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Parkinson's Disease Simulation in Virtual Reality for Empathy Training in Medical Education

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Abstract

Introducing empathy for patients with debilitating diseases to medical students has always been a challenge in medical education, especially during the pre-clinical years. Since the most recent decade, a downward trend in medical students' empathy levels has been observed. With the rapid evolution of technologies, it is possible to use advanced gaming devices as tools to improve teaching efficacy, enhance students' understanding of a specific disease and influence their prosocial behavior towards patients. Studies suggest that virtual reality (VR) game applications are effective in education due to their immersive interaction, fully controllable virtual environment, and the feeling of presence and embodiment . The current study proposes a VR gaming application to enhance medical students' empathy level for patients with Parkinson's disease (PD). By engaging students in the simulated daily life of patients with PD from their perspective, the study aims to help medical students to have hands-on experience of the disease and thus to facilitate their understanding of the symptoms and the patients' experiences. In-game data and pre- and post- measurements are designed for assessment and analysis. By combining the expertise of the human-computer interaction field and the medical field, the application embeds professional and accurate medical knowledge with trending VR techniques and interactive content to promote empathy.

Index Terms: Human-centered computing—Human-computer interaction (HCI)—Empirical studies in HCI; Human-centered computing—Human-computer interaction (HCI)—Interaction paradigms—Virtual reality

1 Introduction

Empathy, the ability to sense other people's emotions and imagine others' thinking or feelings, is proved to be important in public healthcare. The possibility to envision one in another person's place prompts empathy as one of the essential traits for healthcare providers [16]. The lack of necessary compassion for their patients often becomes a barrier to providing the most optimal level of care. PD is a movement disorder caused by the nervous system; patients with PD are facing challenges on simple daily activities. If one does not have similar conditions or know someone close to them who had the experience, it is difficult for perspective-taking [15]. This fact has made it a constant challenge to improve the empathy level by using traditional introductory methods to teach pre-clinical medical students, who are the future physicians. A more efficient approach for improving the empathy level of healthcare providers towards patients with PD is highly in need.

Games can provide an interactive environment thus have been used to help instill knowledge or concepts in a more relaxing setting. They can be used to train perspective-taking, which is one of the core elements of empathy training. Among the newly thriving gaming technologies, VR training is considered more effective because of its capability of embodiment [2]. The immersion and interaction make VR applications capable of provoking a strong feeling of presence. Meanwhile, VR has the advantage to simulate realistic scenarios or create unrealistic scenarios that meet the high requirement of precise control while training users in a safe environment.

Although researchers have found the advantages of VR to be an empathy machine [10], no studies have made use of VR for promoting empathy for PD in medical students. In the current study, a head-mounted, fully interactive VR application has been designed and developed for training empathy for patients with PD. The targeted audience are pre-clinical students of medical schools, who will be introduced to PD presentation for the first time in the curriculum. We aim to let medical students experience the symptoms their patients suffer from and the challenges the patients face every day with fine motor skills through the embodiment aspect of VR. This is also a pilot study to assess the effectiveness of using VR technologies in empathy training and retainment, which can motivate more future projects that may bring significant improvements to the current curricula of medical education.

In the current VR application, the user assumes the role of a patient with PD in a first-person view and simulates the daily routines of the patient. The daily routines have been abstracted into six task scenarios with time constraints. Performance data collection is embedded in the gameplay along with a scoring system. In addition, pre- and post- measurements on the empathy scale and attitudes change toward patients with PD are used to assess the effectiveness of the virtual learning environment. The application is scheduled to be integrated into the medical program 2021 fall curriculum as a novel educational approach.

2 Background

PD is caused by the disorder of the central nerve system resulting in symptoms such as tremor, slow movement, stiffness, and loss of balance [5]. The current treatment for PD can only help reduce or control the symptoms, but can hardly cure it. Therefore, a proper level of empathy and compassion from the healthcare providers can be helpful when patients are receiving care.

VR technologies have been well explored for educational purposes in medical schools; examples include simulations of anatomy [7], training on surgery [9] and emergency triage [14], and more. Besides the commonly-seen hands-on practices, empathy is also one of the core curricula in medical students' professional development. Traditionally, students learn about the diseases by reading textbooks and watching introductory videos. Without self experiences or interaction with the real patients, one can only imagine the suffering and hardship from the description of symptoms and video records. Since the most recent decade, a downward trend in medical students' empathy levels has been observed [11, 20].

