

Enhancing communication and autonomy in dementia through technology: Navigating home challenges and memory aid usage

Alyssia A. Sanchez BEng MASc^{a,b,c,*}, Joy Lai BASc^a, Bing Ye MSc^{c,d}, Alex Mihailidis PhD^{a,b,c,d}

^aFaculty of Applied Science and Engineering, University of Toronto, Toronto, ON, Canada;

^bInstitute of Biomedical Engineering, University of Toronto, Toronto, ON, Canada; ^cKITE, Toronto Rehabilitation Institute, Toronto, ON, Canada; ^dDepartment of Occupational Science and Occupational Therapy, University of Toronto, Toronto, ON, Canada;

*Corresponding author: alysia.sanchez@mail.utoronto.ca

Abstract

Background: As dementia prevalence rises, people living with dementia (PLWDs) and their caregivers encounter complex challenges within home environments. This study focuses on understanding and addressing these challenges while emphasizing memory aid usage. By adopting a user-centered approach, we navigate existing memory aid limitations to create more effective, tailored solutions for dementia care.

Objective: To investigate and co-design innovative assistive memory technologies, the primary research question being addressed is: how can the development and implementation of a reminder system address the multifaceted challenges faced by PLWDs and their caregivers?

Method: By conducting a qualitative analysis through in-depth interviews and prototype demonstrations of a reminder system with dyads of PLWDs and their caregivers, our research facilitated a co-design process by delving into home environment challenges, adaptive strategies, memory aid usage, and opportunities for improvement. The study employed a qualitative methodology to extract valuable insights that inform the development of innovative assistive memory technologies.

Results: Findings revealed multifaceted challenges faced by PLWDs and their coping strategies in daily activities, emphasizing the need for tailored memory aids. Participants expressed preferences for various interaction methods, sizes, and functionalities of reminder units, including digital reminders, smartphone apps, and specialized software. The study revealed that factors such as openness to adopting new technologies and related preferences exhibited notable variations linked to the demographic characteristics of the participants. Noteworthy trends emerged in relation to characteristics such as age, household income, and the severity of dementia. Furthermore, insights obtained from the demonstration of a prototype, showcasing its functionality and user-friendly interface, provided valuable feedback for refining the reminder system. Preliminary outcomes suggested the potential for improvements in both autonomy and communication among PLWDs.

Conclusion: This research contributes valuable insights into the development of assistive memory technologies to enhance autonomy and communication for PLWDs. By bridging gaps in current memory aid usage, our study informs the development of innovative assistive technologies that can significantly impact the quality of life for PLWDs and their caregivers.

Keywords: Dementia, assistive technology, reminder systems, home environments, memory aids

INTRODUCTION

Significant demographic shifts are occurring as global life expectancy rises and the population of older adults is projected to steadily grow until 2050 (United Nations, Department of Economic and Social Affairs, and Population Division, 2020; World Health Organization, 2020). Dementia, strongly associated with aging, currently affects 5% of adults over 65 worldwide, with this prevalence doubling every 5 years (Pappadà et al., 2021). The associated emotional, physical, and financial challenges on people living with dementia (PLWDs), caregivers, and society are

substantial. Due to memory loss, PLWDs face considerable challenges in daily activities, causing stress for the individuals themselves and heightening concerns among family and caregivers about their safety and overall well-being (Duong et al., 2017).

In response to these profound demographic changes, there is growing interest in technological innovations that foster 'aging-in-place.' Assistive technology (AT) has the potential to empower PLWDs by enabling greater independence in daily tasks, thereby enhancing their sense of au-

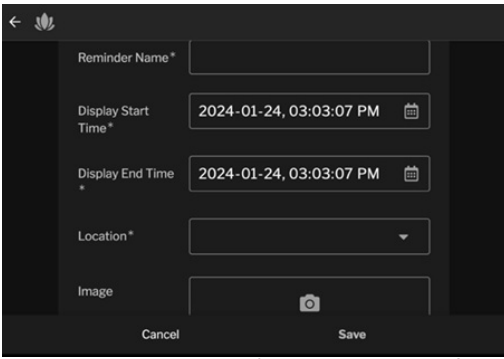


Figure 1. Screen capture for creating a reminder

onomy and dignity. This underutilized resource not only assists PLWDs in managing their lives but also facilitates their active participation in the community (Jönsson et al., 2019). Recent studies, such as those on electronic reminder systems (Mettouris et al., 2023) and adaptive smartphone applications (Fikry et al., 2022), have made significant contributions to improving memory aids for dementia care. Despite these advances, a recent systematic review reveals that caregivers often encounter difficulties with usability due to design inadequacies in ATs, the failure of ATs to meet individual user needs, and a lack of consistency in categorizing ATs for use in dementia care (Sriram et al., 2020).

