Integration of Neurofeedback and Virtual Reality - Innovative approaches to the clinical practice of Attention Deficit Hyperactivity Disorder

https://doi.org/10.56238/sevened2024.016-001

Paula Rocha[1] and Diamantino Ribeiro[2]

ABSTRACT
Attention Deficit Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental disorder characterized by symptoms of inattention, hyperactivity, and impulsivity, which can have an important impact on people's daily functioning and quality of life. Traditional treatment methods, including medication and behavioral therapy, often have limited success and present several challenges. Recent technological developments provide promising alternatives, notably through the integration of *neurofeedback* and virtual reality (VR) into clinical practice. This article explores the potential of combining these innovative tools to improve the treatment of ADHD. Neurofeedback, a technique that trains individuals to regulate brain activity, has been shown to be effective in managing ADHD symptoms. Similarly, VR provides immersive and engaging environments that can be adapted to therapeutic needs. By combining *neurofeedback* with VR, practitioners can create interactive and personalized treatment protocols aimed at improving patient engagement, adherence, and outcomes. In this paper, we discuss the mechanisms of action, current applications and empirical evidence supporting the use of *neurofeedback technologies* and VR in the treatment of ADHD.

Keywords: Neurology, *Neurofeedback*, Virtual reality, ADHD, Innovative treatments.

[1] Lusófona University, Porto, Portugal
E-mail: paularocha@keepcorporate.com
ORCID https://orcid.org/0009-0000-4080-2161
[2] Lusófona University, Porto, Portugal
E-mail: diamantinojtribeiro@gmail.com
ORCID https://orcid.org/0000-0002-7168-8821

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental disorder that affects both children and adults, characterized by persistent patterns of inattention, hyperactivity, and impulsivity. These symptoms can significantly impair academic, occupational, and social functioning, leading to several long-term challenges. Traditional approaches to treating ADHD include pharmacologically-based treatments, such as stimulant medications, and behavioral therapies. While these treatments can be effective, (American Psychiatric Association, 2022) (Beehuspoteea & Bhadrakalimuthu , 2023; Honkasilta & Koutsoklenis , 2022) 1)long-term and variable responses between individuals (Craig et al., 2015; Idrees et al., 2023) .

In recent years, there has been a growing interest in exploring innovative technological solutions to improve ADHD treatment outcomes. Two promising technologies are *neurofeedback* and virtual reality (VR).

Neurofeedback is a form of *biofeedback* that allows individuals to gain control over their brain activity, allowing them to get real-time feedback on brain wave patterns. This technique has shown potential to improve attention and reduce hyperactivity in individuals with ADHD (Tough et al., 2024) (Patil et al., 2022; Simkin et al., 2014) . On the other hand, VR provides immersive and interactive environments that can be adapted to therapeutic needs, through the creation of engaging and motivating contexts for behavioral interventions (Jingilli et al., 2023; Zhao et al., 2023) .

The integration of *neurofeedback* and VR represents a new approach to ADHD treatment, as it can leverage the strengths of both technologies to create more effective therapeutic experiences. Neurofeedback can help individuals with ADHD develop better self-regulation skills, as it directly targets brain functioning, while VR can provide a supportive environment that increases engagement and facilitates the practice of these skills in realistic contexts (Corrado et al., 2024; Sergis et al., 2024) . By combining these tools, practitioners may be able to develop more personalized and dynamic treatment protocols that respond to the unique needs of each patient.

This article aims to explore the potential of integrating *neurofeedback* and VR into the clinical practice of ADHD. Through a brief review of the literature and empirical evidence, the mechanisms of action, efficacy and practical considerations of these technologies are explored. The challenges and opportunities associated with their implementation are observed, with the aim of obtaining information on how they can be effectively incorporated into existing treatment structures. Ultimately, this article seeks to contribute to the ongoing development of innovative treatment strategies for ADHD by highlighting the view of *neurofeedback* and VR as complementary tools to improve clinical outcomes.

