Integrating Shared co-located Clinician-Patient Augmented Reality into rehabilitation tools

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Abstract

Virtual Reality holds great rehabilitation potential, however an adoption barrier for practical use is the disconnect between patients and both clinicians and their physical surroundings. Co-located Augmented-Reality can mitigate these issues by placing both in real-world environments with augmented challenges while avoiding disconnection. As a proof of concept, we implemented a tool with co-located spaces where patients and clinicians can interact with augmented content safely together. We performed a usability study (n=8), which demonstrated the tool's usability and potential. This approach can potentially boost the adoption and effectiveness of augmented rehabilitation tools helping to unlock their potential.

1. Introduction

Recent years have seen the development of a wide variety of Virtual Reality (VR) tools for rehabilitation in the realms of physical and occupational therapy. These include tools for conditions such as stroke Khan et al. (2024), Landim et al. (2024), Parkinson's Kwon et al. (2023), orthopaedic injury Tang et al. (2025) and many more (reviewed in Rutkowski et al. (2020)). These tools are thought to hold the potential to break several significant bottlenecks limiting current rehabilitation tools given their flexibility, naturalness, easier logistics etc. However, their adoption in practice for clinical use still remains limited – why?

One key reason for this is the disconnect involved with VR use, as they block patients' field of vision and present them with a virtual world. However, in doing so, they prevent them from seeing the world around them and the dangers in it. For example, hospital wards where equipment, medical staff, and other patients are found. In parallel, the clinicians are also disconnected from their patients, with whom the interaction takes place outside the virtual environment, which often they either cannot see or can view only via a computer/tablet screen. How can we break this disconnect?

Augmented Reality (AR), in which the user is presented with augmented content while still in the real world may help mitigate the disconnect from the environment and preserve empathy, in addition to causing less nausea De Cecco et al. (2023), Navas-Medrano et al. (2024). And indeed, while still less mature there are several attempts to develop rehabilitation tools using this approach Modlin & Kuo (2025). In parallel, shared collaborative sessions in virtual environments have shown success in reducing the feeling of isolation, mitigating the barrier between patient and clinical staff Marques et al. (2024), Oliveira et al. (2026), Worlikar et al. (2023). However, despite the suggested advantages De Cecco et al. (2023), Navas-Medrano et al. (2024) these two approaches have seen only very limited combinations as previous attempts were limited by expensive hardware and environment setups and the need for controlled in-lab settings that were less naturalistic De Cecco et al. (2023). In contrast, new recently available tools make this approach more practical in terms of cost and setup and can be deployed more naturalistically.

Thus, here we suggest the use of co-located Shared AR via an asymmetric interface as a step forward towards these challenges. We implement such a tool as a proof of concept, and then test its usability in terms of safety and functionality. We chose to implement two tasks that explore different aspects of this approach – a reaching task, which focuses on dynamic interactions between patient and clinician, and a road crossing which enables clinicians to safely train and test users on a dangerous task in the real world.

2. Methods

Terminology. A **Shared virtual environment** is one in which multiple users can perceive the same digital content simultaneously, in this case breaking the disconnect between patient and clinician. A **co-located augmented environment** is one in which both users are in the same physical space in the real world with the augmented targets appearing in the same physical locations. An **asymmetric interface** means that while both users perceive the same augmented content, they are also offered different affordances and options. This enables clinicians to control the task in real-time without the patient changing parameters or getting distracted by controls.

Tools. We used Meta Quest 3 Headsets which offer full-color-passthrough AR for the participants, while the experimenters used a Quest 3 or Quest Pro interchangeably. The software was developed using Unity and programmed in C#. We utilized Meta's "Shared Spatial Anchors" feature. This setup enables multiple users to share and interact with common virtual objects while simultaneously tracking the handheld controllers and headset movements of both patient, the clinician, and any required targets without external equipment. Participants used the controller's grip button to grasp objects and move them around, while the experimenters interface included a standard menu which could be controlled via controller touch or ray-cast.