In light of these challenges, this study is dedicated to the development of memory aid technologies for PLWDs and their family caregivers. Our aim is to enhance autonomy and communication within home settings by innovating beyond the limitations of existing memory aids. The primary focus of this study is to explore the development of personalized memory aid technologies, specifically a reminder system, that not only enhance daily task assistance and communication but are also tailored to individual preferences and specific situational needs. To do so, we have conducted in-depth interviews and prototype demonstrations with PLWDs and their caregivers to aid in designing a system that effectively addresses their unique challenges, whilst ensuring a co-design approach.

Memory aid technology

Reminder methods and technologies are often relied on by PLWDs to compensate for cognitive deficits during task performance (Dada et al., 2022). Conventional memory aids usually include clocks, calendars, whiteboards with electronic timers, noticeboards, and 'Post-It' Sticky notes. However, these solutions are limited due to reliability issues, small sample sizes in studies, and a lack of focus on user outcomes. For example, sticky notes are often ignored, misplaced, and cannot have readily updated reminders (King

& Dwan, 2019). ATs present the opportunity to innovate and expand upon the benefits and advantages associated with conventional memory aids, such as by providing context-aware systems, user-friendly interfaces, and remote communication and monitoring (King & Dwan, 2019; Alzheimer's Society, 2014).

Modern memory aids now include digital reminders, smartphone apps, and specialized software, offering dynamic and interactive ways to manage information (Bharucha et al., 2009). Ubiquitous computing, where technology is integrated seamlessly into everyday objects and environments (Morris et al., 2003), further extends the potential of these aids, enabling more intuitive and accessible memory support systems. This advancement has improved the capacity for storing and recalling information and introduced unprecedented levels of convenience and customization (Bharucha et al., 2009). The integration of these technologies has shown effectiveness in enhancing safety, daily living, and therapeutic interventions, proving invaluable for PLWDs (Nishiura et al., 2021; Armstrong et al., 2010).

Design opportunities and challenges

Recent studies in the field of reminder systems for individuals with cognitive impairments, particularly dementia, reveal both opportunities and challenges. For instance, the eSticky Project, targeting Europe's aging population amidst rising dementia prevalence, developed an electronic reminder system. This system utilized internet-programmable ePaper displays strategically positioned within homes, prioritizing accessibility and user-friendliness (Mettouris et al., 2023). Similarly, a study introduced a smartphone reminder system employing reinforcement learning to customize notification timings based on user response history, highlighting machine learning's potential in optimizing dementia care (Fikry et al., 2022). Another study introduced a personalized wrist-worn smart task reminder system using Global System for Mobile Communication (GSM) technology for individuals with mild-to-moderate dementia, illustrating the potential of wearable technology in providing discreet reminders (Oketch & Mathonsi, 2021). Additionally, wearable devices equipped with advanced sensing and acoustic feedback, known as Earables, offered promise in aiding PLWDs by providing contextual memory cues and modeling user activities (Franklin et al., 2021).

While reminder systems offer significant opportunities for enhancing independence and quality of life for individuals with dementia, they also present challenges. Designing intuitive user interfaces is critical, as complexity can lead to

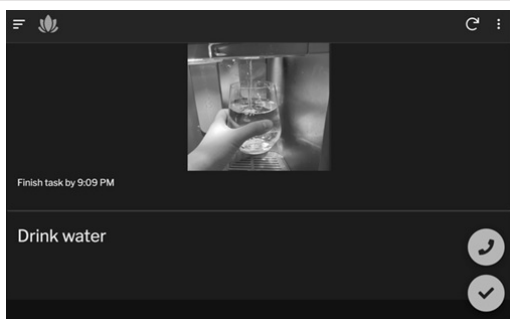


Figure 2. Screen capture for a reminder display, including acknowledgement and call features

frustration and abandonment (Tsai et al., 2023; Brookman et al., 2023). Technological potential should also be balanced with user needs and capabilities to avoid overwhelming users (Braley et al., 2018). Moreover, privacy and security concerns, especially in internet-connected systems, are paramount (Wrede et al., 2021). Integrating these systems seamlessly into users' daily routines is crucial, requiring designs that adapt to changing user requirements over time (Wrede et al., 2022). These challenges should be addressed to fully realize the potential of reminder systems in dementia care.

