CyberTherapy & Rehabilitation

Issue 1 / 2010

The Official Voice of iACToR

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President's Note

Professor Dr. Brenda K. Wiederhold

"As we seek to reduce the cost of healthcare while expanding coverage to all, the editors look forward to increased funding of large-scale clinical trials for pain-relief alternatives such as Virtual Reality."

Dear Reader,

As I write this, I have a headache. I am in good company – 45 million other Americans will suffer from chronic headaches this year.

Wouldn't you be outraged if you knew that one in five people worldwide suffered from a chronic disease that was largely ignored and under-treated? Yet, that is often the case with chronic pain, for a variety of reasons:

Pain is subjective. My pain and your pain are very different. How can we describe it? Only recently have we been encouraged to use a common vocabulary, such as stabbing, burning, or throbbing, to communicate our pain to our doctors, along with the familiar 0-to-10 scale.

Secondary pain takes a back seat to a primary diagnosis. If a doctor discovers I have cancer, they will concentrate on treatments that will result in complete remission. Pain caused by the tumor or the treatment is recognized, but in the doctor's mind, and maybe in my mind too, alleviating the pain is less important than fighting the cancer.

"It's all in your head." Certainly, pain has a psychological component. If I am depressed, I am more likely to have chronic pain. If I allow my negative emotions to take over, my suffering may increase. Nevertheless, this is no reason to ignore my pain, rather, my underlying psychological condition needs to be addressed, too.

If I am a member of a minority group, I may not have equal access to treatment. If I am an African-American living in the U.S. or Western Europe, painkillers may be unavailable in my neighborhood. These barriers to effective treatment are greater in developing countries and in resource-limited neighborhoods worldwide.

The cost of pain is both financial and emotional. "Pain in itself probably costs the American population upwards of $120 billion each year," says Marc Hahn, D.O., president of the American Academy of Pain Medicine. "That's not only in its medical treatment, but in its impact on society, in missed days, and decreased productivity at work." The International Association for the Study of Pain estimates that the global cost is about the same as the cost of cancer or cardiovascular disease.

We cannot ignore the emotional cost of chronic pain. Pan-European and Danish studies found:

From one-half to two-thirds of chronic pain patients were unable or less able to exercise, enjoy normal sleep patterns, perform household chores, attend social activities, drive a car, walk, or have sex.

For one in four sufferers, relationships with family and friends were strained or broken.

For one in three sufferers, an independent lifestyle was either no longer an option or difficult to maintain.

For one in five sufferers, depression was a comorbid condition.

Some days, 17% of sufferers wanted to die.

Among chronic pain sufferers, 39% felt their pain was inadequately managed, and half of these individuals felt their doctor did not view their pain as a problem.

At CyberTherapy & Rehabilitation, we believe that virtual reality pain-management systems can be an important part of the solution. Preliminary results from a study conducted by The Virtual Reality Medical Center (VRMC) showed a 75% drop in self-reported pain ratings, correlated with higher temperature ratings, indicating immersion and physiological stabilization. In studies using VR software at the clinic with patients experiencing pain lasting longer than two years in duration, these patients achieved a 50% reduction in

President's Note (continued from page 1)

pain symptoms in addition to improvements in quality of life scores.

How does it work? We do not have all the answers yet, but Hunter Hoffman has done the most work in this area. His brain imaging study showed that distraction has a real effect in decreasing the intensity of pain signals in the brain, and preliminary research indicates that VR actually changes how the brain physically registers pain, not just people's perception of the incoming signals. His latest published research on the effect of VR on pain shows a reduction of 30% in reports of "worst pain" (sensory component of pain), 44% in "time spent thinking about pain" (cognitive), and 45% in "pain unpleasantness" (emotional). It is interesting to note that this type of treatment can offer relief from the mental affects of pain as well as the physical component of pain itself.

"... distraction has a real effect in decreasing the intensity of pain signals in the brain, and preliminary research indicates that VR actually changes how the brain physically registers pain, not just people's perception of the incoming signals."

Hoffman's work and others is further proving the advantages of using VR as a nonpharmacological treatment option for pain sufferers. Distraction of procedural pain in children appears to be the most mainstreamed of the uses for VR pain distraction because of the desire to avert the risks of using anesthesia with children, but as we gain more insight into the ways VR can provide distraction and pain relief, the applications will become more widespread.

Additional very exciting work is ongoing by Dr. José Mosso of Mexico City. Dr. Mosso has used VR to eliminate general anesthesia in over 500 patients during minimally invasive surgical procedures. The fact that VR can provide significant improvements in safety for patients is really remarkable. Finally, many of these applications continue to be supported on mobile phones and other handheld platforms. This will go a long way in migrating the advantages of VR in the clinic to outpatient settings and the patient's home.

With the worldwide trends of reduction of healthcare costs and expansion of coverage to all citizens, we encourage increased funding of large-scale clinical trials for pain-relief alternatives. We look forward to the consequent acceleration of the mainstreaming of VR to the millions worldwide who will thank us for easing their pain.

Create your own reality!
Brenda Wiederhold

Guest Editorial

Dr. David A. Thomas, NIH/NIDA

"Although the field of 'cybertherapy' is in its infancy, researchers in this field have great passion and vision, and findings thus far are more than encouraging for an array of applications, including pain treatment."

Dear Reader,

The National Institutes of Health (NIH), a component of the United States Department of Health & Human Services, with an annual budget exceeding 30 billion dollars, is the world's largest funder of biomedical research. The NIH funds both basic and applied research on nearly all aspects of disease and health.

The National Institute on Drug Abuse (NIDA), part of the NIH, is among the leading funders of pain research at the NIH. In addition to programs in basic pain research and research on the connections between pain and drug abuse, NIDA has a strong translational pain research program. The focus of this program includes research on reducing the abuse liability of some commonly used analgesics and developing novel pain medications with little abuse liability. Further, NIDA has a long history of funding the development of non-pharmacological technologies to treat pain, including the application of "cyber" technologies (e.g. virtual reality and e-medicine).

NIDA does not stand alone at the NIH in its support and development of various technologies to treat pain, including cyber technologies. NIDA and many other NIH Institutes are members of the NIH Pain Consortium, which was established in 1996 by an act of The United States Congress to "...enhance pain research and promote collaboration among researchers across the many NIH Institutes and Centers that have programs and activities addressing pain."

By law, the NIH must issue announcements of areas of research interest. One major series of pain research funding announcements, issued by nine Institutes and developed in cooperation with the NIH Pain Consortium, is titled *Mechanisms, Models, Measurement, & Management in Pain Research*. In these announcements, many examples of interests in technologies to either measure or treat pain are given. In fact, one bullet specifically mentions "virtual reality."

Why such an interest at NIDA, and across the NIH, in technologies to treat pain? Approximately 50 million people in The United States alone suffer from chronic pain, and each case is somewhat different. There exists no single pain treatment that is good for everyone, or even the majority of people. Research findings are making it abundantly clear that pain has many causes and courses, and can impact individuals in a multitude of ways including on the behavioral, physiological, cognitive, emotional, psychological, social and spiritual levels. It can impact a person's productivity at work, and the lives of their friends and family. Further, pain and analgesic efficacy varies with individual factors such as age, ethnicity, sex, and genetics. Additionally, personal history differences, such as a history of chronic pain or drug abuse, can also have an impact on how pain is felt, how it impacts ones' life and how well analgesics work.

Just as pain varies in many ways, pain treatments need to vary and be individualized. Research is showing that cyber technologies offer one viable option. These technologies are showing promise in reducing pain, either alone or as adjunctive therapies.

The challenges will be to discover how to better harness the power of these therapies to treat pain, to identify those patients who will benefit, and to facilitate the adoption of these technologies into clinical practice.

The NIH is committed to supporting research on understanding and reducing pain and suffering, and this includes research on cyber technologies. Although the field of "cybertherapy" is in its infancy, researchers in this field have great passion and vision, and findings thus far are more than encouraging for an array of applications, including pain treatment. With continued commitment by the NIH and the cybertherapy research community, these technologies will likely be developed to the point where wide clinical application is not only feasible, but essential.

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iACToR is the official voice and resource for the international community using advanced technologies in therapy, training, education, prevention, and rehabilitation.

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Our mission is to bring together top researchers, policy makers, funders, decision makers and clinicians, pooling collective knowledge to improve the quality, affordability, and availability of existing healthcare.

Ultimately, through international collaboration with the most eminent experts in the field, we are working to overcome obstacles and increase access to top-quality healthcare for all citizens. By enhancing public awareness of the possibilities that technology offers, we move toward changing and improving healthcare as it currently exists.

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GENERAL INFORMATION

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CyberTherapy & Rehabilitation Magazine is published quarterly by the Virtual Reality Medical Institute (VRMI), 28/7 Rue de la Loi, B-1040 Brussels, Belgium. The magazine explores the uses of advanced technologies for therapy, training, education, prevention, and rehabilitation. Areas of interest include, but are not limited to, psychiatry, psychology, physical medicine and rehabilitation, neurology, occupational therapy, physical therapy, cognitive rehabilitation, neurorehabilitation, oncology, obesity, eating disorders, and autism, among many others.

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Note: In our last issue, Volume 2, Issue 2, the Table of Contents incorrectly identified the author of "Interactive Mind Rehabilitation" as D. Jianhua. The correct author is XiaoXiang Zheng.

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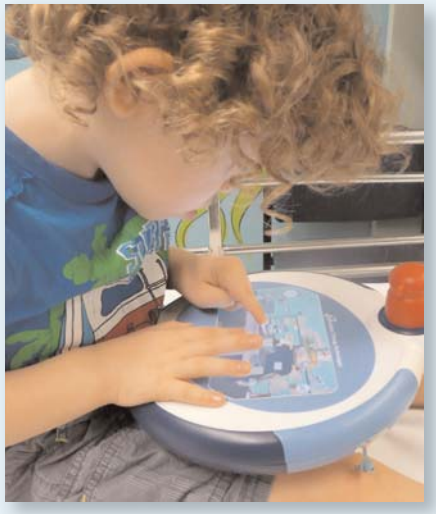
VR to Relieve Burn Patients' Pain

The former belief that Virtual Reality as a distraction technique to relieve pain works only for low-threshold pain is being dispelled by research on burn victims who suffer from some of the highest degrees of pain during healing and rehabilitation. Here, a soldier receives immersive Virtual Reality treatment to reduce his pain during severe burn wound care.



Handhelds for Children

Anxiety and pain felt during procedures is a worry for many patients – particularly children. In Kate Miller's article she explores whether or not "off the shelf" handheld video games provide sufficient distraction for pain relief when compared with specifically designed Virtual Reality software. Treatment for related anxiety is also discussed with an emphasis on education on upcoming procedures to lessen worries.

News from iACToR Members

Organization grows worldwide as Special Interest Groups/Regional Chapters are established

As the official association of CyberTherapy & Rehabilitation, we will be bringing you updated news of various special interest groups and regional chapters of the International Association of CyberPsychology, Training & Rehabilitation as they grow and expand throughout the year. As the organization becomes more well-established, it is further strengthened by growing numbers from around the globe. We welcome iACToR members, as well as our readers, to submit content and updates, as well as suggestions for new groups. You can do so by reaching the Managing Editor at office@vr-phobia.eu.

Mexican iACToR Chapter

Information provided by José Luis Mosso

The Mexican chapter of iACToR is integrating a platform mainly specializing in medicine, using different services in hospitals such as operating rooms, neurology, gynecology and other services including psychology. This chapter includes physicians, surgeons, pediatricians, psychologists, gynecologists, teachers, engineers, students of medicine, etc. with the purpose of using virtual scenarios to reduce pain and anxiety and to develop new technologies. The address of the office of the Mexican Chapter is Avenida Revolucion No. 154, colonia Escandon, México city, México, 11800.

Canadian iACToR Chapter

Information provided by Stéphane Bouchard

A Canadian chapter of iACToR has been formed, with the basis for the formation being progressively built around Canada's Cybertherapy and Anxiety (CCA) Virtual Lab. The CCA Virtual Lab, led by Stéphane Bouchard, regroups 27 researchers who received infrastructure funding to deploy virtual reality and telepsychotherapy systems across the entire country. Part of the project also involves the development of virtual environments for generalized anxiety disorder, obsessive-compulsive disorder, social anxiety and posttraumatic stress disorder. The team consists mostly of psychologists and psychiatrists and is currently laying the foundations of its mode of operations.

