EXPLORING THE FEASIBILITY OF SPATIOTEMPORAL ATTRIBUTES IN VR EXPERIENCES FOR HEALING APPLICATIONS

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Abstract

This research aims to systematically review global case studies of Virtual Reality (VR) therapy and explore the feasibility of applying VR technology to psychological intervention. The core of this research lies in analyzing how the spatiotemporal attributes of VR influence individual cognition, emotion, and behavior, which are innovatively categorized into five key characteristics: "Spatial Boundlessness," "Temporal Plasticity," "Embodied Presence," "Scalability," and Multi-userSynchronicity." These characteristics collectively form an ideal platform for implementing exposure therapy, enabling the creation of safe and controllable virtual environments that transcend physical limitations. The platform allows for the compression, expansion, or reversal of time; lets users embody avatars within the virtual space; facilitates adjustable perceptual scales; and supports real-time multi-user collaboration.

Through the analysis and synthesis of literature and case studies, it is demonstrated that the therapeutic effects of VR are achieved through the creative integration of these attributes. Furthermore, this study provides crucial theoretical foundations and practical references for designers engaged in creating audiovisual content for VR therapy, helping them identify key design priorities when collaborating with healthcare professionals. While VR technology shows significant potential, this paper also objectively addresses challenges related to cost, accessibility, and potential side effects. It emphasizes the necessity of advancing clinical research to optimize protocols and evaluate long-term efficacy and safety. This research contributes to unlocking the therapeutic potential of VR and promoting its scientifically-grounded application.

#virtual reality
#healing applications
#spatiotemporal properties
#exposure therapy
#cognitive impact

1. Introduction

With the ongoing transformation of information dissemination in the new era, traditional printing processes are evolving through virtual reality (VR) technology, transitioning from physical to virtual forms and from two-dimensional planes to three-dimensional spaces. By creating three-dimensional virtual environments, VR offers users immersive experiences that closely mimic — and in some cases even surpass — real-world sensory experiences [1]. According to a report by Fortune Business Insights, the global VR market reached $16.32 billion in 2024 and is projected to grow from $20.83 billion in 2025 to approximately $123.06 billion by 2032, with a compound annual growth rate (CAGR) of over 28.9%. Within the healthcare sector, VR is rapidly emerging as a significant intervention tool. Mental health conditions such as anxiety disorders, depression, and post-traumatic stress disorder (PTSD) pose major challenges to global public health due to their complexity. Data from the World Health Organization (WHO) indicate that around 320 million people worldwide suffer from depression, while more than 260 million are affected by anxiety disorders. These figures highlight both the prevalence and profound social impact of mental health issues. Traditional psychological treatments—including face-to-face counseling and pharmacotherapy — have demonstrated certain effectiveness. However, they also present limitations such as high costs, uneven distribution of resources, and issues related to patient acceptance and adherence (Fig. 1).

In this context, VR technology has attracted significant attention from healthcare professionals due to its unique advantages. By simulating controlled virtual environments, VR provides patients with a safe and manageable space for therapeutic simulations or specific mental exercises. Research shows that VR-based therapy is particularly effective in treating conditions such as

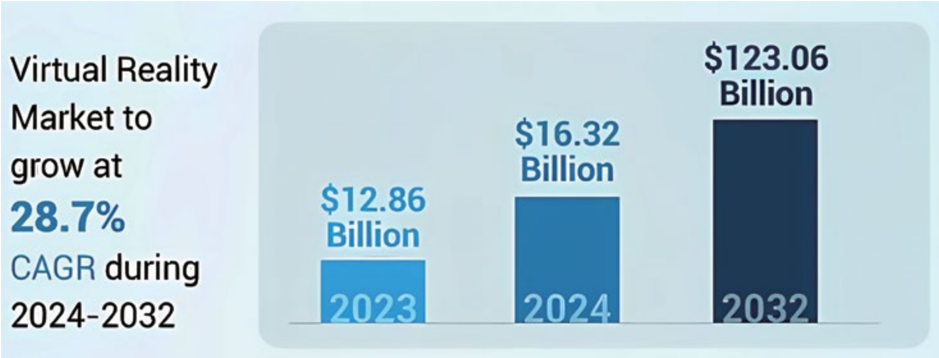


Fig. 1 Statistics and Forecast of VR Market Size ©FORTUNE BUSINESS INSIGHTS.
Source: https://www.fortunebusinessinsights.com/industry-reports/infographics/virtual-reality-market-101378

phobias, anxiety, and PTSD [2]. For instance, one study found that patients with PTSD who underwent VR-assisted exposure therapy showed more significant improvement in symptom reduction compared to those receiving conventional treatments. This approach allows gradual exposure to trauma-related stimuli within a controlled setting, helping patients learn to manage and reduce traumatic responses.