Co-design for opportunistic exploration in dementia care

In the realm of assistive technology for PLWDs, the co-design approach is vital (Sanders & Scott, 2020). Co-design directly involves users in the development process, ensuring that the technology aligns with their actual needs and preferences (Tiersen et al., 2021). This leads to solutions that are not only relevant and user-friendly but also specifically address the challenges faced by PLWDs (Niedderer, 2022). Co-design fosters innovation by bringing together diverse perspectives, including those of caregivers (Rathnayake et al., 2020). Such collaborative efforts are essential in developing technologies that are likely to be more widely adopted and effective, as they are tailored to the real-life experiences of users (Sanz et al., 2021). Moreover, co-design supports a responsive design approach, allowing for adaptations to meet the evolving needs of PLWDs. This approach significantly enhances the utility and relevance of assistive technologies in dementia care (Sumner et al., 2020).

METHODS

We chose to conduct in-depth interviews with both PLWDs and their family caregivers in our study. This decision stems from the understanding that a home-based reminder system would be designed for use by PLWDs and their family or close friends. These interviews would allow us to gather holistic insights about the needs and experiences of both PLWD and their caregivers.

The study started in September 2023 and ended in January 2024. The interview session was conducted following a semi-structured interview guide comprising three parts: the first aimed to uncover challenges in daily activities and current memory aid usage, the second delved into preferences and opportunities for reminder system development, and the third involved a demonstration of our prototype reminder system, a mobile application designed for use on phones or tablets. The development of the interview questions involved a thorough review of the literature and consultation with experts in dementia care. Examples of questions asked include: "Can you describe a typical day and the challenges you face with memory?"; "What types of memory aids do you currently use and how effective are they?"; "What features would you like to see in a new reminder system?".

This reminder system facilitates the delivery of reminders to various locations within a home through a 'base unit' - typically a mobile phone owned by either the PLWD or the caregiver, ensuring portability. Within this system, a 'reminder unit' refers to a tablet strategically positioned within the home, aimed at assisting PLWDs in remembering tasks and events by displaying reminders. Participants were guided through the process of creating reminders using the base unit (Figure 1) and sending them to reminder units in different locations of the home, providing a view of how the reminders would be displayed in a room for the PLWD (Figure 2). Our reminder system aims to leverage ubiquitous computing by embedding assistive memory technologies into the living spaces of PLWDs and their caregivers unobtrusively, ensuring that these tools naturally blend into and effectively support their daily routines.

Participants

We included dyads of family caregivers and people living with mild (18-25 Montreal Cognitive Assessment (MoCA) score) to moderate dementia (10-17 MoCA score), as assessed by the MoCA. Fluency in English and the ability to understand English instructions were prerequisites for all study participants. An additional inclusion criterion for PLWDs was that they were required to self-report having received a mild to moderate dementia diagnosis in the past 2 years. Additional inclusion criteria for caregivers included providing full-time care (at least 30 hours per week) and being a family member or close friend to the person living with dementia. Participant dyads were recruited through advertising research posters on dementia research platforms and through social connections.

Seven caregivers were recruited (6 female, 1 male), ranging in age from 24 to 60 years old, and

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Table 1. Dyad demographics

Dyad	Age range of PLwD (years)	Age range of caregiver (years)	PLwD-Caregiver relationship	Ethnicity of PLwD	Type of dementia	Caregiver's time providing care (years)	Home situation
1	> 60	51-60	Father-Daughter	White	Vascular	6-10	House
2	41-50	41-50	Husband-Wife	East/Southeast Asian	Frontotemporal	6-10	House
3	>60	51-60	Husband-Wife	White	MCI	<1	Condo
4	>60	51-60	Father-Daughter	Black	Vascular	1-5	Retirement home
5	>60	<30	Grandmother-Granddaughter	East/Southeast Asian	Alzheimer's	>10	House
6	>60	>60	Brother-Sister	White	Unknown	1-5	Apartment
7	>60	41-50	Mother-Son	White	Alzheimer's	1-5	House

seven PLwDs were recruited (2 female, 5 male) with a mean MoCA score of 19.57 ± 5.04 (SD), ranging in age from 45 to 93 years old. Additional demographic information is found in *Table 1*.