Korean iACToR Chapter

Information provided by Sun Kim

The Korean chapter of iACToR is currently being represented by The NOVEL (Neuro-mechanism On Virtual Environment Lab) of Hanyang University, Department of Biomedical Engineering and the Clinical Neuro-Psychology (CNS) Lab of Chung-Ang University Department of Psychology in Seoul, Korea.

The NOVEL was established by Professor Sun I. Kim with the aim of developing Virtual Reality (VR) systems for medical applications. It has evolved into a leading research lab conducting innovative research to investigate human behavior and the brain based on VR technology. The main purpose of the NOVEL is to develop VR applications based on more comprehensive evidences on human behavioral or brain functions of populations with diseases like schizophrenia, addiction, OCD, dementia or neglect as well as normal populations, which can be done by applying VR technology into brain imaging modalities. To accomplish this goal, the NOVEL has been making strong, collaborative, domestic and international connections with prominent scientists in psychiatry, neurology, and rehabilitation fields. All members in NOVEL are highly motivated in this field and have outstanding capabilities in developing virtual environments and analyzing patterns of human brain and behavior as well as communicating with other scientists, and will take part in iACToR.

The CNS Lab was founded in 2005 by Professor Jang-Han Lee, and currently has 17 lab members actively involved in lab research projects. The CNS lab is using and/or developing VR programs for, but not limited to, designing mock crime scenarios used in lie detection research, creating eyewitness scenarios used in eyewitness memory (ie: weapon focus effect) research, measuring memory biases in victims of dating violence, researching evacuation behavior in emergency situations, and research on addiction treatment through covert sensitization. All lab members are Master's or Ph.D. students enrolled in the Department of Psychology graduate school, and plan to continue research using virtual environments in a variety of fields of professional organizations after receiving their degrees.

News from iACToR Members

We welcome contributions and new ideas. Please contact us at office@vrphobia.eu.

Military Special Interest Group

SIG Leaders: Melba Stetz and Dennis Wood

The Military Special Interest Group formed under the International Association of CyberPsychology, Training & Rehabilitation promotes the use of advanced technologies for healthcare in the military sector. Our members include mental and physical healthcare providers in the military. This section was formed to address the unique living and working conditions warfighters are exposed to which calls for specified rehabilitation and prevention programs, of which Virtual Reality (VR) and Information and Communication Technologies (ICT) can and already are, playing a large role.

Preliminary findings done by military research groups suggest that using gaming, VR technology and biofeedback equipment are immersive and cost-effective readiness tools that help warfighters and their families during the present wars. These studies not only help address mental and behavioral problems but also build resilience by discussing issues such as combat stress, anger, and nicotine addiction. Military psychology departments also conduct various clinical research protocols on topics such as modified child therapy, couples' therapy, sleep problems, and mindfulness training. Participants in these studies are able to learn coping techniques, such as pain distraction and relaxation. Two main reasons for using this technological immersive praxis are to help deliver services under limited resources, such as staff and time, and to consider the gaming attraction of many of our warfighters.

By joining the group, members will help to further the use of VR and other advanced technologies in important fields related to the military such as pain treatment, the treatment and prevention of Posttraumatic Stress Disorder, cognitive and physical rehabilitation and resiliency training.

Stay abreast of new topics and technology by joining the Military Special Interest Group on http://iactor.ning.com.

Pain Special Interest Group

SIG Leader: Cristina Botella

The International Association of CyberPsychology, Training & Rehabilitation's Pain Special Interest Group promotes the use of Information and Communication Technologies (ICT), specifically Virtual Reality (VR) for pain treatment. Our members include top researchers, specialists in the field of pain treatment and leading psychologists, but is open to any members of iACToR who are interested in learning more about, and participating in, the growing field of nonpharmacological pain management.

Acute pain control has been shown to respond well to VR, which has been demonstrated as a powerful means to draw attention away from pain. Burn patients going through painful procedures like wound care and physical therapy benefit from these strategies. Another field that interests clinicians is chronic pain. Chronic pain includes a wide range of medical conditions which cause a negative impact on the patients' quality of life and is becoming an important public health problem. It is important to develop assessment instruments and intervention programs from multidimensional and multidisciplinary approaches in order to provide a suitable response for chronic pain sufferers.

By joining the Pain Special Interest Group, members have an opportunity to promote and govern direction of the group, develop a network of international contacts of healthcare professionals and policy-makers in the field of pain management and help to strengthen the organization as a whole.

The mission of the section is to improve existing forms of pain treatment by using cutting-edge technology, to further educate others on the possibilities present in the field and to promote opportunities to exchange and disseminate information, materials, and pain treatment techniques to iACToR members and to the public.

We welcome contributions, suggestions for growth and direction of the group and encourage all interested parties to join the Pain Special Interest Group by visiting http://iactor.ning.com.

Battlefield Pain Management: As is and the Road Ahead

By Christopher V. Maani

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of the Army or Department of Defense.

The unique situations that arise during combat make pain management difficult. New technologies aim to improve treatment options and outcomes for patients.

Regardless of how we opine on the current state of healthcare reform, most would agree that pain management is a right, not a privilege. Both the civilian patients we care for everyday and the Wounded Warriors in our military deserve our very best efforts when it comes to controlling their pain and relieving their suffering. Solving the problem of excessive pain may prove more challenging in military populations than in civilian populations. Both physical and emotional suffering are problematic in survivors of combat-related injuries caused by explosions. Patients who experience combat-related blasts have more extensive physical injuries and greater pain severity (Figure 1). Those with combat-related burn injuries require larger opioid doses for pain than soldiers and civilians with non-blast injuries.

Figure 1: Bilateral below knee amputations in a far forward setting following explosive blast injury.

Figure 4: Improved patient satisfaction attributed to regional anesthesia on a combat-wounded soldier in a far-forward setting.

Figure 2: ASP gold needles being placed in the ear for Battlefield Acupuncture.

While this often leads to it being cited as a major healthcare expenditure, pain management is about much more than just dollars and cents.

Reduction of unnecessary pain and suffering is a cornerstone of medicine. Inadequate pain management is something we must act upon. The burden of pain is enough to encumber or overwhelm an individual when it is not treated well. Along with the coincident and inherent mental anguish of being in pain at any given moment, there are long term sequelae as well. These may include Posttraumatic Stress Disorder (PTSD), depression, non-restorative sleep patterns and of course, chronic pain syndromes. Even the ability to perform activities of daily living can be compromised when pain is not managed appropriately. This can be a potential problem for thousands of new patients each and every year.

Thousands of warfighters have suffered severe burn wounds and/or other trauma injuries secondary to the increased use of explosive weapons by enemy insurgents in Iraq and Afghanistan. Over 80% of American casualties are transported from Baghdad to Germany with uncontrolled pain. Severe to excruciating pain often continues during the hospitalizations of these noble men and women injured in combat-related duty while serving their country. U.S. warfighters with severe combat injuries, such as burned hands, broken bones and amputations, must undergo frequent wound care sessions as part of their recovery. Combat pain is horrible – indeed, all sub-optimally managed pain is torture. Whether it is the time-honored dose of 10 mg of morphine or the state-of-the-art technology of immersive virtual therapy, successful analgesia reduces pain and suffering while improving outcomes and the patient's quality of life.

Current pain management techniques often are staid and need both improvement and enhancement. It is easy to see why, when considering the most common pre-hospital pain medication: intramuscular (IM) or intravenous (IV) morphine. IM administration does not lend itself to easy titration, whereas IV titration is more feasible. Both routes of administration require needles and requisite disposal of sharps. These methods also imply a need for exposure of the casualty – a problem in hypothermic trauma victims or soldiers in a tactical and potentially chemical environment. Morphine-induced respiratory and cardiovascular depression can also be especially challenging in this patient cohort which is prone to shock and hemorrhage.

Despite the many challenges in pain management, modern day practices and possibilities are getting better. Available improvements, beyond IM/IV morphine administration, for example, include oral administration of non-steroidal anti inflammatory medications (NSAIDS) and acetaminophen/paracetamol. These can be bundled into a "combat pill pack," which incidentally may also include broad spectrum antibiotics such as levofloxacin in an effort to stem infectious risks. Other currently available medications include the fentanyl lollipop, the opioid hydromorphone and racemic ketamine. While ketamine has historically been used mostly in the setting of military/emergency departments, pediatrics and burns, the widespread battlefield or military use of ketamine in recent conflicts may be becoming more mainstream again.

There are also pharmaceutical products in the developmental pipeline that have yet to receive FDA clearance. Transdermal PCA's utilize iontophoretic principles to maximize drug delivery. Recent technological advancements involving nanotechnology and the "pain vaccine" carry the potential to provide prolonged benefit with analgesic durations lasting from hours to days at a time, without the negative sequelae of opioids. Perhaps the most promising potential medication is S-Ketamine – lauded by many as the next silver bullet in pain control. The S-stereoisomer appears to be more potent than its racemate, and has fewer of the negative side-effects often attributed to the R-isomer and the currently FDA-approved form of RS-Ketamine. Given the current human use of S-Ketamine in the European Union, its U.S. introduction may not be far away.

Current pain control considerations even include topical applications such as lidocaine patches for rib fractures. There is not much in the way of rigorously collected scientific data, but there have been several anecdotal accounts of success with this attractive analgesic option for prehospital or combat pain. TENS units and surface ultrasound have also been considered for their analgesic potential. From isolated extremity injury to musculoskeletal pain of the torso, there is a possibility that these are viable alternatives to the staple narcotic regimen still often encountered today. Battlefield acupuncture is yet another alternative. Popularized by U.S. Air Force physician Dr. Richard Niemtzow in 2002, this simple technique requires only minimal training and very small, portable gold needles that barely penetrate the skin and do not require standard sharps disposal (Figure 2). Other advantages include a lower number of adverse effects or contraindications, and not requiring exposure of the casualty. While battlefield acupuncture has been reported to afford analgesia lasting up to three days, even several hours of pain relief are welcome.

The "Cadillac of pain control" is a phrase often used to describe regional anesthesia techniques. While many peripheral nerve blocks (PNB's) may not be practical for first responder care or self-aid, they do provide an excellent alternative to conventional multimodal therapy. Often requiring relatively minimal supplies (local anesthetic solution with stimulating needle, nerve stimulator, prep solution and sterile gloves); single shot nerve blocks can afford patients analgesic benefits in excess of 18-24 hours (Figure 3). The main advantages include decreased opioid consumption, decreased nausea and vomiting, increased patient awareness and

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Figure 5: Immersive Virtual Reality therapy to assist with pain management during burn wound care.

satisfaction (Figure 4). With military and strategic/tactical considerations, PNB's offer an alternative that can mean the difference between injured Soldiers ambulating themselves and having to be carried off by two or more fellow Soldiers, a result that further decreases mission effective force or fighting strength.

Seemingly a page out of a futuristic science fiction movie, immersive Virtual Reality (iVR) therapy is finding its way into the mainstream management of even the most complicated and severe pain. Long held in regard as the worst pain possible, burn pain appears to respond well to this new technology (Figure 5). Because it uses electronics and not drugs, iVR analgesia does not cloud the patient's thinking or judgment like narcotic analgesics. By satisfying the military's request for battlefield interventions which do not cloud the decision-making process, iVR analgesia has a direct impact on functional unit capability and mission accomplishment. This becomes even more critical when air evacuation is involved since patients are often under-medicated in an effort to stave off cardio-respiratory problems. Additional research is needed to confirm the efficacy and expand the availability of iVR not only in the burn and trauma units, but also as far forward on the modern battlefield as possible, e.g., during medical evacuations and eventually even further forward.

More research and development is needed to study and validate these possibilities. Pain research will continue to light the way for pain clinicians and their patients alike. The interplay of suboptimal pain management and its effects on day-to-day activities cannot be underestimated. Society pays the bill of pain in the currency of work-hours lost, healthcare dollars spent and lives disrupted. Many times these lives are completely uprooted, and entire families are destroyed. The problems these patients and their loved ones face on a daily basis are a reminder of this moral imperative – the need for us to continue our efforts to improve pain management and to provide our patients an escape from the dire consequences of poor pain control.

Figure 3: The author administers regional anesthesia on a combat-wounded soldier in a far-forward setting.

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Virtual Reality and Interactive Simulation for Pain Distraction

By effectively distracting the brain during painful medical procedures, Virtual Reality (VR) environments assure less attention is available for patients to acknowledge, and continue to pay attention to, pain. In the following article, the authors provide an overview of VR treaments to minimize pain and provide a history of related studies.

