia care and how they can be meaningfully integrated into care practice.

Overall, respondents were excited about GRACE's potential to improve daily interactions with PWD and reduce the burden on HCPs and CGs at the same time, confirming the potential to ease caregiving responsibilities as described by Scheider et al. [4] if designed and implemented correctly and efficiently. Respondents particularly appreciated the memory exercise and the onboarding section. The former mainly for its potential to stimulate PWD cognitively and its thematic relevance to everyday life (e.g., shopping list) and the latter for its potential to build initial trust and make the start of interaction exciting and enjoyable. Despite this positive feedback, respondents also pointed out a variety of challenges and barriers to practical implementation. For example, the oftentimes rather low level of digital literacy and hence the possible skepticism toward talking to "robots" instead of people were frequently cited as challenges that could complicate initial implementation. In addition, the current rather harsh nature of GRACE's responses to errors was criticized, as this could, in the view of the respondents, make PWD feel tested and thus create a feeling of discomfort, which in turn could have a negative impact on acceptance and user motivation. In addition, minor technical challenges were mentioned that need to be addressed when GRACE is used in practice. These include, for example, the targeted handling of fragmented, incomprehensible, slow, or inaudible speech patterns on the part of PDWs to avoid interruptions in conversation or frustrating interaction patterns. Additionally, from the perspective of HCPs and CGs, two challenges for

successful implementation were highlighted. First, GRACE must be able to be seamlessly integrated into existing care processes without creating significant additional effort or complexity. Second, the opportunity costs incurred by using GRACE instead of human activities must be offset by clear added value, for example by bridging unstructured periods when caregivers are unavailable or busy with another task.

Participants also raised a set of ethical considerations that should be carefully examined. While most agreed that the benefits of greater inclusion and independence justify data sharing, they emphasized the need for transparent consent procedures, strict data deletion policies, and safeguards against excessive reliance on the system at the expense of human contact. Furthermore, concerns were raised that PWD could develop an emotional attachment to GRACE, which could further increase their social isolation. These observations are consistent with broader discussions on the ethics of digital health, which emphasize the importance of prioritizing human relationships and using technology only as a support rather than a replacement.

These findings both confirm and complement previous research on digital assistive technologies in dementia care. In line with Schneider et al. [4] our respondents saw clear potential for the voice assistant GRACE to provide cognitive stimulation and support everyday routines of PWD, CGs and HCPs. This observation also correlates with findings from further previous research [2, 4, 10, 19-21]. Similarly, multiple prior research [1-2, 10, 20, 22-24] emphasized the importance of user-centered adoption of such tools, which is reflected here in recommendations for thematic and conversational personalization, the described need for joint use in the beginning as well as the need of GRACE to provide a seamless implementation into existing workflows. Additionally, our findings show that low digital literacy among PWD and hence, a potential lack of user acceptance and motivation are the crucial expected barriers when it comes to the adoption of such assistive technology. This aligns with prior research identifying digital literacy and user acceptance as key challenges when implementing assistive technologies in dementia care [1, 10, 20, 24]. Furthermore, ethical concerns identified in this study also overlap with prior findings. Examples include the concerns expressed by respondents in this study regarding issues such as data protection and the risk of replacing people or further isolating them from social life through the use of such tools, which have already been highlighted in previous research projects [2, 10, 19, 25].

Based on these results, CGs and HCPs suggested several improvements to maximize GRACE's usefulness and acceptance. Besides the joint use of GRACE (especially in early adoption stages), personalization was a recurring theme, ranging from tailoring conversation topics to the individual preferences of the PWD to adjusting voice tones and speaking speed to user needs. Interestingly, many envisioned GRACE evolving into a conversation partner able to provide open dialogue supported by generative Artificial Intelligence (AI), allowing the assistant to recall previous interactions and maintain small talk or memory activities in a more natural and human-like way. Respondents envisioned that GRACE could develop into a “companion” that could engage in free conversations with PWD, CGs and HCPs, provide reminders, help to combat loneliness on the part of the PWD, help facilitate coordination between caregivers, or proactively check in with PWD throughout the day. From a more professional point of view, CGs and HCPs also proposed additional support features to help caregivers with supporting PWD. Recommended features included appointment reminders, emergency call functions, dementia stage monitoring and the provision of practical advice from GRACE to CGs and HCPs. Many of these recommendations are also consistent with the findings of previous research projects that examined similar tools. For example, with Balasubramanian [19], who identified the potential of such tools to combat

loneliness, with Bradford et al. [25], who investigated the provision of support functions for PWD, CGs, and HCPs, and with findings from other researchers who investigated the use of reminder functions for PWD, CGs, and HCPs [2, 10, 20, 24]. Finally, the results of this study also provide a glimpse into the future, as respondents suggested potential future areas of use for GRACE.

