The importance of assessing and treating pain was made salient recently when the Joint Commission on Accreditation of Healthcare Organizations (JCAHO, 2000) declared that pain should be regarded as the fifth vital sign. Yet, the literature suggests that problems with undertreatment of pain have only improved modestly. In the 1970s and 1980s, scathing editorials were published by such journals as the *Lancet* and *New England Journal of Medicine* chastising physicians for undertreating this problem (Angell, 1982; Freed, 1976), and this was supported by a number of studies (Anand & Hickey, 1987; Eland & Anderson, 1977; Perry, Heidrich, & Ramos, 1981). Melzack (1990) argued in a *Scientific American* review that the problem persisted, in spite of unwarranted fears about addiction to morphine when used for pain control, and cited compelling evidence for this, such as children frequently receiving major surgery, including limb amputation, with no medication for relief of their postoperative pain.

More recent writings suggest that undertreatment of pain is still a significant problem in a variety of clinical settings (Breitbart et al., 1996; Carr & Thomas, 1997; Ducharme, 2000; Engel, Kartin, & Jensen, 2002; Katz, 2002), including the extremes of age (Banos, Ruiz, & Guardiola, 2001; Feldt & Oh, 2000) and patients with cancer (Frank-Stromborg & Christensen, 2001). The persistence of inadequate treatment is the result of educational factors (e.g., subtherapeutic dosing, lack of documentation of analgesic effect) as well as psychological factors; e.g., pain is subjective, regarded as a “symptom” and not a “disease,” and often cannot be targeted by “magic bullets” (Ducharme, 2000; Jacob & Puntillo, 2000; Resnik, Rehm, & Minard, 2001). Although increased attention to pain assessment and pain management has occurred in recent years, observations that inadequate acute pain management contributes to poor functional outcomes in settings such as burns (Ptacek, Patterson, Montgomery, Ordonez, & Heimbach, 1995)

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David R. Patterson, PhD, ABPH
University of Washington School of Medicine
Harborview Medical Center
325 Ninth Ave., Box 359740
Seattle, WA 98104-2499
and orthopedic trauma (Feldt & Oh, 2000) adds further motivation for designing effective pain therapy. As a result successful treatment of acute pain may pay long-term dividends in other aspects of medical care and outcome.

A salient point of this literature has often been that pain is undertreated through pharmacological means. Opioid analgesics (e.g., morphine/codeine-based drugs) are irrationally withheld from patients. Although undertreatment of pain does occur, and has been a frequent argument in our own writings (Patterson, Doctor, & Sharar, 1999; Patterson & Sharar, 2001), we contend that attention to nonpharmacological alternatives to opioid analgesics for pain control is even more wanting. Few controlled studies on treating acute pain with psychological techniques have been published. Opioid analgesics are indicated for use in a variety of acute pain settings and should be the cornerstone of treatment for the severe pain that accompanies burn injuries (Patterson & Sharar, 2001). However, pharmacologics do not control all pain in all patients (Carrougher & Patterson, 2002; Choiniere, Grenier, & Paquette, 1992; Perry et al., 1981). Further, such drugs do have side effects that can cause complications including nausea, constipation, sedation, itchiness, urinary retention, cognitive impairment, hallucinations, and respiratory depression (Brown, Albrecht, Pettit, McFadden, & Schermer, 2000; Cherny et al., 2001). Further, the use of dose opioids (as often occurs with burn patients) can unduly delay hospital discharge and thus prolong hospital stays, an increasingly pertinent issue in a society conscious of health care costs. Lang et al. (2000) recently demonstrated that hypnosis can decrease both operating room time and the use of expensive sedating/analgesic drugs. Thus, it is essential that more research be performed on psychologically based analgesic techniques, for they can augment pharmacologic analgesia and potentially diminish, or in some cases even eliminate, the need for opioid analgesics.

We contend that our proposed studies offer some innovative, powerful and exciting adjunctive nonpharmacologic approaches to burn pain. To lay a foundation for our proposed studies we will discuss 1) the nature of burn pain and conventional treatments; 2) virtual reality (VR) and distraction; 3) hypnosis; 4) interfacing VR and hypnosis; and 5) psychological and physical outcome of burn injuries.