By Mark D. Wiederhold & Brenda K. Wiederhold

Recent studies show that pain affects 13% to 53% of the population throughout the world, making pain management one of the highest priorities in medicine today. Approximately 10,000 physicians specialize in pain management, yet only 5% of patients with the most severe pain ever get to see a specialist. Although chronic pain is the most common reason for seeking medical care, more than 20% of people with chronic pain do not seek a doctor's care. Chronic pain rises with age and affects a higher proportion of women than men. Although three to six months is the definition for chronic pain, long-term surveys show that 20% to 46% of chronic pain patients have had it for 10 years or more. Pain is of moderate to severe intensity for most patients, and other than the opioid analgesics, few prescription pain drugs achieve acceptable pain relief in more than 50% of treated patients. Evidence shows that there is a clear need for adjunctive pain relief.

Two-thirds of chronic pain patients say that pain interferes with daily activities, especially participating in physical activity—and the less physical activity there is the more acutely pain affects and complicates quality of life. Chronic pain is associated with poor general health and interferes with mental health as well. As a result, more than one-third of pain sufferers feel isolated by their pain, and almost one-third say they feel their families do not understand their pain.

Background

Virtual reality (VR) utilizes innovative technology and software to display virtual environments to users with the aid of a head-mounted display. Head tracking allows the user to interact with and actively view the environment in 360 degrees. Therefore, the images that the user sees reacts to the position they move their head. Another way VR is reactive is through the manipulation of the environment, usually through a mouse or keyboard. These advanced systems allow users to interact on many levels with the virtual environment, exploiting many of their senses, and encouraging them to become immersed in the world they are experiencing.

Immersion is one of the concepts that allow VR environments to distract patients undergoing various medical procedures in ways that go above and beyond other techniques. Immersion relates to how present the user feels in the world and how real the environment seems. When immersion is high, much of the user's attention is focused on the virtual environment, leaving little left to focus on other things such as pain.

Review of Clinical Studies

Clinical applications of VR and other technologies, and experimental research on why it has such a powerful impact on behavioral healthcare, medicine, and neuroscience, have demonstrated an array of success in significantly altering the way we view current methods of treatment for pain and anxiety and opens up exciting new possibilities and areas of improvement and innovation in nonpharmacological adjunctive pain relief. VR has been found to be effective in reducing reported pain and distress in patients undergoing burn wound care, chemotherapy, dental procedures, venipuncture, and many other painful procedures by drawing attention away from the patients' mental processing, thereby decreasing the amount of pain consciously experienced by the patient. Additional-

ly, VR for neurorehabilitation and physical rehabilitation has demonstrated success, as has VR for other such diverse areas such as prosthetics and orthotics training. Promising outcomes have been achieved by research conducted since the 1980's.

Firstly, studies have shown that distraction can take place by performing as simple an action as looking at pictures. A study was conducted in which elderly persons were shown affective images and pictures while performing their physiotherapy exercise and results implied that affective images and pictures appear to be a useful nonpharmacological intervention for pain management of elderly persons.

Preliminary distraction studies, conducted in 1984, investigated three types of distraction with patients undergoing dental procedures to obtain amalgam restorations. The distraction conditions included an audio-comedy program, a video-comedy program, and a video game. Distraction was successfully induced in patients who viewed the video comedy and played the video game during the dental procedure. This finding suggests that an increase in physiologic arousal is connected to effective distraction. This data diverges with earlier reports of the utilization of relaxation which produces a decrease in physiologic arousal during such dental procedures.

More than a decade later, similar studies involving VR distraction were conducted using cancer patients. This work, which consisted of immersing users in the virtual forest walk system, a virtual environment, to investigate the efficacy of VR technology in the psycho-oncological care of patients' mental health, demonstrated that that the exposure had a considerable positive effect in the mental support of cancer patients. In

Figure 1: A patient is immersed in a virtual environment (shown on lap top, foreground) to lessen pain during a medical procedure.

another study, VR distraction intervention for women suffering from cancer was used to control chemotherapy-related symptom distress, boosting patients' ability to remain on schedule for treatment regimens and cope with the disease, and improve patients' quality of life and increasing the chances for survival by decreasing treatment-related symptom distress.

Several studies have identified distraction as a coping mechanism effective for children with cancer. In one study, VR as a distraction intervention for minimizing chemotherapy-related symptom distress in children with cancer was explored where patients wore a Virtual IO headset during an intravenous chemotherapy treatment while playing one of the following three CD Rom-based scenarios – Magic Carpet, Sherlock Holmes Mystery, and Seventh Guest. According to the data analysis of the SDS, VR intervention was effective at decreasing the level of symptom distress immediately after the chemotherapy treatment, however, it did not have a lasting effect. It is interesting to note, though, that the high levels of anxiety during the initial chemotherapy treatment showed a decrease during successive treatments.

Further studies support the idea that in comparison with the no distraction condition, diminutions in pain and anxiety, including lowered pulse rates, were witnessed for children with cancer who used the VR distraction during treatment. Further examinations into the analgesic potential of VR as a distraction intervention for patients with cancer was further examined in a study which showed VR glasses are a practical, age-appropriate, nonpharmacological addition to standard care in handling the pain associated with lumbar punctures in adolescents. In another study, the efficacy of VR as a behavioral intervention designed to reduce distress during a port access for 7-14 year old oncology patients. Distress experienced by the children was evaluated through both subjective self-ratings as well as objective physiological and behavioral ratings. On all measures, VR was effective in decreasing children's distress.

As well as providing distraction from pain during chemotherapy treatment using VR, patients conveyed that they experienced an altered perception of time. These findings support the idea that VR can help make chemotherapy treatments more tolerable; however, using VR doesn't improve chemotherapy-related symptoms. VR can also be used to educate patients and has been shown to lead to significant increases in cancer-related self-efficacy and knowledge through the use of an appealing interactive videogame platform. HopeLab has created a PC-based game, titled Re-Mission, which consisted of 20 missions within fictional cancer patients' lives, undergoing radiation, chemotherapy, and immunotherapy.

Several studies focusing on burn pain, such as work done by Hunter Hoffman (see article on page 14), have led mental healthcare to new frontiers as well. Studies found that immersive VR decreased the amount of pain reported in addition to the amount of time burn patients spent thinking about the pain during physical therapy. The data provides preliminary support that VR can act as a strong nonpharmacologic pain reduction method for adult burn patients. Another study investigated children with acute burn injuries and found strong support for the use of VR-based games in providing analgesia for children's acute pain with minimal side effects, reusability and versatility, as well as little impact on the physical hospital environment.

The effectiveness of VR as a pain distracter has also been examined for patients undergoing venipunctures and wound dressings. One investigation looked at whether VR was more effective at decreasing pain and distress in children undergoing minor procedures versus watching animated movies. These findings indicate that VR is at least as effective as and significantly more pleasant than watching an animated movie. Other research findings suggested that visual stimuli generated by an eyeglass display were a helpful nonpharmacological adjunct for pain relief in elderly patients receiving wound dressings for leg ulcers. Similar findings further supported VR as a pain distracter for children undergoing venipunctures.

In order to understand how VR can effectively reduce pain, work has been done to investigate the neural correlates of VR analgesia. In a particular study, participants' pain-related brain activity was measured using fMRI during conditions of VR and no VR. VR considerably decreased pain-related brain activity in all five regions of interest including the anterior cingulate cortex, primary and secondary somatosensory cortex, insula, and thala-

Figure 2: Shell City, a Virtual World used by VRMC for pain treatment, encourages users to interact with the environment by collecting shells along the beach and creating calming music and images with the shells they have collected.

Table 1: Virtual Reality (VR) and Pain Distraction Studies

Year	First Author	No. of Participants	Procedure	Treatment	Results
1999	Oyama	22	Oncology care	One VR session, virtual forest walk	Better mood, less fatigue post VR, forest had significant effect on mental support
1999	Schneider	22	Chemotherapy	VR during three treatments	Less symptom distress after treatment
2000	Hoffman	12	Physical Therapy	Three minutes with VR and three minutes without	Significant pain reduction during VR
2000	Sullivan	26	Dental procedures	VR exposure	VR reduced pulse but had no significant effect on behavior or anxiety
2002	Sander	30	Lumbar puncture	VR glasses/video and standard care vs only standard care	VR helped distract 77% of experimental group
2003	Reger	57	Venipuncture	HMD VR vs flat-screen VR vs cartoon viewing vs no distractions	Significantly lower affective pain with HMD Reduction in pain for eyeglass display
2003	Tse	33	Wound dressing	Eyeglass display with soundless video broadcast vs static blank screen	Significantly lower pain scores with video images
2004	Gershon	59	Port access (venipuncture)	VR vs non-VR distraction vs no distraction	Reduced pain, anxiety, pulse rate
2004	Hoffman	8	Painful thermal stimuli	Within-subjects design, SnowWorld vs no VR	Significantly reduced pain-related brain activity
2004	Hoffman	39	Painful thermal stimuli	VR helmet/headphones/headtracking vs.see-through VR glasses	VR presence significantly, positively correlated with pain reduction
2004	Schneider	20	Chemotherapy	VR distraction during sessions	Distraction decreased symptom distress
2004	Wiederhold	6	Chronic pain	Icy Cool Fantasy VR HMD	Significant pain reduction, higher skin temperature
2005	Das	7	Dressing changes	VR and pharmaceutical analgesics vs analgesics only	Pain score without VR: 4.1; with VR 1.3
2005	Schneider	92	Chemotherapy	VR vs no VR	Altered perception of time indicating immersion
2005	Tse	15	Physiotherapy	Affective pictures during sessions	Significantly decreased pain score, NS increase in quality of life
2005	Wolitzky	20	Port access procedure	Gorilla habitat VR HMD vs no VR	Children using VR experienced significantly less pain and anxiety
2006	Cole	375	Cancer treatment	RCT, standard video game vs standard and Re-Mission video game	Significantly increased self-efficacy, as well as ability to manage side effects
2006	Lange	44	Venipuncture or wound care	Block randomization, VR vs movie	VR decreased distress, perceived by parents/staff as more effective
2006	Wiederhold	8	Dental procedures	VR vs no VR	Effective distraction and pain management mechanism; as perceived by patients/staff
2007	Mosso	27	Ambulatory surgery	Enchanted Forest VR	Avoidance of general anesthesia
2009	Nilsson	21	Needle-related procedures	VR game	Best results when game type corresponded to procedure
2009	Leibovici	24	Chronic pruritus	Immersive VR	Reduced itching and scratching

mus, as anticipated. Direct modulation of brain pain responses by VR distraction was demonstrated by the data.

These studies support the use of VR to distract patients from pain and anxiety during painful or unpleasant medical procedures. Continuing education and research ensures that the field continues to grow and further direction will be used to begin to dissect and analyze the specific brain mechanisms underlying pain distraction with VR.

Treatment Outside the Clinic

Although it is widely recognized that VR treatment is applicable to treating anxiety and pain in a clinical setting, a certain number of factors has hindered its use outside the office, such as the large amount of space needed for equipment and high cost of utilizing such systems.

A low-cost alternative to the traditional delivery method for VR is the cell phone. Virtual Reality Medical Center (VRMC) has produced a number of PC-based portable medical devices, including programs to treat pain and pain-related anxiety. To test the efficacy of a prototype virtual environment for the cell phone, VRMC compared a pain focus condition to a virtual environment condition in participants with chronic lower back pain. Data on heart rate and skin temperature were collected, as well as pain-intensity ratings obtained from self-report questionnaires. As with VRMC's PC-based product, all participants reported a drop in pain while in the cell phone virtual environment. As in the PC product study, the significant decrease in heart rate and the significant increase in skin temperature while the participant was in the virtual environment substantiates the three self-reported pain ratings, indicates a reduced level of pain and anxiety, and suggests that VR via small-screen display is an effective method of reducing this distress. These findings will support the use of VR distraction outside the doctor's office and encourage patients to address anxiety and pain through nonpharmacological methods.

Work at The Virtual Reality Medical Center (VRMC)

The VRMC specializes in the creation of augmented reality environments that are used to increase levels of immersion and presence, both effective for increasing distraction which can lead to diminished pain, for participants undergoing therapy. Funded by the National Institutes of Health and the National Institute on Drug Abuse, the VRMC developed a VR pain distraction system to be used in the dental office. Patients had a variety of dental procedures including replacement of crowns, fillings, root canals, and cosmetic dental work and during the dental procedures the patients wore a VR head mount and observed a variety of software environments. While the patients were in the virtual environments, non-invasive sensors were used to measure physiological signals including electrocardiogram, skin temperature, skin conductance, and respiratory rate. Overall, dental patients reported a reduction in the level of discomfort and pain while exploring the interactive virtual worlds.

