Improving Patient Experience During In-Office Procedures Using PARVA – Patient Augmented Reality Vibroacoustic Array

The Effects of Virtual Reality Applications in Mental Health

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Introduction

My technical project is about developing a custom Augmented Reality (AR) wearable modular device that can deliver vibroacoustic stimulation with the goal of distracting a patient from pain during a medical procedure. The device, or so called, Patient Augmented Reality Vibroacoustic Array (PARVA) is designed specifically to be used in vocal fold injection (VFI) and laser ablations in Otolaryngology department at the University of Virginia Hospital. These two-common otolaryngology in-office procedures (IOPs) are performed on a conscious patient with an endoscope placed through a nose into the throat and directly into the vocal cords. Due to the conscious state of the patient during these in-office operations, the pain levels may be excruciating and unbearably high. If the patient cannot bear the pain or stress, IOPs are transferred to the operating room where the patient is put under anesthesia, however the cost for this transfer is very expensive. Thus, PARVA will provide visual and auditory distractions along with the vibroacoustic stimulation in the targeted nerve area to temporarily distract the patient from the stress, pain and anxiety during IOPs. The use of PARVA in IOPs would be beneficial for both patients and medical professionals by having a higher procedural volume, decreased medical costs, and improved patient safety and outcomes through avoidance of general anesthesia in operating rooms. Since PARVA deals patients on the neurological level, a mental state of the patient must be taken into account to ensure the safety and effectiveness of our technical research project. Researching the potential of positive mental effects due to a result of using technology is the bridge between my technical project and my STS project. My STS project focuses

on understanding the relationship between virtual reality applications and mental health, particularly to treat, understand and enhance individuals' health and social lives.

Technical Prospectus

The PARVA is a two-pronged solution to a better patient experience during IOPs using a novel, non-pharmacologic device with the goal of improving patient safety and outcomes and decreasing healthcare expenses for the operations. The PARVA will provide satisfying results for both patients and medical professionals with its technology integration of Augmented Reality of the real environment setting along with vibroacoustic stimulation for nerves in targeted area by reducing the levels of anxiety, stress, discomfort, and perception of pain during these procedures.

The Gate Control Theory of Pain asserts that the central nervous system can only process a limited number of stimuli at one time (Braz et al., 2014). It postulates that non-painful stimuli, such as vibration, which activate non-nociceptive sensory neurons can interfere with signals from pain receptors, thereby inhibiting or lessening the transmission of painful stimuli (Zhang et al., 2018). This has been shown to have clinical utility for painful injections and other IOPs as evidenced by reduced perception of pain during procedures when low-frequency vibration is administered (Smith et al., 2004). Some medical devices, such as Buzzy®, employ this theory to reduce pain during vaccine injections and other minimally invasive procedures. However, this theory has yet to be applied to in-office otolaryngology procedures such as vocal fold injection.

In addition to vibrotactile sensation, another mechanism to improve patient experience is virtual distraction (Sil et al., 2014). The virtual simulation model that a patient experience and interacts with serves to give a feeling of an alternate reality. As attention is increasingly focused on that reality, perceived pain decreases (Legrain et al., 2009). The most common approach studied has been the use of virtual reality (VR) by patients either before (Hendricks et al., 2020) or during (Gold & Mahrer, 2018) procedures. Consistently these studies have shown decreased patient anxiety, decreased stress, improved comfort, and/or decreased perception of pain. We are working with the Otolaryngology department at the University of Virginia Hospital and are giving us the required knowledge, funding, and resources that we would need to develop the augmented reality headset and vibratory device. Due to the dual nature of this project, two success metrics will be assessed. One of these metrics will revolve mostly around feedback of patients undergoing the procedures which include the quantitative data of patient pain, anxiety, and stress level scale. We will also determine success by analyzing the financial report of the Hospital which will provide further information on how much PARVA helped to reduce costs of the operations.

My role within the team is planning and designing the device. This incorporates designing the circuitry that will be used for the vibratory devices, as well as drawing the potential model of the vibratory device to fit in different patients. My role also involves directing and aiding in coding the software for the vibratory device's frequency control settings. This involves coming up with a large variety of experiences which may benefit the patient based on their specific scenario. For example, a child may prefer a video game, whereas an adult may

prefer a more calming vacation scene. Overall, I must organize different ideas and plan out the device to match different patients' stress and pain-relieving methods.

