

Design and Evaluation of a VR Therapy for Patients with Mild Cognitive Impairment and Dementia: Perspectives from Patients and Stakeholders

Ruiqi Chen¹, Shuhe Wang¹, Xuhai Xu², Lan Wei¹, Yuling Sun³, Xin Tong¹ *

ABSTRACT

Immersive virtual reality (VR) technology has shown great promise in intervening in Mild Cognitive Impairment (MCI) and Mild Dementia (MD) patients' cognitive therapies. However, current VR applications mainly focus on task performances, ignoring the significant values of other stakeholders (caregivers and therapists) and their roles in MCI/MD patients' therapies. We designed a VR way-finding cognitive task and evaluated its usability and effectiveness by interviewing both MCI/MD patients and stakeholders. Findings suggest that the interventions of stakeholders can improve the performance of the participants. Besides, we identified several significant factors in designing VR cognitive tasks for patients with MCI/MD.

Keywords: Mild Cognitive Impairment, Mild Dementia, Virtual Reality, Way-finding, User ability, Navigation, Stakeholder, Caregiver

Index Terms: H.5.2 [User Interfaces]: User Interfaces—Graphical user interfaces (GUI); H.5.m [Information Interfaces and Presentation]: Miscellaneous

1 INTRODUCTION

Dementia is characterized by a group of chronic and progressive symptoms caused by various brain illnesses that affect memory, thinking, behavior, and ability to perform daily activities [5]. The early intervention treatment for patients with mild dementia (MD) and mild cognitive impairment (MCI) (*i.e.*, the stage between the expected cognitive decline of normal aging and a more severe decline of dementia) has been proven to effectively improve cognitive functions and reducing the risks of dementia progression [3]. In recent years, virtual reality (VR) technologies have been increasingly used in early intervention treatments for MCI/MD through simulated cognitive tasks in real-life scenarios like cooking, way-finding, and image memorizing [4]. However, current VR cognitive training applications mainly focus on patients' task performances without sufficiently evaluating MCI/MD patients' potential adoption and usability issues [4]. Meanwhile, most work primarily investigated patients' experiences and ignored other stakeholders' roles and perspectives [1], such as therapists and caregivers, who could play significant roles in the treatments of MCI/MD patients [8].

Therefore, we aim to examine elderly MCI/MD patients' adoption and perceptions of using immersive VR for cognitive training and understand other key stakeholders' perspectives besides patients, *i.e.*, therapists and caregivers. We developed and designed a way-finding cognitive navigation VR task and collected user feedback through qualitative interviews with three key stakeholders, 11 older adults, 5 dementia therapists, and 3 caregivers. We collected and analyzed patients' performances in the VR navigation task, usability

experiences, and feedback from all three stakeholders regarding their perceptions and feedback.

Our findings suggested that patients had diverse performances regarding their cognitive level and external assistance. The MCI/MD patients performed better in VR equipment management and task completion when they interacted and communicated with their therapists and caregivers during the VR intervention. Moreover, we identified a series of significant factors in designing VR cognitive therapies, which can improve the reality, enjoyment, and feasibility of MCI/MD patients. We provided design insights for creating customized collaborative VR interventions for MCI/MD patients and potential approaches of involving therapists and caregivers in training tasks to shed light on future VR research.

2 RELATED WORK

There has been increasing research attention on people with dementia, especially in aging countries. In the past decade, VR has become a promising technology that can simulate the real scenario in life and can be well used in treating cognitive impairment or dementia [9]. The general design of VR training for dementia people is to emulate the real life of the patients and gamify it to make them more immersive and enjoyable [1]. Way-finding task has been developed to improve patients' navigation ability, usually consisting of a path-learning section with guidance or map and a route repetition task without instruction [6].

Dementia patients' stakeholders include caregivers like spouses or children [7], dementia therapists, and voluntary people within the community [2]. Caregiving interventions for dementia treatment have become increasingly important [8]. The support of the caregivers and experts can help dementia people adjust their memory loss and functional decline, navigate the health and age care system and provide service access [3]. However, very few studies investigated how stakeholders can get involved in VR-based dementia treatment. Most of the existing VR research focused on the experience and involvement of the dementia patients themselves instead of the caregivers and therapists.