NEUROFEEDBACK IN THE TREATMENT OF ADHD

Neurofeedback, a form of *biofeedback*[3] that trains individuals to regulate their brain activity, has emerged as a promising therapeutic approach to ADHD. The technique involves monitoring brain waves through electroencephalography (EEG) and presenting real-time feedback to the individual, often in the form of visual or auditory cues, to reinforce desirable brainwave patterns (Marzbani et al., 2016; Homes are et al., 2023) . The underlying premise is that individuals can learn to modulate their brain activity, which in turn can lead to improvements in cognitive and behavioral functions associated with ADHD. (Martín-Rodríguez et al., 2024)

Neurofeedback works on the principle of operant conditioning, in which individuals receive immediate feedback on the activity of their brain waves, typically focusing on increasing beta waves (associated with concentration and alertness) and decreasing theta waves (associated with inattention and sleepiness). Over successive sessions, this feedback loop helps the brain adopt more optimal activity patterns, thereby improving attention, impulse control, and overall cognitive function (Gruzelier , 2014; Koomen et al., 2021) (Enriquez-Geppert et al., 2017; Gruzelier , 2014; Koomen et al., 2021) .

Research on *neurofeedback* for ADHD has shown promising results. A meta-analysis by Arns et al. (2009) concluded that *neurofeedback* has a large effect on ADHD symptoms, comparable to the effect of stimulant medications. Similarly, a literature review by Lofthouse et al. (2012) reported significant improvements in attention, hyperactivity, and impulsivity in children undergoing (Arns et al., 2009) *neurofeedback* (Lofthouse et al., 2012) treatment. These studies suggest that *neurofeedback* may be an effective non-pharmacological intervention to manage ADHD symptoms.

Several randomized controlled trials have further validated the efficacy of *neurofeedback*. For example, a study by Gevensleben et al. (2009) demonstrated that children with ADHD who participated in *neurofeedback* sessions showed significant improvements in attention and hyperactivity, compared to a control group that received cognitive training. These improvements were maintained at a six-month follow-up, indicating the potential for long-term benefits (Gevensleben et al., 2009) .

Despite the positive results, *neurofeedback* has its challenges and limitations. One of the main concerns is the variability of treatment protocols and the lack of standardized guidelines, which can affect the consistency and reliability of results. In addition, treatment requires a significant time

[3] Biofeedback is a mind–body technique in which individuals learn how to modify their physiology for the purpose of improving physical, mental, emotional and spiritual health. Much like physical therapy, biofeedback training requires active participation on the part of patients and often regular practice between training sessions. Frank, D. L., Khorshid, L., Kiffer, J. F., Moravec, C. S., & McKee, M. G. (2010). Biofeedback in medicine: who, when, why and how? Mental health in family medicine, 7(2), 85–91.

commitment, often involving 20-40 sessions, which can be a barrier for some families. On the other hand, the high cost of equipment and the need for specialized training for professionals can limit accessibility and widespread adoption (Courteous et al., 2016) (Arns et al., 2014) (Faster Capital, 2024; Flanagan & Saikia , 2023)

Neurofeedback represents, despite the limitations described, a promising avenue for the treatment of ADHD, constituting a non-invasive and potentially long-lasting alternative to traditional therapies.

VIRTUAL REALITY IN THE TREATMENT OF ADHD

Virtual reality (VR) technology has made remarkable progress in recent years, through the creation of immersive and interactive experiences that can be harnessed for therapeutic purposes.

In the context of ADHD, VR is envisioned as a unique platform to engage patients in controlled but realistic environments where they can practice attention, impulse control, and other cognitive skills essential to managing their symptoms. (Corrigan et al., 2023; Sergis et al., 2024)

VR systems create simulated environments that users can interact with using specialized hardware such as headsets, motion sensors, and controllers. These environments can be designed to replicate real-world scenarios or abstract spaces that target specific cognitive functions. For individuals with ADHD, VR can facilitate tasks that require sustained attention, executive function, and self-regulation, thereby providing opportunities for therapeutic intervention in a controlled but flexible setting (Freeman et al., 2017) (Bashiri et al., 2017; Cunha et al., 2023) .

The application of VR in the treatment of ADHD is still in its early stages, but initial studies have shown promising results. A study by Cho et al. (2004) demonstrated that children with ADHD who participated in a VR-based mindfulness pilot project showed important improvements in attention and impulsivity compared to a control group. Similarly, a pilot study by Di Giusto et al. (2023) concluded that VR training programs designed to improve executive function led to improved performance on attention and problem-solving tasks in children with ADHD. (Give et al., 2004) (Of Right et al., 2023)

One of the main advantages of VR is its ability to create engaging and motivating therapeutic experiences. Traditional treatment methods can often be found tedious or monotonous by children with ADHD, leading to poor adherence and suboptimal outcomes. VR, on the other hand, can make therapeutic tasks more engaging by incorporating game-like elements and interactive challenges that maintain the user's interest and motivation (Dovis et al., 2015) (Bucchiarone , 2022) .

