

Healthcare Application Design for Older Adults:

The Effects of Demonstration and Split Persona*

Jeongwoo Lee Sungkyunkwan University, M.S.
Doha Kim Sungkyunkwan University, Postdoctoral Researcher
S. Shyam Sundar Sungkyunkwan University/Penn State University, Professor
Jinyoung Han Sungkyunkwan University, Associate Professor
Hayeon Song** Sungkyunkwan University, Professor

This study investigates instructional methods to support older adults in independently using digital healthcare applications for dementia prevention. Grounded in social cognitive theory, the research evaluates the effects of virtual agent demonstrations and “split persona” roles. By employing a 2 (demonstration: demonstration vs. no demonstration) x 2 (split persona: one vs. two) between-subjects design, the study examines the effects on elderly participants’ task comprehension and their attitudes towards agents and the application. Results reveal that agent-led demonstrations significantly enhance both perceived and actual task performance, improve ease of use, and increase the perceived anthropomorphism of agents. In contrast, while employing multiple agents (split persona) reduced perceived difficulty, it did not significantly improve performance or user attitudes, potentially due to increased cognitive load. These findings suggest that intuitive, demonstration-based guidance is essential for overcoming digital literacy barriers among the elderly. The research underscores the importance of user-centric design in digital therapeutics, concluding that virtual agents effectively substitute human assistance when roles are carefully managed to optimize cognitive engagement and independence in aging populations.

Key words : digital healthcare, demonstration, virtual agent, split persona, older adults

* This research was supported by the MSIT(Ministry of Science, ICT), Korea, under the Global Scholars. Invitation Program (RS-2024-00459638) supervised by the IITP(Institute for Information & Communications Technology Planning & Evaluation)

** songhy@skku.edu, Corresponding author

1. Introduction

The rapid increase in the global aging population has highlighted the need for effective health management of chronic conditions such as dementia and cognitive decline. In 2021, an estimated 57 million people worldwide were living with dementia, and nearly 10 million new cases occur every year, highlighting the rapidly growing global burden of the disease (World Health Organization, 2023). The progressive nature of dementia and cognitive decline highlights the importance of prevention and early intervention, as these conditions seldom lead to full recovery once diagnosed (Rockwood et al., 2003).

In recent years, digital therapeutics (DTx) and digital based wellness programs have emerged as innovative tools in managing cognitive abilities, making a direct contribution to treatment and diagnosis. These digital solutions are increasingly being validated through research and enable the design and implementation of dementia prevention measures without direct guidance from professionals. Additionally, by providing cognitive training and support through personal devices, they make health care interventions more accessible and user-friendly (Murray et al., 2016). In Korea, the adoption of digital therapeutics has also begun to accelerate, supported by regulatory advancements and increasing interest in digital-health applications. The approval of the nation's first DTx device by the Ministry of Food and Drug Safety in 2023 signaled a significant step toward the formal integration of digital therapeutics into the healthcare system. This momentum reflects broader developments in the Korean digital-health landscape, where clinical interest, technological innovation, and policy support continue to grow (Shin et al., 2024; Yoon & Kim, 2023).

As aging remains the primary cause of chronic diseases such as cognitive decline and dementia, it is anticipated that the elderly will become the principal users of these digital programs. While cognitive training through digital devices is a promising strategy for the elderly, it is crucial to recognize that not all older adults possess the digital literacy necessary to utilize these tools effectively. Many elderly individuals face challenges using digital tools, which can act as barriers to adopting and applying digital health technologies (Alvseike & Brønneck, 2012; Niehaves & Plattfaut, 2014). As a result, it is recommended that digital

healthcare program designs consider the difficulties experienced by users who are not digitally savvy (Dyer et al., 2013; Nunes et al., 2015).

Addressing this digital divide requires a shift in focus from merely providing cognitive training to enhancing the elderly's ability to understand and independently use these digital applications. Most digital-based health apps rely predominantly on verbal explanations to instruct users to provide users with directions for complex tasks. This mode of communication can be particularly challenging for older people unfamiliar with digital methods, necessitating a more intuitive and effective approach to instruction. In this context, demonstrations can be an exceptionally effective method. A demonstration refers to the act of showing exactly how a task or technique should be performed. This approach aligns closely with concepts such as modeling or observational learning. Albert Bandura's (1986) social cognitive theory posits that modeling is a highly natural method of human learning and individuals learn efficiently by observing the actions of others and their outcomes. This method proves particularly beneficial for elderly users; seeing successful demonstrations increases their likelihood of effectively mimicking the behaviors they have observed. Supporting research suggests that demonstrating how tasks should be performed is a more effective method than simply providing text instructions alone (Martinengo et al., 2022). By focusing on practical demonstrations, this approach can enhance the accessibility and user-friendliness of digital health applications for the elderly, thus improving their engagement and skill in using these vital technological tools.

Additionally, Virtual agents explored as a solution to assist the elderly in digital healthcare. Virtual agents are entities based on computers or machines, designed for effective human interaction. These software programs employ scripted rules and are increasingly utilizing artificial intelligence to offer services or support to individuals. Existing research supports the positive impact of agents on user motivation and task performance improvement (Beinema et al., 2021; Martínez-Miranda et al., 2014; Sebastian & Richards, 2017). Studies involving the cognitively impaired elderly have shown that agents can provide learning effects comparable to human therapists, indicating that agents can effectively substitute for human interaction when designed correctly. For agents to be fully effective, users must feel a sense of intimacy and enjoyment in the interaction, particularly when conveying essential health information

(Gulec, Kvardova & Smahel, 2022). Trust in the information provider is crucial for accepting and adhering to the information provided. Research indicates that agents designed to reflect characteristics such as trust, intimacy, and enjoyment require diverse designs, and agents that combine all these traits into one persona may confuse users, reducing the agent's effectiveness (Baylor & Ebberts, 2003; Baylor & Kim, 2005; Kim & Baylor, 2016). The ability of these agents to stand in for human assistance can be particularly beneficial in supporting elderly individuals who often require consistent help when using digital health applications, ensuring that they can use these apps with greater independence and confidence.

In technology-mediated training, demonstration and peer learning are widely used to help learners understand and retain complex procedures. When a learner can watch an instructor together with a peer-like learner who attempts the task, makes mistakes, and receives feedback, the training process may become more concrete, relatable, and motivating. Building on this idea, the present study focuses on two instructional approaches: demonstration, in which users are shown step by step how to perform the activities, and split persona, in which a teacher-like agent and a peer-like agent share instructional and supportive roles so that the peer-like agent acts as a learner model while the teacher-like agent provides structure and corrective feedback. These features are particularly relevant for older adults, including those at risk of or living with dementia, who often experience working-memory limitations and difficulties processing complex verbal instructions. For such users, visually guided demonstration can reduce cognitive burden by presenting clear and concrete examples, and dividing instructional and supportive functions across two agents may help clarify guidance and reduce confusion when engaging with digital cognitive-health applications.

This research paper aims to enable older adults to engage with digital-based healthcare apps effectively and independently. It focuses on exploring methods of instruction delivery, with a particular emphasis on aiding older individuals in performing dementia prevention activities through digital apps. The study investigates whether employing agents with distinct therapeutic and peer roles, alongside demonstration-based instructions, improves the ease of app usage for the elderly, thereby enhancing their ability to independently understand and complete tasks. Through this, it introduces a user-centric approach that emphasizes ease of

use and clarity within digital health applications tailored for older people.

2. Literature review

1) Virtual Agents in Healthcare

Virtual agents serve as an effective substitute approach for delivering patient care and supporting healthcare workers. These agents, constantly accessible on users' mobile devices, offer a range of health services at minimal cost, marking a significant transformation in the healthcare sector. Ranging from basic chatbots to advanced Embodied Conversational Agents (ECAs), these agents have revolutionized various aspects of healthcare, including patient education, therapeutic intervention, and support in mental health (Beinema et al., 2021; Kramer et al., 2020; Martinengo et al., 2022; Martínez-Miranda et al., 2014; Sebastian & Richards, 2017). Their role extends beyond traditional care, offering innovative solutions in mental health and elderly care.

In mental health, virtual agents have become an indispensable tool in delivering cognitive behavioral therapy and other therapeutic interventions. For instance, platforms like Woebot represent a novel approach in managing anxiety and depression, where mood monitoring and empathetic interactions play a crucial role (Fitzpatrick et al., 2017). Research has also shown the effectiveness of protocol-driven relational agents in alleviating mental stress and enhancing emotional well-being in hospital environments (Bott et al., 2019). Furthermore, the use of text-based conversational agents, exemplified by MYLO, has been recognized for its contribution to cognitive therapy and mental health support (Gaffney et al., 2020).

