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Potential Benefits and Risks Given by the Virtual Reality of the Central Nervous System

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Abstract: The rapid growth and proliferation within healthcare of Virtual Reality (VR) technology's make it a promising platform for treating central nervous system (CNS)-related ailments. From neurorehabilitation to pain management and even cognitive enhancement, there are numerous benefits that VR offers this portion of medicine. Nevertheless, multiple risks among motion sickness and eye strain, exist with utilizing this new tech for CNS treatments. Beyond immediate physical harm concerns like these - researching the long-term impact on this area remains paramount regarding future implementation. The utilization of VR technology in the field of CNS presents considerable promise, the same its potential risks necessitate a meticulous analysis and resolution before its extensive acceptance across clinical settings.

Keywords: virtual reality (VR), central nervous system (CNS), brain, immersive experience, perception, cognition, motor function

1. Introduction

Virtual reality (VR) stands as a technological marvel, allowing users to transcend the boundaries of their physical surroundings and immerse themselves in entirely new realms. This cutting-edge innovation, achieved through the integration of advanced computer graphics with our sensory system, creates a virtual immersion experience that renders the physical environment inconsequential. It is a journey into fantastical dimensions without leaving the confines of one's room, made possible by the seamless interface between technology and human perception. The implications of VR extend far beyond mere entertainment, encompassing a spectrum of applications such as gaming, education, healthcare, and more. The limitless possibilities afforded by this modern technological advancement prompt a closer examination of its effects on the central nervous system (CNS). This article, built upon the foundation of existing research studies, embarks on a holistic exploration of how VR technology influences individuals' CNSs.

Our investigation goes beyond the conventional focus on the brain, delving into the often- overlooked realm of the spinal cord. By comprehensively considering the impact of VR on both the brain and spinal cord, our aim is to provide a nuanced understanding of the potential gains and drawbacks associated with its practical applications. Each author contributes equally to this collaborative effort, underscoring the shared commitment to unravelling the complexities surrounding the intersection of virtual reality and the human nervous system. Through a synthesis of existing research, we aim to shed light on how VR can stimulate neural activity, alter cognitive functions, and contribute to spatial awareness. Moreover, we explore the therapeutic applications of VR, from treating phobias and anxiety disorders to enhancing rehabilitation outcomes in individuals with neurological

conditions. However, our inquiry does not shy away from acknowledging potential drawbacks, including motion sickness, addiction concerns, and ethical considerations related to immersive experiences.

2. The Effects of Virtual Reality on the Brain

The central organ of the CNS is responsible for receiving sensory information and utilizing its processing capabilities to translate these stimuli into understandable output. Virtual reality is a form of procedure that clinical research has recognized as having significant impacts on certain mechanisms controlling physiology perceptive developments relating to movement responses and cognition facilities. Researchers reveal that modifying traditional elements of reality through VR use leads to altered activity within our brains by affecting crucial regions like the prefrontal cortex or parietal lobe. One captivating attribute of virtual reality (VR) is its ability to stimulate high levels of engagement and immersion, contributing significantly towards increased brain activity in accordanc with Slater et al. (2010) [1]. The immersive potentiality of this technology also allows for improved spatial cognition as users can explore, engage with and navigate difficult three-dimensional spaces at ease. Additionally, time perception can be altered when immersed within such environments. To alter how the brain processes time, intense focus and attention are required in virtual reality experiences. This is according to O`Brien et al.'s findings (2011) [2] , which suggest that people's perceptions of time are modified through their exposure to VR environments [3]. Utilizing this technology, researchers have successfully treated patients struggling with phobias and various anxiety disorders; patients undergoing virtual reality exposure therapy exhibited lower levels of fear and anxiety over time [4]. The immersive nature of virtual reality (VR) has been linked with increased activation in the visual cortex responsible for processing information obtained visually. This sensory phenomenon was established by Sanchez- Vives and Slater's study (2005), where they found VR stimuli activated the visual cortex more strongly than traditional two-dimensional stimuli [5]. Therefore, this research implies that incorporating VR is superior when seeking more captivating visual stimulation. Dopamine release boosts are stimulated by VR as proven through multiple studies. In one such study executed by Iassevoli and colleagues (2023) [6], it was observed that participants who engaged in a VR game showcased elevated levels of dopamine discharge compared to those who played conventional 2D games. The role of dopamine cannot be undermined as it is linked with concepts like motivation and reward systems. Extensive research supports the claim that virtual reality technology can enhance certain cognitive abilities as spatial awareness and memory recall of immersive experiences that engage multiple sensory pathways simultaneously. Evidence from Liao et al.'s (2020) experiment indicated marked increases on the hippocampal region's gray matter volume after participants underwent extensive VR training sessions [7]. A burgeoning field of research has suggested that virtual reality can serve as an effective tool for improving underlying motor skills and enhancing rehabilitation outcomes. Researchers such as Qin et al. (2019) have conducted investigations showcasing significant enhancements in gait and mobility among patients with Parkinson's disease who underwent VR-based therapies [8]. Motion sickness and disorientation were reported among some individuals who used VR, according to the findings of Palmisano et al.'s research in 2015 [9]. Addiction has also been suggested as a potential issue with excessive use of this technology, as pointed out by Griffiths et al.'s study in 2019 showing addictive symptoms resulting from overuse of VR is indeed possible [10]. Furthermore, concerns regarding ethical issues associated with exposing users to harmful experiences while navigating within virtual reality arose alongside its development; Madary and Metzinger (2016) discussed such risks at length [11].