Burn pain is an extremely unpleasant form of suffering, and can be difficult to treat. It is well known that a burn injury results in one of the most intense types of nociception imaginable (i.e., nociception = afferent neural signaling that forms the basis of pain). However, the pain that accompanies the treatment of a burn injury creates the true challenge, for typical burn care involves a series of aggressive procedures that stimulate nociceptive afferent fibers on a daily basis for days, weeks, or months after the initial injury. In conventional care, a burn injury is assessed as to its depth and treated accordingly. Shallow burns are allowed to heal on their own, and full-thickness thermal injuries typically are excised and covered with a skin graft (Tompkins et al., 1986). In many burn centers, patients with burns of indeterminate depth undergo a series of wound debridements and dressing changes on a daily basis. The pain of a burn patient can be anticipated and treated, to a large degree, based on the phase of care in which he or she is involved. Burn pain is divided into three distinct types (excluding postoperative pain), depending on the clinical setting in which it occurs. “Background pain” is present continuously from the time of the injury until wound healing is complete, and can vary in severity. Wound cleaning, limb mobility exercises,
therapeutic skin stretching, and other medical procedures result in “procedural pain,” which is of high intensity, but limited duration. When pain control interventions fail, patients experience “breakthrough pain.” Each of these three types of burn-related pain has specific treatment strategies associated with them.

As is the case with any type of trauma, burn recovery can be hindered by the presence of acute pain (Chapman, 1985; Chapman & Bonica, 1983; Chien, 1967; Mackersie & Karagianes, 1990). There are a number of physiological responses to pain and a burn injury that can contribute to an adverse stress response. These include 1) sympathetic activation in the release of catecholamines; 2) sympathetic influences on immune function; 3) adrenergic stimulation of bacterial growth; 4) norepinephrine regulation of myelopoiesis; and 5) release of glucocorticoids. Remarkably, burn pain has been reported to influence posthospitalization emotional recovery, more than the size of the burn, the length of hospitalization, or even the patient’s preinjury mental health. Ptacek and colleagues (Ptacek et al., 1995) reported that pain scores were associated more strongly than any other predictor variable with one-month distress and quality of life scores. A more recent study suggested that this relationship held at one-year posthospitalization (Martin-Herz, Patterson, Ptacek, Finch, & Heimbach, 1998). Future studies will likely substantiate the practical utility and importance of adequate burn pain treatment.

Opioid analgesics or morphine-based drugs form the cornerstone of burn pain treatment (Patterson et al., 1999; Patterson & Sharar, 2001). Such drugs as morphine, oxycodone, hydromorphone, and synthetic forms of morphine such as fentanyl are often used with success (Patterson & Sharar, 2001). Nonopioid drugs such as nonsteroidal antiinflammatories (NSAIDS), topical anesthetics, anxiolytics (tranquilizers such as lorazepam), and anesthetics (propofol, ketamine, and nitrous oxide), are some of the pharmacologic agents used to supplement opioid analgesics (Goldstein, 2001; Moskal & Matsen III, 2001; Patterson et al., 1999; Patterson & Sharar, 2001; Truelove, Dworkin, Burgess, & Bonica, 2001; Villaret & Weymuller Jr., 2001). However, it has been repeatedly demonstrated that pharmacologic agents alone do not provide adequate control of all burn pain and, in some instances, can present serious health drawbacks (Choiniere et al., 1992; Ohrbach, Patterson, Carrougher, & Gibran, 1998; Perry et al., 1981; Ptacek, Patterson, & Doctor, 2000). Because of this, nonpharmacological interventions are often a critical component of a burn pain treatment regimen. Psychological interventions can work in concert with and facilitate the effects of pharmacologic analgesics (Patterson & Ptacek, 1997), reduce the need for such analgesics (Wakeman & Kaplan, 1978) and occasionally can eliminate the need for any pain medication at all (Finer & Nylen, 1961; Ohrbach et al., 1998). It is therefore valuable to study psychological treatments as adjuncts or even substitutions for pharmacologic pain treatments. Unfortunately, randomized controlled studies of psychological treatments for burns and other forms of acute pain are few in number and studies discussing innovative psychological interventions of this nature are even more rare.

As a result of the strong psychological component to pain perception, supplemental use of non-pharmacologic analgesic techniques can be effective; e.g., mental imagery (Patterson, Everett, Burns, & Marvin, 1992), watching a video (Miller, Hickman, & Lemasters, 1992), biofeedback (Knudson-Cooper, 1981), enhanced control (Tarnowski, McGrath, Calhoun, & Drabman, 1987), parental participation (Foertsch, O’Hara, Stoddard, & Kealey, 1996), and hypnosis (Bernstein, 1965; Patterson, Ptacek,
Carrougher, & Sharar, 1997; Patterson, Questad, & Boltwood, 1987). Cognitive-behavioral strategies have been found to be useful for a wide variety of pain etiologies, and significantly reduced pain reports in 85% of 47 studies (meta-analysis; Fernandez & Turk, 1989). Distraction is a cognitive-behavioral intervention particularly useful with burn pain (Miller et al., 1992; Patterson, 1995). Immersive VR is an attention-grabbing illusory reality created in the mind of the VR user/patient. Researchers argue that VR may be an unusually effective distraction (Hoffman, Doctor, Patterson, Carrougher, & Furness, 2000).