According to a report by Verified Market Research, the global virtual reality healing market is expected to reach approximately $1.8 billion by 2023 and surge to around $13.9 billion by 2032, reflecting a CAGR of 25.1% during the forecast period. A major driver of this growth is the integration of VR technology in healthcare settings to improve patient outcomes and enhance the quality of care (Fig. 2).

Department of Geriatrics, Xiangya Hospital, Central South University, Changsha, Hunan, People's Republic of China. Developed a bibliometric study using the advanced retrieval function in the Web of Science (WOS) Core Collection. The search query (TS = ("Mental health") AND TS = ("Virtual reality")) was applied, with a publication timeframe spanning from January 1, 1999, to February 14, 2025. Document types were limited to articles and reviews, yielding 1398 initial publications.The annual publication trends in this field showed a clear growth trajectory for VR and mental health research (Fig. 3). During the initial exploratory phase (pre-2010), publication output

Fig. 2 Statistics and Forecast of VR Healing Market Size ©VERIFIED MARKET RESEARCH. Source: https://www.verifiedmarketresearch.com/product/virtual-reality-in-healthcare-market/?utm_source=googleads&utm_campaign=22298128078&utm_term=virtual%20reality%20therapy%20market&gad_source=1&gad_campaignid=22298128078&gbraid=0AAAAAC5t6V_Vln6ILcQWE9nHe1ChSYi67&gclid=EAIaIQobChMItZq-7IqvjwMVHaJmAh3dvjzUEAAYASAAEgIfRPD_BwE

remained relatively low, indicating the field's nascent stage of development. However, beginning in 2015, coinciding with rapid technological advancements and increasing maturity of VR applications, publication volumes exhibited slight growth. This upward trend became particularly pronounced from 2020, and output continues to rise, reflecting VR's emergence as a research hotspot in mental health applications [3].

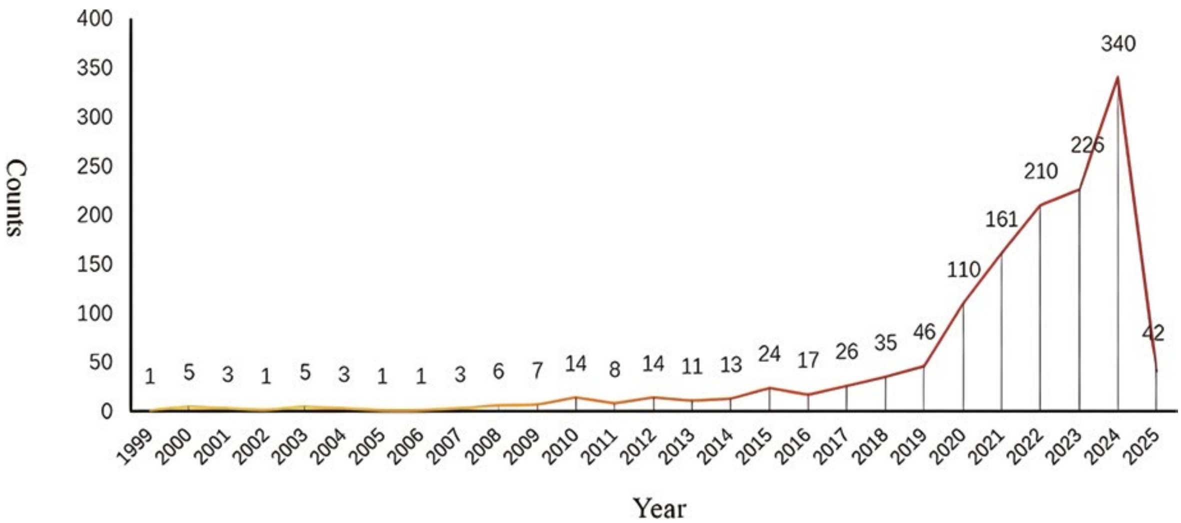


Fig. 3 Analysis of annual publications about the application of VR in mental health care.
Source: https://www.tandfonline.com/doi/full/10.2147/JMDH.S536946#d1e235

