An Immersive Memory Game as a Cognitive Exercise for Elderly Users

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In the healthcare field, games and gamification have been applied as tools to support traditional treatments for dementia, anxiety, and depression. Immersive environments using Virtual Reality (VR) can help elderly users be more focused on the tasks to be done, enhancing their memory skills. This paper proposes a new cognitive exercise called Memo-VR, which combines VR technology with interaction techniques, such as scanning and virtualizing the user's hands, to play a memory game. Memo-VR was evaluated with a group of elderly users who gave positive feedback about the game.

CCS Concepts: • **Human-centered computing → Virtual reality**; • **Applied computing → Health informatics**.

Additional Key Words and Phrases: cognitive exercises, virtual reality, leap motion, elderly, VR games

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1 INTRODUCTION

As we age, brain and cognitive abilities are affected, impairing some basic activities due to motor coordination problems (e.g., remembering passwords, knowing where a specific document is, and use house keys). [8]. Electronic games are a widely-held form of entertainment and recreation and, like other new media types, can help various professional specialties [8]. In the healthcare field, games and gamification have been applied as tools to support traditional treatments for dementia, anxiety and depression, for example [12]. Furthermore, electronic games have been used in research related to psychic and motor coordination and brain training exercises for solving problems quicker [7]. Among several research work, other studies use electronic games to exercise the user's memory through memory games or cognitive exercises [3, 6, 8].

This paper proposes a new cognitive exercise called Memo-VR, which uses Virtual Reality (VR) technology combined with interaction techniques, such as scanning and virtualizing the user's hands, to play a memory game. Memo-VR was evaluated with a group of elderly users who gave positive feedback about the game.

The rest of this paper is structured as follows. Section 2 discusses research related to cognitive games. Section 3 presents the developed game Memo-VR, and Section 4 discusses the tests and preliminary results. Section 5 concludes the paper and points out future work.

2 RELATED WORK

Among the various electronic games for dealing with complaints of memory loss, irregular cognition, or both, the Stroop Game [3] and MemoGinga [6] use the Brazilian digital television platform. The Stroop Game was developed for training the selective attention of the elderly through the exploration of the "Stroop"[1] effect. There is an interference in the reaction time provoked in the brain when conflicting information is presented about an object. For example, in this game, the word "green" in red color can be displayed while asking which word is written. MemoGinga is a game that aims to prevent cognitive problems related to memory, specifically short-term memory. The game presents pairs of colored geometric figures (e.g., triangles, squares, stars) on a screen for memorization. Then, the player is asked on the next screen if a specific figure was previously presented.

Online Memory Games from "Racha Cuca"[2] and "Geniol"[3] are very similar to Memo-VR, presented in this article, in terms of rules, rewards, and gamification, but with the advantage of greater simplicity, as they are games executed in web browsers with only mouse interactions performed. However, as a disadvantage, they do not provide the sensation of immersion that virtual reality allows. Those types of games work with short-term memory and are easy to assimilate.

Pietrzak et al. [10] discuss different rehabilitation methods using VR for people with motor and cognitive disabilities and sensations and emotions resulting from traumatic brain injury (TBI). The presented methods discussed by the authors show improvements mainly in attention levels, spatial and working memory, and visual learning tasks. VR is also seen as a path to provide a more accessible form of rehabilitation in places limited financially and geographically.

It is pretty common for the elderly to have complaints related to lack of memory and cognitive difficulties. Barnes et al. [2] show that older people with high scores on cognitive tests have greater independence and better quality of life.

Glass et al. [4] argue that although electronic games do not achieve results with a high level of brain development or lasting benefits, they can increase perceptual processing speed due to brain stimuli originating from the various new information offered by the activity. Thus, our work focuses on the use of cognitive games for the elderly and virtual reality to enhance the user's immersion and isolation from external sensations that can divert attention from the activities inside the game. Furthermore, it uses interaction based on the user's hand scanning to increase the immersion effect and facilitate interaction with the game objects.

3 THE MEMO-VR GAME

Memo-VR is based on a classic and popular memory card game, and the goal is to find all the matching pairs of cards. The user must flip two cards at a time, revealing their faces to the user. If they are a matching pair, they are removed from the board. Otherwise, the pair is turned face down on the board, and an error is computed transparently to the player. The game interface provides information on the total number of cards on the board, the number of errors, and the current game duration time. Also, the game is set in a virtual sunny living room to convey a cozy feeling to the player. As a penalty for player errors, the game increments the total number of errors. There are three difficulty levels

[1] It demonstrates interference in the brain reaction time when exposed to a mismatch between reading and visualizing colors [3].
[2] https://rachacuca.com.br/passatempos/jogo-da-memoria/
[3] https://www.geniol.com.br/passatempos/ game-da-memory

based on the number of cards on the board: five pairs on easy, seven on medium, and ten on hard level. After the end of each match, the interface shows the final score, game duration time, and total number of errors.