3 METHODOLOGY

The VR System. We designed a VR way-finding VR task to support MCI/MD patients in training their spatial orientation skills, using Unity, and deployed it through SteamVR in HTC VIVE head-mounted display. In the navigation task, participants see the city scene from a first-person perspective and can move around using VR controllers. Meanwhile, participants can see their real-time locations on a virtual map which marks the starting and ending points. In the way-finding task, participants are asked to explore the VR city, locate their positions, and walk toward the destinations marked on the map.

Participants. We first invited five MCI/MD therapists to explore the VR environment and test the tasks, and then conducted semi-structured interviews with them to investigate therapists' feedback on the usability and feasibility of the VR task. Next, we iterated and improved the way-finding task and VR environment design with simpler tasks and more specific instructions. Then, we recruited MCI/MD patients and older adults from a local care center in Shanghai through a convenient sampling approach and conducted user

* Corresponding author: Xin Tong (xin.tong@dukekunshan.edu.cn)

¹Duke Kunshan University

²University of Washington

³East China Normal University

tests with 11 participants (4 with MCI, 2 with MD, and 5 healthy ones, aged from 62 to 89 years old) and 3 caregivers.

Procedures. Before the test, participants experienced the SteamVR exploration scene, where they freely explored the space and described the room layout to familiarize themselves with the VR setup. Participants also learned how to manipulate the VR controllers to move and switch views. This process lasted about 10 minutes. Next, participants entered the simulated VR city to take the test (Figure 1). A map appeared on the left corner and participants were asked to follow the path on the map to navigate from the starting point to the destination.

Measurements. We collected participants' task performances in the VR test and feedback after the test to measure the usability and effectiveness of the tool. We evaluated participants' task performances, including their manipulation abilities, spatial information process abilities, task acceptance, and comprehension levels, by recording their task completion time, number of errors in choosing crossroad, and the ability to combine maps and real-time locations. After the test, we conducted a short interview with both older adults and caregivers about their usability experiences and feedback. For caregivers, we also asked about their attitudes and suggestions about the potentially effective ways to engage them in future MCI/MD VR training tasks.



Figure 1: a) Game view of VR b) Player played with VR controllers

4 FINDINGS

4.1 Qualitative Findings of Therapists' Interviews

To sum up, therapists provided five recommendations in pre-test interviews based on their experiences in VR environment.

- Optimize the movement approach of the navigation task in VR to avoid asynchronous motions and adverse effects, which will reduce the risk of falling when the patients return to the real world.
- Provide more familiar elements and scenes in VR, which can help patients to adapt to the VR environment faster.
- Design more concise and simpler VR tasks to reduce patients' cognitive load for more concentrated attention and longer intervention time.
- Consider caregivers' important role in patients' VR therapy. Elderly patients are more willing to communicate and share their feelings with their caregivers; meanwhile, their caregivers can support patients and take better care of them when they feel discomfort situations.

4.2 Older Adults' VR Test Performances

All participants hesitated about their tasks at the beginning when facing an unfamiliar virtual environment. Older adults' and patients' performances suggested that patients met more challenges and difficulties in adapting and using VR tools and comprehending the way-finding task. In general, healthy older adults with normal cognitive status showed better spatial orientation and hand-eye coordination skills in the way-finding task than patients with MCI. Moreover, healthy older adults had more attention concentrating on

the tasks than MCI/MD patients, who showed poorer performances in identifying directions due to cognitive declines.

With support from their caregivers, the MCI patients gradually accepted to try the VR environment and perform the tasks, while some MD patients still experienced motion sickness. However, patients' levels of fear and motion sickness reduced when their caregivers engaged in the tasks. All patients showed a strong desire to communicate with their caregivers and constantly shared their feelings with their caregivers in the test.

4.3 Qualitative Findings of Caregivers' Interviews

Caregivers responded that they felt patients with MCI/MD were just like children who needed to be cared for, rewarded, and comforted. Thus, they believed that patients would achieve better performances if their caregivers, families, and/or researchers were involved and even collaborated with the patients in the VR interventions. All three caregivers also suggested that they would like to experience the VR environment and tasks before the patients so that they could provide better support and instruction to help their patients and reduce their challenges and fear.

5 CONCLUSION

In general, our study provided better understanding and novel insights about MCI/MD patients' usability experiences of VR cognitive therapies and other important stakeholders' perspectives and perceptions. Meanwhile, we suggest considering various factors besides task performances when designing VR cognitive tasks, e.g., Further, we also suggest that future work take stakeholders' roles and perspectives into consideration when designing VR cognitive interventions and tasks for patients with MCI/MD to potentially better support patients and improve efficiencies.

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