Using VR and Sensors for Anxiety with Children and Adolescents

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Abstract

Virtual reality (VR) in the context of mental health is emerging with several examples, such as relaxation through biofeedback, exposure therapy, pain management, and addiction coping. Furthermore, sensors offer a way to objectively assess the children's response to therapy, which can be associated with self-report questionnaires to give even more accurate feedback to the therapist. The goal of this paper is to shine a light on the current state-of-the-art and reflect on the opportunities and challenges of VR to improve mental health-related outcomes in children and adolescents. We conducted a narrative review focusing on both VR exposure for children and adolescents and sensors' use for VR exposure. Virtual reality exposure therapy (VRET) seems to have similar results to other forms of exposure. Additionally, sensors managed to obtain an objective picture, which allows the therapist to get some objective measures during therapy. Although cybersickness seems to not be a major side effect in children, other limitations such as fear of the equipment and lack of adaptability were identified. Notwithstanding these limitations, VRET is a well-founded alternative to in vivo and imaginal exposures to treat anxiety disorders in children, when associated with physiological sensors and self-report questionnaires. Due to its advantages, it is paramount to continue to perform more studies using this technology, further improving its effectiveness and availability.

Keywords

VR, Sensors, Exposure therapy, Children, Anxiety disorders, VRET

1. Introduction

Exposure therapy is a therapeutic approach where the patient is gradually exposed to traumatic stimuli, which aims to help patients to cope with feelings of fear/anxiety and decrease avoidance. This type of exposure has been used in several anxiety disorders, such as phobias [1], Social Anxiety [2], Posttraumatic Stress Disorder (PTSD) [3], Obsessive-compulsive Disorder (OCD) [4], and Generalized Anxiety Disorder [5]. There are several approaches to exposure therapy, such as imaginal and virtual reality, but the most well-known and well-founded is in vivo exposure therapy. In this approach, the patient experiences (i.e., is exposed to) the traumatic stimulus in the real world. This methodology raises several practical and ethical issues. For instance, for fear of flying (i.e., aerophobia), one would take the patient to an airport and several flights, risking breaking confidentiality and high costs [6].

Virtual Environments (VE) are built using software and aim to recreate the real world. These environments immerse users in realistic settings, allowing them to engage intuitively and intimately with the digital environment [7]. Over the years, further improvements to their realism, general display, and tracking technologies advancements, opened the possibility for its use in health, accompanied by big displays or Head-Mounted Displays (HMD). This technology has already been used in a plethora of different approaches in the context of health, such as reducing pain in children during painful procedures [8], calming patients through biofeedback [9], and coping with anxiety disorders. However, continued efforts are still needed to improve VRET when applied to children and adolescent mental healthcare.

Virtual Reality Exposure Therapy (VRET) has been proven to be effective in the treatment of anxiety disorders in children and adolescents. Studies showed that almost all children prefer VRET compared to in vivo [10]. This is an important finding since most patients with anxiety disorders are reluctant to find treatment due to avoidance. A major limitation of VR-based therapies is cybersickness; however, children seem to be not particularly affected by it [11], being more susceptible to other complications such as fear of getting stuck inside the VR [12] and fear of losing control [13].

Therapists assess the effectiveness of therapy by using well-established self-report questionnaires. However, self-report questionnaires possess some limitations, such as low reliability in young children [14], and being time-consuming (i.e., requiring time to answer), thus eliminating feasibility while exposure therapy takes place. Physiological sensors offer an opportunity for improvement by objectively evaluating how the patient is doing. Although the available sensors still present some limitations (e.g., bulkiness towards children, discomfort), the

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data collected enable therapists to develop (in a more dynamic way) new therapeutic strategies based on the signals collected.

Given the exponential use of virtual reality (VR) as a therapeutic tool to improve mental health-related outcomes, this paper focuses on the current state-of-the-art of VR technology and physiological sensors in the context of exposure therapy in children and adolescents for anxiety disorders. Furthermore, we aim to identify current challenges and opportunities in using VRET to treat anxiety disorders in children and adolescents.

2. Methods

We conducted a narrative review in Google Scholar electronic database, using keywords, such as "virtual reality exposure for children", "virtual reality exposure for adolescents", "virtual reality exposure anxiety disorders", and "sensors for virtual reality exposure" to find relevant papers. The bibliography found showed a lack of studies performed with children in this context, so we extended the search of information to papers regarding adults aiming to find relevant information that could be extrapolated to children. Overall, 43 papers were identified as relevant based on title and abstract content and included in this review. After full-text analysis, some were excluded due to not being relevant to children, being reviews of already known papers, or lack of a future direction.