Despite its potential, the use of VR in the treatment of ADHD is not without its challenges. One of the main concerns is the cost and accessibility of VR technology, as high-quality VR systems can be expensive, and there may be logistical barriers to integrating them into standard clinical practice. Additionally, the immersive nature of VR can sometimes cause motion sickness or other discomfort in some users, which can limit the length and effectiveness of sessions. (Lindner et al., 2019) (Grassini & Laumann, 2020)

Another challenge is the need for specialized training for clinicians to effectively administer and adapt VR-based interventions. This includes not only understanding the technical aspects of VR systems, but also being able to design and implement VR scenarios that align with therapeutic goals. (A. "Skip" Rizzo & Koenig, 2017)

In terms of development, more research is needed to establish standardized protocols and to rigorously evaluate the long-term efficacy of VR interventions for ADHD (Dovis et al., 2015).

Nevertheless, the studies consulted allow us to infer that VR is very promising as an innovative tool for the treatment of ADHD. Their ability to provide immersive, engaging, and interactive therapeutic experiences can complement traditional interventions and potentially improve outcomes for individuals with ADHD.

INTEGRATION OF NEUROFEEDBACK AND VIRTUAL REALITY

The integration of *neurofeedback* and virtual reality (VR) represents an innovative approach to the treatment of ADHD, combining the strengths of both methodologies to improve therapeutic outcomes.

Some researchers argue that this hybrid approach enhances the ability of *neurofeedback* to promote self-regulation of brain activity with the immersive and immersive environments of VR, providing a comprehensive and dynamic treatment modality (Corrado et al., 2024; Corrigan et al., 2023; Sergis et al., 2024; Tough et al., 2024).

The integration of *neurofeedback* and VR involves using VR environments to create the visual and interactive feedback needed for *neurofeedback* sessions. In this setup, EEG sensors monitor the user's brain activity in real-time, and the VR environment responds accordingly. For example, successful regulation of brainwave patterns can result in progression in a VR game or scenario, thereby enhancing desired neural activity through immediate, immersive feedback. This combination aims to increase the involvement, motivation and overall effectiveness of the (A. "Skip" Rizzo & Koenig, 2017) *neurofeedback process* (Enriquez-Geppert et al., 2017), as we mentioned.

Several studies have investigated the effectiveness of combining *neurofeedback* with VR for the treatment of ADHD, as demonstrated by the following examples:

- Rizzo et al. (2004) developed a VR classroom environment where children with ADHD could practice self-regulation and attention control. In this study, *neurofeedback* was integrated into the VR classroom, giving immediate feedback on brainwave activity as children engaged in classroom tasks. Over the course of several sessions, the children showed marked improvements in their ability to stay focused and reduce impulsive behaviors. Teachers reported observable improvements in classroom behavior and academic performance. (A. A. Rizzo et al., 200 C.E.)

— Dovis et al. (2015) conducted a study in which children with ADHD underwent *neurofeedback* sessions in a VR environment designed to improve executive functions such as working memory, planning, and cognitive flexibility. VR scenarios required participants to solve complex problems while receiving n*eurofeedback*. This immersive approach has led to important improvements in tasks related to executive functions, and parents have reported improvements in activities of daily living that require executive skills. (Dovis et al., 2015)

— In an innovative approach, Lindner et al. (2019) evaluated the feasibility and effectiveness of an at-home VR neurofeedback program for children with ADHD. Families received VR headsets and EEG devices to use at home, guided by an app. Over a period of 12 weeks, the children participated in 'gamified' neurofeedback sessions. The study concluded that *VR neurofeedback* at home was not only feasible, but also resulted in a significant reduction in ADHD symptoms, as reported by parents and teachers. (Lindner et al., 2019)

— A study by Bioulac et al. (2020) explored the use of *neurofeedback* in VR to treat children with ADHD and comorbid anxiety. The VR environment included scenarios designed to elicit and then help manage anxiety responses, while also aiming for attention control. Neurofeedback helped children learn to modulate their brain activity to reduce anxiety and improve attention. Integrated treatment resulted in significant reductions in anxiety and ADHD symptoms, highlighting the versatility of *VR neurofeedback* in addressing multiple concomitant conditions. (Bioulac et al., 2020)

Despite the promising results, and in addition to the challenges already described, there is a need for standardized protocols and training for professionals to be able to effectively implement these technologies in practice.

