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The Interplays Among Technology & Content, Immersant & VE

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ABSTRACT

The research program aims to explore and examine the fine balance necessary for maintaining the interplays between technology and the immersant, including identifying qualities that contribute to creating and maintaining a sense of "presence" and "immersion" in an immersive virtual reality (IVR) experience. Building upon and extending previous work, we compare sitting meditation with walking meditation in a virtual environment (VE). The Virtual Meditative Walk, a new work-in-progress, integrates VR and biofeedback technologies with a self-directed, uni-directional treadmill. As immersants learn how to meditate while walking, robust, real-time biofeedback technology continuously measures breathing, skin conductance and heart rate. The physiological states of the immersant will in turn affect the audio and stereoscopic visual media through shutter glasses. We plan to test the potential benefits and limitations of this physically active form of meditation with data from a sitting form of meditation. A mixed-methods approach to testing user outcomes parallels the knowledge bases of the collaborative team: a physician, computer scientists and artists.

Keywords: Virtual Reality, Virtual Environments, Mindfulness, Mediation, Biofeedback, Chronic Pain

1. INTRODUCTION

As technological advancements equip us with faster computing power and more affordable stereoscopic displays, virtual reality (VR) is becoming more accessible to the general public. The first VR applications were flight simulators and data visualizations created for expert users. Although those still exist, the growth of VR applications, along with its increased accessibility result in applications that are created for non-experts. They deal with art, culture and heritage, phobias and pain distraction/management, among many others. While earlier technologists explored the notion of "presence," their focus and expertise were from a predominantly scientific perspective. Because many of the current VR applications are created for a more general public, it seems clear that the knowledge bases of Media Studies, Interactive Art and Interaction Design need to be explored. Knowledge from those domains, combined with that from scientific realms, should reveal how VR technologies need to be more rigorously aligned with the experienced content. This is even more critical for particular kinds of VR applications, such as those aimed at redirecting a user's attention or altering their mindfulness, such as those used for pain distraction, pain management, meditation and tai chi, to name a few. This is because maintaining a sense of immersion is crucial — any disjunctures among technological performance, interactive content, and immersants' interactions "break" a sense of presence. Creating such VR applications are a challenge, because all three aspects need to be taken into account in order to ensure that immersant feels "at one" with the VEs we create.

In this paper, we first briefly examine what constitutes an immersive virtual environment (IVE). Second, we provide background information on what chronic pain is and the motivation behind our current work. Third, we examine other immersive VR applications that have been successfully developed specifically to deal with short-term, acute pain and explain why it is necessary to reorient those approaches when creating VR applications for long-term, chronic pain. We present our projects – the Meditation Chamber and the Virtual Meditative Walk — both of which directly address the complexity of designing VR for chronic pain. Fourth, we explore those aspects that are necessary for maintaining a sense of immersion: producing well-crafted environments that are inextricably tied to the implemented VR technology. We conclude with a brief discussion of current and future work.

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1.1 Virtual Environments: Technology, Content, Immersants

The term virtual environments (VEs) has grown to refer to a wide spectrum of 3D, synthetic environments. These range from fully stereoscopic, real-time, immersive environments to 3D movies, 3D games and virtual communities displayed on desktops and televisions, such as Second Life. In our work, we focus on fully immersive VEs (IVEs), that are comprised of stereoscopic displays, spatialized audio, haptics, and real-time interaction and feedback. In addition, we employ integrated biofeedback technologies and, in the case of the walking meditation project (discussed below) a uni-directional, self-directed treadmill.