In elderly care, virtual agents have demonstrated significant value in enhancing treatment outcomes, particularly by improving the quality of life for older adults through social and emotional support. A significant example is a study where a virtual agent assisted people with dementia, including those with Mild Cognitive Impairment and Alzheimer's, in cognitive training using games. Despite facing challenges such as limited acceptance of new technology

and the impact of memory disorders, the agent enabled these adults to achieve performance levels akin to those under therapist supervision (Tran et al., 2016). This aligns with the findings of Bickmore and Schulman (2006) on agents like Laura, which underscore the positive impact of empathetic interactions in elderly care. Furthermore, these agents' potential in facilitating remote healthcare delivery, particularly in building rapport and aiding in disease management, has been recognized, adding another layer to their significance in elderly care (Kabir et al., 2019).

Building on this work, more studies have examined how virtual agents can be designed to support the specific needs of people with dementia. For example, De Jong et al. (2018) identified user requirements for virtual agents that assist individuals with dementia and their caregivers, emphasizing personalization, cognitive accessibility, and familiarity in agent design. Boumans et al. (2024) further explored a voice-enabled intelligent virtual agent developed for people with memory impairments, showing that users valued simple conversational structures, supportive prompts, and emotionally warm responses-features that contribute to greater usability and acceptance among individuals experiencing cognitive decline. Khot et al. (2025) also examined how chatbot-based agents can help older adults reflect on aging and dementia-related concerns, suggesting design approaches that support emotional processing and future planning. These studies point to diverse ways in which virtual agents are being adapted for dementia care, indicating a need for continued research on how such agents can be further optimized to meet the cognitive and emotional needs of this population.

The design of virtual agents plays a crucial role in determining their effectiveness and user acceptance. Users' tendency to ascribe human-like qualities to these agents significantly influences their interactions with them (Reeves & Nass, 1996). Anthropomorphism, the attribution of human-like intentions, emotions, or social capacities to nonhuman entities, is central to understanding these responses and is conceptually distinct from realism, which refers only to the visual or behavioral fidelity of an agent (Epley et al., 2007; Waytz et al., 2010). While realism concerns how lifelike an agent appears, anthropomorphism reflects users' psychological interpretation of the agent as possessing human-like mental states-an important factor influencing trust, social presence, and engagement. Therefore, designing agents with

well-matched personas is essential for effective user engagement. In addition, studies have highlighted the importance of nonverbal communication elements, such as gestures and eye contact, in enhancing trust and rapport, particularly in mental health settings (Lucas et al., 2017). While virtual agents have shown great promise in improving patient outcomes in mental health and elderly care, further research is needed to optimize their effectiveness. Future studies should focus on the characteristics, roles, and design of these agents.

2) Modeling for older adults

Modeling, often colloquially termed as demonstration, refers to the learning process where individuals observe and imitate the behaviors of others (Bandura, 1986). This concept is a central element of social cognitive theory. Particularly relevant for older adults who may face unique challenges in adapting to new technologies, modeling provides an intuitive way of learning through demonstration and emulation. Studies show that this approach can significantly aid older adults in overcoming barriers to technology use, making it a valuable tool in technology training for this demographic (Ma, Chan, & Teh, 2020; Struve & Wandke, 2009)

One pivotal aspect of modeling in educational contexts for older adults is the use of video-based modeling. Gagliano (1988) and Meade (1996) highlight the benefits of video presentations in patient education, emphasizing their role in improving short-term knowledge acquisition and modeling behaviors. These findings are echoed in studies focusing on older adults, where video modeling, often involving peers or age-appropriate models, proves effective in increasing self-efficacy and reducing anxiety around technology use (Gist, Rosen, & Schwoerer, 1988; Struve & Wandke, 2009). This suggests that older adults benefit from observing behaviors and skills relevant to their experiences, thereby enhancing their engagement and learning outcomes. While behavior modeling using human models remains popular, there has been increasing research on modeling using virtual agents. Virtual agents present another innovative approach to modeling for older adults. These agents, as described by Bertrand et al. (2010) and Bickmore, Pfeifer, & Jack (2009), can simulate complex tasks

and provide empathic, interactive learning experiences. Such agents are not only cost-effective but also add an engaging, interactive element to the learning process, which is crucial for older adults who may require more motivation and engagement in digital environments.

Although modeling has been extensively studied, research that focuses specifically on demonstrations delivered by virtual agents remains limited, particularly in older populations. In digital health and aging research, recent work has begun to examine embodied or conversational agents acting as step-by-step guides or virtual coaches. These agents have shown potential in improving usability, perceived support, and engagement among older adults who manage daily routines or health-related activities, even when task-performance outcomes were not directly assessed (Justo et al., 2020; McTear et al., 2023). This emerging work suggests growing interest in agent-led guidance for aging users, but empirical evidence on how virtual-agent demonstrations shape older adults' comprehension and task performance remains relatively sparse. These observations highlight the need for examining how demonstrations provided by virtual agents operate within digital-health contexts for older adults.

In addition to supporting task comprehension, demonstrations may also influence how older adults perceive both the agent and the application delivering the instruction. Observing an agent perform purposeful actions can function as a social cue, increasing perceptions of human-likeness and contributing to a more personal or relatable interaction experience (Reeves & Nass, 1996). Demonstrations may also reduce ambiguity and clarify system operations, factors known to shape older adults' perceptions of clarity, effort, and ease of use when using digital technologies (Czaja et al., 2006; Mitzner et al., 2010). When a demonstration is delivered by a teacher-like model together with a peer-like learner who practices the task, makes mistakes, and receives feedback, older adults can simultaneously see a correct example and a fallible, peer-like learner being guided, which may create a synergistic effect on both task understanding and social perceptions of the agents. This configuration is consistent with peer learning research showing that observing a similar other being coached by an expert can enhance motivation and self-efficacy through vicarious experience (Topping & Ehly, 2001). In settings involving more than one agent, observing how a teacher agent and a peer agent

coordinate, respond to one another, or provide complementary information may further shape impressions of the peer agent, including perceptions of helpfulness, social presence, and a sense of closeness. From this perspective, the present study examines whether the presence of demonstration in a two-agent setting is associated with more positive attitudes toward the peer agent.

Furthermore, the identity of the model plays a crucial role in the effectiveness of learning. Individuals who exhibit behaviors that are imitated by others are known as models. Aligned with social cognitive theory (Bandura, 2001), which emphasizes the importance of similarity between the model and the learner in educational settings, research indicates that older adults often prefer learning from peers or age-similar individuals. This preference is underpinned by the similarity attraction hypothesis, suggesting that individuals are more drawn to and engaged with social models sharing similar characteristics and attributes (Berscheid & Walster, 1969). Also, older adults find these age-similar models more relatable and credible (Lin et al., 2013; Woodward et al., 2013). This preference is supported by the findings of Mitzner et al. (2008), who note that older adults exhibit more positive training outcomes when instructed by peers or familiar figures.

Research in modeling for the elderly has demonstrated that it plays a crucial role in actively engaging them in learning and achieving positive educational outcomes. Leveraging this understanding, this study seeks to investigate the impact of modeling on older adults within the context of digital healthcare, which often involves complex activities. Unlike traditional approaches that utilize human models, this research aims to employ agent models. Additionally, the study explores the potential of an agent, designed to be relatable and empathetic, acting as a model. This involves assessing whether such an agent can enhance the perception of being accompanied by a friendly peer during activities. An enhanced perception of similarity and relatability through the agent model may make the modeling process more effective in the learning context for the elderly. Furthermore, in our hypotheses, demonstration is used to denote the practical application of modeling in the context of teaching older adults about digital healthcare. It's crucial to understand that demonstration, a specific method of modeling observed in this context, aligns with social cognitive theory's

emphasis on observational learning.

H1. Older adults who receive demonstration, compared to those who do not, will report lower levels of (a) difficulty and show greater levels of (b) perceived performance and (c) behavioral performance (scores achieved in activity tasks).

H2. Older adults who received demonstration, compared to those who do not, will show greater levels of attitudes towards the teacher agent: a) anthropomorphism and b) likeability.

H3. Older adults who receive demonstration, compared to those who do not, will show greater levels of attitudes towards the app: a) satisfaction and b) ease of use.

RQ1. Are there any differences between demonstration and no demonstration condition in terms of the attitude toward peer agent: a) positive evaluation on peer learning and b) peer Intimacy?

3) The Effect of Split Persona on Learning

Agents embodying various personas play a critical role in enhancing the online educational experience. Research on agent personas has shown that personas can significantly influence various learning outcomes, including task performance and motivation. (e.g, Baylor et al., 2003; Baylor & Kim, 2009; Gulz, 2004; Liew et al., 2013; Moreno et al., 2001). Persona refers to the observable characteristics of an agent which significantly influence how users perceive the agent (Baylor, 2011). The concept of persona in agent design encompasses a range of elements including appearance, voice, ability, and roles. Some research has focused on various aspects of agent personas, including the agent's gender and age (e.g., Kim & Baylor, 2006), the realism of the virtual agent's image (Baylor & Kim, 2004), and the instructional role of the agent, such as being an expert-like agent and a peer-like agent (Liew et al., 2013).