Despite promising early results, the practical application of VR in psychological treatment still faces several challenges. High equipment costs, technical accessibility, and the need for professional guidance remain significant barriers to widespread adoption. Moreover, further scientific research is needed to fully understand the long-term effects and potential side effects of VR-based therapy.

In summary, VR technology demonstrates substantial potential and value in the field of mental healing. It not only offers new perspectives and methods for treatment but also presents fresh challenges and opportunities for researchers and clinicians. Investigating how the spatiotemporal properties of VR can facilitate healing may deepen our understanding of mental health treatment mechanisms and contribute to the development of more personalized and effective therapeutic approaches.

2. The Spatiotemporal Properties of VR Technology

The core advantage of virtual reality technology lies in its unique spatiotemporal properties, which grant VR environments unprecedented flexibility and control. Computer technology and virtual technology are two prominent fields in today's societal development, playing vital roles across various industries. Through continuous innovation and advancement in both hardware and software, computer technology enables people to process information and solve problems more efficiently. Meanwhile, virtual technology offers more realistic and immersive experiences by simulating the real world [4]. The synergistic development of these two technologies not only brings great convenience to technical professionals but also creates new opportunities for progress in various sectors.

Using highly advanced computer graphics and sensor technology, VR constructs a manipulable virtual environment where time and space can be controlled, allowing users to tran-

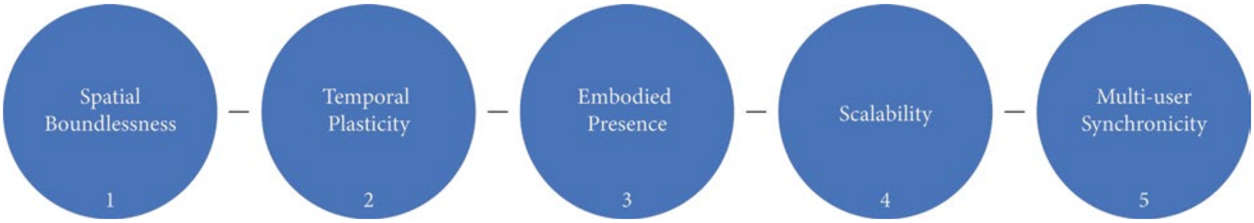


Fig. 4 Five attributes of VR spacetime summarized based on research context. Source: own work.

scend the boundaries between reality and fiction and experience situations beyond physical limitations. In these virtual worlds, time can be accelerated, slowed, paused, or even reversed, while space can be expanded, created, or altered infinitely — breaking geographical, dimensional, and proportional constraints of the physical world. For example, in VR, one might encounter a past or future version of oneself or come face to face with visualized negative emotions.

To facilitate research, we have summarized the spatiotemporal characteristics of VR technology into the following five key properties (Fig. 4).

2.1. Spatial Boundlessness

VR technology breaks the constraints of physical space, allowing users to instantly "teleport" into any digitally constructed or recreated environment, or to see things that do not exist in the physical world. Whether it's the real Martian landscape, a fictional fantasy world, or the interior of a microscopic cell, users can immerse themselves and gain a strong sense of presence, greatly expanding the boundaries of human experience. This reality-transcending capability makes VR a powerful tool for exploring new domains and testing innovative ideas. In medical education, for example, students can use VR to navigate inside the human body and intuitively learn the structure and function of various organs — an experience far beyond what traditional teaching methods can offer [5].

2.2. Temporal Plasticity

VR allows time to be compressed, stretched, paused, or even reversed. Users can observe a glacier melting process — which would normally take decades — accelerated in minutes, pause a bullet-time scene and examine it from 360 degrees, or repeatedly practice an operation at a critical moment. This brings a new dimension of temporal interaction to human activities, enhancing both efficiency and depth of understanding.