Participants. 8 healthy participants (5 males, all right-handed). The experiment was approved by our university's IRB (#1149/25) and all participants signed their informed consent.

Reported Results Format. The usability survey following each task consisted of quantitative Likert scale questions (1–10, 10 high), Binary (Yes/No) compliance checks, and open-ended subjective questions to capture qualitative feedback on experience, usability, and concerns. All results are reported as mean±SE.

2.1. Scenario 1: Reaching Virtual Objects

In traditional treatment methods, the clinicians are limited in the number of objects they can place, their size, their behavior, and especially where they can place them in space so that they challenge specific movements. Here, the clinician can place virtual targets anywhere in the 3D space of the physical environment (i.e. including midair) and the participant is tasked with reaching them, grasping them by bringing their hand to the object location and using the controller's grip button, and then carrying them to target locations and releasing them there (see Fig. 1 A).

The locations of the clinician, target, and patient's head and hands are tracked continuously by the headsets without external equipment. In this scenario the participant interacts with an experimenter in a shared co-located environment.

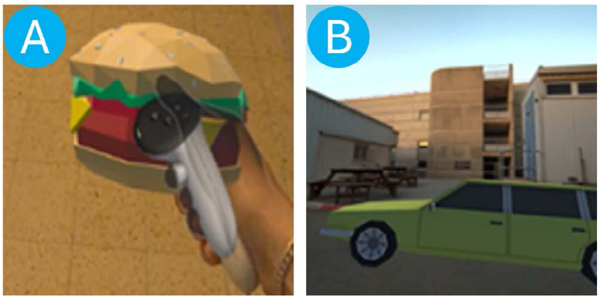

Figure 1: A: Scenario 1 – Reaching task. Patient point of view while performing the reaching task. B: Scenario 2 – Outdoor street crossing task. A patient's point of view of a car crossing the road. The patient needs to wait for the vehicles in their path to pass and when the road is safe, cross safely to the other side.

2.2. Scenario 2: Road Crossing

In traditional real world settings, this task can be dangerous to practice, and practicing in VR with natural locomotion is difficult as it requires a large space and is not naturalistic enough (e.g. stepping off sidewalks). Here, the clinician controls a virtual car placed in a street in front of the participant (Fig. 1 B), and the participant is tasked with crossing the real world street without it colliding with them, which is a safe and naturalistic way to practice it. Here as well, the participant interacts with an experimenter in a shared co-located environment.

2.3. Experimental procedure

Our usability study was aimed at testing if our tool is functional and stable as a proof of concept for this general approach. In addition, our goal was to assess the clarity and intuitiveness of the user interface, the naturalness of the motion of the virtual object, and the overall user experience. Throughout the experiment, the participant performed all tasks co-located with the experimenter. The participants first received an explanation of the experiment and gave their informed consent. Then participants performed three tasks. Each task was followed by a survey to gather feedback on the user experience. Objective overall functionality and participant performance were tracked throughout.

Task 1: Reaching Targets. This task involves a basic interaction scenario where the participant and experimenter are immersed in a shared AR environment through two headsets. First, both donned their headsets and entered into a joint augmented space, but each had different interface options via the asymmetric interface. The experimenter (in the 'clinician' role) then creates a virtual object (a hamburger) and places it in the air within the space (see Fig. 1 A). The participant (in the 'patient' role) is then expected to interact with the virtual hamburger – grab it, move it, place it in the space, and give it back to the experimenter. This task was performed indoors.

After this basic interaction the participants performed scenario 1, in both roles, focusing on interaction with multiple virtual target objects. The experimenter assumes the role of a 'clinician' and creates seven virtual targets and positions them within the space. The participant assumes the role of the 'patient' and is tasked with grabbing each virtual object, one at a time, and placing it into a real basket that is physically present in the environment. Once these steps are completed, the participant and the experimenter switch roles and repeat the process. This task was performed indoors as well.