In some studies on agent personas focusing on the role of agents, the concept of the split persona effect has been proposed. Baylor & Ebbers (2003) introduced the hypothesis suggesting that employing multiple agents, each with specialized functions, could be more advantageous than utilizing a single agent to perform multiple roles. For instance, it has been proposed that using specialized agents for distinct roles, like a teacher-like agent for educational purposes and a peer-like agent for motivational activities, is likely more effective than one agent performing all these functions. Studies have found that this separation can lead to improved learning outcomes and increased ease of learning from the agents (Baylor, 2005; Baylor & Kim, 2005). The design of these agents often focuses on enhancing certain attributes such as trust, intimacy, and enjoyment, which are crucial for effective learning (Baylor & Kim, 2005).

In addition to earlier work on the split persona effect, more recent scholarship has continued to explore how the roles assigned to virtual agents shape users' learning and interaction experiences. For example, Kim and Baylor (2016) reviewed advancements in pedagogical agent role design and discussed how simulated instructional roles—such as expert-, motivator-, or mentor-like agents—can influence learners' cognitive and affective engagement. Their work highlights a sustained interest in role-based agent design and provides a broader conceptual foundation for understanding why assigning distinct functions to multiple agents may be beneficial. Although research directly examining split persona remains limited, several newer studies have explored variations of role-separated agents. Zhao et al. (2024) investigated whether dividing informational and emotional support roles between two instructional agents improved user outcomes, finding mixed effects depending on the nature of the task and the type of support provided. In the healthcare domain, Lee et al. (2025) compared doctor- and nurse-like agents and observed that interactions with a nurse agent produced more favorable evaluations, although the split persona condition itself did not significantly outperform a single-agent design. While split persona research specific to dementia populations remains absent, these studies demonstrate that role-based agent design continues to evolve, offering relevant insights for exploring how divided roles might support older adults in digital healthcare settings. In this context, it is also relevant to consider whether the presence of

multiple agents may interact with core instructional strategies. Demonstration, which serves as a primary mechanism for conveying procedural knowledge in this study, may not function in the same way when delivered by two agents instead of one. The coordination of instructional roles across multiple agents has the potential to influence how guidance is perceived and processed, suggesting that the impact of demonstration may differ depending on the agent configuration. Therefore, this study also considers how multiple agents may support older adults' understanding of complex tasks in digital healthcare settings.

H4. Older adults who engage with two agents, compared to those who engage with one agent, will report lower levels of (a) difficulty and exhibit enhanced levels of (b) perceived performance and (c) behavioral performance (scores achieved in activity tasks).

H5. Older adults who engage with two agents as opposed to a single agent will exhibit enhanced levels of attitudes towards the teacher agent: a) anthropomorphism and b) likeability.

H6. Older adults who engage with two agents as opposed to a single agent will exhibit enhanced levels of attitudes towards the app: a) satisfaction and b) ease of use.

RQ2. What is the interaction effect between the demonstration and the number of agents?

3. Method

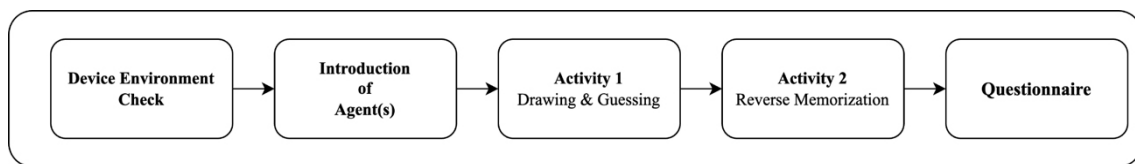
1) Participants

The experiment utilized a 2 (demonstration: demonstration vs. no demonstration) x 2 (split persona: one vs. two) between-subjects design. Before recruitment, we conducted an a priori power analysis using G*Power 3.1 to determine the required sample size for the 2×2

between-subjects design. Assuming a medium effect size ($f = 0.25$) and a significance level of $\alpha = .05$, the analysis indicated that a total of 92 participants would yield an estimated power of .75. Considering the practical constraints of recruiting older adults in community settings, this target was deemed acceptable for the purposes of the study. Participants, all over 60 years of age, were recruited from a senior community located in a metropolitan city. In total, 92 individuals aged between 60 and 87 years participated in the study. All participants were randomly assigned to one of the four groups: one agent (the teacher) with demonstration, two agents (the teacher and a peer) with demonstration, one agent (the teacher) without demonstration, two agents (the teacher and a peer) without demonstration. Each group comprised 23 participants equally. Participants received a voucher worth 8 US dollars (USD) as compensation for their participation. This study was approved by the institutional review board of the university.

2) Procedure

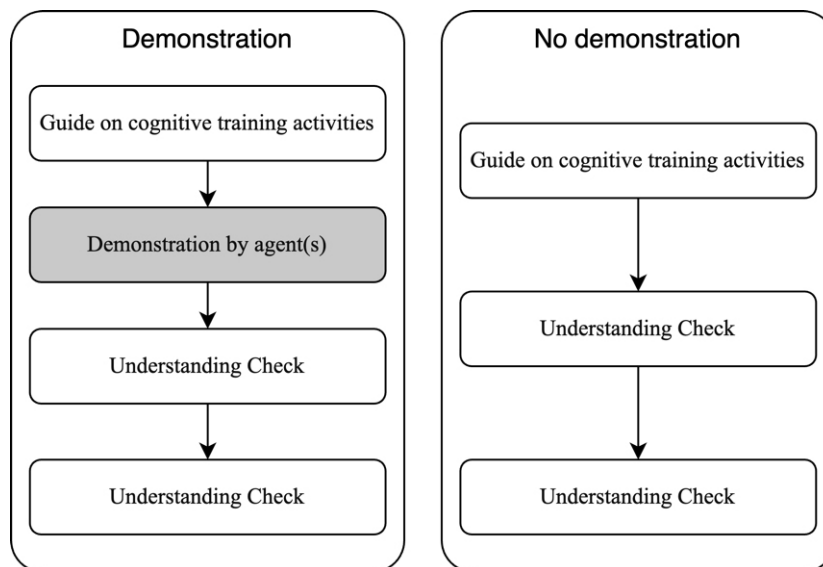
Before commencing the experiment, participants were checked to ensure they had no difficulties in reading or listening for the progression of the experiment. Additionally, their participation requirement, being over 60 years of age, was re-confirmed. Then, they were randomly assigned to one of four conditions and given a tablet PC equipped with a cognitive training program application (see <Figure 1>).



<Figure 1> Manipulation of the Experiment Overview of the experimental procedure

Upon launching the app, a basic device environment check was conducted to ensure the sound was audible and the text was visible. Following this, virtual agent(s) who would assist and participate in cognitive training activities aimed at dementia prevention introduced

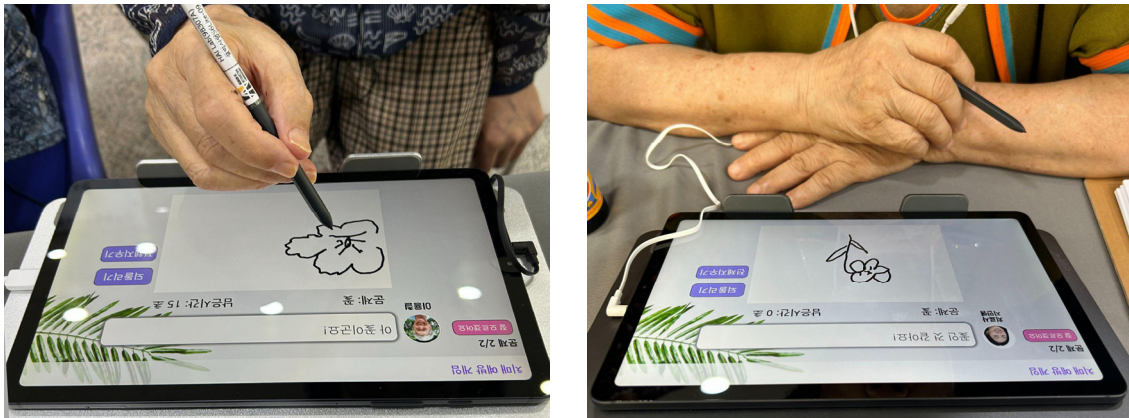
themselves. The process of cognitive training activity is implemented as follows. All participants were guided through the procedures of each cognitive training activity twice by the agent(s) before performing the activity themselves. The agents provided an additional explanation of the activity upon request from the participants. Additionally, in the demonstration condition, participants were given the opportunity to observe the agent(s) directly engaging in the cognitive training activities (see <Figure 2>). Agents facilitate user understanding by demonstrating the tasks that users will perform in the future, thereby aiding in their comprehension. Participants were then asked how well they understood the explained activities and if they found them challenging. Subsequently, they engaged in each cognitive training activity twice. Following the completion of the two cognitive training activities, participants were requested to complete a survey regarding their experience with the app and their perception of the agents. While the entire experiment was conducted under researcher supervision, the researchers did not provide direct assistance to the older adults. This approach was to assess the participants' ability to independently use the app, with only the agents assisting the users in navigating the application.



