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Virtual Reality and Human Consciousness: The Use of Immersive Environments in Delirium Therapy

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Abstract

Immersive virtual environments can produce a state of behavior referred to as “presence,” during which the individual responds to the virtual environment as if it were real. Presence can be arranged to scientifically evaluate and affect our consciousness within a controlled virtual environment. This phenomenon makes the use of virtual environments amenable to existing and in-development forms of therapy for various conditions. Delirium in the intensive care unit is one such condition for which virtual reality technology has not been evaluated to date. We are currently assessing the feasibility and utility of a delirium prevention and treatment system which implements virtual reality to improve quality of sleep, reduce pain, lower usage of sedatives, and stimulate cognition. The proposed system will consist of 3-axis wearable accelerometers, 6-DOF position trackers, a virtual reality system, and apps designed to promote sleep quality and mindfulness. Our *a priori* hypothesis is that our virtual reality therapy system would lower the occurrence of delirium in patients admitted to intensive care units.

Keywords

Virtual Reality; Serious Games; VR Therapy; Delirium; Consciousness; Games for Health; Health; Cognition

INTRODUCTION

Immersive virtual environments can break our common understanding of everyday reality that our senses tell us is the truth. The perception of virtual reality as real is referred to as “presence” (Sanchez-Vives & Slater 2005). When studying consciousness, we clearly see several layers blending together into one common awareness, integrating in it the perception of self and of the external world. The phenomenon of our consciousness being transported

into an alternate virtual reality is what defines presence. In this way, presence becomes consciousness within virtual reality.

As our awareness can be affected in a controlled manner within a virtual environment, it means that presence can be utilized to scientifically affect our consciousness. This phenomenon facilitates the application of virtual environments to various branches of psychotherapy. Delirium in the intensive care unit (ICU) is one such condition for which virtual reality (VR) technology has not been evaluated.

CONSCIOUSNESS AND THE SENSE OF PRESENCE IN VR

The idea of presence in a virtual environment is rooted in the concept of transference – the transfer our consciousness from where our body physically is to a space where we believe we are. An immersive virtual environment is capable of fully engaging our mind so it no longer relates to the actual location of the body, but its totally engaged with the virtual reality that is being experienced.

Immersion in virtual environments most commonly includes vision and sound, while other senses are ideally not exposed. Thus ideally, there will be no strong smells, tastes, or pressures on the body during the experience to minimize distraction from the sense of presence. These restrictions strengthen the link between the quality of the created visuals and sound and the virtual experience, and how they interact to create an experience that is engaging in a realistic manner as to affect a state of presence.

The quality of visuals in a VR unit is dependent on two qualities:

- Resolution of the display screen - higher resolutions permit more realistic imagery. Currently the highest resolution consumer VR device is HTC Vive running at 2160×1200 (1080×1200 per eye).
- The refresh rate of the display screen - higher refresh rates produce more seamless imagery. Currently the highest refresh rate consumer VR devices run at 90hz. Many users report a sense of nausea when experiencing VR content at the refresh rates lower than 60hz.

The quality of audio in an immersive environment is extremely important, as the technology to create high quality sound is accessible and noise canceling headphones are affordable. However, it is the way that sound and vision combine that ultimately creates a sense of presence. Coordinating the input from multiple senses gives a sense of immersion into a different reality. If the sounds and the visuals are out of sync, there is a sense of tearing of virtual reality and the mind becomes aware that something is wrong as presence is disrupted. Therefore, it is imperative that the focus in content production is put on the way in which the virtual world is appearing as one coherent system. Only then can presence be created.

Immersive virtual environments are increasingly utilized for studying various types of psychological therapy. This is one class of its application that cannot operate without presence. The management of anxiety and pain distraction techniques can benefit from it. Once the presence in a virtual environment is established, one’s mind responds to the stimuli

of that virtual environment. This phenomenon is available for manipulation in therapy. For example, if a person is experiencing real pain, then immersion in a virtual reality that is pain free can act as a distraction which reduces that person's perception of pain.