The immersion and embodiment of VR applications help medical students to visualize and thus have a better understanding of patients' feelings. Adopting VR applications for promoting empathy has been recognized more effective in recent studies in medical education [3, 6, 13, 18]. Pilot studies have reported positive feedback using

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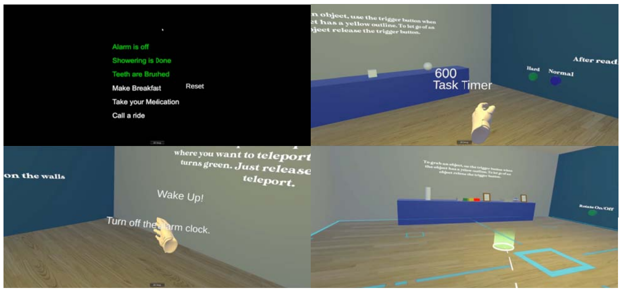

Figure 1: Checklist (upper left), left hand display (upper right), right hand display (lower left), tutorial room and navigation (lower right).

VR to cultivate empathy for older people [4], nausea and vomiting management [19], and visual deficit [1].

3 Our Contribution

No study has been designed explicitly for training empathy for PD using a standardized empathy scale and integrated into a medical school pre-clinical course. Medical school professors and students were involved in game design, playtest, and study design, including the selections of survey questions and measurement scales. The current project is scheduled to be integrated into the medical program 2021 curriculum as a novel educational approach. A long-term data collection and analysis for the outcome assessment have been planned.

4 Methods

4.1 VR Application Design

The symptoms of PD make the patients' movements different from others. Seemingly simple daily scenarios such as grabbing an item or drinking from a cup can be struggling for them. The VR application narrows down the scenarios into six most commonly encountered tasks and challenges the participants to complete these tasks under the impact of simulated symptom (tremor).

4.1.1 System Architecture

The application is VR-based, fully immersive, with narrative and interactive designs, as opposed to a recorded VR 360 video or a simulation of an intervention session. This application aims to fully utilize the presence and immersion experience of VR devices and motion feedback for promoting empathy. Unity game engine is used to develop the game, and the targeted platforms include two popular VR headsets on the market: Oculus Quest and HTC Vive Pro. The game uses a task-based narrative with a first-person view. Head movement, hand movement, and body tracking are integrated to ensure accurate completion of tasks. Voiceover instructions and background music are also incorporated to match the theme.

4.1.2 User Controls and Interaction

The controls used for the gameplay are mainly the standard SteamVR control scheme. Users can use the controller to teleport, grab and drop an object. When hovering over an object, the object will be highlighted in yellow. One additional control added is to use the menu button to toggle open a checklist screen that shows the user's progress. This checklist screen is used to show the user's progress, where each task is listed with color-coded status: completed tasks are shown in green, failed tasks in red, and unfinished tasks in white. The checklist screen and UIs are shown in Fig. 1.

4.1.3 Symptoms Simulation

The simulation of the hand tremors symptoms from patients with PD is the main feature of the current application. While one of the embedded features of VR controllers is the stability of the hands, this application intentionally goes against the feature and creatively simulates the hand tremor. It is done by rapidly shifting the hands of users across several points to give the visual stimulus of having hand tremors. The shifting directions and distances are designed according to medical knowledge, instead of using simple random movement. The haptic feedback can be toggled on or off. Three degrees of hand tremors are implemented by varying the frequency and moving distance. In addition, a free play mode with dynamic difficulty adjustment is implemented for a better game experience and repetitive practice. For data collection consistency, the first students who get trained with the application will use a fixed difficulty level throughout the training program.

While the user in the simulation knows that they do not have hand tremors, the visual stimulus overrides that knowledge, and gives the impression that their hands are shaking. Other symptoms of PD, such as gait and loss of balance, are not implemented, considering the higher possibility of causing nausea and other motion sickness related problems.

4.1.4 Tasks System

The task system operates by prompting instructions through voiceover and text hint floating around the virtual hand wrist. The user can toggle on or off a menu screen that shows the completion status of all tasks. Six daily tasks have been identified and implemented. Each task (except for the first one that triggers the timer) is recorded by a timer and checked for user performance using body, head, and hand tracking. Completing tasks within the time allowed will grant a score based on the time remaining for the task, whereas running out of time will result in a zero score for the task. Each task timer is recorded after the timer is stopped, either by the task being finished or the timer hitting zero.