3. Structural changes on the brain

Amidst decades of scholarly analysis, findings have shown that VR can lead to modifications in neuroplasticity within particular areas related to focus, cognitive function, and navigation skills. Notably among these changes is the augmentation of gray matter

volume in one's hippocampus after ample exposure to virtual scenarios - which is recognized for its involvement with encoding spatial memories. In support of this claim made by researchers is the outcome witnessed by Burgess et al.'s (2001) research, whereby individuals maneuvering through an artificially constructed environment displayed increased growth rates in their hippocampi relative to those excluded from such experience [11]. In their study published in 2015, researchers found that patients diagnosed with schizophrenia who underwent VR-based cognitive training had an increase in hippocampal volume that coincided with positive gains on their memory performance tests [12]. Furthermore, studies show that utilizing VR technology leads to noticeable fluctuations within the brain's cerebellar area concerning motor coordination and balance control (Bobeica et al. 2022) [13].

As described by Wu et al. (2021), playing a virtual reality game can stimulate cerebral structural modifications associated with beneficial neurological effects on cognitive functioning as spatial learning and memory retention in addition to with enhanced motor functionalities characterized by better balance regulation due to heightened grey matter volume within the cerebellum [14].

4. Perception

As awareness surrounding potential alterations in cognitive function due to virtual reality grows, so too does research aimed at examining such changes. Specifically, studies are focusing on shifts in perception occurring across neural channels when engaging with this immersive technology. Participants assigned tasks requiring interaction with a simulated environment displayed heightened activation levels of both their visual and motor cortices during data collection. Exposure to Virtual Reality (VR) has been shown to elicit the brain's understanding of the simulated realm as a real environment, something that can cause radical differences in environmental perception.

Another significant change brought about by exposure is an alteration of one self-trait among users. In one study conducted by Slater and colleagues (2010), participants used avatars with varying sensory feedback profiles; congruent feedback resulted in noticeable changes regarding how users perceived aspects of their molecular reality [1]. Inducing alterations in brain plasticity is believed to be one of the primary ways through which virtual reality affects the central nervous system. This proposition was confirmed by Palaus et al.'s (2017) study, which found that exposure to VR environments led to neuroplastic changes within participants' brains [15]. It was also discovered that these changes could facilitate improved cognitive abilities, motor skills and improved emotional regulation.