Data analysis

Interviews and prototype demonstrations were transcribed verbatim. Subsequently, audio transcripts were analyzed using principles of qualitative data analysis (Sutton & Austin, 2015) and a combination of top-down and bottom-up methods. Initially, thematic categories were identified based on existing literature and research questions. Then, using NVivo, the data were fragmented into smaller, meaningful units and analyzed iteratively to assign descriptive labels/codes capturing key concepts and emerging themes. Reflexivity was maintained throughout the analysis, with researchers acknowledging and addressing potential biases. Most interview sessions were facilitated by two researchers and transcripts were reviewed by both researchers to ensure the reliable interpretation of the interviews.

Privacy, anonymity, and ethics

In accordance with ethical standards, this study prioritizes the protection of participants' privacy and confidentiality. Informed consent was obtained from all participants, clearly outlining the purpose and procedures of the study, as well as their right to withdraw at any stage without consequences. PLwDs were only interviewed in the presence of their caregiver. To ensure anonymity, participant identities have been replaced with numbers throughout data analysis and reporting.

RESULTS

Results from the interview sessions are sorted into three main sections: uncovering challenges and adaptations in daily activities and current memory aid usage, learning preferences and opportunities for reminder system development, and feedback on a demonstration of a reminder system prototype.

Daily routines and current memory aid usage

Examining daily routines and current memory aid usage informs the development of an effective reminder system, offering insights into individuals' unique needs and practices.

Struggles and challenges

Dyads face multifaceted challenges, particularly in communication and memory, which can vary significantly due to factors like the varying severity of dementia. For some dyads, tasks and instructions need to be specific and only one task at a time can be communicated. Dementia, especially in moderate cases, can lead to general challenges in daily tasks, necessitating assistance, and caregivers play a crucial role in reminding individuals to perform activities like changing clothes and bathing.

Cognitive difficulties can make it challenging for PLwDs to initiate tasks or to think about what needs to be done. Short-term memory issues manifest in instances of entering a room and forgetting the purpose. Additionally, frequent misplacement of items and forgetting essential tasks contribute to heightened frustration, highlighting the emotional toll associated with memory difficulties. These challenges extend to daily activities like operating household appliances and managing personal hygiene, for instance, remembering to turn off the oven or ensuring regular toilet use.

The use of memory aids, both technological and non-technological, such as voice assistants and maintaining lists on paper, are implemented to counteract memory challenges. However, it's essential to acknowledge that these memory aids can also pose challenges of their own. Phone usage, for instance, emerges as a substantial obstacle, in some cases prompting considerations for a manual phone to alleviate associated difficulties. Examples of difficulties with using the phone encompass locating the device, ensuring it is charged, answering, and making calls. Reliance on calendars and similar memory aids is also highlighted for time management, but in some cases, consistent verbal reminders from caregivers are needed to ensure their effectiveness.

Adaptations and strategies

Participants described various tactics to support memory loss, highlighting the importance of routine and consistency. Several PLwDs employ strategies such as vocalizing tasks or reminders repeatedly to prompt and reinforce their memory. Notable caregiver communication methods

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Figure 3a. Physical calendar memory aid

included speaking slowly, providing advance notice for tasks, delivering specific instructions one at a time, and allowing ample time for task completion. Visual cues were crucial, with participants discussing the strategic placement of items in designated locations. Maintaining a consistent routine, such as leaving a bowl and cereal on the kitchen table for mealtime prompts, further demonstrated the value of familiarity. Creating predictable and familiar environments can support PLWDs in navigating daily life, emphasizing the importance of returning objects to expected places and performing tasks at regular times.

Regarding medication, the adoption of organizers like blister packs proved beneficial for most PLWDs in aiding medication recall. Furthermore,



Figure 3b. Noticeboard and sticky note memory aids

diverse strategies were employed to remember essential items like keys. Some PLWDs relied on consistent routines, leaving keys in designated pockets or containers near the door for a habitual memory aid. Others opted for preventative measures, avoiding the carrying of unnecessary items by leaving them securely at home. Adaptive approaches included tying keys to walkers or pet leashes—items that they usually carry with them.

The pivotal role of family collaboration in dementia care was consistently discussed. Family members actively engaged in supporting PLWDs, undertaking tasks ranging from medication and meal preparation to assistance with dressing and bathing. In larger families with more than one caregiver, collaborative efforts were evident, with members stepping in to address challenges or introduce proactive strategies, such as verbal reminders and leaving the front door open for ease of access.