Tutorial. Before the tasks begin, the user starts in an introduction room where the controls are explained. In this tutorial room, instructions are shown as text on the walls and explained by a voiceover. In addition to the instructions, there are several objects to practice picking up and learning how to use the teleporting movement. There is no time restriction and no hand tremor in this step, so that the users can take as much time as needed to get accustomed to moving and picking up objects in VR. The tutorial room is shown in Fig. 1.

Alarm Clock. Turning off the alarm clock, while not technically a task since it does not record any timer data, starts the main game timer and begins the first task by giving the first prompt. A screenshot of the alarm clock task is shown as the upper left subfigure in Fig. 2.

Showering. The showering task begins after the alarm clock is turned off. The task timer for the entire game doesn't begin until the shower task is activated. The showering is completed by shampooing the user's hair, then turning off the water. The user has to bring the shampoo bottle close to the user's head to "wash" the hair. A screenshot of the shower task is shown as the upper right subfigure in Fig. 2.

Tooth brushing. The toothbrushing task begins after the shower is completed. The task consists of two parts: applying toothpaste to the toothbrush and then using the toothbrush to "brush" the user's teeth. The brushing is achieved by colliding the toothbrush with a thin hitbox set on the user's head/mouth. A screenshot of the toothbrushing clock task is shown as the middle left subfigure in Fig. 2.

Breakfast. The breakfast task prompts the user to make a sandwich step by step. The task is completed by adding the sandwich components in the correct order, and then eating the sandwich. The "eating" portion is handled the same way as the tooth brushing task,

Figure 2: Alarm clock task (upper left), shower task (upper right), tooth bushing task (middle left), breakfast task (middle right), pills task (lower left) phone task (lower right).

that the user brings the sandwich to their head where it collides with a hitbox. The timer for this task, rather than starting at the end of the previous task, is activated after the user enters the kitchen, to eliminate the recording of movement rather than task completion. A screenshot of the breakfast task is shown as the middle right subfigure in Fig. 2.

Pills. The pills task requires picking up and putting down the correct pills in the correct order. The task currently asks the user to put two of the four pills into the user's bag to "bring to the doctor's office." The pills shown in the scene are either Parkinson's drugs or cardiovascular/blood-thinning drugs. The user has to choose the right medicines for PD to take to the doctor with the text hint as well as the voiceover instruction. The timer begins after the user finishes "eating their breakfast," since both tasks are in the kitchen. A screenshot of the pills task is shown as the lower left subfigure in Fig. 2.

Phone. The final task is to call a driver to visit the doctor. This task requires the use of the phone in the bedroom. The user must dial the phone number by using their finger to push each button. The phone number is displayed twice, one at a time on the user's wrist display, and also on a note beside the phone to make it easier to understand and read. A screenshot of the phone task is shown as the lower right subfigure in Fig. 2.

After the final task, the user is teleported to the final score area, where the score is displayed, and a large red button that ends the game. Upon pushing the red button to finish the game, it takes the recorded time data from each timer and exports them to a file.

4.2 Performance measurement and feedback

The timer system functions by running a series of timers, with each timer being tied to a task. If a timer hits zero with the task being uncompleted, it will force a fail and begin the next task and the next timer. These timers also serve as the way to measure user performance, as the timer data is sent to an external file to be saved. While the score system is not tied to these timers, another set of older timers implemented in the program run concurrently to the timer system and calculate the score of the user as displayed at the end of the game.

5 Experimental Design

5.1 Participants

Participants are recruited via class-list serve emails and in-class announcements. Before being enrolled in the study, volunteers are screened for a history of seizure disorder, current eye infection, and pregnancy status by self-report.

Once subjects consent and get enrolled for the study, they will be given participant IDs and randomly assigned to the intervention group or the control group. The intervention group uses the VR application for training empathy, while the control group uses traditional methods: watching videos of patient testimonials that introduce the challenges of living with PD. The videos are from the Parkinson's 360 website.

5.2 Procedures

Subjects in both intervention and control groups take pre-study surveys. Pre-study surveys include a demographics questionnaire, Jefferson Scale of Empathy (JSE) [12], and the University of California Los Angeles (UCLA) geriatric attitudes assessment.