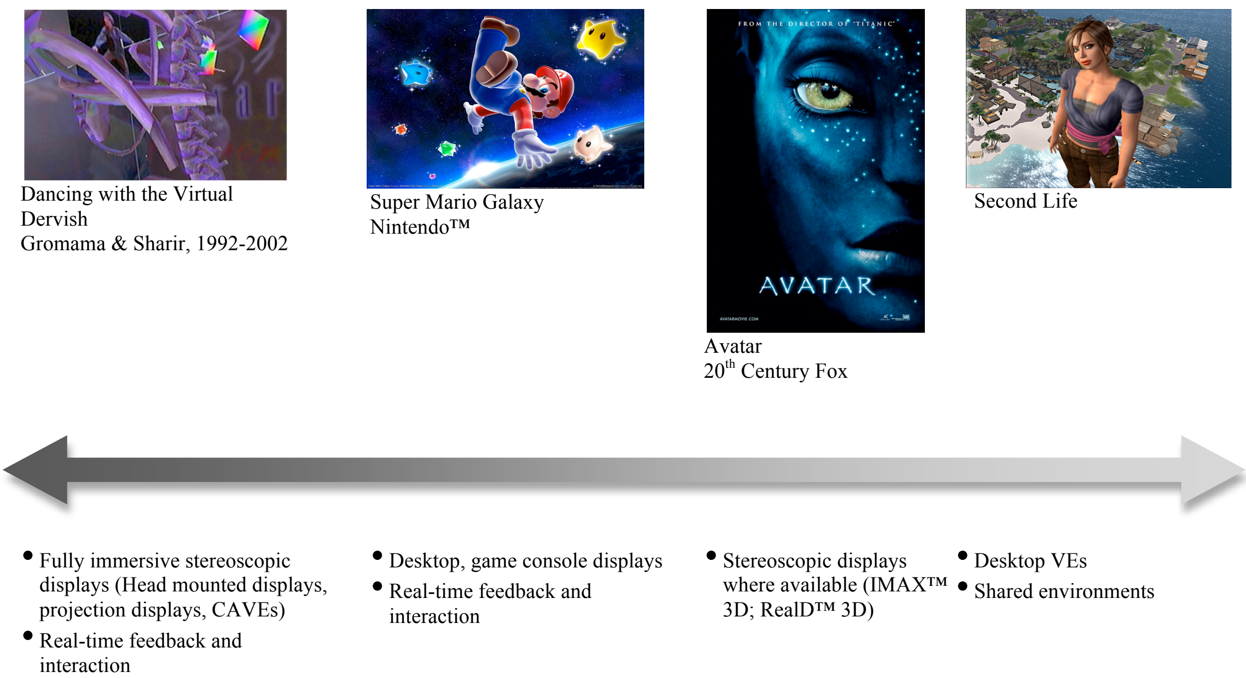

Figure 1.1 Wide Spectrum of Virtual Environments (VEs)

There are 2 specific affordances that are crucial in creating a sense of immersion in IVEs – interaction and presence, a precondition for experiencing immersion (1). At any time during a VR experience, we need to ensure that the user feels immersed in the VE through special VR technologies. Some of the technical aspects of what influences a "seamless" sense of immersion have been explored in the journal Presence. However, we also need to provide real-time interaction and feedback that is similarly seamlessly and directly related to the experienced content. We show this relationship in Figure 1.2: the interplays among the technology, content and immersants need to be inextricably interconnected for a successful VR experience. We emphasize this relationship throughout the paper, as a "break" in any one of these components detrimentally affects the immersant's sense of presence and immersion, which in turn "breaks" the VR experience. This is akin to the "suspension of disbelief" viewers experience when they are engrossed in watching a film although a sense of immersion in an IVE is arguably more difficult to achieve and maintain.

