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A User-Friendly Robot System for Older Adults with Dementia

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Abstract. Technology adoption has become essential in the digital age as the global population ages. However, many older adults face significant challenges when interacting with digital devices due to small font sizes, poor colour contrast, and limited technological literacy. For individuals with dementia, these challenges are compounded by cognitive decline, memory loss, and impaired reasoning, which can hinder their ability to adapt to new technologies, ultimately affecting their independence and quality of life. There is a pressing need to develop user-friendly systems specifically tailored for older adults with dementia, emphasizing intuitive design and accessibility. Current technologies often fail to meet the unique needs of this population, highlighting the necessity for improved design strategies. To this end, we design and develop a simple, straightforward, and accessible system to train cognitive memory for older adults with dementia.

Keywords: Older Adults, User Interface, Motivation, Self-Determination Theory, System Usability.

1. Introduction and Background

The increasing utilization of technology has become a pressing necessity in the digital age [15]. As the global population ages, many older adults face challenges when interacting with digital devices. The barriers can arise from small font sizes, poor colour contrast, weak motor control, and a lack of technological literacy [24, 26]. Dementia is characterized by a group of symptoms, such as cognitive decline, memory loss, and impaired reasoning [6, 17]. It poses significant disadvantages to older adults with dementia, making it difficult to adapt to new technology [1, 19].

1.1 Self-Determination Theory in Aging and Technology

The Self-Determination Theory (SDT) highlights autonomy, competence, and relatedness as fundamental drivers of intrinsic motivation [8]. This framework has been widely applied in the context of ageing and technology [3–5, 11, 27]. Research indicates that enhancing motivation and satisfaction among older adults can cultivate a sense of autonomy in technology use, particularly for those facing cognitive challenges. For instance, Silvia et al. [7] demonstrated that integrating technology into language learning improves linguistic literacy and digital inclusion and enhances emotional and cognitive well-being.

Similarly, SDT has been employed in digital interventions, such as memory aids, where fostering relatedness through social features can help alleviate feelings of isolation among ageing populations. Moyle et al. [14] found that video conferencing effectively fosters relatedness by allowing older adults to connect with friends and family, thereby alleviating loneliness. However, older adults rely on staff assistance to make calls due to age-related cognitive decline. As a result, the technology creates barriers to autonomy (inability to initiate the call independently) and competence (lack of technical familiarity) [22]. The situation emphasizes the need for simplified interfaces.

1.2 Interface Design for Older Adults with Dementia

The adoption of tablets by older adults, particularly those with dementia, poses significant challenges but also offers considerable opportunities. Traditional interfaces often impede usability due to cognitive decline and motor impairments, highlighting the need for user-friendly applications that simplify navigation and enhance accessibility [25]. Existing usability framework, such as the System Usability Scale (SUS) [2], have been utilized to evaluate the effectiveness of technologies designed for this demographic. Research shows that older adults with dementia often struggle with complex interfaces. Orpwood et al. [16] conducted a survey to identify effective design approaches for people with dementia, emphasizing the importance of appearance, verbal prompts, and user monitoring.

Given these challenges, it is essential to prioritize designing and developing user-friendly systems explicitly tailored for older adults with dementia [18]. The system designs are required to consider the unique needs of those with dementia, ensuring intuition and accessibility [12].

While existing frameworks effectively assess usability and integrating SDT in designing a straightforward, inclusive, tailored, and accessible system in Cantonese for older adults with dementia remain underexplored. Consequently, we have developed our system through a rigorous process that included formative and user studies supported by SDT. The objectives are to (1) explore the specific user needs of older adults with dementia in their interactions with our system, and (2) prioritize the design of our system to enhance engagement and motivation while ensuring usability.

2. Methodology

This section discusses demographics, formative study and system design.