3. Virtual Reality Exposure with Sensors

Virtual Reality Exposure Therapy (VRET) alongside the use of Sensors comes to try to overcome some of the issues presented above. By using virtual reality in virtual environments and navigating through them using HMDs, the patient can experience an enhanced Sense of Presence (SoP), which has been associated with improved outcomes in VRET. Moreover, this can be done in the therapist's office at a relatively low cost, tackling two of the limitations associated with in vivo exposure (possible high costs and break of confidentiality). Furthermore, it also gives the therapist more control of the environment and the therapeutic session, allowing for a more tailored and detailed exposure for each patient. With the use of sensors, the therapist can see how the patient is doing in real-time, allowing for the environment to be changed forthwith, thus improving the experience and, therefore, the effectiveness of the exposure. Nonetheless, there is still the need to analyze the correlations/associations between these measures and self-report questionnaires, as the former measures are more indicative of how the patient feels and perceives his/her mental health, which is probably (one of) the most significant metrics in therapy.

Although having its benefits and potentially overcoming some of the limitations that traditional approaches to exposure therapy in children and adolescents have, one of the disadvantages of VRET is the danger of cybersickness [15]. Cybersickness can often be caused by the lack of consistency of the patient's head movement in real life and the virtual environment (high latency), lowering the effects of the therapy depending on the severity of the symptoms. These can range from nausea, eyestrain, headache, and dizziness, among others, depending on the patient and their age and gender. However, children and adolescents are less likely to develop cybersickness or simulation sickness, as most studies report none or minimal symptoms across patients [11].

Despite cybersickness not being a significant limitation due to the targeted groups, some shortcomings still arise. Some younger children reported fear of "getting stuck in the headset and of seeing something scary like in a horror movie" [12], with some children even refusing to wear the headset turned off due to fear of losing control over the situation [13]. Even though these concerns are valid and important, some solutions can be applied so that the patient feels more at ease. An important factor to mediate this is increasing the level of control the child perceives feels they have over the situation [16]; the more in control the patient feels of the situation, the better it will adapt and handle the treatment; simple measures such as letting the children choose the movie they will see [13], increase the sense of control the patient has, thus promoting a faster adaptation to the treatment.

Another limitation of working with VR headsets and physiological sensors is that these are rarely made with children in mind. Moreover, the headset can feel bulky to the patient [11], or even just the sensors, which can make the child anxious or uncomfortable during therapy.

Furthermore, children and adolescents usually adapt and even enjoy being exposed to virtual environments, often developing a high SoP further improving the exposure and potentially the effectiveness of the treatment. However. we did not find any specific ethical challenges (i.e., the therapist being removed from the equation due to not being in the virtual environment with their patient) or reflections towards these.

4. Research Opportunities

The literature shows that the use of VRET with sensors in children is safer and more approachable when compared to its counterparts (in vivo and imaginal). Moreover, most patients preferred VRET over in vivo exposure [10]. Regarding sensors, their use is good to assess how the patient is doing physically at any given moment, which

informs the therapist regarding how stimuli should be manipulated to increase therapy efficacy. In addition, sensors can be used to assess the effectiveness of the treatment, especially if used complementary to self-report questionnaires. However, there is still a lack of studies with bigger test groups and studies focused on children and adolescents. Therefore, we outline a set of open research avenues in this field that would be interesting to pursue to further develop this therapeutic approach.

Explore how to reduce dropout rates with VRET. Dropout rates in exposure therapy, albeit in vivo, imaginal, or virtual reality, are a major challenge. Most of the studies included in the present review do not explicitly report the reasons for the number of dropouts observed [5]. Although the available literature shows that VRET presents similar dropout rates as in vivo exposure therapy [5], it also offers a golden window to understand why patients quit interventions. By using sensors, one can assess how the patient is doing physically at a given point and identify dropout-risky moments, which is the key to finding solutions to minimize the patient wanting to quit treatment.

Self-report questionnaires and sensors hand-to-hand. Physiological sensors can track signals such as Heart and Respiration rates [4], Galvanic Skin Response [17], and diaphragm expansions [18]. Although sensors offer an objective measure towards the physical well-being of a patient, there is the possibility that an improvement in physiological measures might not reflect an improvement in a patient's self-perceived mental state (e.g., patients do not perceive improvements in their coping skills) [13]. On the other hand, self-report questionnaires are more accurate regarding how the patient feels, but they require a certain level of psychological maturity and vocabulary that young children might lack [14]. Furthermore, questionnaires' results are not obtained instantaneously, as the patient needs to take time to answer the questions thoughtfully. Here, the creation of a system that combines these two types of measures might help to mitigate some of the problems raised when sensors and self-report questionnaires are used separately. By combining them, the therapist could correlate the physiological sensors' data with the results of self-report questionnaires to have a more accurate evaluation of the patient's progress, regardless of their age or lack of vocabulary skills.