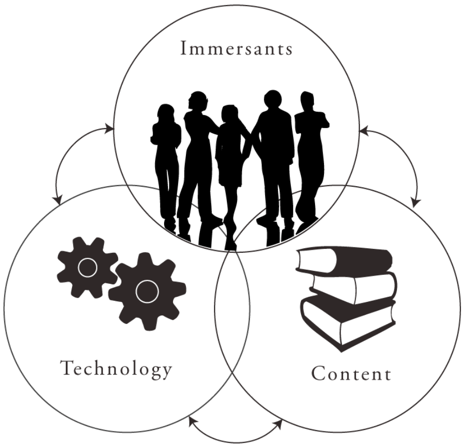

Figure 1.2 Virtual Environments: Technology + Content + Immersants

The importance of this continuous interconnectivity becomes more apparent when creating VR applications that specifically address the issues of chronic pain, which is the main focus of our research. We wish to determine how we can better utilize VR in concert with other emerging technologies, such as biofeedback and mobile technologies, to create alternative environments for the estimated 1 in 5 North Americans who suffer from chronic pain--what is termed the "silent epidemic." In the next section, we explain what chronic pain is and why it is an important field to identify as a major research area in using new technologies. We present the background of how IVR has been used in other areas of acute pain management and how we have turned to mindfulness meditation to address the issues of chronic pain management.

2. CHRONIC PAIN AND IMMERSIVE VES

2.1 Chronic Pain

Acute pain is defined as short-term pain, while chronic pain is defined as pain that is experienced for six months or longer (2). Though difficult to determine because of social stigmas and other issues, it is conservatively estimated that one in five North Americans is affected by chronic pain; similar estimates are apparent in Europe and developed nations. Chronic pain is very different from acute pain in a crucial aspect: rather than being a symptom, chronic pain is now known to be a *systemic dysfunction* involving a complexity of interactions among the nervous system, brain, regulatory (glial) cells in the spinal fluid, and biochemical interactions (3). It is also characterized as a complex experience affecting not only the body, but the mind and culture as well (4). Thus, well-regarded centers of Pain Medicine have been interdisciplinary since the 1950s (5). Over time, chronic pain most often becomes a slowly degenerative and irreversible condition. There are no known cures; rather, a biopsychosocial approach (2) to *managing* pain over time is the common goal of healthcare practitioners, care-providers and patients. Strategies for managing pain are highly specific to individual situations. Historically, opiates were seen as the most effective pharmacological treatment; however, because of the body's adaptation to opiates, dependency is a common problem. However, a handful of less effective but non-addictive medications are commonly used, in tandem with other "tools" such as physiotherapy, psychological treatment, nutritional strategies, and numerous forms of alternative and complementary medicine, such as acupuncture. A review of centers for pain medicine in North America revealed that mindfulness meditation stand out as a well-respected and commonly recommended tool for self-managing pain.

2.2 Immersive VEs for Pain Distraction

IVEs have been designed for medical applications, from surgical training and to therapeutic modalities. As a form of therapy, IVEs prove successful in the treatment of phobias (6), fears (7, 8), post-traumatic stress disorder (PTSD) (9) and acute pain (10), to cite a few. IVEs designed for treating acute pain are especially compelling: VR "pain distraction" consistently proves to be a more effective "analgesic" (11) than the millenia-long gold standard: opiates (10). Though the mechanism for its efficacy is unknown (12), researchers believe that IVEs profoundly "distract" an immersant's attention because it involves many senses and perceptual systems — the distracted experience is described as “presence” (13). IVEs created for purposes of pain distraction, however, exclusively address acute or short-lived pain.

Because chronic pain is very different from short-term, acute pain, we believe the approach of “pain distraction” may not be as effective for numerous reasons (14), including efficacy over time (15). Thus, we are necessarily re-orienting the research approach using IVEs for treating pain from “pain distraction” to investigations of “pain self-modulation.” We define “pain self-modulation” as the ability to consciously and physiologically exert control over one’s experience of pain, particularly over time. Thus, our work integrates VR with biofeedback. Our goal is to train users how to meditate, drawing upon the knowledge gained from decades of study of this learned ability from research in biofeedback and meditation. This measurable ability to “self-modulate” one’s experience of chronic pain and stress is well-documented standard medical research, particularly during the past ten years (16).