Memory aids extend beyond mere reminders by fostering a sense of autonomy and independence. Dyads expressed that unlike instructions given by caregivers, memory aids empower individuals to actively engage with reminders and make autonomous decisions regarding task execution. In our exploration of the various memory aids utilized by dyads, we sought to gain insights into the appreciated features of these aids that could be effectively integrated into reminder system technologies, as well as to identify areas for potential improvement.

Calendars: Dyads often use and cross-reference calendars, in both digital and physical formats, to ensure a comprehensive view of scheduled events and tasks. For digital calendars, families can asynchronously update events to a common calendar, which is advantageous because it allows for real-time collaboration and ensures everyone involved stays informed. Writing down information, particularly in a physical calendar (Figure 3a), is noted as enhancing recall. The calendar provides clarity and offers a clear visual representation of events and schedules. Additionally, it allows for ease of customization and writing positive and uplifting messages for the user. The tactile nature of the calendar, with the ability to physically change and interact with it, is appreciated.

Sticky notes and noticeboards: Favorable for their clarity and customization, noticeboards and sticky notes serve as effective memory aids (Figure 3b). Sticky notes are valued for conveying specific and immediate reminders, especially when a caregiver leaves the house. These can include smaller commercial formats or larger papers strategically placed around the home.

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Figure 4. Example of a place where a PLwD may spend time, such as a favourite chair

The larger size of sticky notes may be preferred for their increased visibility. Noticeboards, providing a comprehensive view of a full week or month, offer a broader overview of upcoming events. While the convenience of placing sticky notes in visible locations is considered positive for quick reference, concerns arise about potential confusion when multiple sticky notes are present, leading to potential dismissal or forgetfulness. Caregivers have suggested that typing out sticky notes, as opposed to hand-writing them, may enhance clarity. Recognizing the dynamic nature of dementia, adaptability in the presentation of these memory aids could further improve their effectiveness.

Notepads and lists: Notepads and lists are valued for their simplicity, practicality, and portability. They provide a convenient way to jot down grocery lists, to-do items, and tasks on the go, offering a tangible and organized method for tracking daily activities. Physically crossing off completed tasks can also foster a sense of accomplishment.

Clocks: Clocks are valued for their role in providing a clear representation of time and in some cases, can provide a sense of grounding and awareness. The visual cues provided by clocks contribute to the maintenance of a structured routine, aiding in the timely completion of tasks and appointments. The familiarity of a clock face and its placement in visible locations contribute to the overall usability of this memory aid.

Medication aids: Medication aids, such as pill box organizers and bubble packs, can aid in ensuring a consistent and organized approach to medication management. The use of containers

and bubble pack systems that clearly label the timing for medication intake simplifies the process, reducing the likelihood of missed doses.

Mobile phones and apps: PLwDs and their caregivers find great utility in using mobile phones and their corresponding applications as memory aids. Mobile phones offer portability and convenience, with users noting that they already carry their phones with them regularly. Users can easily customize content to adapt to changing circumstances, such as adjusting font sizes for improved readability. With applications, mobile phones serve multiple functions, including housing calendars and reminder lists, messaging features, and the ability to make calls. The integration of apps like Life360 can also allow for location tracking (Life360, n.d.). However, concerns revolve around the importance of not losing the phone, which can be easily misplaced.

Smart watches: The rising popularity of smart watches presents potential benefits for PLwDs and their caregivers. Smart watches offer features similar to mobile phones, including receiving reminder notifications, such as calendar events, and messages. Their wearable nature makes them a pervasive and less likely-to-be-misplaced memory aid. However, concerns arise about additional costs associated with purchasing and maintaining a smart watch.

Smart home devices (Alexa, Synced Speakers): Smart home devices, including virtual assistants like Alexa and synchronized speakers, contribute to the independence and autonomy of PLwDs. For example, PLwDs find it beneficial to use Alexa for setting timers and receiving responses to general questions. With their wide functionalities, these devices can create a pleasant and efficient living environment. However, some dyads expressed concerns related to aesthetics, preferring less robotic appearances.