<Figure 2> The process of activities in the demonstration and no demonstration conditions

3) Apparatus

For this experiment, a new cognitive training program app was developed, which was available on tablet PCs used during the experiment and could also be accessed online on various digital devices like smartphones and PCs. The design for the elderly focused on adhering to UX standards by ensuring the app was clear, simple, and intuitive. Large text and buttons were incorporated, and sound levels were adjusted to be loud enough, considering hearing difficulties. To accommodate those unfamiliar with smartphones and tablets, the app was made easy to use, provided one can read and listen (see <Figure 3>).



<Figure 3> Participants using a cognitive training app

The program included two key cognitive activities designed for dementia prevention: *Drawing & Guessing* and *Reverse Memorization*. *Drawing & Guessing* is a part of the imagery training, widely used for enhancing cognitive abilities. In the activity, users view a simple word (e.g., wave, flower) on the screen and then draw an image inspired by that word within 30 seconds. The agent would subsequently attempt to guess the word based on the drawing. This activity, combining art with cognitive exercise, has been shown to be effective in cognitive training. *Reverse Memorization*, adapted from memory training developed by Korea's National Institute of Dementia, challenges users to memorize a four-letter Korean word for 5 seconds. Following this, users have to select the correct word from four options

within 60 seconds, matching it to the displayed color: choosing the word in its original sequence for a red circle, and its reverse sequence for a blue circle. For instance, if participants memorized the word *APPLE* and a blue circle appeared on the screen, they would then select *ELPPA*, which is the reverse order of *APPLE* (See <Figure 4>).



<Figure 4> The screenshot of cognitive training activities

The cognitive training program incorporated distinct teacher and peer agents, each tailored to specific experimental conditions and divided according to their roles. The virtual agents were developed with realistic images and voices tailored to match their respective personas, ensuring that each agent's characteristics were appropriately represented. The teacher agent was included in all conditions, whereas the peer agent appeared only in conditions involving two agents. Upon introduction, each agent identified themselves to participants either as a therapist (the teacher agent) or as a co-participant (the peer agent).

The teacher agent, designed as a young adult female with a bright and youthful voice, was visualized through a photograph of a smiling woman. This agent assumed the role of a therapist, not only explaining the procedures of the cognitive training activities to the participants but also ensuring their understanding by asking follow-up questions. She was programmed to provide detailed and amicable explanations on how to perform the activities, actively engaging with the users to confirm their comprehension and guide them through the process. In conditions where there was only a single agent without a divided role, the teacher agent also assumed the responsibilities of the peer agent, providing encouragement and

motivation to the users.

On the other hand, the peer agent, depicted as a male of a similar age to the participants, served as a learning partner. His appearance was represented by a photograph of a smiling older adult male, and he spoke in a friendly tone characteristic of older people. He engaged in the activities alongside the actual participants. This agent was designed to interact with participants, actively engaging in cognitive training activities, asking and responding to questions from the therapist agent, providing encouragement to the participants. The peer agent was portrayed as an older male to create a clear visual and social distinction from the young female therapist agent, which helped strengthen the intended role differentiation in our experimental manipulation (see <Figure 5>).

In all experimental conditions, the teacher agents consistently provided textual explanations twice on how to perform cognitive training activities. In the conditions with demonstration, participants could observe the agents performing the activities, aiding their understanding of the procedures before attempting them themselves. This was further enhanced by the agents executing the activities in the same manner as participants, complete with effects that participants would experience themselves (such as drawing and selecting options). Furthermore, the peer agent occasionally selected incorrect options, mimicking actual participant behavior, which the teacher agent then corrected. This scenario was presented to the participants to simulate a more realistic learning environment.



<Figure 5> The image of agents

4) Measures

The questionnaire was composed of four main parts. Firstly, understanding of tasks measured in this study included three elements: difficulty ($\alpha = .90$), perceived performance ($\alpha = .88$) and behavioral performance. Difficulty refers to the overall challenges experienced by the elderly in the activities, and it was measured with a 7-point Likert scale (1 = not at all, 7 = very much). The questions consisted of three items: “Understanding how to perform the cognitive training activities was challenging”, “Grasping the correct method to execute the cognitive training activities before starting was not fully clear to me”, and “Comprehending the rules of the cognitive training activities was difficult”. Perceived Performance was measured with a 7-point Likert scale adopting from Quinones (1995). Behavioral Performance refers to the actual performance outcome of how well the elderly executed the cognitive training activities, and it was scored on a scale ranging from 0 to 4 points.

The next part, attitude toward teacher, encompasses two elements: anthropomorphism ($\alpha = .84$) and likeability ($\alpha = .83$). All questions were measured on a 5-point Likert scale. There are four items for anthropomorphism, which were derived from Bartneck et al. (2009), and five items for Likeability, which were also taken from Bartneck et al. (2009).

The third part, attitude toward peer, includes two variables: positive evaluation on peer learning ($\alpha = .96$) and peer Intimacy ($\alpha = .90$). All questions were measured using a 7-point Likert scale. Positive evaluation on peer learning was assessed with three items: “I appreciated the therapist (teacher) coming with the peer,” “I was able to concentrate better because the therapist (teacher) was with the peer,” and “I understood better because the therapist (teacher) was with the peer.” Peer intimacy was measured with two items and was devised by Laurenceau, Barrett, and Pietromonaco (1998).

Lastly, Attitude toward App comprises two factors: perceived satisfaction ($\alpha = .83$) and perceived ease of use ($\alpha = .89$). Both were measured using a 7-point Likert scale. Perceived satisfaction was assessed with four items, adapted from Liaw and Huang (2013). Perceived ease of use was assessed with 2 items and based on Davis (1989).

4. Results

1) Background information

The demographic information of the participants is as follows. Among the 92 participants, 30.43% ($n = 28$) identified as female, while 69.57% ($n = 64$) identified as male. The average age of participants was 74.9 years old ($Mdn = 76$, $SD = 6.7$). To verify group equivalence, a chi-square test of independence was conducted to examine whether gender distribution differed across the four experimental conditions. The analysis indicated no significant association between experimental condition and gender, $\chi^2(3, n = 92) = 3.70$, $p = .30$, confirming that gender was evenly distributed across conditions (see <Table 1>).

<Table 1> Gender of the participants

Demonstration	Split Persona	Female	Male
Demonstration	One	18	5
Demonstration	Two	18	5
No demonstration	One	15	8
No demonstration	Two	13	10

Exploratory analyses that included gender as a factor for the main outcome variables also did not reveal any statistically significant differences between male and female participants. Additionally, to ensure equal variance, an investigation was conducted to determine if there were any differences in age between the conditions (see <Table 2>).

<Table 2> Age of the participants

Demonstration	Split Persona	n	M	Mdn	SD
Demonstration	One	23	75.7	76	6.95
Demonstration	Two	23	73.4	73	5.84
No demonstration	One	23	77.1	78	6.82
No demonstration	Two	23	73.5	75	6.77

2) Demonstration: Effects on Performance and Attitudes

To test hypotheses, a series of Analysis of Variance (ANOVA) was conducted. For task comprehension, the analysis indicated that the demonstration had a significant effect on certain variables (see <Table 3>). Participants in the demonstration condition ($M = 6.50$, $SD = 1.09$) reported higher perceived performance compared to those in the no demonstration condition ($M = 5.91$, $SD = 1.34$), $F(1, 88) = 5.37$, $p = .02$, $\eta^2 = .06$. Furthermore, the demonstration condition ($M = 3.39$, $SD = .68$) resulted in higher behavior performance than the no demonstration condition ($M = 3.00$, $SD = .69$), $F(1, 88) = 7.24$, $p = .01$, $\eta^2 = .08$. No significant differences were observed for difficulty across activities ($p = .07$). These findings supported H1b and H1c but did not support H1a.

Concerning attitudes towards the teacher agent, There was a significant difference in anthropomorphism between the demonstration ($M = 4.73$, $SD = .49$) and no demonstration ($M = 4.45$, $SD = .70$), $F(1, 88) = 5.12$, $p = .03$, $\eta^2 = .06$. On the other hand, There was no significant difference in likeability between the demonstration condition and no demonstration condition ($p = .92$). Thus, H2a was supported, but H2b was not.

The analysis revealed a statistically significant main effect of demonstration on perceived ease of use, $F(1, 88) = 6.63$, $p = .01$, $\eta^2 = .07$. Specifically, participants in the demonstration condition ($M = 6.51$, $SD = .96$) reported higher perceived ease of use than those in no demonstration condition ($M = 5.80$, $SD = 1.60$). However, no statistically significant main effects were observed for perceived satisfaction ($p = .29$). Consequently, H3b was supported, but H3a was not.