Screenshots from VRMC's virtual worlds "Enchanted Castle" (upper left), "Icy Cool World" (upper right), and "Tech City."

Conclusions and Future Directions

After looking at an overview of research involving the use of VR and other types of interactive simulation tools that demonstrate a capability for reduction in painful or other unpleasant symptoms during medical procedures, it is evident that there seems to be a correlation between level of interactivity and immersion in the virtual environments and success in relieving distressing symptomatology. In particular, preliminary evidence suggests changes in brain fMRI patterns that seem to correlate with effectiveness of pain relief during VR interactions. Clearly, management and successful intervention for serious pain requires a

multidisciplinary team of clinical experts. Successful distraction by using these interactive tools may provide an additional augmentative option that is acceptable and often preferred by many patients. Further elucidation of the mechanisms underlying pain relief should be explored so that improvements and the specific creation of environments linked to specific types of pain and specific disease conditions can be developed.

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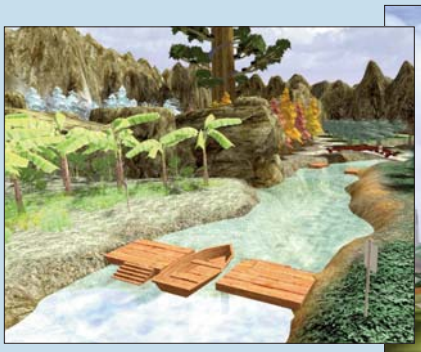

Screenshots from VRMC's virtual worlds "Enchanted Forest" (above) and "The Cliff."

Virtual Reality Analgesia in SnowWorld

By Hunter Hoffman

In the following article the author discusses the Virtual Reality world SnowWorld, a VR system designed specifically for burn patients, and describes how distraction and immersion play an important role in pain management.

Why does a child getting wound care while in the virtual world, SnowWorld, behave as if they are not even in the hospital, when the child knows for sure that

Continued on page 22

Figure 1: A screenshot of what patients see in the goggles during immersive virtual reality pain distraction.

Wounds of War II: Coping with Posttraumatic Stress Disorder in Returning Troops

EDITED BY:
Professor Dr. Brenda K. Wiederhold, Ph.D., MBA, BCIA

WOUNDS OF WAR II: COPING WITH POSTTRAUMATIC STRESS DISORDER IN RETURNING TROOPS

On October 18-21, 2009 the NATO Advanced Research Workshop "Wounds of War II: Coping with Posttraumatic Stress Disorder in Returning Troops drew 30 eminent experts from 14 countries to discuss the impact of war-related stress on participants from current and past conflicts, particularly when it results in increased risk and incidence of PTSD. Held in Klopeiner See, Südkärnten, Austria at the Hotel Amerika-Holzer, discussion topics included increased PTSD as a result of missions, as well as how PTSD may be prevented. Often thought of as an "invisible wound of war," PTSD may manifest in very visible ways, affecting behavior, relationships and society. The ultimate aim of the workshop was critical assessment of existing knowledge and identification of directions for future actions. The co-organizers of this workshop alongside Professor Brenda K. Wiederhold included Professor Kresimir Cosic and Professor Dragica Kozaric-Kovacic of Zagreb, Croatia and Colonel Carl Castro from the United States.

Full papers are being published by IOS Press

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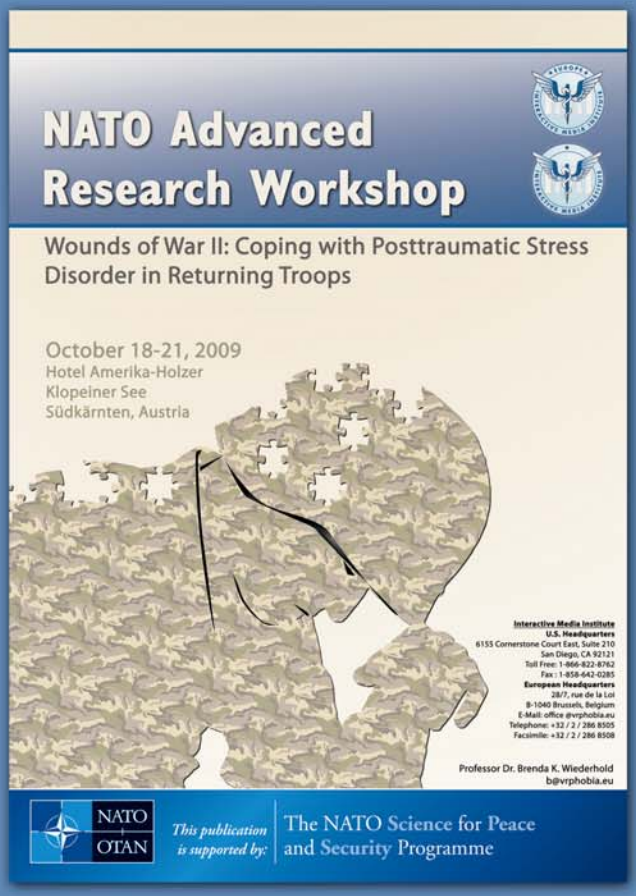

The post-conference book reflects the key topics discussed in the five sections at the workshop:

First Session – Vulnerability

Second Session – Diagnosis and Assessment

Third Session – Training and Treatment

Fourth Session – Technology-Based Training and Treatment

Fifth Session – PTSD and Comorbidity

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Product Comparison Chart:
Pain Management Systems

Here, we provide an overview of popular products on the market to treat pain. Ranging from TENS machines, which treat pain through electrical stimulation of the nerves, that can fit in your pocket, to 3-D pain distraction and relief software which can be used on a mobile platform, such as a cell phone, improved technologies are making pain more manageable on a smaller, more portable level, making these products even more appealing to the user. Virtual Reality pain treatment systems will see more widespread use as mobile platform popularity continues to grow.

PRODUCT	DESCRIPTION OF PRODUCT	MANUFACTURER
Acticare TSE	an improvement on TENS machines, offers transcutaneous spinal electroanalgesia (TSE) therapy, can fit in your pocket and focuses on the central nervous system	Acticare
Pro Sport device	device combines microcurrent transcutaneous stimulation with somatic bio-feedback, adjunctive treatment in the management of post-surgical and post-traumatic pain.	Avazzia BEST
Virtual Reality Pain Management System	3-D interactive VR pain distraction and relief software product, can either be used in clinical, PC-based setting or on a mobile platform such as a cell phone	Virtual Reality Medical Center
The DonJoy® Pain Control Device (PCD)	portable, disposable pump that continuously delivers physician prescribed local anesthetic directly into a surgical site over an extended period of time to manage postoperative pain	DJ Orthopedics Inc.
Virtual Reality Pain Distraction System	system designed to distract patients during painful procedures using head-mounted display (HMD) and game pad or joystick	Fifth Dimension Technologies
Re-Mission	pain distraction PC video game for cancer patients, in the game a heroine battles tumors and chemotherapy side effects inside a human body	HopeLab
SnowWorld	a virtual reality world for burn patients to help reduce their pain, designed to be used when the patient's bandages are changed	Human Interface Technology Lab (HIT Lab)
SCENAR Sport D	hand-held pain relief device intended for delivering general therapeutic non-invasive treatment to the body's physiological systems via skin areas	Scenar Health
TENS Pain Control Units	TENS pain control units, which treat pain through electrical stimulation of the nerve, disrupts the pain signal so the pain is no longer felt	Vitalityweb.com, Inc.
Calmare(R) Therapy Treatment	device, with a biophysical rather than a biochemical approach, uses a multi-processor able to simultaneously treat multiple pain areas by applying surface electrodes to the skin	Competitive Technologies, Inc.
Ben's Game	video games designed to provide a high level of pain distraction, allows the player to battle monsters while keeping the body safe from hair loss and other chemotherapy side effects	Make a Wish Foundation
TENS Units	company sells a variety of TENS pain units that help control pain by sending small electric impulses through electrodes to nerve fibers	Healiohealth

they are not in SnowWorld? Burn patients put on a virtual reality (VR) helmet and have the feeling of being transported to the place depicted by the virtual environment – SnowWorld. These burn patients act as if they are really there. More importantly, when in VR, burn patients often act as if they are not in the real world undergoing painful medical procedures.

While in VR, burn patients report large reductions in pain unpleasantness and pain intensity, they spend much less time thinking about their pain during wound care, and even report having fun during wound care while in VR. Burn patients immersed in SnowWorld during wound care experience potent non-pharmacologic "VR analgesia."

My colleague, Dave Patterson, and I originated the technique of using immersive VR for pain control in the mid '90s. Since then, our interdisciplinary research team at the University of Washington in Seattle, including Hoffman, Patterson, Carrougher, Richards, Seibel, Jensen and Sharar, has been studying how severe burn patients act when immersed in SnowWorld. We have been informally observing patients' pain behavior, such as whether or not they pull their hand away from the nurse. We have also been empirically quantifying how burn patients respond to being in VR – how being in VR affects their pain, as measured with patient pain ratings and fMRI brain scans. We have also begun to explore why burn patients feel less pain while in VR, i.e., the mechanisms of VR analgesia.

Allowing patients to "go into" VR during painful procedures can help reduce excessive pain non-pharmacologically. Compared to standard of care (pain medications with no VR), researchers consistently find 30-50% reductions in pain ratings when VR is used adjunctively, that is, in addition to usual pain meds, during civilian severe burn wound care and during physical therapy to stretch the burn patients newly healing skin. Military patient populations with combat-related burn injuries are showing similar benefits of VR analgesia. In addition, fMRI brain scans testing healthy volunteers receiving brief thermal pain stimuli have shown large reductions in pain-related brain activity associated with VR analgesia (Figure 1). We have also used VR to treat burn patients sitting in a tub of water. Using a custom-made static fiberoptic VR helmet with 800,000 tiny fibers per eye, we showed that VR analgesia can reduce some of the most severe pain in medicine – severe burn wound care/debridement in the hydroscrub tanks. Surprisingly, contrary to prevailing wisdom that distraction is less effective at higher pain levels, our results showed that VR was most effective in patients who needed it the most, those with worst pain scores of seven or higher on a scale from zero to 10.

Figure 1: A patient wears waterfriendly VR goggles while undergoing severe burn wound care at Harborview Burn Center in Seattle, Washington.

Immersive VR is hypothesized to reduce pain via a non-pharmacologic attentional mechanism. Patients look into VR goggles and the goggles block patients' view of the hospital room so they cannot see the wound care. Instead, the goggles substitute synthetic computer-generated images from an illusory 3-D virtual world. Noise-canceling earphones block sounds from the hospital room, and substitute more calming music and sound effects. The patient interacts with the virtual world, throwing snowballs at objects, which makes it even more attention grabbing. According to our logic, pain requires attention and patients have a limited amount of attention available. VR draws upon these limited attentional resources, leaving less attention available to process incoming pain signals. Consistent with involvement of an attentional mechanism, burn patients report spending much less time thinking about their pain during wound care while in SnowWorld. In addition, laboratory pain studies have shown that on a divided attention task, where the participant's primary task is to monitor a string of numbers, performance on the primary task drops significantly when participants go into VR.

Computer Science and Engineering

To maximize VR analgesia for burn patients in SnowWorld, my colleagues and I have designed our VR systems (hardware and software) to maximize immersion of the VR system in an attempt to maximize VR analgesia. In laboratory studies at the University of Washington, Seattle, based on the earlier framework of immersion laid out by Slater and Wilbur, we have manipulated helmet quality and interactivity to see if these manipulations affected the chances that participants would see if these manipulations would affect the amount of VR analgesia reported by participants in our VR systems. Immersive VR appears to show a non-pharmacologic dose-response relationship where more immersive VR systems (presumed to be more attention grabbing) reduce pain more effectively than less immersive VR systems. For example, in a between-groups, double blind analog pain study manipulating only hel-

met quality, more immersive medium field of view VR goggles (via a commercially available NVIS SX LCD helmet) led to clinically meaningful reductions in pain in two out of three participants, whereas less immersive narrower field of view VR goggles (Cy-Visor) led to clinically meaningful reductions in pain in only one out of three participants. In another study, one group interacted with the virtual world via a trackball and the other group was not given a trackball and thus viewed SnowWorld passively. Interactivity increased the objective immersion of the VR system, and as predicted, increased the analgesic effectiveness of immersive VR.