Types of reminders

PLwDs often require a diverse array of reminders to navigate their daily lives effectively, and the types of reminders needed vary immensely based on the severity of dementia. In the early stages, those with mild dementia may benefit from reminders related to daily schedules, appointments, grocery lists, and to-do lists. As dementia progresses to moderate stages, the need for reminders expands to encompass more aspects of daily life. Key types of reminders encompass daily schedules and activities, including mealtimes and activities of daily living. Medication reminders, facilitated by tools like blister packs, ensure a consistent and organized approach to health management. Appointment reminders, including doctor visits and sched-

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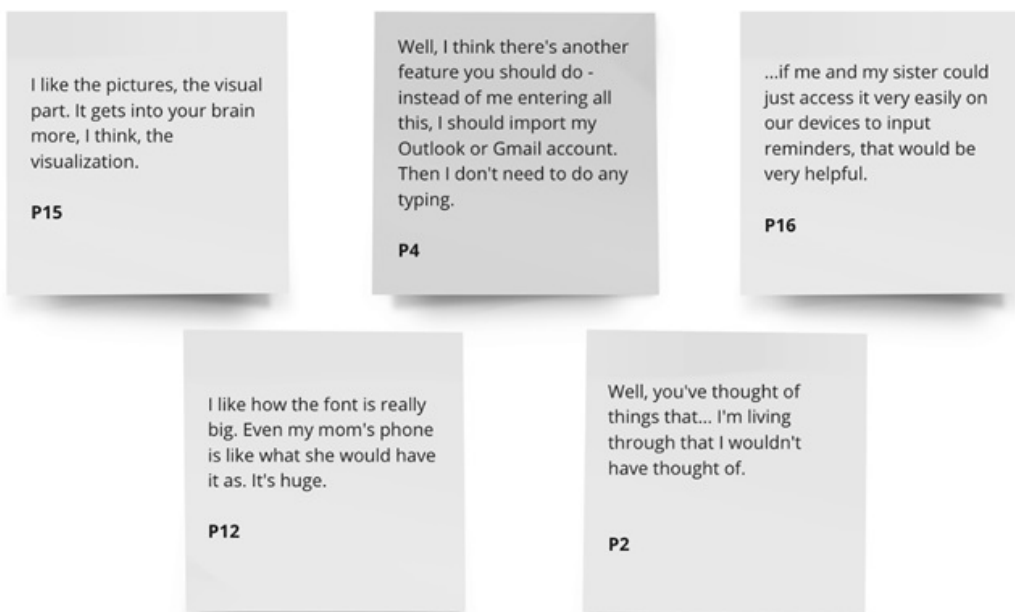


Figure 5. Excerpts of feedback received from the prototype demonstration

uled meetings, play a crucial role in maintaining a structured routine. Memory aids extend to self-care and personal hygiene routines, with prompts for activities like bathing and changing clothes. Nighttime reminders may include shutting off electronic devices and attending to specific tasks, such as letting pets back in the house. Additionally, engagement in social activities, such as square dancing, instrument lessons, and bridge, benefits from reminders. The adaptive nature of reminders reflects the dynamic challenges associated with dementia, highlighting the importance of flexible and personalized memory aids.

Preferences and opportunities for reminder system development

Exploring preferences and opportunities for reminder system development includes user interactions, optimal locations for placing reminder units, and key features, providing crucial insights for crafting a user-friendly and tailored solution.

Methods of system interaction

During the interview, participants were initially asked to examine how PLwDs would like to interact with reminder units in their homes, i.e., user-initiated interaction with the system, considering options like voice command (such as verbal cues to accept a reminder), touch command (such as interacting with the button on a touchscreen), and gestural command (such as waving at a screen) for acknowledging reminders. They were then prompted to reflect on how they would like reminder units to notify or alert PLwDs about reminders, i.e., system-initiated in-

teraction with the user. Methods included audio prompts (such as music, notification sounds, or reading reminders aloud) or visual prompts (flashing lights).

User-initiated interaction with the system: The overall results suggest a diversity of preferences. While voice command was generally favored for its straightforward nature, concerns were raised about the clarity of verbal cues, particularly for noisy backgrounds, individuals with hearing difficulties, or lower voice volumes. Touch command, particularly on larger and simpler interfaces, was deemed the most convenient, but the feasibility of touch interaction varied based on personal preferences, severity of dementia, and cognitive abilities. Gestural commands were considered, especially for individuals with mobility challenges who may prefer to interact with the system from a distance. However, this was the least popular among the choices due to concerns related to practicality, physical limitations, and the potential for confusion. Therefore, the importance lies in the customization and adaptability of reminder systems, with an emphasis on intuitive designs that require minimal cognitive effort. Participants highlighted the need for clear and straightforward interfaces, accommodating the specific needs and capabilities of PLwDs, and ensuring the usability and accessibility of reminder units in various home environments.

System-initiated interaction with the user: Most participants preferred audio prompts because they found them effective and easy to use, especially those who preferred auditory cues.