APPLICATIONS OF VR IN DELIRUM THERAPY

Use of VR is a promising application for patient care and rehabilitation. Interventions using VR have produced feasible and effective therapies for pain perception in sufferers of traumatic injury (Patterson, Jensen, Wiechman, & Sharar 2010), treatment compliance in burn victims (Sharar et al. 2008), and cognitive deterioration in the elderly (Cherniack 2011). Applications for VR continue to expand towards improving patient care and comfort for serious medical conditions.

Delirium in the ICU is one such condition for which VR technology has not been evaluated. There is good reason to believe VR applications can help treat pain perception (Hoffman et al. 2007), quality of sleep (Chang, Wang, & Yu 2014), and cognitive deterioration (Optale et al. 2010)—all major risk factors of delirium in the ICU. Delirium is a serious and common complication of patient hospitalization. Between 29% and 64% of general hospital patients (Inouye, Westendrop, & Saczynski 2014) are either admitted with delirium or develop delirious symptoms during their hospital stay. In critical care settings, as many as 80% of patients are diagnosed with delirium (Mistraletti et al. 2012). Delirium is characterized by an acute decrease in awareness of one's environment and confused thinking level leading to changes in cognition, activity level, consciousness, and alertness. The annual costs of delirium in the United States are estimated to be about $38 to $152 billion dollars each year. The symptoms of delirium contribute to prolonged hospital stays, are strongly associated with negative health outcomes after hospitalization, and carry a 70% increased mortality rate upon diagnosis (Barr et al. 2013). Risk factors associated with delirium include a wide range of conditions such as age, preexisting cognitive dysfunction, vision and hearing impairment, severe illness, dehydration, electrolyte abnormalities, overmedication, alcohol abuse, and disruptions in sleep patterns. There is no known single cause of delirium (Maldonaldo 2013; Inouye et al. 2014). As such, most recommended strategies to detect, prevent, and treat delirium require generalized and multicomponent approaches. The American Nurses Association (2018), UK National Clinical Guideline Center (2010), Mayo Clinic (Mayo Clinic Staff 2015), and numerous critical care researchers (Brummel & Girard 2013; Desai, Chau, & George 2013; Weinhouse 2014) emphasize the promotion of good quality sleep, pain management, and helping patients remain calm and well-oriented as strategies to prevent or reduce the severity of delirium. Some research suggests calmness and good sleep are important in patient outcomes and the development of delirium (Mills & Bourne 2012; Rompaey et al. 2012; Kamdar et al. 2013).

CRITICAL COMPONENTS OF THERAPEUTIC VIRTUAL ENVIRONMENTS

Interactive environments are not new in the field of medicine. For decades, if not centuries, doctors have used simple games to facilitate patient recovery. But are these virtual worlds effective as a means of gaining knowledge? Are they just a current fad, or do they present the way of the future? The early evidence, both anecdotal as well as scientific, suggest that

the interactive virtual environments work (Ledoux 1998). Based on the initial research it seems that interactive virtual environments are changing the way in which the patients are treated, and that those exposed to them are having a measurable and concrete increase in recovery time.

Based on the studies conducted to date, there seems to be a consensus that the highly interactive virtual environments do improve the patient recovery process. However, it is still not clear why it is so. We propose four different arguments based on games and interactivity:

1. Games are interactive, and this interactivity allows us to continuously gauge patients state as well as progress (reflexes, speed of play, length of play, etc.). The game effectively becomes a sensor that monitors players feedback in real time. It can continuously track and compare data over time, and trigger notifications when anomalies are detected. Most of these measurements can be obtained by a qualified nurse as well; however, such an approach is very difficult to scale. It requires a very low nurse-to-patient ratio, as otherwise a nurse is not capable of dedicating the necessary attention to the performance of each patient.

   Technology is working on solving the challenge of scale. By utilizing games and virtual environments, coupled with advanced Artificial Intelligence, scientists are working on recreating the type of attention that the patients in the past received, while being able to multiply it exponentially (as software can be installed on many machines).