To address the research question of whether there are differences in attitudes toward the peer agent between demonstration and no demonstration conditions, independent-samples t-tests were conducted for participants assigned to the two-agent condition. The analysis showed that participants in the demonstration condition ($M = 6.58$, $SD = .68$) evaluated peer learning more positively compared to those in the no demonstration condition ($M = 5.51$, $SD = 1.59$), $t(44) = 2.98$, $p = .01$. Furthermore, attitudes towards the peer agent were also more favorable in the demonstration condition ($M = 6.57$, $SD = .73$) than in the

no demonstration condition ($M = 5.76$, $SD = 1.17$), $t(44) = 2.81$, $p = .01$. These findings suggest that the demonstration condition contributes to a more positive evaluation on peer learning, and a heightened sense of closeness with the peer agent. Therefore, it can be inferred that the presence of demonstration in a two-agent condition leads to more positive attitudes towards peer agents. A summary of the hypothesis results is presented in <Table 4>.

<Table 3> Main Effects of Demonstration on Dependent Variables

Variable	Demonstration		No demonstration		F	p	η^2
	M	SD	M	SD			
Difficulty	2.45	1.53	3.06	1.72	3.34	.07	.04
Perceived performance	6.50	1.09	5.91	1.34	5.37*	.02	.06
Behavior performance	3.39	.68	3.00	.69	7.24*	.01	.08
Anthropomorphism	4.73	.49	4.45	.70	5.12*	.03	.06
Likability	4.70	.77	4.72	.55	.01	.92	.43
Perceived satisfaction	6.43	1.10	6.25	.94	1.15	.29	.01
Perceived ease of use	6.51	.96	5.80	1.60	6.63*	.01	.07

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

<Table 4> Hypothesis Test Result for the Effect of Demonstration

Hypothesis	Variable	Testing result
Hypothesis 1-a	Difficulty	Not supported
Hypothesis 1-b	Perceived performance	Supported
Hypothesis 1-c	Behavior performance	Supported
Hypothesis 2-a	Anthropomorphism	Supported
Hypothesis 2-b	Likability	Not supported
Hypothesis 3-a	Perceived satisfaction	Not supported
Hypothesis 3-b	Perceived ease of use	Supported

3) Split Persona: Impact on Performance and Attitudes

Again, a series of ANOVA was performed to assess the hypotheses H4, H5, and H6 concerning the number of agents. The results indicated that two agents in cognitive training activities had a significant effect on difficulty (see <Table 5>). Participants with two agents ($M = 2.41$, $SD = 1.41$) reported less difficulty across the activities compared to those with one agent ($M = 3.10$, $SD = 1.81$), $F(1, 88) = 4.14$, $p = .04$, $\eta^2 = .45$. However, no statistically significant main effects were observed for perceived performance ($p = .39$) or behavior performance ($p = 1.00$). As a result, H4a found support, whereas H4b and H4c did not.

The main effect of the number of agents was not significant for attitudes towards the teacher agent. There were no significant differences between two agents and one agent for anthropomorphism ($p = .24$) or likeability ($p = .18$). Thus, H5 was not supported.

Similarly, the main effect of the number of agents on attitudes towards the app was also insignificant. no difference in perceived satisfaction ($p = .89$) or perceived ease of use ($p = .37$) was observed between two agents and one agent. Thus, H6 was not supported. Hypothesis results are summarized in <Table 6>.

<Table 5> Main Effects of Split Persona on Dependent Variables

Variable	Two agents		One agent		F	p	η^2
	M	SD	M	SD			
Difficulty	2.41	1.41	3.10	1.81	4.14*	.04	.45
Perceived performance	6.32	1.09	6.09	1.39	.74	.39	.01
Behavior performance	3.20	.69	3.20	.75	.00	1.00	.00
Anthropomorphism	4.52	.68	4.67	.54	1.39	.24	.02
Likability	4.62	.93	4.78	.58	1.81	.18	.02
Perceived satisfaction	6.34	1.01	6.37	.92	.02	.89	.00
Perceived ease of use	6.28	1.18	6.03	1.51	.82	.37	.01

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

<Table 6> Hypothesis Test Result for the Effect of Demonstration

Hypothesis	Variable	Testing result
Hypothesis 1-a	Difficulty	Not supported
Hypothesis 1-b	Perceived performance	Supported
Hypothesis 1-c	Behavior performance	Supported
Hypothesis 2-a	Anthropomorphism	Supported
Hypothesis 2-b	Likability	Not supported
Hypothesis 3-a	Perceived satisfaction	Not supported
Hypothesis 3-b	Perceived ease of use	Supported

The interaction effects between demonstration and the number of agents were also examined to address RQ2. None of the interaction effects were statistically significant for any dependent variable, indicating that the effects of demonstration did not differ depending on whether instruction was delivered by one or two agents. Descriptive statistics for all dependent variables across the four experimental conditions are reported (see <Table 7>).

<Table 7> Descriptive statistics by condition

Variable	<i>n</i>	Demo		Demo		No demo		No demo	
		Oneagent		Twoagents		Oneagent		Twoagents	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Difficulty	23	2.72	1.67	2.23	1.51	3.41	1.95	2.59	1.42
Perceived performance	23	5.78	1.58	6.53	.63	5.78	1.44	5.93	1.29
Behavior performance	23	3.43	.66	3.35	.71	2.96	.77	3.04	.64
Anthropomorphism	23	4.71	.52	4.76	.48	4.62	.57	4.28	.78
Likability	23	4.87	.32	4.69	.49	4.79	.33	4.54	.67
Perceived satisfaction	23	6.57	.71	6.48	.90	6.27	.84	6.24	.86
Perceived ease of use	23	6.52	.96	6.50	.98	5.54	1.81	6.07	1.34

Note. Demo = demonstration; No demo = no demonstration

5. Discussion

1) Overall Discussion

This study suggests the significance of enabling elderly users to independently understand and utilize digital healthcare applications, including the cognitive-behavioral therapy (CBT) activities. The challenges that elderly users frequently encounter in using applications are largely due to a lack of digital literacy and difficulties in comprehending complex activities due to cognitive decline. To overcome these barriers, the study presents digital healthcare app design elements that enable elderly users to use them independently without assistance and explores methods to enhance task completion and understanding. The results indicate that demonstration-based learning effectively improved the elderly's understanding of tasks and impacted their perception of the agent. Additionally, the study explored the effects of multiple agents through role division, showing minimal results, suggesting a need for further investigation.

This research evaluated the impact of using virtual agents in demonstrations on the comprehension and performance of elderly users within digital health applications. The findings indicate that elderly participants who observed the demonstrations showed significant improvements in both perceived and actual performance compared to those who did not. Such enhancements in task comprehension and execution are consistent with existing research (Struve & Wandke, 2009; Ma, Chan, & Teh, 2020). Demonstrations conducted by agents provided practical information in an accessible and tangible format, enabling the elderly to independently navigate application functionalities and accurately perform complex tasks, such as cognitive behavioral therapy (CBT) activities. The study also underscores the effectiveness of using virtual agents as demonstration models for the elderly. These agents, by realistically mimicking real-user interactions within digital environments, significantly improved cognitive engagement and task understanding among older users. In essence, as the elderly observed agents performing tasks as actual users would, there was an enhanced comprehension of the applications and an improved ability to perform tasks. Thus, agents can adequately substitute

human assistance, empowering the elderly to independently manage app activities. However, a refinement in the experimental approach is warranted. Typically, older adults are defined as those aged 65 and over, but with advancing societal aging and a younger outlook on the aging process, there is a discourse advocating for the elevation of this threshold to 70 years and above. People in their 60s may often be considered comparatively youthful and potentially more adept with digital devices. In light of this, future research might benefit from a narrower age range among participants to more accurately discern the impact of demonstrations targeted at the elderly. This adjustment could enhance our understanding of the effectiveness of demonstrations within the more senior segments of our population.

Moreover, demonstration influenced elderly users' perceptions of and experiences with agents, highlighting the positive impact of demonstration on agent perception and user experience. Demonstration increased anthropomorphism towards the teacher agent and improved the app's ease of use. Our findings support Reeves and Nass (1996), suggesting that users tend to ascribe human-like qualities to agents. Given that anthropomorphism involves attributing human-like intentions and emotions to nonhuman entities (Epley et al., 2007; Waytz et al., 2010), the higher anthropomorphism scores in the demonstration condition suggest that observing the teacher agent's goal-directed, instructive behavior led older adults to interpret the agent as a more intentional and socially capable partner in the interaction. In our study, interacting with and observing the agents' behaviors contributed to older adults perceiving them as more human-like-an observation that is consistent with recent HAI research showing that human-like design cues in conversational agents can meaningfully shape user perceptions and engagement (Park, Kim, & Song, 2025; Sun, Chen, & Sundar, 2024; Zhou & Hu, 2024). According to Bandura's (2001) social cognitive theory, which emphasizes the importance of similarity between the model and the learner, characteristics of the model-such as who provides guidance and how similar the model appears to the learner-can influence how people attend to and interpret learning situations. In this context, the present study suggests that the way older adults perceive the agents they interact with may be an important consideration in digital learning environments. While the study did not explore how perceived similarity or anthropomorphism relates to learning or performance

outcomes, these perceptual shifts offer meaningful insight into how elderly users engage with agent-based demonstrations. Future research may further investigate how such perceptions correspond to learning processes among older adults.