2.3. Embodied Presence

In a VR experience, the user does not merely "watch" a virtual space — they "enter" and "exist" in it through an avatar or first-person perspective. The user's physical movements are mapped in real time into the virtual world, enabling interaction with the environment and objects, thereby creating a strong sense of bodily ownership and embodied presence. This is a fundamental difference between VR and traditional 3D displays, creating a truly immersive "I am there" experience. It serves as the foundation for remote collaboration, social interaction, and skills training.

2.4. Scalability

VR can freely alter the perceived scale of the user's body and the environment, leading to changes in field of view and content. Users can become giant-sized to overlook an entire city, or shrink to the size of an ant to examine the texture of a leaf. This arbitrary shift in perspective offers new ways of observing the

Atrybuty czasoprzestrzenne VR	Przypadki terapii i chorób wspomaganych przez VR
Spatial Boundlessness	Pain Phantom Limb (PLP), Anxiety Disorder, Mild Cognitive Impairment, Chronic Kidney Diseases (CKD), Post-Traumatic Stress Disorder (PTSD), Spacific Phobia, Mindfulness and Meditation Training
Temporal Plasticity	Post-Traumatic Stress Disorder After War, Attention Deficit Hyperactivity Disorder (ADHD), Alzheimer's Disease, Dipolar Affective Disorder
Embodied Presence	Autism SPectrum Disorder (ASD), Parkinson's Disease, Depressive Disorder, Schizophrenia and Related Disorders, Substance Use Disorders od Addictive Behaviours, Eating Disorder, Paralytic, Patients with Chronic Pain, Avatar Therapy, Physical Activity and Physical Rehabilitation Therapy
Scalability	Acrophobia, Cognitive-Behavioral Therapy, Exposure Therapy
Multi-User Synchronicity	Social Anxiety Disorder, Depressive Disorder, Bipolar Affective Disorder, Substance Use Disorders od Addictive Behaviours, Social Skills Remediantion Therapy

Fig. 5 Matching Relationships Between VR Attributes and Therapeutic Cases/Diseases. Source: own work.

world. It provides an exceptionally powerful tool for scientific visualization (e.g., observing molecular structures or celestial movements), artistic expression, and education.

2.5. Multi-user Synchronicity

Multiple users can simultaneously access and share the same virtual space despite being in different physical locations. They can see each other's avatars and communicate, collaborate, and interact in real time, jointly manipulating and altering objects and events in the virtual environment. This creates a shared experience that transcends geographical barriers, forming a core paradigm for the future of social interaction, remote work, collaborative design, and multiplayer gaming — defining a new form of spatiotemporal "co-presence."

The five spatiotemporal attributes mentioned above are intricately interwoven, bringing numerous advantages and innovative potential to VR-based therapeutic interventions. In this study, our team has mapped the correlations between VR attributes and therapeutic cases and medical conditions worldwide (as illustrated in Fig. 5). This serves as a valuable reference for VR creators to identify key priorities when collaborating with healthcare professionals, while also being essential for optimizing VR's therapeutic potential and addressing its associated challenges.

3. Application of VR Audiovisual Content in Healing

3.1. A New Approach to Psychotherapy

As an innovative pathway in psychological treatment, virtual reality technology offers a unique immersive experience that enables individuals to confront and process their psychological issues within a fully controlled environment [6]. The approach of

Fig. 6 University of Southern California Research on VR Therapy for "Post-War Psychological Syndrome". Source: https://www.voachinese.com/a/vr-treatment-20170717/3947732.html

exposure therapy is particularly suitable for people who have experienced traumatic events, as the spatial boundlessness of VR allows therapy to take place without exposing individuals to the actual traumatic setting — thereby reducing the risk of re-traumatization. The temporal plasticity of VR enables patients to gradually approach and adapt to scenes that may trigger traumatic memories, without the concern of real-world negative consequences.

For example, for veterans suffering from post-traumatic stress disorder (PTSD) due to wartime experiences, VR-based therapy can assist them in gradually processing combat-related psychological trauma within a virtual battlefield environment, thereby alleviating post-traumatic anxiety and fear (Fig. 6).

