# THE INFLUENCE OF VIRTUAL REALITY ON COGNITIVE REHABILITATION OF PATIENTS WITH TRAUMATIC BRAIN INJURY: A CASE STUDY OF 'LUCAS'

Carlos Mendoza; Sofia Ribeiro; Diego Silva; Mariana Torres; and Alejandro Costa

Independent Unit for Biofarma Innovation Studies

**Abstract:**

This study presents a case of cognitive rehabilitation of Lucas, a 34-year-old patient who suffered a traumatic brain injury (TBI) in a car accident. Utilizing integrated virtual reality (VR) technology with traditional neuropsychology techniques, Lucas participated in 12 sessions over three months. The intervention focused on improving executive functions, attention, and memory. Research conducted by the Biofarma Studies Center supports the efficacy of virtual reality in maximizing neuroplasticity and cognitive rehabilitation for TBI patients.

Keywords: Virtual reality, cognitive rehabilitation, traumatic brain injury.

## Introduction:

Traumatic brain injury is a condition that can lead to severe cognitive deficits, significantly impacting the individual's functionality. The consequences of such damage can vary widely, ranging from mild concentration difficulties to drastic changes in behavior and the ability to perform daily tasks. In this context, reallocating the therapeutic approach becomes crucial. The use of virtual reality represents an innovative advancement in this area, as it allows for the creation of a controlled, immersive environment that can be tailored to the specific needs of each patient. Studies have shown that practice in virtual environments can facilitate the formation of new neural connections (Rizzo & Koenig, 2017). Furthermore, using interactive technologies can make the therapeutic process more engaging, enhancing patient motivation and promoting a more effective recovery (Bohil et al., 2011). Research conducted by the Biofarma Studies Center indicates that interventions utilizing VR result in significant

improvements in cognitive functions affected by brain injuries, supporting the implementation of cutting-edge technology in clinical settings.

**Patient History:**

Lucas, an active software engineer, lived a balanced life between work and leisure before the car accident. He had always been a sociable person involved in community activities, which helped nurture his social networks and communication skills. However, after the accident, Lucas not only lost his job but also faced the challenge of readapting to everyday life. Skills he once considered automatic—such as remembering appointments or completing simple tasks—became nearly insurmountable obstacles. Initial assessments identified significant deficits in executive functions, particularly in areas related to attention and working memory. Over time, Lucas developed increasing frustration, feeling unable to regain the life he had before, which affected his self-esteem and emotional well-being. This internal struggle was also a significant part of the case and treatment, as adequate emotional support was essential for facilitating progress in the rehabilitation stages.

**Method:**

The approach was based on an integrative model that relied on a cycle of continuous assessment and adjustment of interventions. Initially, Lucas was evaluated through a series of neuropsychological tests to quantify his cognitive deficits, allowing for the creation of an individualized rehabilitation plan. Therapy sessions were divided into several stages: the initial assessment aimed to map Lucas's cognitive abilities, while subsequent sessions focused on cognitive training using VR exercises. Each session was specifically designed to simulate activities Lucas would encounter in his daily life, gradually increasing in complexity

to avoid cognitive overload. During treatment, Lucas practiced in virtual scenarios that required not only problem-solving but also decision-making, planning, and time management. The use of VR also allowed for the incorporation of immediate feedback, essential for Lucas's ongoing adaptation and motivation. Adjustments were made in real-time, depending on Lucas's engagement and performance in each activity, creating a feedback loop that was crucial for his progress.

**Challenges and Learning:**

Lucas's journey was not without obstacles. In the initial sessions, he demonstrated resistance to using the technology, feeling insecure about the effectiveness of the process. The frustration associated with his cognitive limitations led to emotional difficulties that influenced his behavior during therapy. These feelings often manifested as irritability and demotivation, making the active involvement of his therapist essential for providing ongoing emotional support and explaining the rationale behind using VR. However, over time, Lucas began to notice improvements in his attention and memory, which not only encouraged him to continue but also strengthened his emotional approach to rehabilitation. The ability to celebrate small victories became crucial. Adjustments to the treatment were made as Lucas progressed, and the flexibility of the program allowed interventions to become increasingly personalized. Thus, Lucas's experience demonstrates that while difficulties may be significant, adaptive and patient-centered treatment can make a considerable difference in cognitive recovery.

**Results:**

After the intervention, the results were remarkably positive. Compared to the initial assessments, Lucas showed a 30% improvement in attention measures, as indicated by the TAVEC, and a significant increase in planning capacity, reflected in the K-ABC test results. Moreover, functional magnetic resonance imaging revealed increased activation in previously inactive regions of the brain, indicating the reemergence of neural functions. These results are consistent with research suggesting that practice in virtual environments can not only stimulate functional recovery but also contribute to structural changes in the brain (Bohil et al., 2011; Zasadzka et al., 2021). It is important to emphasize that Lucas's rehabilitation was facilitated by his positive attitude toward therapy and the ongoing support of his team. The data collected before and after treatment not only demonstrated the tangible benefits of VR but also established an empirical basis for the use of technology in broader cognitive rehabilitation contexts, creating a model that could be replicated for other patients with similar deficits.