STS Prospectus

Virtual reality (VR) devices in the medical field have been rapidly developing, and the technology is transitioning from a research curiosity to more of a clinically applied technology. Currently, there are three main uses of VR devices: education and training systems, image guided surgery, and diagnostics. My goal in this STS project is to determine the significance and potential of VR in beneficiating mental health for individuals in these areas. This research will set the grounds for the global healthcare industry and create a new paradigm of integration of technology with healthcare that has never been possible before. In the past decade, virtual reality applications have been studied and shown to improve mental health by reducing symptoms of diagnosis and fear, distracting individuals from pain, and having higher accuracy in medical practices conducted by health professionals in operation rooms. Although these mental health enhancements are led by the virtual reality applications, these technologies are mostly developed in entertainment industry. Statistics have shown that healthcare industry takes up only 15 percent of the global VR market whereas videogames and consumer entertainment take up over half of the market (Statista, 2020).

In the past studies, the contribution of virtual reality in educational training for medical professionals was mind-blowing. This new immersive technology was applied in different medical groups to determine their level of competence for medical procedurals. Samadebeik et al. (2018) have not only found that there was

74% of improvement in learning when VR was used to train medical professionals, but also 87% of higher accuracy in medical practice by providers trained through virtual reality. Not only such technology could be used for surgical guidance or training specialists, but it could also be varied and used as patient distraction, stress relief, cognitive rehabilitation and treatment for mental illness, such as posttraumatic stress disorder (PTSD), eating disorders and anxiety disorders.

Virtual reality applications are widely used in therapies and counseling sessions for patients with psychiatric disorders. When in used conjunctionally, VR provides therapists greater controlled delivery of the stimuli and responses (Maples-Keller et al., 2017). This allows the therapists to detect, diagnose, and control the most clinically relevant sensory stimulation and adjust the process to the specific focused needs of each patient for the effectiveness of the treatment. According to Maples-Keller et al. (2017), virtual reality-based techniques are cost-effective and ideal for exposure therapy for individuals with anxiety disorders. These techniques give the patients the opportunity to immerse in their individually tailored environment of their fear structures and alter these structures to overcome their anxieties.

For example, posttraumatic stress disorder, also known as PTSD, approximately 8% of the population experience with PTSD in their lifetime. Most are usually veterans or survivors of traumatic events, and in order to treat these patients, VR techniques are used to enable them to adapt to the stress that their virtual exposure brings. Overtime, the adaptation of stress will decrease the feelings of anxiety as the virtual exposure gradually intensifies (Park et al., 2019). In Srivastava et al. (2014) study, virtual reality has been used to assess symptoms

of PTSD and identify predictors of PTSD. They have found that at first, VR application in their therapy sessions led to rapid advances in paranoia, but after 6 months, the study has shown a significant reduction of diagnoses and PTSD symptoms, which decreased by 67% (Srivastava et al., 2014). Also, according to Eichenberg & Wolters (2012), their virtual reality application for Vietnam veterans suffering from PTSD showed significant drop on the Clinician Administered PTSD Scale (CAPS), ranging from 15 to 67% decrease in symptoms, and most importantly, self-reported intrusion symptoms measured by the Impact of Event Scale were drastically lower compared to baseline.

In addition to the positive effects and improvements made by virtual reality application to patients with disorders, VR applications within children have proved to be effective. Ryu et al. (2017) performed a clinical trial of how immersive virtual reality-tour could reduce preoperative anxiety in young patients. Preoperative anxiety was assessed by using the modified Yale Preoperative Anxiety Scale (m-YPAS) and perioperative anxiety was assessed by using Procedural Behavior Rating Scale (PBRS). Children patients who used virtual reality-tour of the operating room scored lower than the those who did not use the tour and showed more cooperation when undergoing anesthesia. Also, Chad, Emaan, & Jillian (2018) conducted a study among pediatric subjects to test the rationale of trypanophobia using virtual reality headset as fear reduction and pain distraction tool. Their study found that 94.1% of pediatric subjects showed improvement in coping with needles during immunization while using the headset and scored lower on Wong-Baker FACES Pain Rating Scale (Chad, Emaan, & Jillian, 2018). Research must be continued in understanding the current state of the art, how effective the virtual reality

applications can be in individuals' mental health, especially this emerging technology is rapidly growing in every aspects of human life.