In summary, so far, high tech VR helmet quality, such as wide field of view goggles, and interactivity, such as playing SnowWorld with a mouse-like trackball or other input device, have been isolated as important factors contributing to VR analgesia. Improvements in the field will become pertinent in future research, such as a pair of scanning fiber VR goggles that Hoffman's team are currently working on building.

This article is a synopsis of the keynote presentation Dr. Hoffman gave at RAVE-2010 in Barcelona on March 3, 2010.

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"Surreal" Pain Research

"Surreal World," one of the virtual worlds discussed in the following article, features interactive environments based on paintings done by Dalí and Miró and aims to captivate users' attention as they interact with various objects, including a representation of the sensation of pain.

By José Gutierrez-Maldonado

In past years, research on the use of virtual reality (VR) in pain has received considerable support in Spain due to financial aid calls for research on chronic pain supported by "Fundació La Marató de TV3" in 2007. The consortium formed by the research groups led by Jose Gutierrez-Maldonado (University of Barcelona), Mel Slater (University of Barcelona) and Cristina Botella (University Jaume I) obtained this type of financial aid and coordinate their work in the frame of the project "Development and application of technologically-advanced methods based on VR for attention-diversion, visualization and body image modification, as adjunct analgesic techniques against chronic pain." One of the main aims of the subprojects of the coordinated project mentioned above is the development of virtual environments for attention-diversion, beliefs modification, body schema modification, mood induction and behavioral activation.

The virtual environments, aiming to provide attention-diversion, were developed by the group led by Jose Gutierrez-Maldonado along with Vicky Rangel, Ivan Alsina, Desiree Loreto, Katia Cabas, Olga Gutierrez-Martinez and Ruben Nieto. Called "Surreal World," the first prototype was released in 2007. The current version (Surreal World 3.0) allows the user to navigate through virtual environments that recreate Dalí and Miró paintings and focus on obtaining the patient's attention through interaction with objects that generate surprise due to their surreal features. This research group has also developed an environment that al-

Figure 1: A screenshot from "Surreal World."

lows the patient to interact with a geometric figure that represents the sensation of pain. The patient is expected to transfer the experience of control obtained with the virtual symbolic representation of pain to the real pain experience. It is hypothesized that these environments can be used as a resource for attention-diversion, for the modification of non-adaptive beliefs and attitudes, for their substitution of strategies more appropriate for coping with pain such as relaxation, and to explore alternative ways of experiencing pain for greater consistency with well being.

The group, led by Mel Slater and Maria V. Sanchez-Vives, along with Joan Llobera, Ausies Pomes, Mar Gonzalez and David Corominas, seeks to take advantage of the virtual body ownership illusion as a method to alleviate certain types of chronic pain. Building on the results obtained using the virtual body illusion combined with the insights gained from the employment of VR in neurorehabilitation, experiencing the absence of all the signs of pain in a virtual body or limb could result in sufficient neural reorganization resulting in a positive impact on the experience of pain, thereby decreasing it. Furthermore, their subsidiary hypothesis is that the visualization of movement will enhance the actual movement that the patient experiences compared to the restricted movement experienced as a consequence of pain.

Another group, led by Cristina Botella, Rosa Baños and Azucena Garcia-Palacios, is exploring the use of an adaptive display (EMMA's world) in the application of relaxing techniques and mindfulness for patients with fibromyalgia as a component of a wider cognitive behavioral treatment program. Azucena Garcia-Palacios has been working in this field for many years, collaborating with researchers of the University of Washington like Mark Jensen.

Paul Verschure of the University Pompeu Fabra of Barcelona is conducting research in this field as well. His group attempts to characterize the sensory and emotional components of the responses to repeated pain stimuli in patients with chronic neuropathic pain. VR systems are used by his team to promote reorganization of central nervous system circuits.

In upcoming years, publications will be released and presentations in scientific meetings will be held showing the results of these projects, leading Spain to a point of major development in the context of aplications of VR to treat acute and chronic pain.

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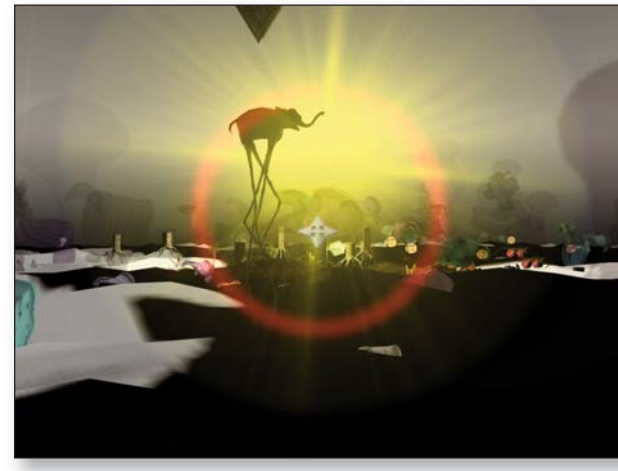
Figures below: Screenshots from "Surreal World"



Tools of Distraction:

Video Games vs. Handhelds

"... in the context of the current computer generation, it stands out that video games have the potential to be the ultimate distraction technique. But the question remains: Are 'off the shelf' handheld video games enough?"

By Kate Miller et al.

Despite current distraction techniques showing mixed results for pain management across a range of medical procedures, clinicians continue to use them. Literature in the procedural pain field has continued to provide a "list" of necessary attributes for distraction techniques including the terms multi-sensory, interactive, intuitive and motivating. Most accessible distraction tools fail to meet these criteria. However, in the context of the current computer generation, it stands out that video games have the potential to be the ultimate distraction technique. But the question remains: *Are "off the shelf" handheld video games enough?*

Figure 1: A child engaging in pre-procedural preparation using the Multi-Modal Distraction device to alleviate fears about the procedure.

In reflection, simple handheld games have not been studied extensively in procedural pain literature. Only a few studies have investigated video games' impact on pain or anxiety preoperatively, during induction, port access, burn injury, venipuncture and laboratory cold pressor tests. This is surprising, given the fact that this simple, accessible and cost-effective technology is not only motivating for children but also interactive, multi-sensory (visual/auditory) and intuitive. Results for children aged three to 18 years are mixed, but indicate that video games are somewhat effective as distracters but overall offer a "better than nothing" approach to pain management. One study compared a standard video game console to playing the same game through virtual reality technology. The results showed no differences. Another technology upgrade has partly considered clinical and developmental needs when developing the Pedisedate ®, that involved the adaptation of an off the shelf video game to reduce anxiety during nitrous oxide sedation. Results were mixed for the three to nine years olds, with age impacting the usability of the device, reflecting the developmental usability of off the shelf gaming systems. These studies indicate that perhaps both the content and the game console need to be considered in order to meet the physical, cognitive and emotional needs of the user.

Hand-held devices such as Multi-Modal Distraction (MMD) have considered the developmental needs of the user in terms of both content and console, which have led to reduced pain experiences during burn wound care procedures, with orthopedic procedures and preoperative studies following similar trends. We engaged consumers (children and clinicians) within the clinical context, involved developmental experts and technology consultants to ensure games, and included stories and other content to meet children's distraction needs. Trials have indicated that off the shelf video games are not enough in managing pain when compared to this customized hand held MMD device.

Rassin described the process of developing a computer game to prepare children for surgery, taking the use of video games for procedural pain to another level. This paper did not trial a device but merely discussed what needed to be considered in developing it. It did, however, highlight how customizing allows innovative solutions to procedural pain problems. Our work expanded on Rassin's customization process by producing content that allowed for an innovative approach to procedural preparation to alleviate fear. Procedural education via the interactive, child-friendly MMD device in the areas of wound care has shown significant reduction in pre-procedural and procedural pain scores.

Non-pharmacological procedural pain management has moved beyond the "better than nothing" approach. Innovative technology has superseded hand held video games that can limit children's pain through better quality distraction and preparation techniques.

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Warfighters and Pain

Work done at the Tripler Army Medical Center is aiming to provide comprehensive assessment and treatment of the complex factors and consequences of pain through the creation of the Pain Rehabilitation Program.

By Melba C. Stetz et al.

Figure 1: A patient is treated using VR therapy at the psychology pain clinic.

The International Association for the Study of Pain (IASP) defines pain as, "an unpleasant sensory and emotional experience arising from actual or potential tissue damage or described in terms of such damage." IASP and others recommend identifying pain with the help of the following categories/axes: (1) anatomical location; (2) body system involved; (3) temporal characteristics; (4) intensity and time since onset; (5) etiology; and (6) neurochemical mechanism. Similarly, in the behavioral sciences, there have also been attempts to diagnose pain. Some of the diagnoses found in the Diagnostic and Statistical Manual of Mental Disorders (DSM) are: (1) psychogenic pain disorder; (2) somatoform pain disorder; and (3) pain disorder. Therefore, defining pain itself can be a "painful experience."

In the United States, we have many war fighters supporting the longest fight in our history. Many of these war fighters, and their families, experience some type of pain. With this in mind, the Department of Psychology at the Tripler Army Medical Center has created the Pain Rehabilitation Program. This program provides comprehensive assessment and treatment for the complex interaction of physical, emotional, and social factors related to pain perception. This program's mission is to provide warfighters,

veterans, and military families with innovative, integrative, high quality, and multidisciplinary bio-psycho-social-spiritual clinical care. Specifically, it incorporates conventional, complementary, and alternative medicine to optimize military readiness, retention and overall wellness. Desired outcomes are to minimize pain, to maximize function and return patients to highly productive lives.

There is currently an active protocol called "A Comparison of Guided Imagery and Virtual Reality for the Treatment of Chronic Pain." The proposed research investigates whether VR enhances the effectiveness of traditional imagery techniques, specifically somatic body imagery, to alter the perception of pain. Patients referred for chronic pain to the Pain Management Program at Tripler Army Medical Center will be recruited to participate in this study. Each volunteer will use an imagery technique in three modes: audio-tape guided imagery, therapist guided imagery (conventional treatment), and therapist guided imagery presented in a virtual environment. Each mode will be presented for one session. Outcome measures include a pre- and post-session rating of the intensity of pain, a self-efficacy rating scale to measure a patient's perception of how helpful and effective they perceived the intervention technique, and biofeedback measures, consisting of muscle tension (EMG), temperature, and skin conductance (EDG). Equipment used includes the emagin headseat and "Shell City" VR environments (VRMC, San Diego). The study consists of three visits where the effectiveness of technology vs. face-to-face interaction with relax personnel is compared.

These studies will help to determine which method of pain treatment is the most effective and whether advanced technologies will be further employed to help the military deal with rehabilitation and injuries resulting in pain.

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Multisensory Environments and Their Effect on Pain

Studying how pain is affected by stimulating various senses can be applied to many forms of pain treatment. The author discusses a study in which pain sufferers are immersed in such an environment and points to future areas for growth.

▸ By Mimi Tse

The concept of Snoezelen, or a sensory environment, was first highlighted by two Dutch scientists working with learning disabilities. The word Snoezelen means "to sniff" and "to doze" in Dutch. The original concept was to use colored paper and light bulbs with tin foil to stimulate all the primary senses to achieve relaxation and calm down agitated clients. It was Pat Schofield who pioneered the use of multisensory environment concepts for individuals with chronic non-malignant pain and his studies resulted in positive outcomes.

In my recent study of community-dwelling older adults with pain, a multisensory stimulation environment was created, in which our primary senses (hearing, seeing, smell, taste and touch) were gen-

Figure 1. Patients practice deep breathing and relaxation while smelling a pleasant fragrance via a diffuser.

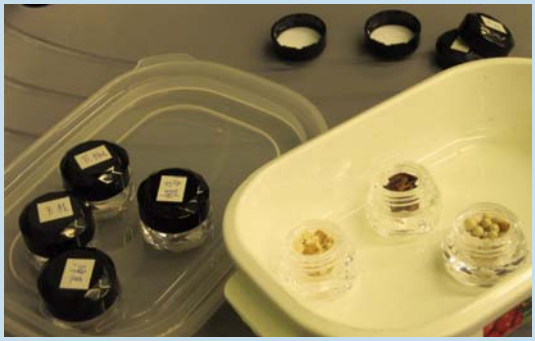

Figure 1: Various herbs and leaves help to stimulate the sense of smell.

tly stimulated. Soft music was played and fragrant lotion given to each participating older person to apply to both hands. They were then asked to close their eyes and practice deep breathing while listening to the music. They were reminded to feel their bodies and smell the fragrant lotion as well as gently massage the acupressure points along their faces, hands, back and legs. They were also asked to smell the essential oil that was distributed by a diffuser. Tea was provided at the end of the session to appeal to the taste buds, and they worked in groups to put together attractive puzzles. All participants showed positive responses to the multisensory stimulation environment and reported lower pain and anxiety scores.