The logic for how VR analgesia works is as follows. Attention involves the selection of relevant information. Each human has a finite amount of attention that can be divided between tasks (Kahneman, 1973; Shiffrin & Schneider, 1977). Immersive VR (involving a head mounted display that blocks the user’s view of the real world) gives patients the illusion of “going into” the 3-D computer-generated environment. The strength of the illusion of presence is thought to reflect the amount of attention drawn into the virtual world (Hoffman, 1998). Because it is by nature a highly attention-grabbing experience, VR may prove to be an especially effective psychological pain control technique, reducing the amount of attention available to process pain. Less attention to pain can result in a reduction in perceived pain intensity and unpleasantness, and can also reduce the amount of time patients spend thinking about their pain.

Although still new and innovative, VR is showing promise in other clinical applications besides pain control. For example, VR exposure therapy (a form of cognitive-behavioral clinical therapy) is proving to be an effective medium for treating anxiety disorders such as Posttraumatic Stress Disorder (PTSD) from September 11th (Difede & Hoffman, 2002); PTSD in Vietnam veterans (Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001); fear of spiders (Carlin, Hoffman, & Weghorst, 1997; Garcia-Palacios, Hoffman, Carlin, Furness, & Botella-Arbona, 2002); fear of heights (Rothbaum et al., 1995); fear of flying (Rothbaum, Hodges, Smith, Lee, & Price, 2000); and claustrophobia (Botella, Banos, Villa, Perpina, & Garcia-Palacios, 2000; Botella et al., 1998).

We recently reviewed the literature on hypnosis and pain control and our work has been published in *Psychological Bulletin* (Patterson & Jensen, 2003). Enthusiasm for hypnosis is on the upswing and recent notable articles published in the *Lancet* and *Science* demonstrate that hypnosis can reduce operating room costs (Lang et al., 2000) and that hypnotic analgesia can show demonstrable brain function changes in neuroimaging studies (Rainville, Duncan, Price, Carrier, & Bushnell, 1997). Research on hypnotic analgesia is built on a rich bed of laboratory pain research. Trait theories have demonstrated that hypnotic analgesia is related to hypnotizability that can be measured with scales (Freeman, Barabasz, Barabasz, & Warner, 2000; Hilgard & Hilgard, 1975; Miller, Barabasz, & Barabasz, 1991). Sociocognitive models demonstrate that hypnotic analgesia is associated with contextual variables, instructional set, compliance, and expectancy (Kirsch & Lynn, 1995; Spanos & Katsanis, 1989; Spanos, Kennedy, & Gwynn, 1984; N.P. Spanos, Perlini, Patrick, Bell, & Gwynn, 1990). The neodissociative theorists of hypnosis contend that consciousness is split off during hypnosis and hypnotic analgesia (Hilgard & Hilgard, 1975) and the dissociated control theory of hypnosis (Bowers, 1992) stresses the automaticity of behavior that occurs under hypnosis. Theoretical laboratory research has been buttressed by a number of studies that demonstrated physiological changes with hypnotic analgesia. A number of studies...
have demonstrated alterations in sympathetic responding (De Pascalis & Perrone, 1996); evoked potentials (Arendt-Nielsen, Zachariae, & Bjerring, 1990; Barabasz & Lonsdale, 1983; Crawford et al., 1998); EEG recordings (Crawford, 1990); patterns of brain activity (blood flow mapping; Price & Barrell, 2000; Rainville et al., 1997); and possible inhibition at the spinal cord level (Kiernan, Dane, Phillips, & Price, 1995).

Our *Psychological Bulletin* review (Patterson & Jensen, 2003) indicated that anecdotal reports of hypnotic pain relief have been published for virtually every type of pain imaginable. We were able to find 17 randomized controlled studies on the use of hypnosis for acute pain (invasive medical procedures, burn pain, labor pain, and bone marrow aspiration). With respect to chronic pain, we were able to find 12 studies including that from headaches, cancer, fibromyalgia, and mixed etiologies. We concluded that the evidence for hypnotic analgesia for both acute and chronic clinical pain is strong and that hypnotizability is related to outcome in most studies when this variable is measured. Hypnosis appears to be particularly well suited for acute pain such as that repeatedly experienced by patients with burns.