It can thus be said that the findings of this study both confirm earlier research results with empirical data whilst simultaneously adding to them with greater thematic depth. By systematically collecting the opinions of HCPs and CGs, our study provides solid insights into how the potential of voice assistants is perceived in real-world dementia care. While previous work has largely outlined general use cases, our results indicate exactly which intervention components are most valued in practice, which specific barriers need to be overcome, and how such a system can be integrated into the everyday lives of direct caregivers. We thus close an important knowledge gap regarding how tools such as GRACE can be developed responsibly, used ethically, and integrated sustainably into the everyday lives of PWD, CGs and HCPs. Furthermore, these findings provide concrete guidelines, prioritization criteria and insights on potential future areas of use that will guide the next iterations of GRACE's features, interactions, and deployment strategies to ensure its continuous optimization and successful adoption into practice.

Limitations

This qualitative study, which used inductive thematic analysis, collected feedback on the GRACE language assistance prototype from HCPs and CGs using qualitative interviews. Although the results are valuable for further investigation, some limitations should be considered when interpreting them.

First, the study included a relatively small sample consisting of eight HCPs and four CGs (five individuals). Although saturation was observed among the HCPs, it was less evident in the CG group. The diverse characteristics of the participants (e.g., technology affinity, age, experience) combined with a multifaceted sampling strategy may have led to selection biases that may limit the representativeness of our sample. For example, participants recruited through personal networks may have had a more positive opinion than those recruited through other channels.

Second, participants' responses may have been influenced by several biases. Given the sensitivity of dementia care, social desirability bias is particularly likely to have an influence on the results. In addition, it is likely that memory biases also influenced the quality of the responses. This is partly because the CG respondents often reported on past experiences and partly because the interviews on GRACE were conducted exclusively based on a demonstration video sent out to them in advance. This could have influenced the depth and accuracy of the feedback provided and must therefore be considered when interpreting the results.

Third, although flexible, the semi-structured interview methodology led to variations in the topics discussed, which made it difficult to synthesize and compare participants' responses. Inconsistent interview contexts, including different locations and occasional technical glitches, may have further influenced the participants' answers.

Finally, limitations also arose from the analysis process. The inductive thematic analysis was conducted primarily by a single researcher, assisted by a second researcher, which may have introduced subjectivity and research-related biases in the interpretation and coding of the interviews. In addition, linguistic discrepancies

arising from multiple translations from Swiss German to German for transcription and then to English for coding pose a risk of losing or distorting insights along the way.

Conclusion

Overall, the findings from this study reveal that GRACE holds substantial promise as a supportive tool for PWD, CGs, and HCPs. Initial impressions indicated a high degree of openness and interest from both CGs and HCPs, along with constructive feedback on existing functionalities. The identified strengths of GRACE's onboarding and the memory exercise, alongside detailed insights into areas for improvement in exercise design and responsiveness, provide a clear roadmap for iterative development. Importantly, the study identified significant potential barriers to adoption, primarily concerning PWD's technological know-how, motivation to use, and the ethical implications surrounding human replacement, security and data privacy. The comprehensive recommendations for future enhancements, including technical refinements, user experience improvements, and expanded functionalities underscore the importance of user-centered and ethically conscious design. Addressing these study insights will be paramount in ensuring GRACE's successful, beneficial, and safe integration into dementia care, solidifying its role as a valuable complementary tool rather than a replacement for human interaction.

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Author Contributions

FW: data curation, investigation, formal analysis, visualization, writing (original draft) & writing (review & editing). NBA: funding acquisition & writing (review & editing). TK: conceptualization, funding acquisition, methodology, supervision & writing (review & editing). RV: conceptualization, funding acquisition, methodology, project administration, supervision, validation, visualization, writing (original draft) & writing (review & editing).

Statements and Declarations

Ethical Considerations

On 17 September 2024, the Ethics Committee of the University of St. Gallen issued a letter exempting the study from a formal review. The exemption was granted because the interview study did not fall under the Swiss Federal Act on Research Involving Human Beings, did not expose participants to physical or psychological risk, nor involve vulnerable populations, or require collection of sensitive personal data.

Consent to Participate

All participants were fully informed about the study and provided written informed consent prior to participation in the research study.

Consent for Publication

All participants provided written informed consent for the publication and dissemination of research results obtained from their interview data in anonymized form.

Declaration of Conflicting Interest

TK and RV are affiliated with the Centre for Digital Health Interventions (CDHI), a joint initiative of the Institute for Implementation Science in Health Care, University of Zurich; the Department of Management, Technology, and Economics, ETH Zurich; and the Institute of Technology Management and School of Medicine, University of St. Gallen. CDHI is funded in part by the Swiss health insurer CSS, the Austrian health care provider (and corporate start-up of UNIQA) Mavie Next, and the Swiss investor MTIP. TK is also a cofounder of Pathmate Technologies, a university spin-off company that creates and delivers digital clinical pathways. However, neither CSS, Mavie Next (UNIQA), nor MTIP were involved in this study. Furthermore, TK has neither shares of Pathmate Technologies nor any formal role in the company.

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Data Availability

The datasets generated during and/or analyzed during the current study are available in the OSF repository, <https://osf.io/qtxkc>.

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Suggested Additional Exercises