It is hoped that pain will be better controlled in the future via medications and the creation and use of a multisensory stimulation environment as coping strategies.

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Does Content Matter?

Which virtual environments do we need for pain management?

By Andreas Mühlberger and Paul Pauli

In this article the authors address the question of whether the actual content of a virtual world can affect how effective pain management will be. Furthermore, they explore if it is it the interactivity of the world, resulting in distraction, or the resulting emotions invoked, that affect how the patient perceives pain.

Distraction techniques are frequently used for pain management. However, it is still a matter of controversy which components are necessary to enhance distraction during painful events and thus to reduce the experience of pain. As mentioned by Kate Miller et al. in this issue (see page 17),these components may be constituted of multi-sensory, interactive, intuitive and motivating attributes. Basic research from our group repeatedly found that emotion is an important modulator of pain perception and pain experience. In comparison to neutral stimuli, negatively valenced visual stimuli, such as a picture of rotten food, enhanced pain perception, while positively valenced visual stimuli, like erotica, decreased perception of pain. Furthermore, pain-associated stimuli, such as pictures depicting mutilations, were found to further enhance pain experience, even compared to pain-unrelated negative stimuli. Importantly, these emotional effects are independent of distraction effects, although these studies verified that distraction generally reduces pain perception.

In recent years, mainly Hunter Hoffman and his group have impressively shown that virtual environments are important and impressively useful tools for pain management (see Hoffman article, page 19).

Although the efficacy of his team's approach has been repeatedly demonstrated, many questions about the mandato-

ry features of the treatment, as well as the underlying processes and mechanisms, remain unanswered. Is it necessary to use virtual worlds that are by no means associated with pain (e.g., winter environment to ameliorate burn pain)? Is the distraction or the elicited emotion relevant for pain management? To answer these questions, studies directly comparing effects of specific features of the virtual environment on pain perception are needed. These studies focusing on the basic processes and mechanisms may help to further improve treatment efficacy.

We recently investigated whether movement in a virtual world is an essential feature to affect pain perception and pain experience assessed as heat and cold pain thresholds. Results clearly demonstrated that movement and the possibility to look around in the virtual world, realized with a head tracking device, enhanced the pain reducing effect of this intervention. This study, however, does not answer the question of whether the movement in the virtual environment OR the enhanced interactivity due to the use of the head-mounted display is the core component reducing pain perception.

Is it necessary to use virtual worlds that are by no means associated with pain? Is the distraction or the elicited emotion relevant for pain management?

Figure 1. Screenshot of the "hot" virtual environment.

Figure 2. Screenshot of the "cold" virtual environment.

Another yet unanswered question is whether the content of the virtual world is important for the reduction of pain. Thus, we examined how "hot" (represented by red-colored autumn leaves, see Figure 1) and "cold" virtual worlds (represented by a snow-covered winter environment, see Figure 2) affect heat and cold pain thresholds in the Enchanted Forest & Dream Castle virtual environment created by the Virtual Reality Medical Center. Our intuitive assumption was that virtual environments that do not correspond to the pain stimulus, and thus are less associated with the specific kind of pain, will more effectively reduce the experience of pain. For example, a white winter environment was expected to decrease heat pain while the red autumn environment was expected to reduce cold pain. Surprisingly, we did not find any differential effects of the two virtual environments – both ameliorated heat and cold pain perception. Clearly this single study is not sufficient to prove that the content of the virtual environment has no influence on the reduction of pain. Specifically, this was an analogue study investigating students and not pain patients, and dependent measures were experimentally but not clinically relevant pain stimuli. However, we think that studies of this kind which try to target how specific features of the virtual environment influence pain perception are necessary to enhance our knowledge of mechanisms that aid in distraction reducing pain. In the long run, these studies will allow us to further optimize the requirements of the virtual worlds to realize the best possible non-pharmacological pain management.

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Pocket-size Pain Relief

Mobile Devices for the Assessment of Chronic Pain

To accurately assess pain in chronic pain conditions, it is important to track daily fluctuations and factors that can influence perceived pain such as mood and fatigue. The use of a handheld device, such as a cell phone, encourages patients to keep a daily log.

By Azucena Garcia Palacios et al.

Chronic pain includes a wide range of medical conditions which cause a negative impact on the patient's quality of life and is becoming an important public health problem. Fibromyalgia is among the most prevalent of chronic pain conditions . It is estimated that around 0.7-3.2% of the general population suffer from fibromyalgia. Most of them are women.

It is important to develop assessment instruments and interventions from multidimensional and multidisciplinary approaches in order to provide a suitable response to fibromyalgia sufferers. These patients suffer widespread pain with fluctuations in intensity. Most patients report feeling some pain at all times and its intensity fluctuates depending on physical activity, mood, fatigue, and patterns of sleep.

The Initiative of Methods Measurement and Pain Assessment in Clinical Trials (IMMPACT) recommends the daily assessment of pain intensity. The gold standard for the assessment of pain intensity and other related variables are self-report ratings that the patient has to fill out daily. However, this assessment procedure presents limitations because the recollection is usually retrospective, it requires effort and patients are not always compliant. These limitations have an effect on the reliability of these measures. Information and communication technologies can help to improve the assessment of pain intensity and other related measures by making it easier for the patient to answer questions during programmed sessions throughout the day.

Figure 1. Assessment of pain intensity and mood using a mobile device.

Our research team has developed an assessment tool (e-TI pain) running on a mobile device, in this case a cell phone, to recollect daily ratings of pain intensity, fatigue intensity and mood. The system has an alarm program that asks the patients to rate these measures on a daily basis. This tool allows data to be collected daily and facilitates prolonged assessment over time. It also allows a more reliable and non-retrospective assessment. Lastly, it requires less effort from the patient and it runs on a common device, the cell phone.

This assessment tool can contribute to a more reliable and valid assessment of core measures in the study of chronic pain. The design chosen has been carefully studied in order to be attractive and easy to use for middle-aged women with a very heterogeneous level of expertise in the use of information and communication technologies (Figure 1). The usability studies conducted support that the system is easy to use for most patients. At this moment, the system is being evaluated comparing its use with the use of a traditional handout and further data will be provided in the future.

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White Coat Syndrome?

Portable VR System Reduces Preoperative Anxiety

Preoperative anxiety can have major repercussions for patients, including increased pain during procedures. Here, the authors explore VR to address this problem.

By Alessandra Gorini et al.

Figure 2. A patient included in the VR group wears a HMD during the operation.

The thought of being "cut open," the fear of pain, or the idea that something could go wrong are common preoperative worries that lead to increased anxiety and stress in surgical patients. Preoperative anxiety, or anxiety regarding impending surgical experiences, can be a major problem for patients and often becomes associated with a a large amount of discomfort before the operation and with a number of maladaptive post surgery outcomes, including postoperative fatigue and pain, higher risk of surgical site infection, sleep disturbances, lack of full postoperative recovery, and, in the worst cases, post-traumatic stress disorder. Preoperative anxiety can also increase the intensity of pain experienced during surgery.

As drug treatments alone have frequently proved to be inadequate to reduce anxiety in clinical contexts, there is an increasing interest in non-invasive complementary and alternative medical therapies (CAM) that diminish psychological discomfort during preoperative and postoperative phases. Being an advanced imaginative system as effective as reality in inducing emotional responses, and having gained recognition as a means of attenuating distress and pain during various medical procedures, virtual reality (VR) can be considered a technologically-advanced form of CAM therapy. VR provides a particularly intense form of immersive cognitive and emotional distraction that taxes the patient's limited attention capacity, resulting in the withdrawal of attention from the real, noxious, external stimuli with a subsequent reduction in perceived pain and stress.

Figure 1. A screenshot of the Green Valley, the virtual environment used to help patients become relaxed during surgical operations.

On the basis of these considerations our laboratory, in collaboration with the Regional Hospital No. 25 of the IMSS in Mexico City, developed a small, portable and immersive VR system to reduce anxiety in a sample of patients who underwent minor surgical procedures (lipoma or cyst removals). The experimental study performed on a sample of 47 patients showed that, even if provided in a non-interactive modality, immersion in the Green Valley, a relaxing VR environment included in the NeuroVR software, caused a rapid and significant decrease of perceived anxiety that was not observed in the group of subjects exposed to relaxing music alone.

In a following study, in order to analyze the role played by the cultural and technological background of the users on the emotional responses to VR, we applied the same experimental protocol to a sample of patients living in El Tepeyac, a small, rural and isolated Mexican village characterized by a very primitive culture, who had to undergo a minor surgical operation. El Tepeyac is located at an elevation of 2,220 meters, 12 hours drive from Mexico City. Its inhabitants belong to the Tlapanecos community, a large and very poor community of Mexican indigenous people who live on the mountains located north-east of Acapulco. In El Tepeyac people live in a very marginalized condition without any kind of integration with the rest of the civilized world. Their most advanced technological pieces of equipment are two-way radios and closed-circuit televisions transmitting only local information between villages, with no news about the rest of the world. Contrary to our findings with other patients, when immersed in the Green Valley during the surgical operation, people from El Tepeyac showed a significant reduction in heart rate, but not in their perceived anxiety. A possible interpretation of

these results is that the difference between civilized and non-civilized people regards their attribution process – the civilized patients who were able to attribute the reduced arousal to the VR experience reported a significant reduction in the self-reported level of anxiety, while people from El Tepeyac, who did not attribute the relaxation process to the VR experience, showed a reduction in their physiological reactions, but not in their perceived anxiety.

These two studies highlight the role of a portable VR system in reducing anxiety that usually occurs in patients who undergo ambulatory surgical operations in two very different cultural contexts. Given the limited costs of this approach, these findings should encourage surgeons to adopt the use of similar systems in order to help patients face minor surgical procedures with reduced levels of anxiety.

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Night Vision in Open Surgery

Dark Operating Rooms Could Improve VR Immersion

By José Luis Mosso et al.

Studies now support that Virtual Reality (VR) immersion can act as an effective tool to distract a patient during painful medical procedures. Further research is being conducted to explore ways in which virtual environments and resulting feelings of presence can be made more realistic. This study explores the use of night vision technology to perform open surgery on rabbits. This could make ambulatory surgery on humans possible in a setting of total immersion, with the intent to reduce pain and anxiety while patients navigate virtual scenarios and surgeons perform surgeries in total darkness with the ability to control light.

Physicians make diagnoses everyday employing methods dating since the last century that use fixed black and white or color images, like X-Ray images or pictures showing motion, like sonographs. There is also sophisticated equipment used to perform invasive procedures like vascular exploratory examinations with a catheter, or liquid extraction from amniotic fluid with sonographs, a method used in obstetrics. In battle settings, soldiers use night vision with green, black and white colors to identify military targets. The equipment they use is mounted on casks, enabling a panoramic view.

In 2009, at the Department of Surgery at the Panamericana University, Mexico City, we conducted a study to integrate these two practices using a wireless microcamera with infrared light mounted on the head of a surgeon, and night vision infrared stealth goggles for the first assistant. These goggles were used throughout the operation.

It was possible to perform eight surgeries on rabbits without surgical complications. Surgeries performed included one laparotomy, one appendectomy, three nephrectomies, one splenectomy, one left thoracotomy, and one right thoracotomy, which were done under general anesthesia. The surgical and anesthesia techniques didn't change in this project, but all lights in the operating room were turned off. The surgeon and first assistant had the ability to see the surgical field in total darkness. Technical limitations included difficulties such as a short distance between the microcamera, located on the surgeon's head, and the power source. The short length of the cables limited the surgeon's movement, but the limitation was easily resolved. It was possible to recognize large surgical tools in black and white, such as scissors, graspers, needle holder, and retractors. However, the catgut cromic 00 suture was difficult to grasp because it is clear or transparent. It also became apparent that it is easier to recognize veins than arteries in darkness. We included a control group using traditional techniques, with the lights turned on. Surgical times were similar, with a slight delay during the surgeries performed in total darkness. The two rabbits used in this project were euthanized after the surgeries.

Open surgeries performed on rabbits with the aid of night vision technology showed promising results. In future works, it is necessary to improve the resolution of microcameras and all participants in the operating room must use the same equipment. Future surgical procedures which could be performed on humans using this technique include non-complicated hernia repairs, large lipomas in soft tissue, subclavian catheter insertions and leg amputations. This technology could be improved with technology such as augmented reality and 3-D vision. Cybertherapy could thus be used during surgical applications to allow patients to be immersed in total darkness during surgery, making VR immersion more realistic.