This study also explored the impact of agent role division in digital health apps on the task comprehension and user experience of older adults. Contrary to expectations, the effect of split persona did not show positive results in these users. The presence of two agents with distinct roles reduced perceived difficulty, but did not significantly impact other performance metrics. This suggests that while role division may simplify the presentation of information and reduce perceived difficulty, it does not necessarily lead to task performance improvements in elderly learners, differing from other studies related to the split persona effect (Baylor, 2005; Baylor & Kim, 2005).

Two reasons are proposed for the absence of a significant split persona effect. First, the elderly struggled with understanding interactions between multiple agents due to cognitive limitations. The presence of multiple agents may have increased cognitive load, potentially decreasing the effectiveness of the learning process. Second, the study found that agents conveying information through text and voice alone were inadequate in mimicking real-life situations. Especially, our agent demonstrations might not have provided adequate situational information to elderly users unfamiliar with digital environments. This limitation became evident as text and voice alone are insufficient for delivering contextual cues essential for modeling and observational learning. Conditions featuring two agents with roles divided based on functionality caused confusion among the elderly. They often failed to discern whether the teacher agent was addressing them or engaging in conversation with the peer agent due to the purely linguistic nature of the interaction. This lack of situational context likely had a negative impact on task performance and user experience. In addition, the interaction between demonstration and the number of agents was not statistically significant. This pattern may reflect that, once a demonstration was provided, the cognitive demands of the tasks were relatively modest, limiting the extent to which the two factors could jointly influence outcomes. We postulate that when task complexity is low, demonstration alone may provide sufficient guidance, reducing the likelihood that differences between the one agent condition

and the two agents condition produce distinguishable effects. Consequently, the instructional impact of demonstration may have manifested uniformly across both conditions. The study suggests that video demonstrations might help overcome these contextual issues, providing realistic situational information vital for effective modeling in social cognitive theory. Future research should explore enriching contextual cues through videos or other visual materials.

Although the present study was conducted in a dementia-prevention context, the mechanisms underlying the effects of demonstration, such as reduced cognitive load and clearer interpretability of agent-guided instruction, are not specific to dementia. These characteristics are also relevant for older adults with mild cognitive impairment, age-related memory decline, or other chronic conditions that affect task processing. Moreover, because these mechanisms target general age-related cognitive constraints rather than disease-specific symptoms, the same design principles are likely to support older adults' use of a wide range of digital therapeutics and digital education/training programs that require understanding and carrying out multi-step activities (e.g., cognitive training, medication management, chronic disease self-management, or everyday technology training). For this reason, the findings may be cautiously generalized to older adult populations who exhibit comparable cognitive challenges and to related digital-health applications, while underscoring the need for future studies that systematically test these design principles across diverse clinical groups and application domains.

2) Contribution and Implications

This study emphasizes the importance of enabling elderly users to comprehend and autonomously operate digital health applications, focusing on strategies that can enhance the accessibility and effectiveness of digital healthcare. By prioritizing user understanding and independence, it suggests that digital healthcare can become more inclusive and beneficial for the elderly community. The study provides empirical evidence that demonstrations can be an effective means for older adults to use digital health applications. While most studies have focused on human models, this research can be used as a positive example when virtual

agents are utilized as models. It also examines the effects of engaging multiple agents, divided according to roles, beyond the use of a single agent in demonstrations. From a theoretical standpoint, this study refines how social cognitive theory can be applied to technology-mediated learning for older adults. In line with Bandura's framework, the findings provide empirical evidence that core processes of observational learning, such as learning by watching a model perform a task, observing errors and corrective feedback, and building self-efficacy through vicarious experience, can be instantiated through virtual agents rather than only human demonstrators. In this sense, agent-based demonstrations in the present study operationalize social cognitive theory in a digital health context, showing that virtual agents can function as effective instructional models for older adults. The results also underline the importance of contextual cues in supporting observational learning: when situational information is limited, even agent-led demonstrations may not fully translate into improved task performance. Finally, the mixed findings for the split-persona manipulation suggest that the benefits of dividing roles across multiple agents may depend on task complexity and cognitive load, helping to specify the conditions under which particular agent configurations are more or less likely to be theoretically and practically useful. Therefore, this study contributes to extending the scope of application of existing research on modeling and agent-assisted instruction to the domain of digital health for older adults. It also offers a broader discussion of what can occur when elderly learners engage in digital learning environments without sufficient situational information, underscoring the need to incorporate richer contextual cues more systematically into task instructions in future research.

Furthermore, the study is significant as it provides practical design guidelines that can be useful in creating actual digital health apps tailored to the needs of the elderly. Specifically, these findings indicate that agent-based demonstrations may have a positive effect on elderly users, based on experiments conducted with real elderly participants. Thus, agent-based demonstrations can be an effective element to support the independent use of elderly users. Based on these findings, it advocates including agent-based demonstrations in the early stages of designing health care applications that involve cognitive training or complex tasks. This approach promises to make such applications more friendly and accommodating to the unique

needs of older adults, bridging the technological gap, and enhancing the overall user experience.

3) Limitations and future directions

This study has several limitations. Researchers minimized intervention during the experiment, and most elderly participants completed the survey independently to reduce researcher influence. Despite these efforts, the possibility of self-report bias due to social desirability cannot be excluded. Bogner and Landrock (2015) noted that participants might guess what interviewers want to hear and respond positively. Despite efforts to minimize interaction with participants during the experiment, controlling all situations was not entirely possible due to participant recruitment and participation processes. These aspects suggest that participants' responses might not fully reflect their actual experience and attitude.

Additionally, the lack of behavioral measures is a limitation. The study primarily focused on the elderly participants' ability to perform cognitive training. However, self-report data alone cannot sufficiently determine how demonstration and agent design influenced actual behavioral changes in elderly participants. Future research should complement the limitations of self-report data and include more concrete behavioral measures such as actual activity performance time or the number of requests for assistance.

The study did not systematically examine the influence of gender on the outcome variables. Bandura (1986) argued that the similarity between the model and observer could impact learning effectiveness. Furthermore, research by ter Stal et al. (2020) suggests that the gender of the agent could influence attitudes and preferences of male and female elderly users towards the agent. However, our study did not treat gender as a primary analytic factor when designing and evaluating the teacher and peer agents. For successful manipulation with a strong distinction between the teacher and the peer agent, we assigned different genders to each agent. However, the gender of the peer may have introduced some effects, as it could influence the instructional effectiveness depending on how similar users perceived themselves to be to the peer agent. Future research may consider exploring cases where gender is

matched according to role and conduct additional studies that vary the gender of both agents and users.

Although demonstration increased anthropomorphic impressions of the teacher agent, the present study did not examine how such perceptions relate to learning or performance outcomes. Relationships such as whether anthropomorphism, perceived similarity, or other agent characteristics mediate or predict performance were beyond the scope of this work. Future studies could investigate these potential mechanisms more directly, offering a clearer understanding of how agent-related perceptions may contribute to older adults' engagement and task performance.

Beyond these study-specific limitations, it is also important to consider how the present findings might be extended to other application domains. Beyond the healthcare context, future research should explore how demonstration-based support can benefit older adults in other domains that involve structured, multi-step tasks. Many areas of later-life learning-such as digital literacy training, online banking and financial management, mobility service apps, or civic-service platforms-require complex interactions that may similarly benefit from clear, modeled demonstrations. Investigating these broader contexts would help determine how demonstration-based guidance can support independent technology use among diverse older-adult populations.

6. Conclusion

This study emphasizes the importance of demonstration and agent design in enhancing cognitive training outcomes for older adults in digital healthcare settings. Demonstration significantly improves performance and perceived ease of use, whereas the number of agents primarily influences perceived difficulty. These findings underscore the need for tailored digital solutions for cognitive training in dementia prevention among the aging population. The study advocates for more explorative design research to optimize digital health applications for older adults. This study highlights the importance of demonstrations and agent design in

digital healthcare for older adults, revealing that these elements significantly improve task performance and ease of use. Demonstrations, especially when paired with strategically designed virtual agents, effectively address the challenges older adults face in digital environments. While the role division among agents simplifies information presentation, it does not necessarily correlate with task performance improvements, suggesting a need for clarity in agent design to prevent confusion and cognitive overload.