VR technology has also demonstrated significant therapeutic potential in treating anxiety disorders, social phobias, and various other specific phobias. Through realistic virtual environment simulations, patients can safely confront anxiety-inducing situations — such as public speaking, heights, or specific animals — under completely secure conditions. This gradual exposure helps patients build the capacity to face and overcome their fears step by step.

Compared to traditional exposure therapy, VR treatment offers greater controllability and flexibility, allowing adjustments in exposure intensity and environment based on the patient's specific needs and progress. Furthermore, VR can simulate therapeutic environments that are difficult to recreate in real life, providing patients with unique treatment experiences. For instance, using VR technology, therapists can recreate environments from a patient's childhood, helping them revisit early life experiences and explore the roots of psychological issues. This therapeutic method opens new possibilities for in-depth exploration of individual psychology, potentially unlocking previously inaccessible areas in mental health treatment.

Fig. 7 Social VR game "VR Chat" scenario.
Source: https://citizenside.com/technology/what-is-vr-chat/

3.2 Cognitive Behavioral Therapy Assistant Tool

As an auxiliary tool in cognitive behavioral therapy (CBT), VR technology provides a unique interactive platform for treatment. By simulating various real-life scenarios in virtual environments, patients can practice and improve their cognitive and behavioral patterns without real-world social risks. This is particularly valuable for treating socially related psychological disorders such as social anxiety and agoraphobia [7].

In virtual environments similar to social VR games like "VR Chat" and "Rec

Room" (as shown in Fig. 7), patients can repeatedly practice social interactions — such as conversing with virtual characters or participating in virtual gatherings — to gradually build confidence and reduce anxiety in real social situations. This is made possible through the combined effects of VR's spatial boundlessness and embodied presence.

The application of VR in cognitive behavioral therapy extends beyond social skills training. It also helps patients identify and challenge negative thoughts in a controlled environment. Through simulated scenarios, patients learn how to apply new cognitive and behavioral strategies in real life. For example, for individuals with depression, VR can simulate daily situations that may trigger negative thinking. With guidance from therapists, patients can learn to apply positive thought patterns in these contexts.

Furthermore, the multi-user spatiotemporal synchronicity of VR technology offers a more authentic and dynamic therapeutic experience. This helps increase patient engagement and involvement, thereby improving treatment outcomes. At the same time, the controllable nature of VR environments makes the therapeutic process safer and more efficient. Therapists can monitor patients' reactions in real time through virtual avatars and adjust treatment strategies as needed.

Fig. 8 Daniel Freeman's psychology team at the University of Oxford uses VR to treat acrophobia (fear of heights). Source: https://news.pts.org.tw/article/399684

Fig. 9 The psychology team led by Daniel Freeman at the University of Oxford uses VR to treat claustrophobia. Source:https://www.oushinet.com/static/content/europe/other/2022-04-07/961686348530855936.html

3.3. Emotional Regulation and Psychological Rehabilitation

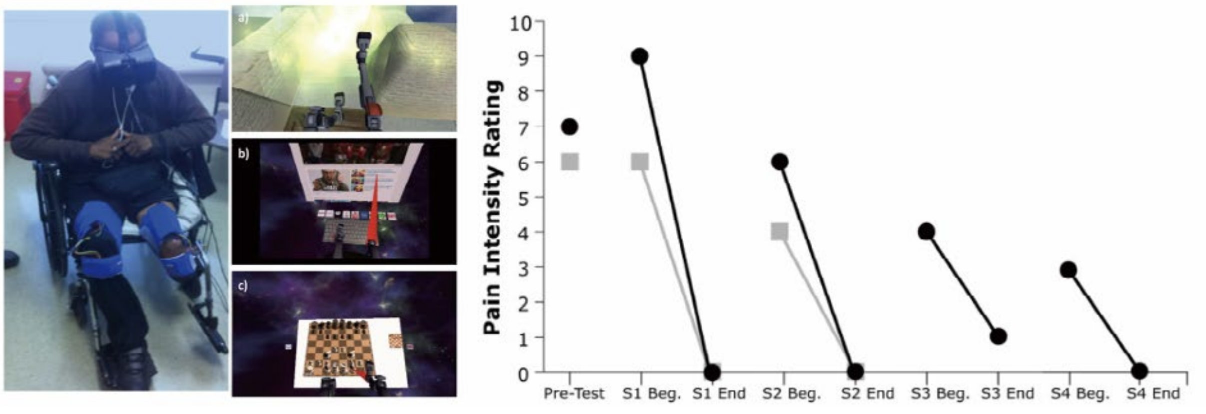
Emotional regulation and psychological rehabilitation represent a significant application of virtual reality (VR) technology in the healthcare field. By delivering immersive environmental experiences, VR can effectively influence and modulate an individual's emotional state, demonstrating unique advantages in addressing anxiety, depression, and other mood disorders.