Research that investigates the effect of differing forms of content is sparse. Nonetheless, it is a promising area, particularly because numerous works in pain distraction can be analyzed from this perspective. As an example, the pain distraction IVE created for those who suffered from burns depicted snow and wind (17). While this may seem obvious and appropriate, the effects of this “content” have not been studied per se. In addition, IVEs that involve the interplay of both VR and AR also provide promising analysis (18). Of course, all the implications of VR pain distraction cannot be addressed immediately, by one expert or in one field — VR pain distraction is still in a nascent stage. Since this area of research deals with highly subjective aspects (20) and issues of culture (20), researchers in the domains of Design (21) and the Humanities (22) — particular media studies — may be the best-suited to pursue this aspect of IVE research.

2.3 Mindfulness Meditation

Dr. Jon Kabat-Zinn has been a key researcher of the effectiveness of mindfulness meditation and has brought it into the realm of the public as well (23). He describes mindfulness meditation as a class of meditative practice known as *vipassana*, or insight meditation. Not simply a form of casual relaxation, this is an acquired skill that demands regular practice. It initially focuses attention in order to cultivate calmness during a defined session. With intensive practice, it progresses to a kind of self-observational skill and form of inquiry that can be called upon – moment to moment, as events in the field of one’s awareness. The scientifically verifiable benefits that are most often studied include: sharp drops in psychological problems such as anxiety and depression; improvements in health-related attitudes, motivation, and abilities for self-care, particularly among chronic pain patients; reduced stress levels; improvements in the immune system; and dramatic improvements in medical patients who suffered from panic attacks. (23, p.268) While mindfulness meditation can be practiced while sitting, but other basic forms are walking, lying down, standing (16, p.268).

3. MEDITATION CHAMBER

Reported briefly at Enactive 2007 (24), the Meditation Chamber is a Virtual Environment that uses biofeedback technologies, audio and immersive imagery to guide an immersant’s meditative experience. With this project, we hoped to discover if these technologies could help a user enter and maintain a meditative state. To enhance a user’s sense of agency and perception of their autonomic functions, the Meditation Chamber used biofeedback technologies. After decades of evaluation, biofeedback measures such as Galvanic Skin Response (GSR) and Heart Rate are considered reliable indicators of relative changes in physiological states, and can be used as an approximate indicator of the immersant’s reaching a meditative state.

Figure 3.1 Users wear a head-mounted display, providing them stereoscopic imagery and sound. Interaction primarily occurs by users as they strive to manipulate their physiological states via biofeedback. Biometric sensors are attached to two fingers with Velcro, tracking GSR and heart rate. A flexible chest band tracks respiration.

The three phases of the *Meditation Chamber* experience began with the immersant sitting comfortably in a gently reclined position, wearing a head-mounted display, and with three biometric sensors that measured GSR, heart rate and respiration. The first phase presented the image of the sun in the sky, and the immersant was asked to concentrate on relaxing and making the sun set and the moon rise, as controlled by decreases in GSR. In phase 2, the immersant was presented with a number of posed 3D body models drawn from the first person perspective, and asked to first tense then relax their muscles while in the illustrated pose. In the final phase, the immersant was taken through a breathing and guided meditation exercise, accompanied by soothing flowing images of swimming jellyfish and voice coaching. As the biometrics moved towards a more relaxed state, the audiovisuals decreased in intensity.