5. Cognition

Alterations in cognition arise from virtual reality's capacity to immerse users and interact with them. One of the changes is better spatial awareness and spatial memory, as Loomis et al.'s (1999) research demonstrated by exposing participants to a VR-based world that enabled exploration and navigation [16]. Results indicate that subjects who received Virtual Reality exposure showed marked improvement in spatial awareness abilities as well as navigational aptitude when compared with those not receiving such training. Another notable outcome seen with the use of VR technology includes its influence on increasing one's focus power and attentiveness. According to research carried out by Goharinejad et al. (2002), immersion in virtual reality worlds can lead to additional attention span along with better concentration skills through interactive engagements created in these environments [17]. Those having received VR treatment demonstrated significantly elevated levels of both attention and concentration. The introduction of VR technology can offer noticeable enhancements in decision-making and problem-solving capabilities in accord to a study conducted by Parsons et al. (2017) [18]. By using a simulated environment similar to the one encountered outside of virtual reality, people are able to make decisions rapidly whilst also honing their ability for problem-solving within said environment. Crucially, the participants from this study exhibited better results when completing

tasks than other participants who didn't use VR throughout their learning process. In a recent investigation conducted by Rizzo et al. (2019), the idea emerged that utilizing VR may yield notable benefits for both learning capacity and long-term memory development [4]. By introducing a stimulating, interactive dimension, this technology enables learners to fully engage with and retain subject material. Study data indicated participants who utilized VR demonstrated significantly greater retention success than their non-VR counterparts.

5. Motor Function

By providing a simulated environment where participants can practice fundamental tasks, virtual reality enhances the capacity of one's ability to learn new movements and increase proficiency. This discovery was supported by a study conducted by Merians et al. (2002), which found evidence showing greater effectiveness in utilizing a simulation-driven approach rather than the usual conventionally-practiced method for developing new skills [19].

Providing a feedback mechanism to monitor and adjust movements, virtual reality (VR) has the potential to enhance motor control and coordination in individuals, as demonstrated by Pompeu et al.'s (2012) study [20]. Specifically, those who underwent VR training showed better outcomes than their counterparts trained using traditional methods. Moreover, through promoting neuroplasticity in brain function, VR offers further benefits concerning motor learning in accord with Zimmermann-Schlatter et al. (2008) [21]. The potential of virtual reality (VR) technology in facilitating motor function was confirmed by a study showing enhanced cortical excitability among participants trained through VR. Moreover, VR shows great promise as an effective motor rehabilitation tool for people with neurological disorders. Findings from Laver et al.'s (2017) investigation show that patients recovering from stroke may benefit greatly from VR-based interventions, which create stimulating and encouraging environments for practicing fine and gross motor skills [22].

6. The Effects of Virtual Reality on the Spinal Cord

Increasingly popular within numerous industries as entertainment, education and medicine; however scientific inquiries are limited concerning the effects of virtual reality (VR) technology specifically on the human spine. A major aspect under consideration pertains to how VR potentially impacts postural stability since involvement with this apparatus presents challenges culminating from redistributions of weight-bearing loads thereby resulting in modifications to activation patterns employed within the anatomy of the spinal cord. Meanwhile a prior comparative study carried out by Lohse et al.(2014) demonstrated possible beneficial outcomes from using VR among patients with Spinal Cord Injuries indicating notable gains via improved sensory-motor integration capabilities and increased motor coordination when compared with non-treatment interventions. Spinal cord injury(SIC) patients stand to benefit from incorporating virtual reality(VR) into their routine exercising, particularly when it comes to retaining or increasing their range of movement, joint flexibility and overall muscular strength [23]. Studies conducted by researchers such as Riva et al. (2005) have affirmed that VR submits stimulus similar to regular activity that can activate muscles, hence offering much-needed therapy for this demographic [24]. This approach may prove especially useful for older adults with mobility challenges or those who lack access to traditional physical therapy resources. The training and learning of motor skills essential for improving the quality of life in individuals with SCI can be enhanced through immersive environments provided by VR technology. With its ability to create artificial yet realistic experiences, VR can play a significant role in enabling patients with SCI to regain motor function. Individuals with SCI typically struggle with fear of falling, which can significantly impact their quality of life. However, VR technology has emerged as a viable solution for addressing this issue, enabling them to increase their confidence and reclaim control over their lives.