In terms of future prospects, one of the ways forward is to invest in the development of more flexible and cost-effective *VR neurofeedback* solutions . This may include, as Enriquez-Geppert et al (2017) point out, the creation of portable and cost-effective devices that can be easily integrated into various clinical and home settings. (Enriquez-Geppert et al., 2017)

Large-scale randomized controlled trials are also needed to establish efficacy and best practices for *VR neurofeedback* in the treatment of ADHD. Exploring the integration of this technology with other therapeutic approaches, such as cognitive behavioral therapy, could further improve treatment outcomes and allow for more comprehensive care to be provided for individuals with ADHD. (A. “Skip” Rizzo & Koenig , 2017)

Overall, it can be noted that the integration of *neurofeedback* and VR represent a cutting-edge approach to the treatment of ADHD, as it is a dynamic and engaging platform for cognitive and behavioral treatments.

FINAL THOUGHTS

The integration of *neurofeedback* and virtual reality (VR) in the treatment of ADHD is, at this point, a promising and innovative approach that brings together the strengths of both technologies.

This combined method allows you to treat the main symptoms of ADHD, such as inattention, hyperactivity, and impulsivity, while increasing engagement and motivation through immersive and interactive experiences.

The case studies presented in this exploratory study highlight the potential benefits and applications of this integrative approach, constituting in our view a basis for further research and development. These case studies demonstrate that combining *neurofeedback* with VR can lead to improvements in attention, impulse control and executive function.

One of the main advantages of integrating *neurofeedback* and VR is increased user engagement and motivation. Traditional *neurofeedback* can sometimes be perceived as monotonous, making it challenging for the therapist to maintain adherence from participants. The immersive nature of VR transforms therapeutic tasks into interactive and enjoyable experiences, thereby increasing motivation and the likelihood of sustained participation. This is particularly important for children with ADHD, who often have difficulties maintaining attention and engagement. (Lindner et al., 2019)

In addition, the flexibility and adaptability of VR environments allow for the creation of personalized therapeutic scenarios tailored to individual needs. This personalized approach can be programmed to the specific symptoms and challenges faced by each patient, increasing the overall effectiveness of the treatment.

Despite the promising potential, there are several challenges to overcome if the benefits of integrating *neurofeedback* and VR into ADHD treatment are to be fully realized. As we have shown, cost remains a major barrier, as high-quality VR systems and *neurofeedback* equipment can be expensive. Reducing the cost of these technologies and increasing accessibility will be crucial for widespread adoption. In addition, there is a need to develop standardized protocols and training for clinicians in order to ensure effective implementation and maximize therapeutic benefits.

Another consideration is the potential for side effects, such as motion sickness or eye strain, associated with VR use. It is essential to ensure that VR experiences are comfortable and safe for all users. At the same time, long-term studies are needed to assess both the sustained efficacy and possible risks of long-term exposure to VR in therapeutic settings. (Grassini & Laumann , 2020)

Therefore, based on the literature, we believe that it is essential to deepen the investigation and improve the integration of *neurofeedback* and VR. This includes developing cost-effective solutions that are accessible to a wider range of clinical and patient settings. As Bioulac et al. (2020) state, large-scale randomised controlled trials are needed to establish the efficacy and best practices for this integrative approach.

In the same vein, investigating the combination of VR *neurofeedback* with other therapeutic modalities, such as cognitive-behavioral therapy, could provide a more comprehensive and multifaceted treatment strategy.

In addition, technological development will also play a key role in increasing the feasibility and effectiveness of *neurofeedback* in VR. As Enriquez-Geppert et al. (2017) point out, innovation in portable and affordable VR devices, as well as user-friendly software, can facilitate the integration of these technologies into everyday clinical practice and home interventions.