Some of the primary gaps in the clinical hypnosis literature have to do with strengthening the effect, size of treatment, and generalizing its impact to greater number of patients. Hypnotic training and interventions that reach low to moderate hypnotizable subjects are particularly needed. Specifically, patients who score low on tests of hypnotizability tend to show less clinical benefit from such interventions. However, several have argued that there are means to improve receptivity in such patients (Holroyd, 1996). An important step in this line of research will be either to increase the response of low hypnotizables or find alternative psychological interventions to which they will respond.

The interface between VR and hypnosis represents a logical and practical progression of the theories underlying both of these modalities. In several of our previous publications, we have proposed attention and distraction as the underlying mechanisms behind VR-based analgesia. Our reasoning has been that pain requires conscious attention to process. To the degree that attention can be drawn away from pain through immersion in the VR environment, patients will think less about pain and report less pain intensity and bothersomeness (Hoffman, Doctor et al., 2000; Hoffman, Patterson, & Carrougher, 2000). This explanation is certainly consistent with the gate control model of pain (Melzack & Wall, 1973). Melzack and Wall (1973) proposed that even though pain is largely modulated through a “gate” located in the dorsal root of the spinal cord, higher level cognitive-attentional processes have the potential to modulate and even override modulation at the gate level. For example, the patient’s attention to their pain, beliefs about pain, expectations, and attributions are thought to inhibit or modify the nociceptive signals, and also to limit the negative emotional impact of pain (Turk, Meichenbaum, & Genest, 1983).

“Presence” describes the degree to which patients have a sense of “going inside” the 3-D computer-generated virtual environment, as if it is a place they visit. Consistent with the line of reasoning proposed, patients’ self-ratings of presence in the VR environment have been associated with the amount of analgesia demonstrated both by normal subjects receiving experimental pain (Hoffman, Sharar, Patterson, Everett, Ciol, Richards, & Coda, in press) and by patients experiencing clinical pain (Hoffman, Doctor et al., 2000; Hoffman, Patterson, et al., 2000).
Attentional processes are also regarded as central to hypnosis and hypnotic analgesia. Attention is often described as a critically important step in a hypnotic induction (Crawford, 1989, 1991; Crawford, 1994; Crawford, Brown, & Moon, 1993). Hypnosis is counter-indicated in patients that have brain damage that interferes with attentional processes. Gruezelier (1990) has presented a neurophysiological model of hypnosis in which language and attentional processes that reside largely in the left hemisphere (in right hand dominant people) initially become activated. As a hypnotic induction continues, the control that the left hemisphere has over the right hemisphere is attenuated. Not only is attention thought to be essential to basic hypnosis, Crawford, Gur, Skolnick, Gur, and Benson (1993) have demonstrated attentional processes to be central to hypnotic analgesia. Specifically, Crawford has used regional cerebral blood flow to map brain processing during hypnosis and hypnotic analgesia. Crawford’s mapping demonstrates initial greater activity in the areas of the brain that reflect an increase attentional effort during hypnotic analgesia but the executive control system remains active during the induction and also during analgesia.

With attentional mechanisms as a common denominator, the uniquely attention-grabbing qualities of VR and the suggestion inherent in hypnosis, the potential for a synergistic effect between these modalities is significant. Subjects may show apprehension about immersing themselves in a virtual world, and hypnotic suggestion may help them relax in this respect. Hypnotic suggestion can also be used to deepen a willing subject’s sense of presence in the virtual world. Conversely, VR may be instrumental in facilitating hypnotic suggestion. Once a subject’s attention has been captured in the virtual environment, they may be only a short cognitive step away from being more receptive to suggestion. This potential interactive effect, as promising as it may be, remains untested in both laboratory and clinical situations.

As a result of the preceding literature review, we are proposing several studies. The proposed project will focus on alleviating severe pain in hospitalized burn patients using novel combinations of virtual reality and psychological interventions (hypnosis), as well as offering a comprehensive longitudinal follow-up study on the psychological outcome of burn patients. Four studies are proposed. Study One will test a newly developed approach to delivering hypnosis through immersive reality technology. Study Two will compare high technology and low technology virtual reality distraction delivered through a “water friendly” delivery system. Both Studies One and Two will be random controlled studies conducted with hospitalized burn patients undergoing dressing changes. Study Three will investigate the interaction between hypnotic suggestibility and virtual reality in controlling thermally induced experimental pain in college students, again using a randomized controlled design. Study Four will be the most comprehensive longitudinal study on the psychological and physical outcome of adult burn survivors conducted to date. The proposed project is significant in that it seeks to test the efficacy of interventions to increase pain control and decrease stress in a trauma population, better understand the mechanism of action of these interventions, and better understand the long term consequences of improved pain control. The innovative techniques proposed should be applicable to patients suffering pain from multiple other etiologies.
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