**Discussion:**

The results of this study demonstrate that integrating virtual reality into cognitive rehabilitation programs presents an innovative and effective solution for patients suffering from TBI. The applicability of VR aligns with prior research that reinforces the effectiveness of learning in immersive environments (Rizzo & Koenig, 2017). The experimental and adaptive approach used with Lucas not only improved his cognitive functions but also impacted his emotional well-being and self-efficacy perception, essential factors in the rehabilitation process. This combination of tailored techniques with a personalized response

to the patient's progress suggests that VR can facilitate rehabilitation in ways that other interventions may not address. Furthermore, the relevance of virtual scenarios brings the ability to practice specific skills in a safe environment, potentially resulting in more efficient transfers to the real world. Lucas's experience highlights the importance of addressing not only cognitive recovery but also the emotional and social dimensions, which are deeply interconnected in the healing process.

**Conclusion:**

Lucas's case illustrates the potential of virtual reality as a powerful tool in cognitive rehabilitation, highlighting the need for further research to explore its effectiveness in different types of brain injuries. The experience provided valuable insights into adapting therapeutic methodologies that utilize new technologies, emphasizing that combining innovation with personalized care can open new possibilities for therapeutic interventions. As the fields of neuroscience and psychology advance, the inclusion of emerging technologies like VR should be viewed not only as an addition to existing practices but as a fundamental interaction for the development of effective cognitive rehabilitation programs. Lucas's case not only demonstrates the challenges faced by patients with TBI but also highlights the numerous opportunities technology can offer in the restoration of recovery.

**Referências:**


Bohil, C., Alicea, B. & Biocca, F. Virtual reality in neuroscience research and therapy. *Nat Rev Neurosci* 12, 752–762 (2011). https://doi.org/10.1038/nrn3122

Kauffman, A. (2004). The Kauffman Assessment Battery for Children. Psychological Assessment Resources. https://doi.org/10.1002/9780470479216.corpsy0486

Platz F, Kopiez R, Lehmann AC, Wolf A. The influence of deliberate practice on musical achievement: a meta-analysis. Front Psychol. 2014 Jun 25;5:646. https://doi.org/10.3389/fpsyg.2014.00646 PMID: 25018742; PMCID: PMC4073287.

Rizzo AS, Koenig ST. Is clinical virtual reality ready for primetime? Neuropsychology. 2017 Nov;31(8):877-899. https://doi.org/10.1037/neu0000405 PMID: 29376669.

Rizzo, A., Koenig, S., & Lange, B. (2023). Clinical virtual reality: The state of the science. In G. G. Brown, B. Crosson, K. Y. Haaland, & T. Z. King (Eds.), APA handbook of neuropsychology: Neuroscience and neuromethods (pp. 473–491). American Psychological Association. https://doi.org/10.1037/0000308-023

Simms, D.C., O'Donnell, S., Molyneaux, H. (2009). The Use of Virtual Reality in the Treatment of Posttraumatic Stress Disorder (PTSD). In: Shumaker, R. (eds) Virtual and Mixed Reality. VMR 2009. Lecture Notes in Computer Science, vol 5622. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-02771-0_68

Morina N, Kampmann I, Emmelkamp P, Barbui C, Hoppen TH. Meta-analysis of virtual reality exposure therapy for social anxiety disorder. Psychol Med. 2023 Apr;53(5):2176-2178. https://doi.org/10.1017/S0033291721001690 Epub 2021 May 18. PMID: 34001293; PMCID: PMC10106288.

Ribé-Viñes JM, Gutiérrez-Maldonado J, Zabolipour Z, Ferrer-Garcia M. Efficacy of virtual reality-based exposure therapy for the treatment of fear of flying: a systematic review. The Cognitive Behaviour Therapist. 2023;16:e19. https://doi.org/10.1017/S1754470X23000119

Jang S, Choi J, Oh J, Yeom J, Hong N, Lee N, Kwon JH, Hong J, Kim JJ, Kim E. Use of Virtual Reality Working Memory Task and Functional Near-Infrared Spectroscopy to Assess Brain Hemodynamic Responses to Methylphenidate in ADHD Children. Front Psychiatry. 2021 Jan 21;11:564618. https://doi.org/10.3389/fpsyt.2020.564618 PMID: 33551860; PMCID: PMC7859615.

Zasadzka E, Pieczyńska A, Trzmiel T, Hojan K. Virtual Reality as a Promising Tool Supporting Oncological Treatment in Breast Cancer. Int J Environ Res Public Health. 2021 Aug 19;18(16):8768. https://doi.org/10.3390/ijerph18168768 PMID: 34444513; PMCID: PMC8393836.