In summary, the integration of *neurofeedback* and VR represents a cutting-edge approach to the treatment of ADHD, constituting a dynamic and engaging platform for cognitive and behavioral treatments. While there are still challenges, the potential benefits of this innovative method can be very substantial. Ongoing research and new technologies will be essential to realize the full potential of this integrative approach, improving the quality of life for individuals with ADHD.

REFERENCES

1. American Psychiatric Association. (2022). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5-TR) (Revised)*. American Psychiatric Association.

2. Arns, M., de Ridder, S., Strehl, U., Breteler, M., & Coenen, A. (2009). Efficacy of Neurofeedback Treatment in ADHD: The Effects on Inattention, Impulsivity and Hyperactivity: A Meta-Analysis. *Clinical EEG and Neuroscience, 40*(3), 180–189. https://doi.org/10.1177/155005940904000311

3. Arns, M., Heinrich, H., & Strehl, U. (2014). Evaluation of neurofeedback in ADHD: The long and winding road. *Biological Psychology, 95*, 108–115. https://doi.org/10.1016/j.biopsycho.2013.11.013

4. Bashiri, A., Ghazisaeedi, M., & Shahmoradi, L. (2017). The opportunities of virtual reality in the rehabilitation of children with attention deficit hyperactivity disorder: a literature review. *Korean Journal of Pediatrics, 60*(11), 337. https://doi.org/10.3345/kjp.2017.60.11.337

5. Beehuspoteea, N., & Badrakalimuthu, V. R. (2023). Exploring the relationship between ADHD and dementia. *Progress in Neurology and Psychiatry, 27*(2), 5–9. https://doi.org/10.1002/pnp.784

6. Bioulac, S., Micoulaud-Franchi, J.-A., Maire, J., Bouvard, M. P., Rizzo, A. A., Sagaspe, P., & Philip, P. (2020). Virtual Remediation Versus Methylphenidate to Improve Distractibility in Children With ADHD: A Controlled Randomized Clinical Trial Study. *Journal of Attention Disorders, 24*(2), 326–335. https://doi.org/10.1177/1087054718759751

7. Bucchiarone, A. (2022). Gamification and virtual reality for digital twin learning and training: architecture and challenges. *Virtual Reality & Intelligent Hardware, 4*(6), 471–486. https://doi.org/10.1016/j.vrih.2022.08.001

8. Cho, B.-H., Kim, S., Shin, D. I., Lee, J. H., Min Lee, S., Young Kim, I., & Kim, S. I. (2004). Neurofeedback Training with Virtual Reality for Inattention and Impulsiveness. *CyberPsychology & Behavior, 7*(5), 519–526. https://doi.org/10.1089/cpb.2004.7.519

9. Corrado, S., Tosti, B., Mancone, S., Di Libero, T., Rodio, A., Andrade, A., & Diotaiuti, P. (2024). Improving Mental Skills in Precision Sports by Using Neurofeedback Training: A Narrative Review. *Sports, 12*(3), 70. https://doi.org/10.3390/sports12030070

10. Corrigan, N., Păsărelu, C.-R., & Voinescu, A. (2023). Immersive virtual reality for improving cognitive deficits in children with ADHD: a systematic review and meta-analysis. *Virtual Reality, 27*(4), 3545–3564. https://doi.org/10.1007/s10055-023-00768-1

11. Cortese, S., Ferrin, M., Brandeis, D., Holtmann, M., Aggensteiner, P., Daley, D., Santosh, P., Simonoff, E., Stevenson, J., Stringaris, A., Sonuga-Barke, E. J. S., Asherson, P., Banaschewski, T., Brandeis, D., Buitelaar, J., Coghill, D., Cortese, S., Daley, D., Danckaerts, M., … Zuddas, A. (2016). Neurofeedback for Attention-Deficit/Hyperactivity Disorder: Meta-Analysis of Clinical and Neuropsychological Outcomes From Randomized Controlled Trials. *Journal of the American Academy of Child & Adolescent Psychiatry, 55*(6), 444–455. https://doi.org/10.1016/j.jaac.2016.03.007

12. Craig, S. G., Davies, G., Schibuk, L., Weiss, M. D., & Hechtman, L. (2015). Long-Term Effects of Stimulant Treatment for ADHD: What Can We Tell Our Patients? *Current Developmental Disorders Reports, 2*(1), 1–9. https://doi.org/10.1007/s40474-015-0039-5