2. Creating patient engagement is most successful within a well understood context. Video games and virtual environments can provide that context. When we have an emotional stake in the experience, only then does our brain release the chemicals in the amygdala and hippocampus necessary for memory (Ledoux 1998). It is our body's mechanism that decides which data are relevant and to be remembered versus which data are to be discarded. This is why it is easier for us to remember a good novel versus a bad textbook. In school, we often learn the best when there is a presence of fear of the upcoming test. The very emotional involvement in these situations is what makes us engage better in what we experience.

   In combining the context and emotional involvement, many have argued that failure is necessary to learn (Kieth & Frese 2008). Thus, creating medical intervention paradigms in which failure is safe, is of the essence to recovery. Games are exactly such environments, which allow for experimentation and failure in a structured and safe format.

3. One cannot learn to ride a bicycle from a great lecture, the saying goes. And what is true of riding a bicycle may be true of negotiating and strategizing, as well as other skills involving complex repertoires. Often the participation is a necessary component in an experience, that makes us recall it afterwards. The process of converting experiential expertise into linear material such as books and lectures, strips out most of what is valuable in the content to begin with (Aldrich 2009). Video games allow for individual participation of all patients,

and thus are a valuable tool in the system of medicine. Many of us have experienced working in a group on a single computer, where on different occasions, different people would ask to take over the mouse and actively participate in creation. Or when a group of children play a video game, often there is a desire in many of the individuals in the group to have the controller and play the game, simply watching it is not enough.

Virtual and Augmented reality environments are potentially powerful tools, as they provide learners with opportunities to experience trying out new knowledge and skills in a “safe” virtual or augmented space and with a structure for reflecting on those experiences that makes them meaningful and memorable. Rehabilitation and therapy in these spaces is a result of action and reflection in a consequential and purpose-driven context. Virtual environments are easily accessible, intuitive, and effective forms of virtual reality that provide secure real-time interaction between potentially multiple users with many applications to real-time experiential learning, training, and therapeutic treatment modalities (Rose, Brooks, & Rizzo 2005). Based on the studies conducted to date (Levy et al. 2009), there seems to be a consensus that the highly interactive virtual environments indeed do improve the patient recovery process.

4. Sound and music based immersive therapies have yielded results. Various types of sound frequencies have been used with significant success in medical interventions for years, including sonography, ultrasound, lithotripsy, and magnetic resonance-guided focused ultrasound. Music is comprised of another type of organized sound frequencies, and in the late 20th century a number of researchers noted correlations between music/relaxation techniques and physical health (Rider, Floyd, & Kirkpatrick 1985). Palliative care researchers also found that a single-session music therapy intervention effectively increased patient pain control, physical comfort, and relaxation (Krout 2001). Using documented methods including entrainment (Vuilleumier & Trost 2015), the confluence of aural and immersive multimedia engagement would appear to suggest a useful therapeutic intervention for patients at risk for or with delirium.

VR IN DELIRIUM THERAPY - Project D.R.E.A.M.S. (Digital Reality Environment Augmenting Medical System)

The aim of our study is to develop and assess the feasibility of a novel, immersive, intelligent system to prevent delirium by improving the quality of sleep, reducing pain, lowering the usage of sedatives, and stimulating cognition.

The purpose of our project - Digital Rehabilitation Environment Augmenting Medical System (D.R.E.A.M.S.) is to research the feasibility and clinical potential of an immersive digital reality-augmenting system in reducing the occurrence of cognitive, behavioral, and emotional consequences of critical illness (such as pain, anxiety, agitation and insomnia) and environmental exposures (such noise and light exposures) that are risk factors for the development of delirium, a common and devastating complication in the ICU.

This study is designed as pilot case-control study in which patients at risk for delirium will be exposed to DREAMS and compared to the standard hospital care. Our hypothesis is that DREAMS will be able to reduce the occurrence and duration of ICU delirium through the reduction of these risk factors in patients at risk of delirium.