Make the therapy well-suited for each patient. By gathering data on how the patient is performing and feeling in real time, sensors open another window of opportunity: changing the VR experience in real-time. By catering the therapy and changing it in real time, focusing on data collected from each patient, the therapist can perform a more tailored exposure therapy, which may increase the SoP and, therefore, the effectiveness of the treatment.

Hardware adapted to children. Most hardware used in studies was not made for children. Moreover, Head-Mounted Displays can often feel bulky, and the interfaces are sometimes hard to understand [11], which can affect the effectiveness of the therapy. Sensors can also cause discomfort and anxiety when too invasive and big. A possible solution for this problem would be to adapt the technology to the children, and not the children to the technology. This would also work well to increase SoP, which is shown to be important for the effectiveness of the therapy [19]. The creation of smaller and more child-adapted VR-Headsets and sensors, specifically designed for VRET in children and adolescents, might help overcome this problem. Hopefully, this can eliminate some barriers that hamper children's adoption of VRET.

Improve self-report questionnaires for children. Clinicians use several well-established and children-designed self-reports such as Clinician-Administered PTSD Scale for DSM-5 (CAPS-5), Screen for Child Anxiety Related Emotional Disorders (SCARED), and the Spence Children's Anxiety Scale (SCAS) [20]. Although these and others exist, there is always an opportunity for improvement in this field, as some of these questionnaires can be outdated, not reflecting the daily constraints and sources of anxiety that were nonexistent maybe 15 years ago, such as social media exposure and a decrease in socialization skills. We suggest further research regarding self-report questionnaires by working directly with children and adolescents to explore how anxiety is experienced and what factors might trigger or aggravate it by using a combination of up-to-date self-reported questionnaires and sensors to consolidate results.

Perform more studies with VRET and OCD in children. Although VRET in children has shown encouraging results, there is still a lack of research on other mental health disorders, such as obsessive-compulsive disorder. This is mostly because this disorder is unpredictable, and presents itself in various ways, making it difficult to treat. The five most common types of OCD are organization, contamination, intrusive thoughts, ruminations, and checking. Usually, the obsessive and ritualistic behaviors (symptoms), can arise from an attempt by the patient to get more control of the surrounding environment and, therefore, lower their anxiety levels. In the review conducted, we found some evidence validating the use of VRET for contamination-type symptoms [4]. Focusing on one type of OCD symptom can make it easier to develop working exposure to mitigate some of the symptoms and difficulties patients live with, serving as a stepping stone to other types of this disorder.

Give the patient more control and autonomy over their therapy. Some children reported being afraid of losing control of the situation while engaged in the virtual environment [13]. Control over the situation also improves SoP and makes the patient more engaged in

the virtual environment, working as a catalyst to up the effectiveness of the exposure. VRET opens the possibility for a more nuanced experience regarding control, as it lets the virtual environment be completely changed to the patient's needs and/or actions.

5. Conclusion

As anxiety disorders in children become increasingly common, especially after the COVID-19 pandemic [21], it is imperative that alternatives made for children become more available.

By conducting this narrative review of the literature, it was possible to identify that VRET combined with sensors is a promising approach for the development of effective and accessible approaches to exposure therapy. VRET allows the recreation of more intense scenarios that one would not typically find in in vivo. Moreover, VRET is a less "invasive" option than traditional exposure therapy approaches, enabling the therapist to focus on the patient while having more control over the session. When sensors are combined with the VRET, the therapist can take some measures quickly, and change the virtual reality environment/experience in real time if needed. Furthermore, the combination of sensors and self-report questionnaires seems a promising approach to further knowledge on the effectiveness of VRET.

Performing more studies regarding VRET is of seminal importance, as it will make treatment more accessible, affordable, and less frightening for patients (including adults).

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References

[1] A. Garcia-Palacios, H. G. Hoffman, S. Kwong See, A. Tsai, C. Botella, Redefining therapeutic success with virtual reality exposure therapy, CyberPsychology & behavior 4 (2001) 341–348.

[2] P. Anderson, B. O. Rothbaum, L. F. Hodges, Virtual reality exposure in the treatment of social anxiety, Cognitive and Behavioral Practice 10 (2003) 240–247.

[3] M. Gerardi, B. O. Rothbaum, K. Ressler, M. Heekin, A. Rizzo, Virtual reality exposure therapy using a virtual iraq: case report, Journal of Traumatic stress: official Publication of The International society for Traumatic stress studies 21 (2008) 209–213.