7. Potential benefits for central nervous system using virtual reality

Virtual reality (VR) technology remains an increasingly popular tool used to support enhancements toward human physical and mental health. One exciting prospect currently being discussed involves leveraging VR as an intervention for the central nervous system (CNS). In particular, research conducted by scientists at the University of California, San Francisco shows that utilizing VR training promotes neuroplastic changes within neural networks. These types of alterations refer to how new experiences can shape a person's brain function and have positive implications in terms of improving motor function among stroke survivors (Gijbels et al., 2015)[25]. In addressing the essentials for better healthcare treatment options available for sufferers of chronic pain conditions, researchers have looked into exploring alternative therapies beyond conventional methods. For instance, Jones et al.'s (2016) systematic review detailed how incorporating virtual reality interventions could lead to decreased levels of both pain intensity and anxiety suffered by patients with chronic disorders [26]. Such outcomes carry significant implications regarding advancing comprehensive treatment options fit for diverse patient requirements nationwide. The potential health benefits of incorporating virtual reality into daily life cannot be overstated enough. Such potential benefits include improved cognitive functions alongside heightened relaxation responses substantially diminishing stress levels experienced by individuals who took advantage of virtual reality programs designed for these purposes. For instance, a survey featured in the Journal Reports: Alzheimer's Disease has detailed significant advancements made by seniors even if they had mild Cognitive Impairment through engaging Virtual Reality-centered brain exercises for improving their focus/attention/memorization capabilities- this all according to Manera et al.'s conducted studies (2016) [27]. Consideringly as highlighted by Rizzo et al. (2005), it is worth it when considering the promising yet generally untapped prospects who exist in utilizing Virtual Reality based programs for anxiety as well as stress reduction [28].

VR technology can be utilized to boost social skills among those diagnosed with autism spectrum disorder. An investigation done by Maggio and colleagues (2019) revealed that VR-based social skills training led to enhanced social communication abilities for this Population [29]. Enhancing memory function is among the benefits that VR offers to various populations, particularly those with traumatic brain injury. A study presented in the Journal of Head Trauma Rehabilitation revealed that memory training through VR resulted in significant improvement, according to Demeco et al. (2023) [30]. The utilization of virtual reality (VR) as an educational tool is particularly beneficial for individuals working within therapeutic and healthcare fields. Empirical evidence presented by Matheis et al. (2007) supports the efficacy of VR-based medical education, as it results in enhanced knowledge retention and clinical skills among participants [31]. The advantages of using virtual reality (VR) extend beyond simply providing entertainment; they hold promising potential for aiding individuals in developing essential motor skills as well. Researchers have found that VR can particularly benefit those tasked with mastering complex movements, showcasing its superiority over traditional training techniques based on the outcomes of a study published by deBruin et al. (2010) in the Journal of NeuroEngineering and Rehabilitation where VR-based instruction demonstrated significant improvement regarding surgical proficiency [32]. Achieving improved emotional stability and well-being can be accomplished through VR applications. As per a research article published in the Journal of Medical Internet Research, individuals who underwent mindfulness programs executed through virtual reality showed noticeable diminution in depressive and anxious feelings (Chang et al., 2022) [33]. Likewise, those diagnosed with Alzheimer's disease may experience betterment in their spatial orientation abilities following simulation-based navigation training involving VR techniques. The Journal of Neurology presented such findings regarding the positive impacts of utilizing virtual reality technology for navigation procedures (Broeren et al., 2007) [34]. Considering recent research findings, it is evident that VR has diverse applications that can benefit individuals across different populations. For example, utilizing advanced virtual environments for attention exercises purpose can significantly enhance cognitive performance among healthy adults (Parsons

et al., 2008) [35]. Moreover, leveraging VR-based empathy training strategies is an efficacious way of improving social understanding and emotional recognition skills in individuals with autism spectrum disorder (Riva et al., 2005) [24]. Additionally, when used within multimodal rehabilitation programs, VR may contribute positively towards improving recovery rates amongst those with central nervous system injuries. As suggested in Wallach et al.'s (2009) study on multimodal rehabilitation interventions involving VR-based treatments, significant improvements can be achieved regarding patients outcome following traumatic brain injuries [36]. Interestingly though, another benefit that has emerged from making use of virtual reality technologies is their capability to provide clinicians with precise and objective methods to assess clients' neurological functioning - a feature demonstrated yet again by Dascal et al.'s (2017) evaluation of balance and gait deficiencies among Parkinson's patients utilizing virtual environments [37]. Virtual reality (VR) based interventions may hold promise for improving patients' ability to engage in powerful motor-imagery techniques - such as those used during stroke rehabilitation protocols. In support of this contention, Palacios-Navarro et al.'s recent investigation discovered that individuals who participated in VR-enhanced mental-simulation exercises experienced enhanced levels of cortical activity along with improved overall post-stroke locomotor capacities - compared directly against controlled patients receiving traditional care methods alone (Palacios-Navarro et al., 2019) [38].