Additionally, this research emphasizes the need for user-friendly digital health applications tailored to older adults, advocating for designs that accommodate varying levels of digital literacy. Future studies should focus on refining agent characteristics and exploring the impact of demographic factors, such as age and gender, to enhance user experience and learning outcomes. Overall, this study significantly contributes to improving digital healthcare for the elderly by demonstrating the effectiveness of well-designed virtual agents and demonstrations, paving the way for user-centric interventions that enhance the quality of life and independence of the aging population.

Reference

- Alvseike, H., & Brønnick, K. (2012). Feasibility of the iPad as a hub for smart house technology in the elderly; effects of cognition, self-efficacy, and technology experience. *Journal of Multidisciplinary Healthcare*, 5, 299-306.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, 52(1), 1-26.
- Bartneck, C., Kulić, D., Croft, E., & Zoghbi, S. (2009). Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. *International Journal of Social Robotics*, 1(1), 71-81.
- Baylor, A. L. (2005, January). The impact of pedagogical agent image on affective outcomes. In *International Conference on Intelligent User Interfaces*, San Diego, CA (p. 29).
- Baylor, A. L. (2011). The design of motivational agents and avatars. *Educational Technology Research and Development*, 59(2), 291-300.
- Baylor, A. L., & Kim, S. (2009). Designing nonverbal communication for pedagogical agents: When less is more. *Computers in Human Behavior*, 25(2), 450-457.
- Baylor, A. L., & Kim, Y. (2004, August). Pedagogical agent design: The impact of agent realism, gender, ethnicity, and instructional role. In *International conference on intelligent tutoring systems* (pp. 592-603). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Baylor, A. L., & Kim, Y. (2005). Simulating instructional roles through pedagogical agents. *International Journal of Artificial Intelligence in Education*, 15(2), 95-115.
- Baylor, A., & Ebbers, S. (2003). The pedagogical agent split-persona effect: When two agents are better than one. In *EdMedia+ Innovate Learning* (pp. 459-462). Association for the Advancement of Computing in Education (AACE).
- Baylor, A., Ryu, J., & Shen, E. (2003). The effects of pedagogical agent voice and animation on learning, motivation and perceived persona. In *EdMedia+ innovate learning* (pp. 452-458). Association for the Advancement of Computing in Education (AACE).
- Beinema, T., op den Akker, H., van Velsen, L., & Hermens, H. (2021). Tailoring coaching strategies to users' motivation in a multi-agent health coaching application. *Computers in Human Behavior*, 121, 106787.
- Berscheid, E., & Hatfield, E. (1969). *Interpersonal attraction* (Vol. 69, pp. 113-114). Reading, MA:

Addison-Wesley.

- Bertrand, J., Babu, S. V., Polgreen, P., & Segre, A. (2010, September). Virtual agents based simulation for training healthcare workers in hand hygiene procedures. In *International Conference on Intelligent Virtual Agents* (pp. 125-131). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Bickmore, T. W., Pfeifer, L. M., & Jack, B. W. (2009, April). Taking the time to care: empowering low health literacy hospital patients with virtual nurse agents. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 1265-1274).
- Bickmore, T., & Schulman, D. (2006, April). The comforting presence of relational agents. In *CHI'06 Extended Abstracts on Human Factors in Computing Systems* (pp. 550-555).
- Bogner, K., & Landrock, U. (2015). Antworttendenzen in standardisierten Umfragen. *Mannheim, GESIS - Leibniz Institut für Sozialwissenschaften (SDM Survey Guidelines)*, 1-9.
- Bott, N., Wexler, S., Drury, L., Pollak, C., Wang, V., Scher, K., & Narducci, S. (2019). A protocol-driven, bedside digital conversational agent to support nurse teams and mitigate risks of hospitalization in older adults: case control pre-post study. *Journal of Medical Internet Research*, 21(10), e13440.
- Boumans, R., Thill, S., Gerritsen, D., & Bosse, T. (2024, December). A voice-enabled intelligent virtual agent for people with memory impairments: Thematic analysis of focus group results. In *International Symposium on Chatbots and Human-Centered AI* (pp. 112-131). Cham: Springer Nature Switzerland.
- Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., & Sharit, J. (2006). Factors predicting the use of technology: findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging*, 21(2), 333.
- Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use and User Acceptance of Information Technology. *MIS quarterly*, 13(3), 319-340.
- De Jong, M., Stara, V., Von Döllen, V., Bolliger, D., Heerink, M., & Evers, V. (2018, November). Users requirements in the design of a virtual agent for patients with dementia and their caregivers. In *Proceedings of the 4th EAI International Conference on Smart Objects and Technologies for Social Good* (pp. 136-141).
- Dyer, E. A., Kansagara, D., McInnes, D. K., Freeman, M., & Woods, S. (2013). *Mobile applications and Internet-based approaches for supporting non-professional caregivers: A systematic review*. VA-ESP Project #05-225. Washington, DC: Department of Veterans Affairs.
- Epley, N., Waytz, A., & Cacioppo, J. T. (2007). On seeing human: a three-factor theory of anthropomorphism. *Psychological Review*, 114(4), 864.
- Fitzpatrick, K. K., Darcy, A., & Vierhile, M. (2017). Delivering cognitive behavior therapy to young adults

- with symptoms of depression and anxiety using a fully automated conversational agent (Woebot): a randomized controlled trial. *JMIR Mental Health*, 4(2), e7785.
- Gaffney, H., Mansell, W., & Tai, S. (2020). Agents of change: understanding the therapeutic processes associated with the helpfulness of therapy for mental health problems with relational agent MYLO. *Digital Health*, 6, 2055207620911580.
- Gagliano, M. E. (1988). A literature review on the efficacy of video in patient education. *Academic Medicine*, 63(10), 785-92.
- Gist, M., Rosen, B., & Schwoerer, C. (1988). The influence of training method and trainee age on the acquisition of computer skills. *Personnel Psychology*, 41(2), 255-265.
- Gulec, H., Kvardova, N., & Smahel, D. (2022). Adolescents' disease-and fitness-related online health information seeking behaviors: the roles of perceived trust in online health information, eHealth literacy, and parental factors. *Computers in Human Behavior*, 134, 107318.
- Gulz, A. (2004). Benefits of virtual characters in computer based learning environments: Claims and evidence. *International Journal of Artificial Intelligence in Education*, 14(3-4), 313-334.
- Justo, R., Ben Letaifa, L., Palmero, C., Gonzalez-Fraile, E., Torp Johansen, A., Vázquez, A., ... & Torres, M. I. (2020). Analysis of the interaction between elderly people and a simulated virtual coach. *Journal of Ambient Intelligence and Humanized Computing*, 11(12), 6125-6140.
- Kabir, M. F., Schulman, D., & Abdullah, A. S. (2019). Promoting relational agent for health behavior change in low and middle-income countries (LMICs): issues and approaches. *Journal of Medical Systems*, 43(7), 227.
- Khot, R., Arets, T., Wester, J., Burger, F., van Berkel, N., Brankaert, R., ... & Lee, M. (2025, April). Challenging Futures: Using Chatbots to Reflect on Aging and Dementia. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems* (pp. 1-14).
- Kim, Y., & Baylor, A. L. (2006). A social-cognitive framework for pedagogical agents as learning companions. *Educational Technology Research and Development*, 54(6), 569-596.
- Kim, Y., & Baylor, A. L. (2016). based design of pedagogical agent roles: A review, progress, and recommendations. *International Journal of Artificial Intelligence in Education*, 26(1), 160-169.
- Kramer, L. L., Ter Stal, S., Mulder, B. C., de Vet, E., & van Velsen, L. (2020). Developing embodied conversational agents for coaching people in a healthy lifestyle: scoping review. *Journal of Medical Internet Research*, 22(2), e14058.
- Laurenceau, J. P., Barrett, L. F., & Pietromonaco, P. R. (1998). Intimacy as an interpersonal process: the importance of self-disclosure, partner disclosure, and perceived partner responsiveness in interpersonal exchanges. *Journal of Personality and Social Psychology*, 74(5), 1238.