2.1 Participant

Nine older adults with dementia (1 male and 8 females) (El to E9) aged from 69 to 97 from the same elderly centre (¯ = 86.74-year-old, =9.02) participated in the study, including formative, formal and user studies. The inclusion criteria for older adults to join the study were: (1) able to communicate with Cantonese; (2) being diagnosed with dementia; (3) having no other physical disabilities that might affect their interaction with the tablets; and (4) having experience using digital devices, such as tablets. Before experimenting, informed consent was obtained from the guardians of the older adults. Participation was entirely voluntary and contingent upon their consent. The experimental protocol received approval from the University Institutional Review Board (IRB). Participants did not receive any form of remuneration.

2.2 Formative Study

To better understand the unique needs of older adults with dementia, we conducted a formative study to understand their user requirements for interacting with the digital system.

Methods. The formative study consisted of a survey and an interview to understand the preferences of older adults with dementia and encouragement in interacting with digital systems. The study began with a survey to gain a broad understanding of older adults' preferences, engagement levels, and feedback mechanisms. This information will inform the design of a more effective and user-friendly system tailored to their needs. To deepen our understanding of the needs and challenges of the older adults, we conducted individual interviews with them. We distilled the interview questions based on the survey results. We derived the design requirements based on the interview feedback.

Formative Study (Survey)

1. What type of instructional format do you find most helpful when learning new information?
2. How do you prefer to engage with questions during practice sessions?

3. How many times do you typically need to see or listen to questions before you feel you understand the content?
4. When answering questions, how do you prefer to manage your time?
5. After completing a question, how important is it for you to receive encouragement?
6. What type of encouragement do you prefer after completing a question?

Formative Study (Interview)

1. When logging into the game, which login screen design do you prefer, and why?
2. On the score display page, which design do you prefer, and why?

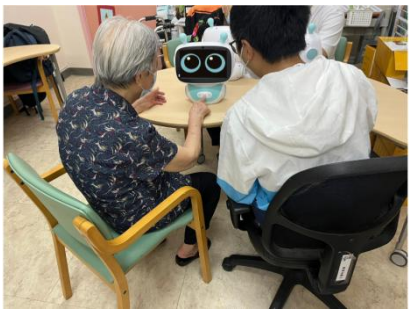

Fig. 1. An older adult was conducting the formative in the elderly center.

3. Between these two game pages, which design do you prefer, and why?
4. Between these two recording game pages, which design do you like, and why?
5. Between these two recording game pages, which design for displaying "Recording" do you prefer, and why?
6. Between these two dictation game pages, which design for displaying "Dictation" do you prefer, and why?

Survey Results. Most participants favoured text instructions over graphic instructions, indicating that written guidance is perceived as clearer and more effective. Additionally, many respondents preferred to read the questions themselves rather than having them read aloud, reflecting a desire for autonomy in their learning process. Responses regarding the need for repetition varied. Some participants often required multiple exposures to questions to fully understand the content, while others stated they could comprehend after a single exposure. Participants expressed a preference for controlling the time they took to answer questions. However, some were open to adhering to predetermined time limits, highlighting a need for flexibility in the response process. Furthermore, many participants indicated a desire for encouragement after completing questions, emphasizing the role of positive reinforcement in their learning experience. When asked about the type of encouragement, there was a strong preference for verbal praise, with some respondents also expressing interest in animated encouragement, such as positive animation.

Interview Results. The interviews were held for an hour face-to-face in the elderly centre. We asked the older adults different questions to explore their needs and desires when interacting with digital systems. The first author transcribed all content and conducted a thematic analysis with other authors. The first author conducted the initial coding to generate preliminary codes. Following this, three rounds of discussions were held to group and refine these codes, ensuring a thorough understanding of the feedback received. Based on the insights gathered from the interviews, we have distilled the following design requirements (DRs) for developing user-friendly systems tailored to older adults. DR1: Provide Flexible Question Presentation Options. DR2: Allow Control Over Response Time. DR3: Incorporate Varied Encouragement Methods. DR4: Offer Multiple Feedback Display Formats.