Once pre-study surveys are completed, subjects in the control group and intervention group will be brought into separate study rooms. The control group watches a video on the patient's daily struggles of living with PD. The intervention group uses the VR application to simulate completing multiple activities of daily living in the setting of hand tremors. They are not aware of which tasks are the beginning and end of checkpoints for performance recording.

After completion of the interventions, both groups will complete post-study surveys consisting of the JSE and UCLA geriatrics attitudes assessment [20]. The intervention group also receives an additional VR satisfaction survey. Data will be analyzed with the Wilcoxon signed-rank test and ordinal logistic regression. The experiment is still ongoing and more participants will be recruited in order to assess and thus improve the learning environments.

6 Measurements

Quantitative measures are used in assessing the objectives of the game. Informed by the literature of empathy games, the following measures are selected and designed for the current study.

1. Virtual reality experience measures. To analyze the efficacy of using VR as a tool for empathy elicitation, a questionnaire derived from [8] includes a few questions about the presence and immersion experience after the session. VR measures also include in-game recorded performance data.

2. The pre- and post- empathy scale, JSE [12]. The JSE is a commonly used and validated scale to test the empathy level for health professionals. The S-version that is dedicated for medical students is used.

3. UCLA geriatric attitudes assessment [17]. It is a 14-item scale developed to assess health care providers' attitudes toward elderly patients.

4. Demographics questionnaire. The questionnaire proceeds with general questions that do not include identifiable data, such as age, gender, experience level with games or technologies, and so on.

7 Discussion

The VR application has been playtested by medical faculty, medical students, and game design students throughout the design and development stage. Feedback includes improving interaction mechanism with objects and separating tasks by different rooms, having different difficulty levels, all later incorporated in the current application. While the first version with the tutorial and six tasks are ready to be used for the study and integrated into the course curriculum, the authors and developer team are continually working on the second version to add more features and tasks.

8 CONCLUSION

In the present research project, a VR-based simulation of activities of daily living for PD patients has been developed. The application includes time constraint tasks and control challenges purposefully designed for classroom use. We hope that this work will help students and healthcare providers to develop empathy for patients with PD. A link to the game trailer can be found below. https://youtu.be/qngTQsdzPSY.

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REFERENCES

[1] D. Alexander, T. Nguyen, P. Keller, J. Orlosky, S. Brown, E. Wood, O. Ezenwoye, and W. Jirau-Rosaly. Design of Visual Deficit Simulation for Integration into a Geriatric Physical Diagnosis Course. In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pp. 838–839, Mar. 2020. doi: 10.1109/VRW50115.2020.00270

[2] E. Bang and C. Yildirim. Virtually Empathetic?: Examining the Effects of Virtual Reality Storytelling on Empathy. In *Virtual, Augmented and Mixed Reality: Interaction, Navigation, Visualization, Embodiment, and Simulation*, pp. 290–298. Springer, Cham, July 2018. doi: 10.1007/978-3-319-91581-4_21

[3] P. Bertrand, J. Guegan, L. Robieux, C. A. McCall, and F. Zenasni. Learning Empathy Through Virtual Reality: Multiple Strategies for Training Empathy-Related Abilities Using Body Ownership Illusions in Embodied Virtual Reality. *Front. Robot. AI*, 5, 2018. doi: 10.3389/frobt.2018.00026

[4] A. M. H. Chen, M. E. Kiersma, K. S. Yehle, and K. S. Plake. Impact of an Aging Simulation Game on Pharmacy Students' Empathy for Older Adults. *Am J Pharm Educ*, 79(5):1–10, Oct. 2015. doi: 10.5688/ajpe79565

[5] T. M. de Melo Cerqueira, J. A. de Moura, J. O. de Lira, J. C. Leal, M. D'Amelio, and F. A. do Santos Mendes. Cognitive and motor effects of Kinect-based games training in people with and without Parkinson disease: A preliminary study. *Physiother Res Int*, 25(1):e1807, Jan. 2020. doi: 10.1002/pri.1807

[6] E. Dyer, B. J. Swartzlander, and M. R. Gugliucci. Using virtual reality in medical education to teach empathy. *J Med Libr Assoc*, 106(4):498–500, Oct. 2018. doi: 10.5195/jmla.2018.518