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Table 2. Preferred reminder system features and justifications

Reminder system features	Preference justification
Simplicity and ease of use	New technology can be complex and discouraging, users prefer simple interfaces.
Familiarity	Participants appreciate features that seamlessly align with existing habits.
Date and time display	Seen as grounding elements and participants appreciated additional features like weather updates or positive messages.
Customization	Each person has unique preferences. Examples of customization options discussed include uploading personal photos or videos for reminders, changing fonts and font sizes, and changing system colours and interface sizes.
Cost	Participants acknowledged potential higher initial costs for new technology and expressed a willingness to pay within reasonable limits.
Call/Help button	Promotes safety and accessibility.
Ability to add reminders	People living with mild dementia prefer to add and manage their own reminders, whereas people living with moderate dementia may require their caregivers to manage reminders.
Integration with existing devices	Facilitates the convenient sending of reminders from mobile devices, such as mobile phones and/or smart watches.
Integration with existing digital calendars	Allows for easier integration and sharing with family members.
Direct visual and auditory cues	In some cases, including the PLwD's name and the word 'reminder' on the reminder display screen for more direct prompting was indicated as being useful and less confusing to the PLwD. For example, "This is a reminder: Emily, you have a doctor's appointment at 10 am."

Some participants emphasized the importance of having a unique and recognizable sound or tone to grab attention, such as their favourite song. Additionally, participants appreciated that audio prompts allowed PLwDs to hear reminders even if they were farther away from a reminder unit or not facing it. Combining audio with visual prompts was also suggested, providing a multi-sensory approach to ensure that reminders were noticed. The idea of repeating reminders, either through multiple auditory cues or a combination of visual and audio prompts, was highlighted as beneficial, particularly for individuals who might need reinforcement due to memory challenges. Overall, participants favored a flexible and customizable approach, allowing users to personalize the reminder system to meet their specific needs, whether through the selection of tones, music, or the frequency of prompts.

Locations of reminder units

Participants identified key locations in their homes where reminder units would be most useful. The most preferred locations were consistently the kitchen, bedroom, and living room. Participants stressed the importance of placing reminder units on frequently used furniture, such as desks, tables, and favourite chairs (Figure 4), or mounted on walls at eye level.

The kitchen emerged as a focal point for reminder units, with participants emphasizing its significance due to the high level of activity and time spent in this area. The bedroom was also commonly mentioned, specifically beside the bed or on the wall adjacent to it. The living room or den was recognized as a logical choice, especially for those who spend a significant amount of time

engaged in various activities, such as watching TV or reading. Some participants viewed the bathroom as a location where reminders might be unnecessary due to the presence of caregivers or constant supervision during activities, though this perspective was not universally shared. Personal preferences and daily routines played a crucial role in determining the need for reminder locations. What works for one person may not apply to another, emphasizing the importance of personalized solutions in designing reminder systems. Caregiver presence, cognitive abilities, and daily habits were key factors influencing the choice of locations for memory aids.

Important features

Table 2 summarizes important features valued by participants for an effective reminder system, in order of their frequency of preference among dyads. The insights presented highlight user preferences, offering a reference for designing reminder systems that cater to diverse needs.

Prototype demonstration feedback

The feedback from the prototype demonstration was positive overall, emphasizing the reminder system's potential to alleviate caregiver responsibilities and enhance the daily life of PLwDs, with participants perceiving it as promising for enhancing their autonomy and independence. Participants appreciated the user-friendly interface, particularly highlighting the main reminder screen and reminder grid overview. They expressed a preference for integration with existing tools like Outlook and Gmail calendars. Some recommendations included simplifying the reminder creation process by including only the reminder content and timing of reminder delivery,

as well as providing generic or pre-set images for reminders. The participants envisioned broader applications for the system, suggesting its potential benefits for healthy older adults or children with developmental disabilities. Excerpts of feedback received from the initial prototype demonstration are included in *Figure 5*.

DISCUSSION

The participants' insights shed light on the system's usability, its potential impact on caregiver responsibilities, and the importance of integration with existing routines and tools. In this section, we delve into the implications, significance, and user feedback stemming from the interview sessions and demonstration of a prototype reminder system for PLwDs and their caregivers.