2.3 System Design

This section introduces the system design and details for older adults with dementia. We co-designed the system with two rounds of iterations. In each iteration, we collaborated with older adults with dementia through the following process. First, we obtained participants' consent to mark down the co-design process. Next, we thoroughly elaborated on the study scope, design objectives, and functionalities to ensure that participants understood how to interact with the system. Following this, we asked the participants to freely explore the system for 30 minutes, during which time they could modify the design. After that, we conducted a user study and allowed participants to utilize the system for four weeks (i.e., one hour per week) with pre-/post-questionnaires with SDT.

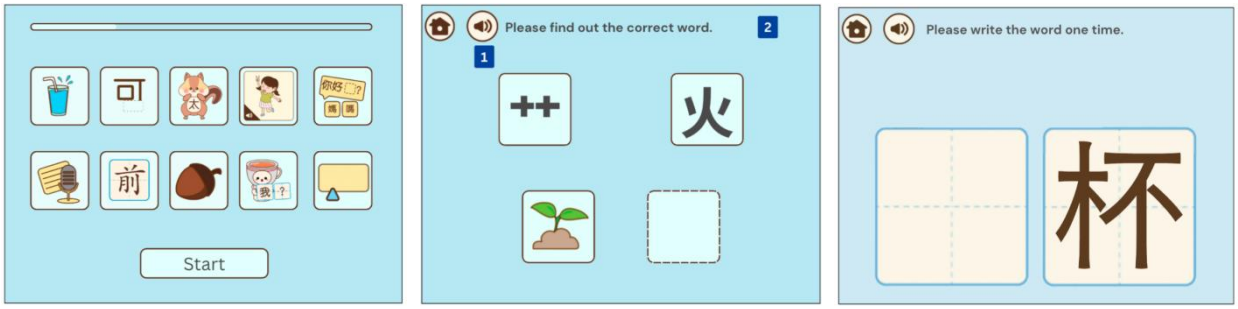

Fig. 2. Overview of our system design

3. Discussion

Older adults are willing to accept new technologies, such as tablets and mobiles. However, they find these devices are not user-friendly, especially for older people with poor eyesight and weak motor skills. Simple and easy-to-use systems can increase older adults' confidence when using them, which aligns with the research of Iancu and Iancu [10]. They mentioned that technology is often viewed as challenging to use, even by younger seniors who have owned smart devices for years, highlighting the need for simplicity and consistency in design and functions to enhance self-trust and usability.According to Verloo et. al. [20], technologies used by older adults do not necessarily require significant innovations. Instead, they should be tailored and adapted to meet their specific needs.

Use of Colour. According to Liu and Wang [13], older adults want warm, high-brightness colours and are generally aversion to low-brightness and certain cool-toned colours. In Chinese culture, red symbolizes auspiciousness and joy, leading many Chinese individuals to incorporate red elements into their designs [23]. In this study, older adults with dementia preferred bright colours, favouring red or white-red over the system's original background colour.

Use of Font. Regarding font size design within the system, older adults with dementia preferred larger font sizes in this study. Many older adults experience a decline in visual acuity, making eye-catching fonts and clear instructions essential for better visibility [22]. Therefore, it is important to enlarge the font size in the system design without compromising usability, ensuring it is suitable for older adult.

3.1 Limitation

The results indicated that our system positively impacted the usability of cognitive training. However, we found some limitations, including the small sample size of nine participants, with only one male participant. Future recruitment will aim for a larger and more balanced gender ratio. Additionally, we plan to include typical older adults in the study. As the older population grows, an

impulsive and accessible user interface design can enhance their technical literacy and digital communication.

4. Conclusion and Future Works

This study offers several key contributions to multimodal interaction and user-centered design. First, we provide empirical insights into the user needs of older adults with dementia, drawn from qualitative feedback and quantitative data collected during user studies. Second, we present design recommendations for user-friendly tablet systems, emphasizing design features to enhance inclusivity. Third, we deliver evidence from SDT-based pre-/post-tests, demonstrating how tailored technology can improve motivation, engagement and usability for this underserved population. These findings advance the understanding of technology adoption in dementia care, offering practical guidance for developers and researchers aiming to create inclusive digital solutions that improve quality of life.

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