Although virtual reality showed great potential in an individual's mental health in prior studies, there is a major side effect that come along with it. Park et al. (2019) have found that this technological application may result in significant discomfort for majority of the patients. Virtual reality can induce sickness such as dizziness, nausea and headache which are very common motion sicknesses caused by visual perception and being still during treatment. Also, the patient may feel eyestrain, reduced limb control, and decreased in sense of presence by being preoccupied or deluded to the virtual reality settings. This may limit treatment options for patients who develop seizures when exposed to electronic devices such as watching TV or playing video games (Srivastava et al., 2014).

To minimize the risks in the near future, a systematic guideline to apply this efficacious treatment modality to patients with psychiatric illnesses should be established. VR will play a role as an alternative option for psychiatrists to use in supporting psychiatric assessments and treatments in patients. Currently, there is a Health & Safety Usage Guidelines for Virtual Reality devices (i.e., headsets) which underlines the precautions such as loss of balance, delusion from reality, physical injuries caused by unawareness of surroundings, and overuse of the device. However, there is no governing apparatus set in stone for virtual reality application in mental health.

Birckhead et. al (2019) found that using the Food and Drug Administration (FDA) Phase I-III pharmacotherapy model as guidance was helpful to identify special attributes and intervention of VR application in clinics. The pharmacotherapy

model set up the framework of how ethical, feasible, tolerable and viable VR treatments could be in health industry. As Baniasadi, Ayyoubzadeh, & Mohammadzadeh (2020) stated, it is critical to clearly define the responsibility when using modern technologies in medical treatments at such early stage such as virtual reality. Identifying technical and non-technical limitations of virtual reality applications in health would be a key point in the success use of this efficacious treatment modality. By using the framework provided by Birckhead et. al (2019), there is a hope that the limitation gaps such as lack of suitable standards, insufficient infrastructure, organizational culture, and management support would evaluate and validate the VR application in the future studies when assuring the proper design of software applications and interface both consumers and sellers.

Conclusion

Currently, Virtual Reality is used as a tool to in the medicine field for education, training, diagnosis, and therapy. Even though the technique is still new in the field and will need more time and testing before it can be put to routine use, it is predicted to have a lot of potential. Results have indicated that the application of virtual reality will unleash new capabilities of training different medical groups based on individual and group needs (Samadebeik et al., 2018).

Over and over, many studies and clinical trials have used virtual reality and simulation as a distraction tool for patients with psychiatric illnesses. These illnesses, such as PTSD, anxiety, specific phobia, schizophrenia, autism, dementia, and heavy stress, have all shown to be effectively changed by exposing them to sources of fear, presenting interactive virtual environments of cognitive

approaches, and contributing to other rehabilitation applications, thus proving a gateway into a deeper and more useful medical benefit from using virtual reality (Park et al.,2019).

In practice, patients with a psychiatric diagnosis such as depression, bipolar disorder, anxiety disorder, schizophrenia, and even alcohol use disorder share common characteristics such as anxiety, avoidance, and poor insight to their illnesses. Modern VR systems can deliver an ideal place where one can confront the problem which needs to be overcome, not only through talking with doctors, but also through virtual environments with well-controlled sensory stimuli. This may produce cognitive and behavioral changes in patients with psychiatric disorders including autism and dementia. They also have benefits in reducing chronic pain and intensive stress. However, VR needs to overcome technical hurdles such as motion sickness and dry eyes, as well as user hurdles such as preoccupation and addiction. Despite the risks that virtual reality could pose to patients, the application of virtual reality in healthcare has shown to improve real-life adaptation of patients with psychiatric problems (Park et al.,2019), and train healthcare professionals to be more competent in operations (Samadebeik et al., 2018).

Given the evidence for a growth in the field of emerging technologies in health, it is important to consider expanding in use in treatment for mental health. Although virtual reality devices are envisioned as tools for entertainment purposes, they hold unique opportunities for use in health care. The applications of this innovative technology are numerous and at times, unbelievable. This immersive technology of the future will assist in offering relief and health promotion for individuals.

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