13. Cunha, F., Campos, S., Simões-Silva, V., Brugada-Ramentol, V., Sá-Moura, B., Jalali, H., Bozorgzadeh, A., & Trigueiro, M. J. (2023). The effect of a virtual reality based intervention on processing speed and working memory in individuals with ADHD—A pilot-study. *Frontiers in Virtual Reality, 4*. https://doi.org/10.3389/frvir.2023.1108060

14. Di Giusto, V., Purpura, G., Zorzi, C. F., Blonda, R., Brazzoli, E., Meriggi, P., Reina, T., Rezzonico, S., Sala, R., Olivieri, I., & Cavallini, A. (2023). Virtual reality rehabilitation program on executive functions of children with specific learning disorders: a pilot study. *Frontiers in Psychology, 14*. https://doi.org/10.3389/fpsyg.2023.1241860

15. Dovis, S., Van der Oord, S., Wiers, R. W., & Prins, P. J. M. (2015). Improving Executive Functioning in Children with ADHD: Training Multiple Executive Functions within the Context of a Computer Game. A Randomized Double-Blind Placebo Controlled Trial. *PLOS ONE, 10*(4), e0121651. https://doi.org/10.1371/journal.pone.0121651

16. Enriquez-Geppert, S., Huster, R. J., & Herrmann, C. S. (2017). EEG-Neurofeedback as a Tool to Modulate Cognition and Behavior: A Review Tutorial. *Frontiers in Human Neuroscience, 11*. https://doi.org/10.3389/fnhum.2017.00051

17. Faster Capital. (2024, June 16). Behavioral health biotechnology Advancements in Neurofeedback Technology for Mental Health. *Faster Capital*. https://www.fastercapital.com/content/Behavioral-health-biotechnology-Advancements-in-Neurofeedback-Technology-for-Mental-Health.html

18. Flanagan, K., & Saikia, M. J. (2023). Consumer-Grade Electroencephalogram and Functional Near-Infrared Spectroscopy Neurofeedback Technologies for Mental Health and Wellbeing. *Sensors, 23*(20), 8482. https://doi.org/10.3390/s23208482

19. Freeman, D., Reeve, S., Robinson, A., Ehlers, A., Clark, D., Spanlang, B., & Slater, M. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine, 47*(14), 2393–2400. https://doi.org/10.1017/S003329171700040X

20. Gevensleben, H., Holl, B., Albrecht, B., Vogel, C., Schlamp, D., Kratz, O., Studer, P., Rothenberger, A., Moll, G. H., & Heinrich, H. (2009). Is neurofeedback an efficacious treatment for ADHD? A randomised controlled clinical trial. *Journal of Child Psychology and Psychiatry, 50*(7), 780–789. https://doi.org/10.1111/j.1469-7610.2008.02033.x

21. Grassini, S., & Laumann, K. (2020). Are Modern Head-Mounted Displays Sexist? A Systematic Review on Gender Differences in HMD-Mediated Virtual Reality. *Frontiers in Psychology, 11*. https://doi.org/10.3389/fpsyg.2020.01604

22. Gruzelier, J. H. (2014). EEG-neurofeedback for optimising performance. II: Creativity, the performing arts and ecological validity. *Neuroscience & Biobehavioral Reviews, 44*, 142–158. https://doi.org/10.1016/j.neubiorev.2013.11.004

23. Honkasilta, J., & Koutsoklenis, A. (2022). The (Un)real Existence of ADHD—Criteria, Functions, and Forms of the Diagnostic Entity. *Frontiers in Sociology, 7*. https://doi.org/10.3389/fsoc.2022.814763

24. Idrees, I., Bellato, A., Cortese, S., & Groom, M. J. (2023). The effects of stimulant and non-stimulant medications on the autonomic nervous system (ANS) functioning in people with

ADHD: A systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews, 144*, 104968. https://doi.org/10.1016/j.neubiorev.2022.104968

25. Jingili, N., Oyelere, S. S., Nyström, M. B. T., & Anyshchenko, L. (2023). A systematic review on the efficacy of virtual reality and gamification interventions for managing anxiety and depression. *Frontiers in Digital Health, 5*. https://doi.org/10.3389/fdgth.2023.1239435