[4] A. J. Cullen, N. L. Dowling, R. Segrave, A. Carter, M. Yücel, Exposure therapy in a virtual environment: Validation in obsessive compulsive disorder, Journal of Anxiety Disorders 80 (2021) 102404.

[5] D. Opriş, S. Pintea, A. García-Palacios, C. Botella, Ş. Szamosközi, D. David, Virtual reality exposure therapy in anxiety disorders: a quantitative meta-analysis, Depression and anxiety 29 (2012) 85–93.

[6] B. O. Rothbaum, P. Anderson, E. Zimand, L. Hodges, D. Lang, J. Wilson, Virtual reality exposure therapy and standard (in vivo) exposure therapy in the treatment of fear of flying, Behavior therapy 37 (2006) 80–90.

[7] K. Stanney, J. Cohn, Virtual environments (2009).

[8] S. Q. Scapin, M. E. Echevarría-Guanilo, P. R. B. Fuculo, J. C. Martins, M. d. V. Barbosa, M. J. L. Pereima, Use of virtual reality for treating burned children, Revista brasileira de enfermagem 70 (2017) 1291–1295.

[9] S. Gradl, M. Wirth, T. Zillig, B. M. Eskofier, Visualization of heart activity in virtual reality: A biofeedback application using wearable sensors, in: 2018 IEEE 15th international conference on wearable and implantable body sensor networks (BSN), IEEE, 2018, pp. 152–155.

[10] F. Dehghan, R. Jalali, H. Bashiri, The effect of virtual reality technology on preoperative anxiety in children: a solomon four-group randomized clinical trial, Perioperative Medicine 8 (2019) 1–7.

[11] M. Tennant, N. Anderson, G. J. Youssef, L. McMillan, R. Thorson, G. Wheeler, M. C. McCarthy, Effects of immersive virtual reality exposure in preparing pediatric oncology patients for radiation therapy, Technical Innovations & Patient Support in Radiation Oncology 19 (2021) 18–25.

[12] O. D. Kothgassner, A. Felnhofer, Lack of research on efficacy of virtual reality exposure therapy (vret) for anxiety disorders in children and adolescents: A systematic review, neuropsychiatrie 35 (2021) 68–75.

[13] B. Buldur, M. Candan, Does virtual reality affect children's dental anxiety, pain, and behaviour? a randomised, placebo-controlled, cross-over trial, Pesquisa Brasileira em Odontopediatria e Clínica Integrada 21 (2020).

[14] R. S. McGinnis, E. W. McGinnis, J. Hruschak, N. L. Lopez-Duran, K. Fitzgerald, K. L. Rosenblum, M. Muzik, Rapid anxiety and depression diagnosis in young children enabled by wearable sensors and machine learning, in: 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), IEEE, 2018, pp. 3983–3986.

[15] Y. Shiban, Virtuelle expositionstherapie bei angststörungen., Der Nervenarzt (2018).

[16] N. Ahmadpour, M. Keep, A. Janssen, A. S. Rouf, M. Marthick, et al., Design strategies for virtual reality interventions for managing pain and anxiety in children and adolescents: scoping review, JMIR serious games 8 (2020) e14565.

[17] A. C. Katz, A. M. Norr, B. Buck, E. Fantelli, A. Edwards-Stewart, P. Koenen-Woods, K. Zetocha, D. J. Smolenski, K. Holloway, B. O. Rothbaum, et al., Changes in physiological reactivity in response to the trauma memory during prolonged exposure and virtual reality exposure therapy for posttraumatic stress disorder., Psychological Trauma: Theory, Research, Practice, and Policy 12 (2020) 756.

[18] M. Van Rooij, A. Lobel, O. Harris, N. Smit, I. Granic, Deep: A biofeedback virtual reality game for children at-risk for anxiety, in: Proceedings of the 2016 CHI conference extended abstracts on human factors in computing systems, 2016, pp. 1989–1997.

[19] B. O. Rothbaum, L. F. Hodges, The use of virtual reality exposure in the treatment of anxiety disorders, Behavior Modification 23 (1999) 507–525.

[20] P. Muris, H. Schmidt, H. Merckelbach, Correlations among two self-report questionnaires for measuring dsm-defined anxiety disorder symptoms in children: The screen for child anxiety related emotional disorders and the spence children's anxiety scale, Personality and Individual Differences 28 (2000) 333–346.

[21] L. A. Lebrun-Harris, R. M. Ghandour, M. D. Kogan, M. D. Warren, Five-year trends in us children's health and well-being, 2016-2020, JAMA pediatrics 176 (2022) e220056–e220056.