VR environments can simulate a range of settings — from serene natural landscapes to therapeutically designed virtual scenes — offering patients an escape from real-world stress and facilitating mental relaxation and recovery [8]. For instance, through VR, users can experience walking through a forest, strolling on a beach, or meditating in a tranquil space. These immersive nature-based experiences have been shown to significantly reduce symptoms of anxiety and depression, thereby promoting psychological well-being.

In the context of psychological rehabilitation, VR serves not only as a tool for emotional regulation but also as an auxiliary means in psychotherapy. For individuals who have undergone severe trauma or are affected by chronic psychological stress or fear, VR-based therapeutic environments allow them to safely confront and process traumatic memories, supporting gradual recovery. The controllability of VR settings enables therapists to tailor treatment plans according to each patient's specific needs, making the process more personalized and effective.

Within psychotherapy, VR can also recreate past traumatic experiences or stressful situations, helping patients process and overcome psychological barriers in a secure setting (as shown in Fig. 8-9). Similarly, VR can simulate future environ-

Fig. 10 Alexander Miller et al.'s study on immersive low-cost virtual reality treatment for phantom limb pain. Source: https://pubmed.ncbi.nlm.nih.gov/29515513/



ments, allowing users to better evaluate potential outcomes when facing decisions. For instance, a study led by Daniel Freeman, Professor of Clinical Psychology at the University of Oxford, in collaboration with Oxford VR, demonstrated that virtual reality technology can simulate typical confined spaces such as elevators and subway cars, providing claustrophobia patients with a controlled exposure environment. This enables them to safely and gradually adapt to and overcome their fears[9]. The virtual reality exposure therapy developed by the team is also applicable to acrophobia. By having patients complete specific tasks step-by-step in a controlled virtual high-altitude environment, their anxiety levels and avoidance behaviors can be significantly reduced.

Moreover, VR technology can integrate music, sound, and visual elements to create multi-sensory therapeutic experiences. Such integrated sensory stimulation plays a crucial role in promoting psychological recovery. These benefits arise from the combined effects of VR's spatial boundlessness, scalability, and embodied presence.

3.4. Application in the Treatment of Specific Diseases

Virtual reality technology has demonstrated unique value in the treatment of specific diseases, particularly in areas such as cognitive impairment, Alzheimer's disease, stroke rehabilitation, and chronic pain management. By simulating therapeutic environments and activities, VR offers innovative methods and perspectives for treating these conditions [10].

For instance, in the treatment of cognitive impairment and Alzheimer's disease, VR can simulate daily living environments and tasks, helping patients practice memory, attention, and other cognitive functions, thereby slowing disease progression. This simulated daily task training plays a significant role in maintaining patients' self-care abilities and improving their quality of life.

Most amputees experience phantom limb sensations, often including intense and persistent phantom limb pain (PLP). Standard treatments fail to relieve PLP in most cases, but VR's embodied presence and spatial boundlessness have shown promising potential. In a study titled "Immersive Low-Cost Virtual Reality Treatment for Phantom Limb Pain" led by Alexander Miller's team, patients viewed a first-person perspective of two fully rendered legs in a head-mounted display while playing a series of custom VR games. The movement of both limbs was controlled using measurements from inertial sensors attached to the intact limb and the residual limb.