Task 2: Road Crossing. In this task, the participants perform scenario 2. The experimenter (in the 'clinician' role) remotely controlled the virtual vehicle's movement (as described in Scenario 2). The participant must determine the right time to cross the road while the vehicle is moving and safely cross it ten times. To ensure participant safety and prevent real-world hazards, the task was conducted in a semi-isolated university zone equipped with a physical barrier to block vehicular entry. Testing was restricted to low-activity afternoon hours, and a second experimenter actively monitored the environment throughout the protocol to mitigate any real-world safety risks.

3. Results

All of the participants successfully completed the tasks, reaching all targets and safely avoiding the virtual car, with no adverse effects or nausea being noted. Data was extracted successfully from the controllers and headsets' movements throughout the experiment.

From a technical perspective, participants reported that the tool was easy to operate both in terms of hardware ("How comfortable was the physical equipment to use?"; 8.5 ± 0.6; Likert 1-10, 10 easy) and software ("How comfortable was the software interface to use?"; 9.75 ± 0.25). A strong sense of co-presence was maintained across both environments ("How much did you feel a sense of presence in a shared space with the clinician?"; 9.75 ± 0.25 10 high).

In task 1, participants reported that it was highly intuitive to initialize the collaborative space ("How clear was it to create a new room?"; 9.8 ± 0.1; Likert 1-10, 10 easy), join it ("How clear was it to join a room?"; 9.8 ± 0.1), and instantiate new virtual objects ("How clear was it to create a new virtual object?"; 10 ± 0). Spatially locating targets ("How easy was it to locate the objects in virtual space?"; 9.5 ± 0.2) and manipulating them ("How well were you able to grab and transfer the objects?"; 9.7 ± 0.2) scored consistently high. There were no reports of nausea or dizziness during the first (1.62 ± 0.37; Likert 1-10, 10 uncomfortable) or the second part of this task (2.0 ± 0.53). Open subjective remarks from this task were overall enthusiastic.

In task 2, participants found the simulation elements to be satisfactory, but indicated a deficit in environmental presence ("To what extent did the experience resemble crossing a real road?"; 6.6 ± 0.9), and noted the car design and movement as insufficiently realistic. Moreover, participants had mixed feelings regarding physical deployment ("Did you feel comfortable being outdoors with a headset on?"; 6.2 ± 0.8); some found it exciting and saw great potential, while others felt uneasy, fearing the possibility of tripping, the potential arrival of an actual vehicle, and of "looking weird" to passerbys.

4. Discussion

In this manuscript we described a proof of concept for the use of co-located augmented spaces utilizing standard commercial headsets for tasks which can be used for rehabilitation. Our results supported this approach – the tool which we implemented was intuitive and easy to use in different scenarios both when participants played the roles of clinicians and of patients. However, while this demonstrates the potential of this approach, this is far from a mature system, as evidenced by some of the user comments for scenario 2. Furthermore, the participants were able-bodied, limiting the ability to generalize to patients, and not with clinical background limiting generalizability to clinical staff – the combination of these factors limits the evaluation of the tool to basic usability only as a first step of demonstrating the potential of this approach. The next steps are to further develop this system, and others like it within this approach, and to test them in depth with both clinical staff and patients.

5. Conclusions and future work

We successfully implemented our tool, and then successfully tested its usability, demonstrating that it is both functional and user-friendly and without adverse effects. The tool was well received by participants, who reported ease of use and an overall positive experience and were enthusiastic about its potential for rehabilitation use. Most importantly, participants reported high levels of connectedness to the clinician and to their surroundings. However, the test also highlighted areas for improvement, particularly in the realism of virtual object movements, such as the car in the road crossing scenario. While some participants found the outdoor application of the tool exciting and beneficial, others expressed concerns about comfort, stigma and safety outdoors. This proof of concept demonstrates the potential of this approach for rehabilitation and we aim to now further develop such tools and test them with patients and clinical staff.

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Disclosure of Interests

The authors have no competing interests to declare.

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