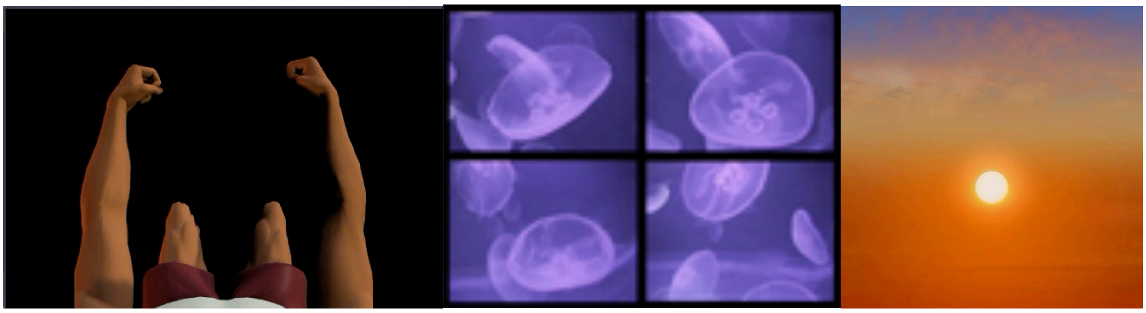

Figure 3.2 Phase 1: Progressive Muscle Relaxation and Phase 2: Mindfulness Meditation

The *Meditation Chamber* was exhibited for 5 days at the SIGGRAPH annual conference, where more than 411 immersants entered the 18-minute experience and answered a few pre- and post-experience questions about their level of relaxation and meditation practice. Our analysis of these data indicated that most immersants experienced a statistically significant increase of relaxation as a result of using the *Meditation Chamber*. We also analyzed the biometric data of SIGGRAPH attendees, concentrating on GSR metrics, since this measure is most closely associated with relaxation. The analysis revealed two broad classes of user experience – users who were new to meditation vs. expert meditators. Novice meditators exhibited a GSR pattern that shows a decrease in GSR during the first phase, significant variation in GSR during muscle tension and relaxation (phase 2), and a large decrease in GSR during the third phase. Novices also tended to exhibit steadier and deep breathing in the last phase compared to the first. By contrasts, expert meditators show a rapid decrease in GSR during the first phase, and these users maintain a low GSR reading and a steady breathing throughout the experience.

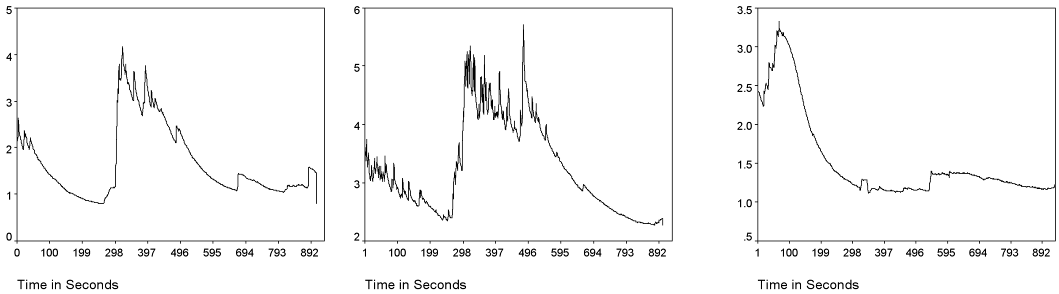

Figure 3.4 Results on Novice and Expert Users

4. VIRTUAL MEDITATIVE WALK

As the symptoms and quality of life of chronic pain patients will tend to regress due to lack of exercise and increased periods of immobility, we are working on developing a virtual walking meditation application. Patients with chronic pain often avoid exercise as movement can hurt but strengthening muscles despite discomfort can diminish pain by improving muscle tone, strength, flexibility, and endurance. (25). Our current version of the virtual meditation chamber, the Walking Meditation application, incorporates a uni-directional treadmill that is used in conjunction with also the stereoscopic display and biofeedback (e.g. GSR, heart rate, breath) devices and well as a uni-directional treadmill (see Figure 4.1). As the user walks on the treadmill, the visual and auditory qualities of the environment respond in real-time to the user's current physiological state.