[7] C. Ekstrand, A. Jamal, R. Nguyen, A. Kudryk, J. Mann, and I. Mendez. Immersive and interactive virtual reality to improve learning and retention of neuroanatomy in medical students: a randomized controlled study. *CMAJ open*, 6(1):E103–E109, Feb. 2018. doi: 10.9778/cmajo.20170110

[8] C. J. Falconer, A. Rovira, J. A. King, P. Gilbert, A. Antley, P. Fearon, N. Ralph, M. Slater, and C. R. Brewin. Embodying self-compassion within virtual reality and its effects on patients with depression. *BJPsych open*, 2(1):74–80, Feb. 2016. doi: 10.1192/bjpo.bp.115.002147

[9] M. Graafland, J. M. Schraagen, and M. P. Schijven. Systematic review of serious games for medical education and surgical skills training. *Br J Surg*, 99(10):1322–1330, Oct. 2012. doi: 10.1002/bjs.8819

[10] R. Hassan. Digitality, Virtual Reality and the 'Empathy Machine'. *Digital Journalism*, 8(2):195–212, Feb. 2020. doi: 10.1080/21670811.2018.1517604

[11] M. Hojat, S. Mangione, T. J. Nasca, M. J. M. Cohen, J. S. Gonnella, J. B. Erdmann, J. Veloski, and M. Magee. The Jefferson Scale of Physician Empathy: Development and Preliminary Psychometric Data. *Educ Psychol Meas*, 61(2):349–365, Apr. 2001. doi: 10.1177/00131640121971158

[12] M. Hojat, S. Mangione, T. J. Nasca, S. Rattner, J. B. Erdmann, J. S. Gonnella, and M. Magee. An empirical study of decline in empathy in medical school. *Med Educ*, 38(9):934–941, Sept. 2004. doi: 10.1111/j.1365-2929.2004.01911.x

[13] A. K. Louie, J. H. Coverdale, R. Balon, E. V. Beresin, A. M. Brenner, A. P. S. Guerrero, and L. W. Roberts. Enhancing Empathy: a Role for Virtual Reality? *Acad Psychiatry*, 42(6):747–752, Oct. 2018. doi: 10.1007/s40596-018-0995-2

[14] P. Luigi Ingrassia, L. Ragazzoni, L. Carenzo, D. Colombo, A. Ripoll Gallardo, and F. Della Corte. Virtual reality and live simulation: a comparison between two simulation tools for assessing mass casualty triage skills. *Eur J Emerg Med*, 22(2):121–127, Apr. 2015. doi: 10.1097/MEJ.0000000000000132

[15] M. Martinez, N. Multani, C. J. Anor, K. Misquitta, D. F. Tang-Wai, R. Keren, S. Fox, A. E. Lang, C. Marras, and M. C. Tartaglia. Emotion Detection Deficits and Decreased Empathy in Patients with Alzheimer's Disease and Parkinson's Disease Affect Caregiver Mood and Burden. *Front. Aging Neurosci.*, 10, 2018. doi: 10.3389/fnagi.2018.00120

[16] M. Moudatsou, A. Stavropoulou, A. Philalithis, and S. Koukouli. The Role of Empathy in Health and Social Care Professionals. *Healthcare*, 8(1):26, Mar. 2020. doi: 10.3390/healthcare8010026

[17] D. B. Reuben, M. Lee, J. W. Davis Jr., M. S. Eslami, D. G. Osterweil, S. Melchiore, and N. T. Weintraub. Development and Validation of a Geriatrics Attitudes Scale for Primary Care Residents. *J Am Geriatr Soc*, 46(11):1425–1430, Nov. 1998. doi: 10.1111/j.1532-5415.1998.tb06012.x

[18] B. Swartzlander, E. Dyer, and M. R. Gugliucci. We Are Alfred: Empathy Learned Through A Medical Education Virtual Reality Project. *Library Services Faculty Posters. 2.*, May 2017.

[19] M. Taubert, L. Webber, T. Hamilton, M. Carr, and M. Harvey. Virtual reality videos used in undergraduate palliative and oncology medical teaching: results of a pilot study. *BMJ Support. Palliat. Care*, 9(3):281–285, Sept. 2019. doi: 10.1136/bmjspcare-2018-001720

[20] J. M. Triffaux, S. Tisseron, and J. A. Nasello. Decline of empathy among medical students: Dehumanization or useful coping process? *L'Encéphale*, 45(1):3–8, Feb. 2019. doi: 10.1016/j.encep.2018.05.003