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FURTHER AFIELD:
Prospects for Future Virtual Reality Applications in China

By Lingjun Kong

Recently, Virtual Reality (VR) has been increasingly attracting attention in China from the government, the research community, and technology developers. As a relatively new technology in China, VR has been incorporated into many areas of science, technology, engineering, medicine, and the entertainment industry. It is clear that VR is a priority on the agenda for future technology development. VR has found itself traveling an untraveled pathway. Numerous applications have been successfully employed in a wide variety of fields that have not experienced the use of VR before. Fields such as urban planning, large-scale projects panoramic virtual tour, digital hotels, exhibitions and museum displays, e-commerce, education and training, and entertainment are beginning to actively apply VR technologies. Moreover, the maturity of VR applications in the medical field, the gaming industry, and education, is accelerating and will certainly have a profound impact on people's lives.

As a cutting-edge technology, VR uses computer-generated simulation systems that integrate computer graphics technology, computer simulation technology, artificial intelligence, sensor technology, display technology, and network technology. Because it is immersive, interactive, and intuitive, and can be utilized by many applications, VR has been given a great deal of focus and funding from government agencies, including the Chinese National Foundation of Sciences, the "85", the "95", and the Key State Project. Research facilities have been built in all major Chinese cities. Many universities have set up VR and simulation labs, engineering their research results into applied technologies. The unique environment in China is the ideal atmosphere for researchers dedicated to VR technologies, which is sure to support substantial growth in various fields.

Consumer-focused VR Hardware

China already has the groundwork that fosters VR research in its consumer-focused hardware. High-end computers, low-cost head mounted displays which can be used with a PC, iPods and television sets, and an assortment of gaming controllers and peripherals are already well developed and widely used. Additionally, physiology sensors, data gloves, and olfactory devices are effortlessly integrated into the VR system infrastructure. The existing establishment allows for continuous development for future technologies at the consumer level. Moreover, the online virtual community, internet driven gaming and the entertainment industry benefit the market that drives the improvement of current VR hardware, setting a foundation that focuses on research and development, while keeping costs low.

Humanized Computer Interactive Interface in Training and Education

In the field of training and education, VR technology has a wide range of roles and influence. It improves current systems by adding human touches. Human and emotion-oriented human-computer interaction improves the learning experience and will be the future of VR technology. VR enhances the passive viewing methods of contemporary education practices into immersive experiences that exemplify the "show, not tell" lesson. This new mode of training will be applied to current programs in the military sector, sports, classrooms, and job training, bringing them to new levels of effectiveness.

Ultimate Assistant for Medical Practice

VR has a newfound, dominating presence in the medical sector. With surgical skills training, stress inoculation training, and medical procedure training, simulations are beginning to be heavily integrated into hospital procedures, research in anxiety disorders and smoking cessation. Mixed reality rehabilitation is actively being pursued with the addition of haptics technology and realistic simulations. Medicinal applications are growing into one of the most important uses of VR technology.

All Shopping All the Time

E-Commerce has grown into a very active community and industrial opportunity in China. Users are frequently looking towards online venues to shop for goods. VR technology offers an interesting tool for e-Commerce. Previously, e-Commerce had the disadvantage of risk in that consumers were not able to test what they were buying. With VR technology, businesses can now create three-dimensional models of their products, giving consumers the opportunity to fully view online products. The online shopping experience is enriched through the 360 panoramic view. Future applications could include smells, textures, and sounds to allow shoppers the opportunity to fully experience a product before checkout.

China's VR community is constantly growing. The advanced applications such as Virtools and Quest3D are becoming household names in the community. New and exciting applications are sprouting up in every field, giving VR a dominating presence in the future of technology.

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Presence as a Cognitive Process

Understanding the Feeling of "Being There"

"While the design of VR technology has brought the theoretical issue of presence to the fore, few theorists argue that the experience of presence suddenly emerged with the arrival of VR."

–Frank Biocca, Director of the Media Interface and Network Design (M.I.N.D.) Lab

By Giuseppe Riva

In its more general use in relation to experiences mediated by digital information technology, the term "presence" has referred to a widely reported sensation experienced during the use of virtual reality (VR) – the feeling of being inside the experienced virtual environment. However, as noted by Frank Biocca, Director of the Media Interface and Network Design (M.I.N.D.) Lab., and agreed upon by most researchers in the area, "While the design of VR technology has brought the theoretical issue of presence to the fore, few theorists argue that the experience of presence suddenly emerged with the arrival of VR."

"... the presence process can be described as a sophisticated but unconscious form of monitoring of action and experience, transparent to the self but critical for its existence."

In the last twenty years many authors have tried to elaborate upon a consistent theory about presence. Specifically, there have been several attempts to define the concept that can be summarized by two general approaches – "media presence" and "inner presence."

One group of researchers describes the sense of presence as "Media Presence," a function of our experience of a given medium. The main result of this approach are the definitions of presence such as the "perceptual illusion of non-mediation" produced by means of the disappearance of the medium from the conscious attention of the subject. The main advantage of this approach is its predictive value – the level of presence is reduced by the experience of mediation during the action. The main limitation of this vision is questions that are not answered such as, "What is presence for?" "Is it a specific cognitive process?" "What is its role in our daily experience?" It is important to note that these questions are unanswered even for the relationship between presence and media.

To address these questions, a second group of researchers considers presence as "Inner Presence," a broad psychological phenomenon not necessarily linked to the experience of a medium, whose goal is the control of the individual and social activity. In this paper we will support this second vision, trying to detail its main claims.

Recent research in neuroscience has tried to understand human action from two different but converging perspectives – the cognitive and the volitional. On one side, cognitive studies analyze how action is planned and controlled in response to environmental conditions. On the other side, volitional studies analyze how action is planned and controlled by subjects' needs, motives and goals. Here, we suggest that presence is the missing link between these two approaches. Specifically, we consider presence as a neuropsychological phenomenon, evolved from the interplay of our biological and cultural inheritance, whose goal is the inaction of volition: presence is the prereflexive perception of successfully transforming our intentional chain into action (inaction). Within this vision, we sug-

gest that the ability to feel "present" in a VR system – an artifact – basically does not differ from the ability to feel "present" in our body and the surrounding physical environment in which we are situated.

More in detail, the presence process can be described as a sophisticated but unconscious form of monitoring of action and experience, transparent to the self but critical for its existence. The main experiential outcome of this process is the sense of agency – we feel that we are both the author and the owner of our own actions. In this view, a higher level of presence is experienced as a better quality of action and experience. The more the subject is able to enact his/her intentional chain in a successful action, the more he/she feels present. We also suggest that it is the feeling of presence that provides to the self with key feedback about the status of its activity. The self perceives the variations in the feeling of presence and tunes its activity accordingly.

For this reason, the feeling of presence is not separated by the experience of the subject but is directly related to it. A greater feeling of presence is experienced by the self as a better quality of action and experience. The agent perceives directly only significant variations in the feeling of presence: breakdowns and optimal experiences.

Why do we consciously track presence variations? Our hypothesis is that these variations are a sophisticated evolutionary tool used to control quality of behavior. Specifically, the subject tries to overcome any breakdown in its activity and searches for engaging and rewarding activities (optimal experiences). It provides both the motivation and the guiding principle for successful action.

This cognitive-driven vision can drive the development of better and more immersive virtual experiences. Below there are some general guidelines derived from the "inner presence" approach:

▶ For presence, action is more important than perception: The user is more present in a perceptually poor virtual environment (e.g. a textual MUD) where he/she can act in many different ways than in a real-like virtual environment where he/she cannot do anything.

▶ Subjects with different intentions, such as exploring the environment or reducing the anxiety level, will not experience the same level of presence, even when immersed in the same virtual environment. This means that understanding and supporting the intentions of the user will improve his/her presence in the virtual world.

▶ The more complex the task is, the more difficult it is to induce a high level of presence. It is easier to induce presence during simple tasks (operations) such as removing spark plugs, than in complex tasks (activities) such as repairing a car.

▶ Maximal presence is achieved when the environment is able to support the full intentional chain of the user, including his/her motor intentions. This can explain the success of the Nintendo Wii over competing consoles or the need of a long-term goal to induce a high level of presence after many experiences of the same virtual environment.

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Technology for the Disabled Population

The Growth of Virtual Reality Rehabilitation in China

Recent rapid growth in advanced technologies for healthcare has led to researchers applying virtual reality to rehab.

▶ By Chen Weidong

Statistics from the Second China National Sample Survey on Disability indicated that China's population contained nearly 83 million disabled people in 2006. In contrast to the figure is the underdeveloped infrastructure and social services. Only 23.3% of disabled people can get rehabilitation treatment and most of them still have to suffer from great amounts of pain – both physically and psychologically. There is a heightened need for an increase in effective rehabilitation systems in China.

The related technologies of computer graphics and virtual reality (VR) have been thriving for the past thirty years. In the last decade, with the rapid growth of processor speed and storage capacity, VR and related technologies have been widely used in education, manufacturing, pilot training, medicine, entertainment and other areas worldwide. In China, administrative departments, universities and companies have all seen the possibilities and advantages

VR possesses and begun to promote the use of the VR in many areas, including the treatment and rehabilitation of disabled people. However, unlike the wide usage of VR in the U.S. and Europe, its application in China is still at the very beginning stage.

The Qiushi Academy for Advanced Studies (QAAS), Zhejiang University, was founded in 2006. It is an interdisciplinary research center with students and researchers from bio-engineering, computer science, clinical medicine and material science. It is one of China's pioneers in promoting VR technology in rehabilitation. The main research interest of QAAS includes brain-computer interfaces, neural interfaces, neural signal processing and mathematical modeling, human-computer interaction, and ubiquitous computing, among others. They have also performed a large amount of research on implanted neural interfaces. Currently, drawing on the solid work Zhejiang University has done in computer graphics and VR, QAAS is exploring the possibilities of using virtual or mixed reality for physical and psychological treatment and rehabilitation, and to integration of these technologies to build innovative technical aids for the disabled to help restore their daily functions.

Figure 1: Virtual car interior and exterior display system.

Many other universities and research institutes, such as the University of Electronic Science and Technology of China, Huazhong University of Science and Technology, Fudan University, East China Normal University and Tsinghua University have also realized the prospect of VR and mixed reality-based rehabilitation and have begun to investigate the possible usage of the technologies in related applications. The different aspects of VR or mixed reality used for rehabilitation include the application of cognitive treatment, orthopedics, stroke rehabilitation, psychological treatment and brain-computer interface-based training, many of which are still far from clinical or practical application.

Figure 2: Virtual house navigation using brain computer interface.

The National Science Foundation of China provides funding for hundreds of domestic projects and international exchange and cooperation programs. This provides many opportunities for Chinese institutes and universities to participate in international collaborations, not only to fund their research work but to disseminate and globalize their studies as well. During recent years, the connections between China and the rest of the world, including Europe, North America, Japan and Australia, have improved drastically. The overseas funding not only helps to support the institutes and researchers in continuing their work, but also provides a possibility to collaborate with international scientists and research groups standing at the forefront of their fields. Researchers and institutes in China will benefit from the opportunities for future advancement in science and technology.

During the past two years, QAAS, for example, has established broad links with top laboratories in the U.S., Italy, Switzerland and other countries, for research and academic cooperation in joint research proposal writing, as well as student and scholar exchanges. The effective collaboration between QAAS and the leading foreign research institutes not only broadens the view, but advances its research and development of VR or mixed reality-based rehabilitation. Just in the last few years, QAAS has become one of the leading laboratories in China in these related fields.

It is believed that the rehabilitation industry in China will continue to grow at a rapid rate in the near future, as well as the demands for VR or mixed reality-based rehabilitation. However, the relatively high price, unfriendly user interface, heavy weight of the devices and other factors have hindered the prevalence and acceptance of VR or mixed reality based-rehabilitation in China. The aim of researchers and developers will then be to develop more affordable and acceptable rehabilitation systems. Once this happens, the VR or mixed reality-based rehabilitation system will truly pave its way into ordinary families and millions of disabled people will benefit from the technologies. Undoubtedly, the future is bright, but the road is tortuous.