The game uses the virtual reality headset HTC Vive[4] , responsible for receiving the virtualization from the computer and displaying it to the user. The other piece of equipment is the Leap Motion Controller[5], a device fixed in front of the headset responsible for scanning the user's hands, allowing its visualization in the virtual environment. With Leap Motion, users can interact with the game using their own hands without holding conventional physical controls. The game was developed using Unity, a game engine with virtual reality support compatible with the Windows 10 operating system, and that has a free non-commercial use license.

4 TESTS AND PRELIMINARY RESULTS

Tests were performed with a group of 7 (seven) elderly participants just before the pandemics. The experiments have been interrupted due to COVID-19. All of them were females aged between 61 and 85 years, with a level of education ranging from elementary school to graduate school. All users were participants in a project to teach how to use computers to the elderly, and all had some contact with computer equipment. However, only one of them had used virtual reality equipment before. Almost half of them (42.9%) had complaints of lack of memory, but none had a memory disorder diagnosed by a physician.

All tests were performed with the players seated to reduce discomfort and increase the level and safety of the experiment, as illustrated in Figure 1(a). With the support of an accompanying person, the game was monitored and displayed on an additional screen in real-time, as illustrated in Figure 1(b). All tests followed the rules described and approved by the Research Ethics Committee of Universidade Federal Fluminense (UFF) in Brazil (register no. 250.132).

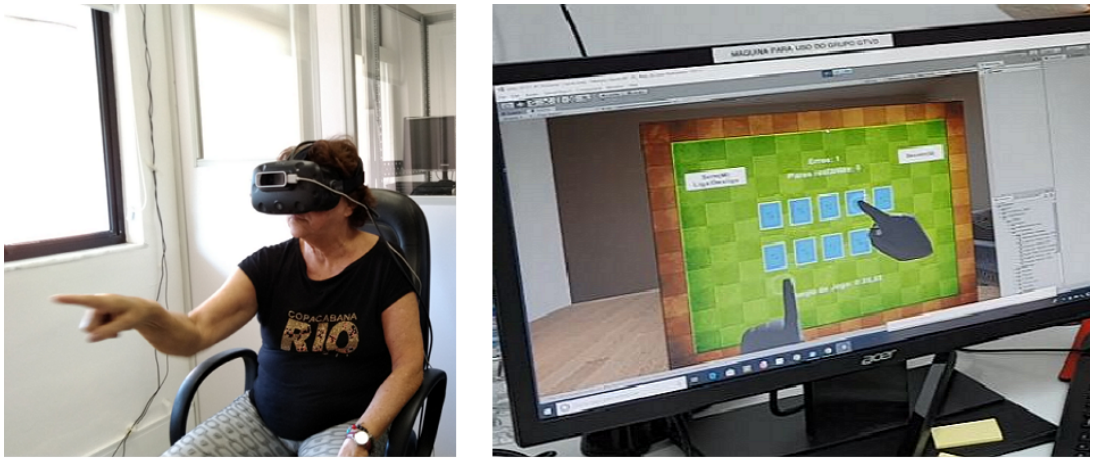

Fig. 1. User interacting with Memo-VR

All users had free time to play until they felt comfortable with the environment and tools (around 90 seconds). Then, each one played the easy, medium, and hard game levels, and their results were recorded. After the tests, they

[4]https://www.vive.com/us/
[5]https://www.ultraleap.com/

Table 1. User experiment average scores and Standard Deviations (SD).

	Easy level		Medium level		Hard level	
	Average	SD	Average	SD	Average	SD
Play Time (s)	57,7	35,3	87,7	39,7	187,5	106,4
Number of Errors	5	2,5	14	6,4	23	10,9

answered a questionnaire containing: questions about age, education level, memory loss complaints; the SUS (System Usability Scale) [9] questionnaire; and a work-based user experience questionnaire [11]. Preliminary results obtained are discussed as follows.

In Table 1, we can observe the growth in the number of errors and the average time to perform the tasks with the respective Standard Deviations (SD) according to difficulty levels. The SUS and the user experience questionnaire used the Likert scale [5], which divides responses into a five-point scale, indicating the degree of disagreement or agreement with a statement. For the SUS questionnaire, an average score of 83 points was obtained, which means a level B classification, that is, excellent, according to [1], who provided in their work an absolute rating scale for interpreting the average score obtained with SUS. Our tests indicated a good acceptance of the game by the elderly users ("I felt happy playing it") and that it has the potential to be frequently used as a cognitive exercise ("I think I would like to play this game often"). Another highlight is the use of hand interaction, in which all users agreed that they enjoyed using it ("I liked to interact with the game using my hands").