The proposed DREAMS system combines:

A. An immersive digital reality-augmenting system consisting of a commercially-available VR headset to deliver a calming experience through software-facilitated meditation practice.

B. A measurement system including physiologic sensors for measurement of movement, physiologic and emotional responses (3-axis wearable accelerometers, video camera) and environmental sensors for light and noise exposures.

C. Electroencephalogram (EEG) sensors for measurement of sleep quality and response to therapy.

Our hypothesis is that DREAMS will be able to reduce the occurrence and duration of ICU delirium through the reduction of these risk factors in patients at risk of delirium.

Conclusion

The impact of virtual environments on distraction from pain has already been researched with patients who were undergoing very painful therapy for severe skin burns. One of the most painful phases of skin burn therapy is the process of changing patients bandages. The patients who were given opportunity to interact with immersive VR content during this process have reported less awareness of pain, and required less medication.

This relationship between presence and transfer of consciousness requires future research. The results obtained with the current technology are encouraging, and it is to expect that the technical qualities of VR sets will only improve in the period to come. Visual interface will increase in terms of resolution, refresh rate, and field of view. Thus the future headsets will be capable of delivering 3D graphics that are beyond our eyes capability to discern the difference between the virtual environment and verified environment. Beyond sight and vision, other senses can be stimulated. Haptic response is already in experimental stages, and motion chairs that connect to VR sets are commercially available today.

Our perception of presence in a virtual environment will continue to grow with further improvements in technology. As presence overwhelmingly moves from our actual reality to an immersive reality, our consciousness will continue its own transport from one reality into another.

Biography

References

Aldrich C (2009), The Complete Guide To Simulations And Serious Games. San Francisco: Jossey-Bass/Pfeiffer.

American Nurses Association and the American Delirium Society. (2018), 'Delirium: Prevent, Identify, Treat', http://www.nursingworld.org/Delirium-Prevent-Identify-Treat, Accessed 3 January 2018.

Barr J, Fraser GL, Puntillo K, Ely EW, Gelinas C, Dasta JF, Davidson JE, Devlin JW, Kress JP, Joffe AM, Coursin DB, Herr DL, Tung A, Robinson BRH, Fontaine DK, Ramsay MA, Riker RR, Sessler CN, Pun B, Skrobik Y, & Jaeschke R (2013), 'Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit', Critical Care Medicine, 41:1, pp. 263–306. [PubMed: 23269131]

Brummel NE, and Girard TD (2013), 'Preventing delirium in the intensive care unit'. Critical Care Clinics, 29:1, pp. 51–65. [PubMed: 23182527]

Chang LC, Wang CY, and Yu P (2014), 'Virtual reality improves sleep quality amongst older adults with disabilities', International Journal of Geriatric Psychiatry, 29:12, pp. 1312–1313. [PubMed: 25394270]

Cherniack E (2011), 'Not just fun and games: applications of virtual reality in the identification and rehabilitation of cognitive disorders of the elderly', Disability and Rehabilitation: Assistive Technology, 6:4, pp. 283–289. [PubMed: 21158520]

Desai S, Chau T, and George L (2013), 'Intensive care unit delirium', Critical Care Nursing Quarterly, 36:4, pp. 370–389. [PubMed: 24002427]

Hoffman HG, Richards TL, Van Oostrom T, Coda BA, Jensen MP, Blough DK, and Sharar SR (2007), 'The analgesic effects of opioids and immersive virtual reality distraction: evidence from subjective and functional brain imaging assessments' Anesthesia and Analgesia, 105:6, pp. 1776–1783. [PubMed: 18042882]

Inouye SK, Westendorp RGJ, and Saczynski JS (2014), 'Delirium in elderly people', The Lancet, 383:9920, pp. 911–922.