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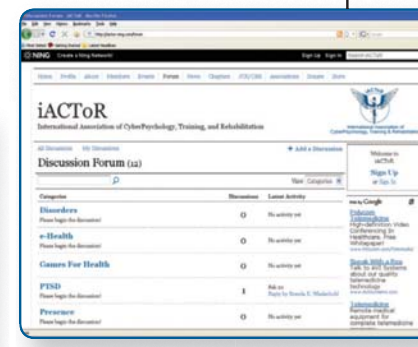

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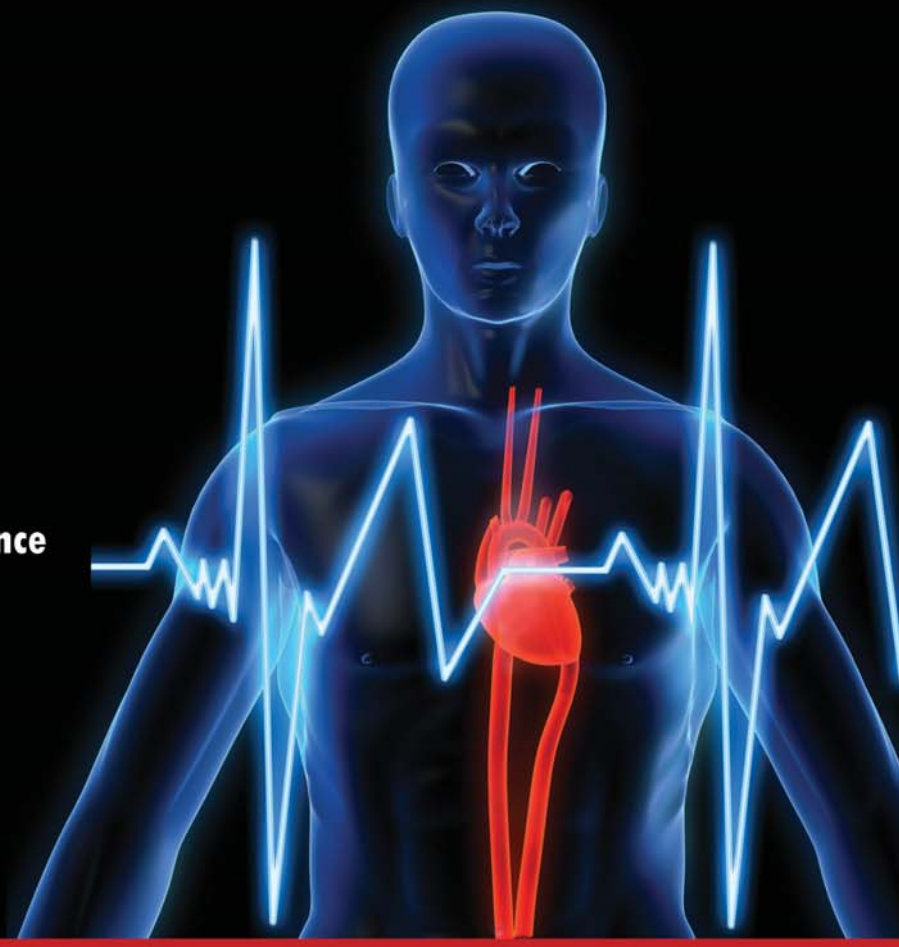

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> **COUNTRY** FOCUS

C&R in China

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Containing one-fifth of the world's population and with a heavy reliance on time-honored traditional treatment methods, modern psychiatric treatment has been slow to expand in China. Now, as the number of specialists and researchers grows, the field of Virtual Reality is catching on and growing at a consistent rate.

Traditional Chinese medicine has been used for thousands of years to treat mental disorders and only fairly recently, in the 1990's and new century, has the force of modern psychiatry as the Western world knows it gathered momentum. Particularly in rural areas and throughout China today, traditional Chinese medicine is the preferred treatment method over Western practices and many psychiatric hospitals have specialists in traditional methods, often resulting in a mixture of traditional and modern treatments chosen by patients.

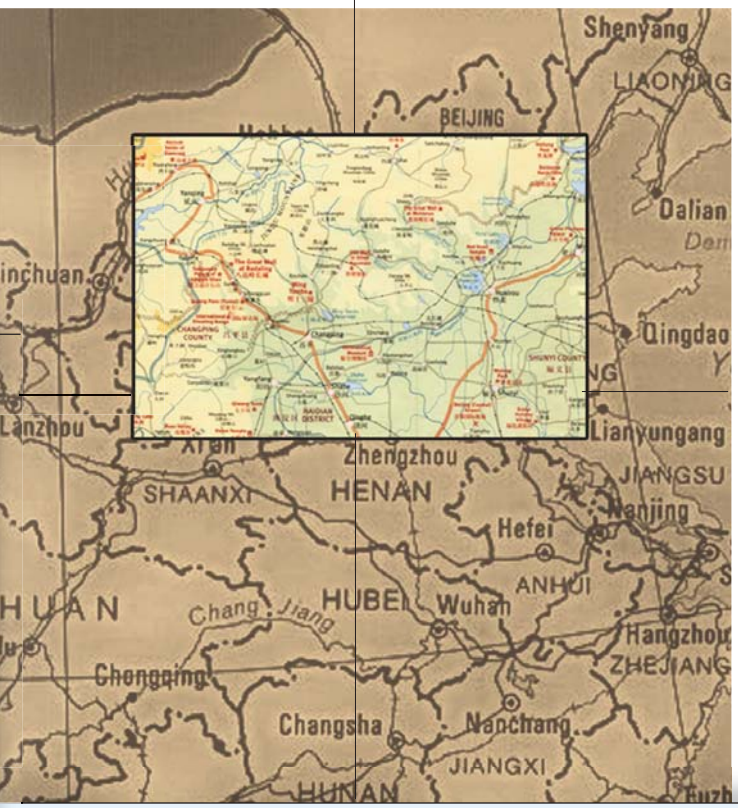
The cultural stigmatization of psychological interventions to treat mental disorders has greatly hindered large-scale advances. To this day, the vast majority of mentally ill patients refuse psychiatric treatment of any kind. This is common to many Asian societies and awareness is slowly increasing as a result of the actions performed by leading organizations and researchers, and healthcare advocates.

Western neuropsychiatry was introduced in China at the end of the 19th century and developed slowly at first. The first Chinese mental illness classification system was not established until 1979 and in 2007 only 17,000 psychologists per capita were licensed to practice – ten percent of the number per capita in most developed countries. Increasing prevalence of mental illness in China has been a worry for decades. In 1950, 2.7% of the population was afflicted with severe mental illness. The number rose to 5.4% in 1970, 11.1% in 1980, and 13.47% in 1990. This is due to rapid socio-cultural changes such as changes in traditional family structures and values, the demands of higher standards of living and the transition from a planned to free market economy. It is important to keep in mind that these statistics are arguably affected by increased acknowledgment of mental health disorders.

China, containing one-fifth of the world's population, has taken measures to tackle the problem of treating disorders affecting such a large and widespread group of people by establishing organizations such as the Society of Psychiatry and the China Association for Mental Health (CAMH) which aims to promote the development of mental health sciences and improve the overall mental health treatment system of the Chinese people.

VR Applications in China

As was discussed previously in Dr. Weidong's article (see page 34), the past thirty years has seen a huge increase in the



Population (Billion)	1.3
Percentage of Urban Population	45.4%
Unemployment Rate	No Official Rate
Life Expectancy (Years)	71.9
Fertility Rate	12.14
Mortality Rate	7.06
Psychiatrists (per 100,000 Inhabitants)	1.26
Suicide Rate (per 100,000)	23
Total Hospitals	19,712
Psychiatric Hospitals	598
Psychiatric Hospital Beds (per 100,000)	7,175
Psychiatric Hospital Inpatients Yearly	742,905
Psychiatric Hospital Patient Yearly Number of Visits	16,305,419
Extrapolated Prevalence to Schizophrenia	1%
Extrapolated Prevalence to Anxiety Disorders	5.6%

applications and development of computer graphics and virtual reality (VR) throughout China. With increased processor speed and storage capacity seeing new developments in the past 10 years, in particular, VR has been increasingly used by diverse companies and universities in fields such as education, manufacturing, entertainment and much more. The Qiushi Academy for Advanced Studies (QAAS) at Zhejiang University, Qingdao University University of Electronic Science and Technology of China, Huazhong University of Science and Technology, Fudan University, East China Normal University and Tsinghua University are at the forefront of universities and research institutes who have recognized the importance of this growing technology and are using it to explore mixed reality-based rehabilitation and other related applications. Specified lab work is also being done to enchance VR applications, such as computer vision research.

Computer Vision Research at Qingdao University

A large amount of exploratory work on computer vision research has recently been conducted in a VR lab at Qingdao University. The head of the group, Professor Weizhong Zhang, directs the project team's research which specifically focuses on computer vision, image processing and pattern recognition, particularly LCD-based camera calibration, reconstruction of 3-D structures based on multiple images and key technologies of photogrammetry based on the use of digital cameras.

Specific work done by the project team includes creating a camera calibration method based on LCD in which a calibration table with circular feature points of different sizes is displayed on an LCD screen. Several images of the calibration table are shot by rotating the camera around the optical axis, using camera parameters based on a calibration algorithm calculated by Dr. Zhang. A new approach to estimate poses of the camera based on multi-view geometry and an algorithm of reconstruction of space points is also being explored. Lastly, a novel method has been implemented to calculate the measurement of 3-D curve structures by using a hand-held digital camera.

Professor Zhang's unique contributions and the work of other experts will help to advance the growing field by improving the quality of VR and encouraging its applications to become more diverse and widely-used throughout China.

Future Improvements

A reliance on traditional Chinese medicine, as well as a reluctance to acknowledge or seek treatment for mental disorders, continues to shape the way mental

The projects which Dr. Zhang's research group undertook include:

State 863 Program' project: Research on Harmony Intelligent CACD System about Footwear Products

NSFC: Research on key technologies about 3-D Flexible measurement Based on Single CCD camera

Natural Science Foundation of Jiangsu Province: Research on the Key Technologies for Flexible Measurement of Feature Data Based on Single CCD Camera

The program's Shandong Provincial Education Department project: The Three-dimensional Measurement System for Foot Type Based on Digital Camera

Qingdao Municipal Science and Technology Commission: Research on the Key Technologies for Feature data for close-range photogrammetry based on digital camera

health treatment is carried out. As well as society's increased acceptance of mental disorders, obstacles to be overcome in the future include a shortage of funds and professionals, factors dependent on the large population and size of the country.

With the established reputation and acceptance of VR treatment in other parts of the world, China benefits greatly by collaborating with foreign research institutes. The National Science Foundation of China works to provide funding for not only domestic projects, but also international and exchange projects. China has recently experienced drastic improvements in its relationships with North America, Japan, Australia and Europe and is beginning to link with top laboratories to work on projects together. By looking to model its growth in advanced technologies for healthcare after other countries throughout the world, and with large steps in the right direction, China is making vast improvements in the field and will continue to do so with further growth and attention.

Sources:

Personal communication with Professor Weizhong Zhang, Chinese Psychiatry Online and Chinese Ministry of Health.

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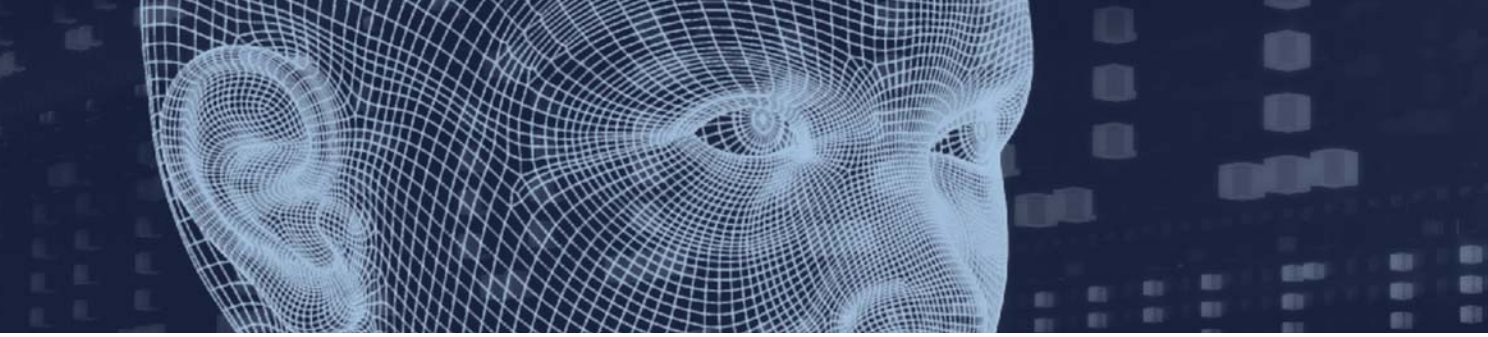

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