8. Potential risks for central nervous system using virtual reality

The utilization of virtual reality (VR) creates various advantages while carrying some associated risks to the central nervous system (CNS). Therefore, this section will discuss how VR brings potential hazards compounded by current literature. Specifically, when using VR, individuals may experience motion sickness - a commonly recorded side effect characterized by an incongruity between visual cues displayed in a simulated environment and physical movements made by the person's body causing symptoms such as nausea or dizziness (Munafo et al., 2017) [39]. As hypothesized by Kim et al. (2018), cybersickness is a medical concern for potential users of virtual reality headsets due to feelings of sickness and disorientation felt [40]. To go further on this topic Kasteleijn-Nolst Trenité (2012). identified that susceptibility to photosensitive epilepsy could provoke seizures when exposed to specific VR stimuli such as flashing lights [41]. Ultimately, Read's team demonstrated how prolonged use of these headsets might have dire impacts on our vision muscles and result in eye strain who translates into severe headaches, dry eyes or even worse - blurry visions. While virtual reality (VR) is widely celebrated for its immersive experiences, research has highlighted some potential drawbacks associated with its prolonged usage. Notably, evidence suggests that prolonged exposure to VR may result in vision problems like myopia among younger individuals (Walline et al., 2021) [42]. Furthermore, Dominguez-Tellez et al. (2019) found that the disruption of balance and coordination was common during interactions with virtual objects or performing tasks involving movement [43]. Virtual Reality(VR)'s impact on human health has attracted attention from experts worldwide; however, limited information exists regarding its potential long-term results relating to Central Nervous System(CNS). Primary research surrounding this topic finds an association between contact to VR and ensuing alterations within critical regions linked with spatial orientation and sensory fusion as discussed by Gay et al. (2020) [44]. According to recent studies, extended usage of virtual reality (VR) headsets that emit low levels of radiation may cause central nervous system impairment, thereby raising safety concerns about this popular technology (Georgiev et al., 2021) [45]. Additionally, some users report experiencing sensory overload when using these immersive systems - this issue tends to affect those who are hypersensitive to certain stimulus in particular (Chung et al. 2022) [46]. Lastly there are unanticipated consequences related active nuisance -VR electromagnetic pollution facilitated through harnessed electropower. The meddling with electronic implants like pacemakers or hearing aids should not be ruled out while using VR-headgear (Peng et al, 2021) [47]. Given the complexities and unpre-

dictabilities of the contemporary world, skillful critical thinkers are increasingly important for success in academic, professional, and personal pursuits within higher education. Students who possess this essential quality are able to evaluate arguments critically, identify biases or fallacies, generate novel insights and perspectives, transform uncertainty into possibility or ultimately achieve greater academic excellence [48, 49, 50, 51].

9. Conclusion

Virtual reality technology provides opportunities for individuals to engage in immersive experiences that significantly affect their central nervous systems through improved cognitive function, motor rehabilitation or emotional regulation. The resulting increase in brain plasticity coupled with stimulated neural networks prepares one for enhanced mental acuity at various tasks. Accordingly, virtual reality tech has become valuable when used as therapy or treatment modality aimed at specific neurological disorders like Parkinson's disease or trauma-induced brain injuries. Nevertheless information on optimal methods such as duration, intensity along with other vital intervention procedures consider their feasibility based on individual patient situation. To make full use of virtual reality technology's promise as a tool in neuroscience research - an innovative way to diagnose disorders and design interventions - we must proceed with circumspection. It's important to bear in mind that excessive or prolonged use of such technologies can lead to addictions or unwanted physical sensations like cybersickness. Therefore, it's recommended that we weigh carefully both benefits and limitations associated with this novel medium.

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