Kandar BB, King LM, Collop NA, Sakamuri S, Neufeld KJ, Bienvenu OJ, Rowden AM, Touradji P, Brower RG, and Needham DM (2013), 'The effect of a quality improvement intervention on percieved sleep quality and cognition in a medical ICU', Critical Care Medicine, 41:3, pp. 800–809. [PubMed: 23314584]

Keith N, and Frese M (2008), 'Effectiveness of error management training: A meta-analysis', Journal of Applied Psychology, 93:1, pp. 59–69. [PubMed: 18211135]

Krout RE (2001), 'The effects of single-session music therapy interventions on the observed and self-reported levels of pain control, physical comfort, and relaxation of hospice patients', American Journal of Hospice and Palliative Medicine, 18:6, pp. 383–390. [PubMed: 11712719]

Ledoux J (1998), The Emotional Brain. New York: Simon and Schuster.

Levy CE, Oliverio J, Sonke J, Hundersmark T, Demery J, Tassin C, … Omura D (2009), 'Virtual environments for cognitive and affective dysfunction in MTBI and PTSD: Development of a 21st century treatment platform', Military Health Research Forum.

Maldonado JR (2013), 'Neuropathogenesis of delirium: review of current etiologic theories and common pathways', American Journal of Geriatric Psychiatry, 21:12, pp. 1190–1222. [PubMed: 24206937]

Mayo Clinic Staff. (2015), 'Delirum', https://www.mayoclinic.org/diseases-conditions/delirium/symptoms-causes/syc-20371386. Accessed 3 January 2018

Mills GH, and Bourne RS (2012), 'Do earplugs stop noise from driving critical care patients into delirium?', Critical Care, 16:4, p. 139. [PubMed: 22805535]

Mistraletti G, Pelosi P, Mantovani ES, and Gregoretti C (2012), 'Delirium: clinical approach and prevention', Best Practice and Reserach Clinical Anaesthesiology, 26:3, pp. 311–326.

National Clinical Guideline Centre. (2010), 'Delirium Diagnosis, Prevention and Management', https://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0033845. Accessed 3 January 2018.

Optale G, Urgesi C, Bustavo V, Piron L, Prifitis K, Gamberini L, Caopdieci S, and Bordin A (2010), 'Controlling memory impairment in elderly adults using virtual reality memory training: a randomized controlled pilot study', Neurorehabilitation and Neural Repair, 24:4, pp. 348–357. [PubMed: 19934445]

Patterson DR, Jensen MP, Wiechman SA, and Sharar SR (2010), 'Virtual reality hypnosis for pain associated with recovery from physical trauma', International Journal of Clinical and Experimental Hypnosis, 58:3, pp. 288–300. [PubMed: 20509069]

Rider MS, Floyd JW, and Kirkpatrick J (1985), 'The effect of music, therapy, and relaxation on adrenal corticosteroids and the re-entrainment of circadian rhythms', Journal of Music Therapy, 22:1, pp. 46–58. [PubMed: 10271532]

Rompaey B, Elseviers MM, Drom W, Fromont V, and Jorens PG (2012), 'The effect of earplugs during the night on the onset of delirium and sleep perception: a randomized controlled trial in intensive care patients', Critical Care, 16:3, p. R73.

Rose FD, Brooks BM, and Rizzo AA (2005), 'Virtual reality in brain damage rehabilitation: review', CyberPsychology & Behavior, 8:3, pp. 241–262. [PubMed: 15971974]

Sanchez-Vives MV, and Slater M (2005), 'From presence to consciousness through virtual reality', Nature Reviews Neuroscience, 6, pp. 332–339. [PubMed: 15803164]

Sharar SR, Miller W, Teeley A, Soltani M, Hoffman HG, Jensen MP, and Patterson DR (2008), 'Applications of virtual reality for pain management in burn-injured patients', Expert Review of Neurotherapeutics, 8:11, pp. 1667–1674. [PubMed: 18986237]

Vuilleumier P, and Trost W (2015), 'Music and emotions: from enchantment to entrainment', Annals of the New York Academy of Sciences, 1337, pp. 212–222. [PubMed: 25773637]