Preliminary insights on a reminder system prototype

In evaluating the usability and user experience of our prototype reminder system, participants provided valuable insights based on demonstrations rather than direct usage. The feedback not only highlights positive aspects that garnered appreciation but also delves into specific features that resonated with the users. By examining their experiences, we gain a nuanced understanding of how the prototype aligns with user expectations and needs. This is instrumental in refining the design and functionality of the system to ensure a seamless and user-friendly interaction for PLwDs and their caregivers.

Variations in preferences among dyads

As we explore the user experience and acceptance of assistive memory technologies, it becomes evident that these perceptions are deeply influenced by demographic variations among dyads. Noteworthy trends emerge in relation to factors such as the severity of dementia, age, household income, and living situation. It is crucial to recognize that the nuanced preferences of individuals experiencing mild dementia, along with their caregivers, can significantly differ from those in the moderate dementia stage. Those with mild dementia often express a desire to create and manage their own reminders, have infrequent notifications for specific activities, and prefer subtle alerts. In contrast, individuals with moderate dementia may benefit more from reminders created by their caregivers, frequent notifications across diverse activities, and more loud and obvious alerts.

Age-related disparities also surface, with older individuals often exhibiting hesitancy towards new technologies compared to their younger counterparts, who see the value of integrating novel technologies with existing technologies. Economic considerations come into play as well,

with concerns about the cost of deploying multiple reminder units in homes with lower incomes potentially impeding enthusiasm for technology adoption. Lastly, the living situation of dyads is a pivotal factor; dyads with younger caregivers may exhibit a more receptive stance towards new technologies, benefitting from the caregiver's familiarity and ability to guide the PLwD through the learning process. Conversely, those living with dementia who reside alone may encounter heightened challenges in navigating new technology independently.

Impact on caregiver responsibilities

Caregivers face challenges in maintaining consistent use of traditional memory aids, such as sticky notes, due to the demanding nature of their responsibilities and fast-paced lifestyles. These challenges highlight the need to explore the impact of assistive memory technologies on caregiving. Caregivers actively seek innovative solutions to ease their responsibilities and enhance the well-being of PLwDs. This openness reflects their recognition of technology's potential to improve the caregiving experience and overall quality of life. The introduction of technological aids, like assistive memory technologies, signals a shift from constant supervision to targeted and timely assistance, including the capability to provide remote care. This change allows caregivers to focus on emotional support and address complex needs, fostering a more balanced and sustainable caregiving environment, while also affording caregivers more time to attend to their own well-being.

Limitations and future directions

While this study offers valuable insights into the preferences and challenges associated with assistive memory technologies for PLwDs and their caregivers, it is essential to acknowledge certain limitations. Firstly, the sample size does not fully capture the diverse spectrum of experiences and preferences within this population. Additionally, the study primarily focuses on participants in a home setting, where a family caregiver is often present, and the applicability of these findings to different care environments should be considered.

Future research could explore the impact of assistive memory technologies in varied caregiving contexts, such as assisted living facilities or memory care units. Further exploration into the long-term effectiveness and user satisfaction with assistive memory technologies, such as through long-term usability testing with dyads, would enhance our understanding of their sustained impact on the daily lives of both PLwDs and their caregivers. These insights would enable us to improve the prototype as necessary.

CONCLUSION

By understanding the nuanced needs, values, attitudes, and challenges of PLWDs and their caregivers, assistive memory technologies have the potential to enhance autonomy, alleviate caregiver responsibilities, and foster a more balanced caregiving environment. However, to fully realize their potential, ongoing collaboration and innovation are crucial. Future endeavors should

focus on refining these technologies through user-centered design and long-term usability testing, ensuring they effectively support the diverse needs of PLWDs and their caregivers. Through concerted efforts, we can pave the way for a more compassionate and empowering approach to dementia care, ultimately improving the quality of life for those affected by this condition.

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Statement of ethics

This study protocol was reviewed and approved by the University of Toronto Research Ethics Board, approval number 00044727. Written consent was obtained from all participants prior to participating in this study.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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Author contributions

AS (Co-Author): Facilitated all interviews, performed qualitative data analysis, and translated data into meaningful results.

JL (Co-Author): Facilitated interviews, transcribed interviews, and performed qualitative data analysis.

BY (Co-Author) - Provided expert guidance, facilitated outreach efforts, and contributed to manuscript review and editing.

AM (Co-Author): Led the direction of the research, provided expert guidance, and facilitated outreach efforts.

Data availability statement

The data for this study is not publicly available due to privacy and ethical considerations. Given the sensitive nature of the information gathered from participants, sharing the raw data could compromise the confidentiality and privacy of the individuals involved.

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