- Lee, Y., Kim, D., Rau, P. L. P., Sundar, S. S., Han, J., & Song, H. (2025). The split persona effect in healthcare: Focusing on the different roles of agent. *Health Communication Research*, 24(2), 145-175.
- Liaw, S. S., & Huang, H. M. (2013). Perceived satisfaction, perceived usefulness and interactive learning environments as predictors to self-regulation in e-learning environments. *Computers & Education*, 60(1), 14-24.
- Liew, T. W., Tan, S. M., & Jayothisa, C. (2013). The effects of peer-like and expert-like pedagogical agents on learners' agent perceptions, task-related attitudes, and learning achievement. *Journal of Educational Technology & Society*, 16(4), 275-286.
- Lin, Y. C., Liang, J. C., Yang, C. J., & Tsai, C. C. (2013). Exploring middle-aged and older adults' sources of Internet self-efficacy: A case study. *Computers in Human Behavior*, 29(6), 2733-2743.
- Lucas, G. M., Rizzo, A., Gratch, J., Scherer, S., Stratou, G., Boberg, J., & Morency, L. P. (2017). Reporting mental health symptoms: breaking down barriers to care with virtual human interviewers. *Frontiers in Robotics and AI*, 4, 51.
- Ma, Q., Chan, A. H., & Teh, P. L. (2020). Bridging the digital divide for older adults via observational training: Effects of model identity from a generational perspective. *Sustainability*, 12(11), 4555.
- Martinengo, L., Jabir, A. I., Goh, W. W. T., Lo, N. Y. W., Ho, M. H. R., Kowatsch, T., ... & Tudor Car, L. (2022). Conversational agents in health care: scoping review of their behavior change techniques and underpinning theory. *Journal of Medical Internet Research*, 24(10), e39243.
- Martínez-Miranda, J., Bresó, A., & García-Gómez, J. M. (2014, August). Look on the bright side: a model of cognitive change in virtual agents. In *International Conference on Intelligent Virtual Agents* (pp. 285-294). Cham: Springer International Publishing.
- McTear, M., Jokinen, K., Alam, M. M., Saleem, Q., Napolitano, G., Szczepaniak, F., ... & Wieching, R. (2023). Interaction with a virtual coach for active and healthy ageing. *Sensors*, 23(5), 2748.
- Meade, C. D. (1996, June). Producing videotapes for cancer education: methods and examples. In *Oncology nursing forum* (Vol. 23, No. 5, pp. 837-846).
- Mitzner, T. L., Boron, J. B., Fausset, C. B., Adams, A. E., Charness, N., Czaja, S. J., ... & Sharit, J. (2010). Older adults talk technology: Technology usage and attitudes. *Computers in Human Behavior*, 26(6), 1710-1721.
- Mitzner, T. L., Fausset, C. B., Boron, J. B., Adams, A. E., Dijkstra, K., Lee, C. C., ... & Fisk, A. D. (2008, September). Older adults' training preferences for learning to use technology. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 52, No. 26, pp. 2047-2051). Sage CA: Los Angeles, CA: Sage Publications.
- Moreno, R., Mayer, R. E., Spires, H. A., & Lester, J. C. (2001). The case for social agency in

- computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents?. *Cognition and Instruction*, 19(2), 177-213.
- Murray, E., Hekler, E. B., Andersson, G., Collins, L. M., Doherty, A., Hollis, C., ... & Wyatt, J. C. (2016). Evaluating digital health interventions: key questions and approaches. *American Journal of Preventive Medicine*, 51(5), 843-851.
- Niehaves, B., & Plattfaut, R. (2014). Internet adoption by the elderly: employing IS technology acceptance theories for understanding the age-related digital divide. *European Journal of Information Systems*, 23(6), 708-726.
- Nunes, F., Verdezoto, N., Fitzpatrick, G., Kyng, M., Grönvall, E., & Storni, C. (2015). Self-care technologies in HCI: Trends, tensions, and opportunities. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 22(6), 1-45.
- Park, Y., Kim, D., & Song, H. (2025, March). I Know You're Listening: Designing Visual Backchannels for Voice User Interfaces. In Companion Proceedings of the 30th International Conference on Intelligent User Interfaces (pp. 56-59).
- Quinones, M. A. (1995). Pretraining context effects: Training assignment as feedback. *Journal of applied psychology*, 80(2), 226.
- Reeves, B., & Nass, C. (1996). *The media equation: How people treat computers, television, and new media like real people* (Vol. 10). Cambridge, UK: Cambridge University Press.
- Rockwood, K., Wallack, M., & Tallis, R. (2003). The treatment of Alzheimer's disease: success short of cure. *The Lancet Neurology*, 2(10), 630-633.
- Sebastian, J., & Richards, D. (2017). Changing stigmatizing attitudes to mental health via education and contact with embodied conversational agents. *Computers in Human Behavior*, 73, 479-488.
- Shin, H. J., Cho, I. T., Choi, W. S., Kim, H. R., Kang, M. B., & Yang, W. J. (2024). Digital therapeutics in Korea: current status, challenges, and future directions - a narrative review. *Journal of Yeungnam Medical Science*, 42, 8.
- Struve, D., & Wandke, H. (2009). Video modeling for training older adults to use new technologies. *ACM Transactions on Accessible Computing (TACCESS)*, 2(1), 1-24.
- Sun, Y., Chen, J., & Sundar, S. S. (2024). Chatbot ads with a human touch: A test of anthropomorphism, interactivity, and narrativity. *Journal of Business Research*, 172, 114403.
- ter Stal, S., Tabak, M., op den Akker, H., Beinema, T., & Hermens, H. (2020). Who do you prefer? The effect of age, gender and role on users' first impressions of embodied conversational agents in eHealth. *International Journal of Human-Computer Interaction*, 36(9), 881-892.
- Topping, K. J., & Ehly, S. W. (2001). Peer assisted learning: A framework for consultation. *Journal of*

- Educational and Psychological Consultation*, 12(2), 113-132.
- Tran, M. K. P., Robert, P., & Bremond, F. (2016, June). A Virtual Agent for enhancing performance and engagement of older people with dementia in Serious Games. In *Workshop Artificial Compagnon-Affect-Interaction 2016*.
- Waytz, A., Cacioppo, J., & Epley, N. (2010). Who sees human? The stability and importance of individual differences in anthropomorphism. *Perspectives on Psychological Science*, 5(3), 219-232.
- Woodward, A. T., Freddolino, P. P., Wishart, D. J., Bakk, L., Kobayashi, R. I. E., Tupper, C., ... & Blaschke-Thompson, C. M. (2013). Outcomes from a peer tutor model for teaching technology to older adults. *Ageing & Society*, 33(8), 1315-1338.
- World Health Organization. (2023, March 15). *Dementia*.
<https://www.who.int/news-room/fact-sheets/detail/dementia>
- Yoon, U. Y., & Kim, Y. (2023). National research and development (R&D) status of digital therapeutics for dementia patients in Korea. *Korean Journal of Geriatrics and Gerontology*, 24(1), 34-40.
- Zhao, J., Rau, P. L. P., & Liu, Y. (2024, June). To Split or Not to Split? Evaluating IA Roles Providing Knowledge and Emotional Support. In *International Conference on Human-Computer Interaction* (pp. 193-205). Cham: Springer Nature Switzerland.
- Zhou, J., & Hu, Y. (2024, July). Beyond Words: Infusing Conversational Agents with Human-like Typing Behaviors. In *Proceedings of the 6th ACM Conference on Conversational User Interfaces* (pp. 1-12).

최초 투고일: 2025년 09월 25일
논문 수정일: 2025년 12월 19일
게재 확정일: 2025년 12월 15일

노인을 위한 헬스케어 애플리케이션 디자인:

시연 효과와 분할 페르소나*

이정우 성균관대학교, 석사

김도하 성균관대학교, 박사후연구원

S. Shyam Sundar 성균관대학교/펜실베이니아주립대학교, 교수

한진영 성균관대학교, 부교수

송하연** 성균관대학교, 교수

본 연구는 고령층이 치매 예방을 위한 디지털 헬스케어 애플리케이션을 독립적으로 사용할 수 있도록 돕는 교수 학습 방법을 탐구하였다. 사회인지이론을 바탕으로 가상 에이전트의 시연과 분할 페르소나의 효과를 검증하였다. 이를 위해 2(시연: 시연 있음 vs. 시연 없음) x 2(분할 페르소나: 1명 vs. 2명) 집단 간 설계를 적용하여 고령 참여자의 과업 이해도와 에이전트 및 애플리케이션에 대한 태도를 분석하였다. 연구 결과, 에이전트의 시연은 고령자의 주관적, 객관적 과업 수행 능력을 유의미하게 향상시켰으며, 앱의 사용 용이성과 에이전트에 대한 의인화 인식을 높이는 것으로 나타났다. 반면, 에이전트의 역할을 분할하여 제시하는 방식은 인지된 난이도를 낮추는 효과는 있었으나, 실제 수행 능력이나 태도 개선에는 유의미한 영향을 미치지 못했으며 이는 인지 부하의 영향일 가능성이 있다. 결과적으로 본 연구는 고령층의 디지털 문해력 장벽을 해소하기 위해 직관적인 시연 중심의 안내가 필수적임을 시사한다. 또한 가상 에이전트가 고령자의 독립성과 삶의 질 향상을 돕는 유용한 도구가 될 수 있음을 입증하며, 사용자 중심의 디지털 치료제 설계에 대한 실무적 시사점을 제공한다.

주제어 : 디지털 헬스케어, 시연, 가상 에이전트, 분할 페르소나, 노인

* 본 연구는 과학기술정보통신부 및 정보통신기획평가원의 디지털분야해외석학유치지원 연구결과로 수행되었음(RS-2024-00459638).

** songhy@skku.edu, Corresponding author