26. Koomen, A., Keeser, D., & Sonja, V. (2021). The effects of neurofeedback on attention and sleep in individuals with and without ADHD or insomnia: a literature review. *Applied Neuroscience and Mental Health, 1*(1), 30–49. https://doi.org/10.31739/ANAMH.2021.1.30

27. Lindner, P., Miloff, A., Fagernäs, S., Andersen, J., Sigeman, M., Andersson, G., Furmark, T., & Carlbring, P. (2019). Therapist-led and self-led one-session virtual reality exposure therapy for public speaking anxiety with consumer hardware and software: A randomized controlled trial. *Journal of Anxiety Disorders, 61*, 45–54. https://doi.org/10.1016/j.janxdis.2018.07.003

28. Lofthouse, N., Arnold, L. E., Hersch, S., Hurt, E., & DeBeus, R. (2012). A Review of Neurofeedback Treatment for Pediatric ADHD. *Journal of Attention Disorders, 16*(5), 351–372. https://doi.org/10.1177/1087054711427530

29. Martín-Rodríguez, A., Gostian-Ropotin, L. A., Beltrán-Velasco, A. I., Belando-Pedreño, N., Simón, J. A., López-Mora, C., Navarro-Jiménez, E., Tornero-Aguilera, J. F., & Clemente-Suárez, V. J. (2024). Sporting Mind: The Interplay of Physical Activity and Psychological Health. *Sports, 12*(1), 37. https://doi.org/10.3390/sports12010037

30. Marzbani, H., Marateb, H., & Mansourian, M. (2016). Methodological Note: Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications. *Basic and Clinical Neuroscience Journal, 7*(2). https://doi.org/10.15412/J.BCN.03070208

31. Patil, A. U., Madathil, D., Fan, Y.-T., Tzeng, O. J. L., Huang, C.-M., & Huang, H.-W. (2022). Neurofeedback for the Education of Children with ADHD and Specific Learning Disorders: A Review. *Brain Sciences, 12*(9), 1238. https://doi.org/10.3390/brainsci12091238

32. Rizzo, A. A., Schultheis, M., Kerns, K. A., & Mateer, C. (200 C.E.). Analysis of assets for virtual reality applications in neuropsychology. *NEUROPSYCHOLOGICAL REHABILITATION, 14*(1/2), 207–239. https://verduvr.com/wp-content/uploads/2019/09/13.-Analysis_of_assets_for_virtual_reality_application.pdf

33. Rizzo, A. "Skip," & Koenig, S. T. (2017). Is clinical virtual reality ready for primetime? *Neuropsychology, 31*(8), 877–899. https://doi.org/10.1037/neu0000405

34. Sergis, N., Troussas, C., Krouska, A., Tzortzi, C., Bardis, G., & Sgouropoulou, C. (2024). ADHD Dog: A Virtual Reality Intervention Incorporating Behavioral and Sociocultural Theories with Gamification for Enhanced Regulation in Individuals with Attention Deficit Hyperactivity Disorder. *Computers, 13*(2), 46. https://doi.org/10.3390/computers13020046

35. Simkin, D. R., Thatcher, R. W., & Lubar, J. (2014). Quantitative EEG and Neurofeedback in Children and Adolescents. *Child and Adolescent Psychiatric Clinics of North America, 23*(3), 427–464. https://doi.org/10.1016/j.chc.2014.03.001

36. Tosti, B., Corrado, S., Mancone, S., Di Libero, T., Rodio, A., Andrade, A., & Diotaiuti, P. (2024). Integrated use of biofeedback and neurofeedback techniques in treating pathological conditions

and improving performance: a narrative review. *Frontiers in Neuroscience, 18*. https://doi.org/10.3389/fnins.2024.1358481

37. Vatrano, M., Nemirovsky, I. E., Tonin, P., & Riganello, F. (2023). Assessing Consciousness through Neurofeedback and Neuromodulation: Possibilities and Challenges. *Life, 13*(8), 1675. https://doi.org/10.3390/life13081675

38. Zhao, X., Ren, Y., & Cheah, K. S. L. (2023). Leading Virtual Reality (VR) and Augmented Reality (AR) in Education: Bibliometric and Content Analysis From the Web of Science (2018–2022). *SAGE Open, 13*(3). https://doi.org/10.1177/21582440231190821