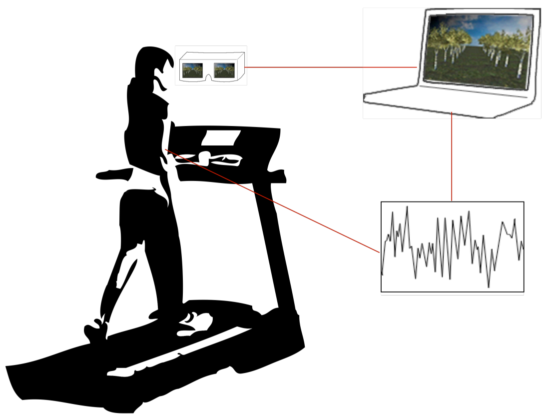

Figure 4.1 Virtual Meditative Walk Setup

A virtual forest has been modeled (see Figure 4.2) which is traversed in sync with the user's movement on the treadmill. The virtual environment of the forest gradually responds and changes as the user's physiological data are fed through the computer. In addition to the subtle changes to the environment such as the leaves swaying, the representation of the trees changes from realistic to more abstract trees (see Figure 4.3) as the immersant gradually enters deeper meditative states. This is an example of how we explore the concept of the visual rhetoric.

Figure 4.2 Virtual Meditative Walk: Meditator on Treadmill & Virtual Environment

Visual rhetoric refers to the different ways images are represented and interpreted by viewers, whether they are conscious of their interpretations or not. No matter the intention of the image maker, humans ascribe meaning to images in complex ways, affected by their cultural experience, beliefs, and numerous other factors. As a very simple example, the color used in funerary contexts is black in some cultures, white in others. Similarly, the way a spider is depicted in an IVE designed to address arachnophobia would doubtlessly affect exposure therapy: a spider rendered as a cartoon, watercolor animation, or photorealistically affects the immersant in subtle or direct ways. This kind of knowledge has long historical roots in art and design, but has not been as thoroughly studied as technological aspects.

In our work-in-progress, the Virtual Meditative Walk, we are interested in how people *experience and ascribe meaning* to what they see in the VE. As an example, we use different representation of trees to communicate the user's meditative state: photorealistically rendered trees gradually become more abstract as immersants learn to lower their physiological states. We have taken this approach because we know that abstract images generally allow for a greater range of free-play. For instance, this was demonstrated in Virtual Vietnam, an IVE designed to treat veterans who suffer from post-traumatic stress disorder (PTSD). When people are given less "realistic" visuals, their imagination comes into play, filling in the void (26).

We know that people interpret images in two ways – what they think it literally means (denotation), combined with what it may allude to symbolically or culturally (connotation). (27). Denotatively, a depiction of an apple thus is understood as a piece of fruit. Connotatively, depending how it is represented, it may allude to a computer, the garden of Eden, knowledge, good health, to name a few. Currently, we are experimenting with how specific representations of trees are experienced and understood by immersants, and how that affects the interplay with the technology.

Figure 4.3 Abstractions of Trees

5. CONCLUSIONS AND FUTURE WORK

In this paper, we presented our ongoing work with IVEs focusing on patients suffering from chronic pain. The Meditation Chamber, tested on over 400 subjects, continues to prove to be a viable tool for pain management. We are currently extending our research to a virtual walking meditation application called the Virtual Meditative Walk. In this work-in-progress application, we are also exploring the concept of the "virtual rhetoric" — not only how images but sensed environments in IVEs affect the way immersants experience it, and how they ascribe meaning to what they see, hear, and experience. In the case of the Virtual Meditative Walk, this is done through representation of trees: photo-realistic renderings gradually morph into abstractions; a response to the immersant's meditative state via physiological data. As technology becomes more readily accessible for the general public, we emphasize the importance of the interplays of the technology, content and immersants in creating "seamless" immersive VEs. In all our past and present work, we pay special attention to the interplays among the different components, because our focal point in creating IVEs is on the relationship between mind and the body in addressing the issues of pain management. We are continuously researching alternative ways to utilize new technologies that can better the lives of chronic pain patients. In the near future, we will be extending our applications to mobile technologies where the users and physicians will be able to longitudinally keep track of the patient's progress, provide on-the-go pain visualizations as well as provide innovative ways patients can self-express pain wherever, whenever. Lastly, we plan to further examine the different cultural aspects of meditation.

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