Two unilateral transtibial amputees received multiple VR therapy sessions over several weeks. Each participant experienced immediate and significant pain reduction after every VR session, and their preoperative pain levels also decreased substantially over the course of the study. Subject 1 reported a 100% reduction in pain intensity after the first and second sessions, while Subject 2 showed an average reduction of 93.7%. Five out of six recorded post-session pain scores were at the minimum value of 0 (on a 10-point scale), indicating complete absence of pain. Although preliminary, these findings support the view that VR-based interventions may serve as an effective low-cost treatment for PLP in lower-limb amputees [11] (Fig. 10).

In stroke rehabilitation, VR technology provides simulated physiotherapy environments where patients can perform various motor and activity trainings. These simulated therapeutic activities not only make rehabilitation more engaging but also allow personalized adjustments based on the patient's progress and needs, thereby enhancing recovery outcomes. The interactivity and feedback mechanisms in VR environments enable real-time assessment of patient progress, helping healthcare professionals design and adjust rehabilitation plans more effectively.

For chronic pain management, VR technology helps reduce pain perception by diverting the patient's attention. Through relaxation exercises and meditation in VR environments, patients can learn to control pain and improve emotional states, significantly enhancing their quality of life. Additionally, VR can simulate specific treatment procedures, helping patients understand and prepare for upcoming medical interventions, thereby reducing pain exacerbated by fear and anxiety.

3.5. Challenges and Future Directions in Therapeutic Applications

While virtual reality (VR) technology shows broad prospects in therapeutic applications, its development also faces multiple challenges. The rapid advancement of technology and the growing demand for healthcare require that we seriously consider and address the accompanying issues as VR-based healing approaches are promoted.

A major challenge lies in the high cost and technical complexity involved. Although the price of VR devices has gradually decreased, high-end medical-grade VR systems remain expensive, limiting their widespread adoption across healthcare institutions. Moreover, operating these advanced systems requires specialized technical support and maintenance, posing a significant burden for many medical facilities. Therefore, reducing costs and simplifying technical operations are essential prerequisites for expanding the use of VR in therapeutic settings [12].

On the other hand, although VR technology holds great potential in healing applications, research on its long-term effects and safety is still insufficient. While short-term outcomes of VR-based interventions have been positive, the long-term impacts — especially prolonged use on vision, cognition, and mental health — require further clinical trials and scientific validation. In addition, the applicability and safety of VR therapy need more in-depth research across different populations, such as children, the elderly, and individuals with specific health conditions.

Despite these challenges, the future of VR in therapeutic applications remains highly promising. As technology continues to advance, future VR devices will become more lightweight, user-friendly, and affordable, greatly facilitating their use in healthcare. At the same time, growing research will enhance our understanding of VR's therapeutic effects, helping to improve and optimize treatment protocols for greater personalization and effectiveness.

Furthermore, the integration of VR with other advanced technologies such as artificial intelligence (AI) and machine learning opens new possibilities for innovative healthcare solutions. By incorporating AI algorithms, VR systems can better adapt treatment plans in real time based on patient feedback and progress, enabling more precise and efficient personalized therapies. This technological convergence not only enhances treatment outcomes but also provides healthcare professionals with powerful tools to support clinical decision-making and therapeutic processes.

4. Impact on Cognition, Emotion and Behavior

Virtual reality (VR) technology has become a focus in psychological and cognitive science research due to its ability to influence human cognition, emotion, and behavior. By creating immersive virtual environments, VR can profoundly alter an individual's psychological state and behavioral patterns, making it a valuable tool for both studying and treating cognitive and emotional disorders.

At the cognitive level, VR can reshape perception and cognitive processes through simulated environments and scenarios. By engaging users in targeted tasks within these environments, VR helps improve attention, enhance memory, increase learning efficiency, and support overall cognitive function. For instance, complex problem-solving scenarios simulated in VR can train and improve spatial cognition and reasoning skills [12]. Moreover, VR can replicate diverse cultural and historical settings, offering researchers a unique platform to study cross-cultural cognitive differences.

On the emotional level, VR elicits and regulates emotional states through highly realistic situational simulations. This capability makes it a powerful tool for studying emotional responses and treating mood disorders. Within virtual settings, environmental factors such as context, intensity, and interactive elements can be precisely controlled to evoke specific emotions — such as joy, sadness, fear, or anger — in a safe and controlled manner. This approach is particularly valuable for understanding emotional mechanisms and developing targeted treatments for disorders like anxiety, where VR can simulate high-stress scenarios to help patients learn emotional regulation.