5 CONCLUSIONS

This work introduced Memo-VR, an immersive memory game proposed as a cognitive exercise for elderly users. Although our research is still in progress, the game was already evaluated with a group of seven users. The average score of 83 points obtained for the SUS questionnaire indicates that the game has good usability. Users also pointed out that they felt more immersed and focused in virtual reality.

As a limitation of this work, the small number of evaluations is highlighted, which does not allow entirely conclusive results, but more tests are planned as future work. Thus, a more effective evaluation can be made, realizing if there are correlations between the level of education and amount of time or correct answers; age and performance; and if virtual reality helps to improve memorization and concentration.

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REFERENCES

[1] Aaron Bangor, Philip Kortum, and James Miller. 2009. Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of usability studies* 4, 3 (2009), 114–123. https://dl.acm.org/doi/abs/10.5555/2835587.2835589

[2] Deborah E. Barnes, Jane A. Cauley, Li Yung Lui, Howard A. Fink, Charles McCulloch, Katie L. Stone, and Kristine Yaffe. 2007. Women who maintain optimal cognitive function into old age. *Journal of the American Geriatrics Society* 55, 2 (feb 2007), 259–264. https://doi.org/10.1111/j.1532-5415.2007.01040.x

[3] Gustavo de Paula, Pedro Valentim, Flávio Seixas, Rosimere Santana, and Débora Muchaluat-Saade. 2020. Sensory Effects in Cognitive Exercises for Elderly Users: Stroop Game. In *2020 IEEE 33rd International Symposium on Computer-Based Medical Systems (CBMS)*. IEEE, Rochester, Minnesota, USA, 132–137. https://doi.org/10.1109/CBMS49503.2020.00032

[4] Brian D. Glass, W. Todd Maddox, and Bradley C. Love. 2013. Real-Time Strategy Game Training: Emergence of a Cognitive Flexibility Trait. *PLoS ONE* 8, 8 (8 2013), e70350. https://doi.org/10.1371/journal.pone.0070350

[5] Rensis Likert. 1974. A method of constructing an attitude scale. *Scaling: A sourcebook for behavioral scientists* 1 (1974), 233–243.

[6] Luiz F. Matos, Mayara H. Santos, Yolanda Boechat, Glauco Amorim, and Débora C. Muchaluat-Saade. 2018. MemoGinga: Jogo Interativo para TV Digital como Exercício Cognitivo para Idosos. In *Anais do Simpósio Brasileiro de Computação Aplicada à Saúde (SBCAS)* (Natal). Sociedade Brasileira de Computação - SBC, Porto Alegre, RS, Brasil, 12. https://doi.org/10.5753/sbcas.2018.3686

[7] Rui Nouchi, Yasuyuki Taki, Hikaru Takeuchi, Hiroshi Hashizume, Takayuki Nozawa, Toshimune Kambara, Atsushi Sekiguchi, Carlos Makoto Miyauchi, Yuka Kotozaki, Haruka Nouchi, et al. 2013. Brain training game boosts executive functions, working memory and processing speed in the young adults: a randomized controlled trial. *PloS one* 8, 2 (2013), e55518. https://doi.org/10.1371/journal.pone.0055518

[8] Adam C. Oei and Michael D. Patterson. 2013. Enhancing Cognition with Video Games: A Multiple Game Training Study. *PLoS ONE* 8 (3 2013), e58546. Issue 3. https://doi.org/10.1371/journal.pone.0058546

[9] John e outros Brooke. 1996. SUS-A quick and dirty usability scale. *Avaliação de usabilidade na indústria* 189 (1996), 4–7.

[10] Eva Pietrzak, Stephen Pullman, and Annabel McGuire. 2014. Using virtual reality and videogames for traumatic brain injury rehabilitation: a structured literature review. *GAMES FOR HEALTH: Research, Development, and Clinical Applications* 3, 4 (2014), 202–214. https://doi.org/10.1089/g4h.2014.0013

[11] Rômulo Santos Silva, Camila Almeida Carlos, Artur Martins Mol, and Lucila Ishitani. 2018. Avaliação da Experiência da Terceira Idade com Realidade Virtual na Área de Jogos Digitais para Smartphone. *Art Des Track* 1 (2018), 79–87.

[12] Amir Vazini Taher, Maryam Khalil Ahmadi, and Pak Zamir. 2015. Effects of multi-sensory stimulation on cognition function, depression, anxiety and quality of life in elderly persons with dementia. *International Journal of Sport Studies* 5, 3 (2015), 355–360. http:www.ijssjournal.com