In terms of behavior, VR enables the simulation of real-world scenarios where users can practice and refine interactions and skills. The authenticity of these simulations supports both behavioral research and effective training. By repeatedly practicing specific behaviors — such as social interactions, public speaking, or technical tasks — in a risk-free virtual space, users can build confidence and improve real-world competence. For patients undergoing rehabilitation, such as those recovering from stroke or brain injury, VR offers a safe and effective platform to restore motor and cognitive functions through guided simulation.

While VR shows considerable promise in supporting cognitive, emotional, and behavioral change, its long-term effects and potential risks require further study. Extended exposure to virtual environments may alter perceptions of reality or encourage psychological dependence and escapism. Therefore, continued research is essential to optimize VR's use in education and therapy while identifying and mitigating any adverse outcomes.

5. Advantages and Limitations in Therapeutic Applications

Virtual reality offers notable advantages in therapeutic settings, introducing a novel form of treatment that provides a safe and controllable environment where patients can engage in rehabilitation free from real-world pressures. Through immersive experiences, VR captures patient attention and enhances engagement and motivation. This high level of immersion and interaction has proven especially effective in treating anxiety, PTSD, phobias, and other psychological disorders. Patients can repeatedly confront challenging situations without actual risk, gradually reducing fear and anxiety while building coping skills.

Another significant advantage of VR is its customizability. Healthcare professionals can tailor virtual environments to individual patient needs, enabling truly personalized treatment plans [13]. This individualized approach not only improves therapeutic outcomes but also increases patient satisfaction and comfort. For conditions that are difficult to address using conventional methods, VR offers innovative solutions through simulated environments, expanding treatment options and possibilities.

Despite these advantages, VR therapy also has limitations. A primary concern is its technological dependency. High-quality VR experiences typically require costly equipment and technical support, limiting accessibility in under-resourced settings. Additionally, operating VR systems demands technical expertise, which may pose a barrier for some healthcare providers and patients. Another limitation involves potential side effects such as eye strain, dizziness, and nausea—symptoms related to visual-vestibular mismatch. Extended VR use may place strain on the visual and balance systems, particularly for individuals with pre-existing conditions, making it essential to monitor and manage these effects.

Although VR delivers strong immersion and realism, it remains a simulated experience and may not fully replicate the complexity and dynamism of the real world. This gap may impact the transfer effect — the ability of patients to apply skills and insights gained in VR to daily life. Therefore, VR-based therapy should be integrated with other treatment approaches to ensure sustained and comprehensive outcomes.

Finally, during the implementation of VR-based therapeutic interventions, several challenges require careful consideration by clinical teams: how to protect sensitive biometric data collected through VR systems, how to ensure equitable access to VR technology across different socioeconomic groups, and how to mitigate risks of vulnerable populations developing overreliance on immersive technologies.

6. Conclusion

The exploration of virtual reality in therapeutic applications reveals significant potential as an innovative intervention tool. By offering immersive, safe, and controlled virtual environments, VR enables patients to address psychological and physical issues in new ways. Its unique spatiotemporal attributes and high degree of customizability allow for personalized and targeted treatment, improving both efficacy and patient engagement.

However, the application of VR in healing is not without challenges. Technical costs, accessibility, and potential side effects remain important barriers. Moreover, differences between virtual and real-world contexts may influence the transfer of learning, underscoring the need to carefully integrate VR experiences with real-life applications.

Future research should focus on optimizing VR content design to enhance therapeutic efficiency and effectiveness. This necessitates conducting more nuanced studies targeting specific types of disorders and developing virtual treatment environments that better align with user needs. Concurrently, it is imperative to validate the long-term efficacy and safety of VR-based therapies through rigorous clinical trials, thereby establishing solid empirical foundations for their application. Furthermore, as VR experiences undergo a profound transition from visual dominance to full sensory engagement, future efforts should explore how to leverage multisensory integration to reshape patients' engagement patterns and internal meaning-making mechanisms, ultimately deepening the therapeutic experience.

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