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Analgesic Effects of Posthypnotic Suggestions and Virtual Reality Distraction on Thermal Pain

D. R. Patterson
University of Washington School of Medicine

H. G. Hoffman and A. Garcia Palacios
University of Washington

M. J. Jensen
University of Washington School of Medicine

The individual and combined effects of posthypnotic suggestion (PHS) and virtual reality distraction (VRD) on experimentally induced thermal pain were examined using a 2 × 2, between-groups design. After receiving baseline thermal pain, each participant received hypnosis or no hypnosis, followed by VRD or no VRD during another pain stimulus. Consistent with the hypothesis that hypnosis and VRD work via different mechanisms, results show that posthypnotic analgesia was moderated by hypnotizability but VRD analgesia was not. The impact of PHSs for analgesia was specific to high hypnotizables, whereas VRD was effective independent of hypnotizability. Results also show a nonsignificant but predicted pattern for high hypnotizables: Audio hypnosis combined with VRD reduced worst pain 22% more and pain unpleasantness 25% more than did VRD alone. Theoretical and clinical implications are discussed.

Keywords: virtual reality, hypnosis, analgesia, distraction, pain control

Virtual reality (VR) and hypnosis are two compelling nonpharmacological approaches for reducing acute pain. Acute pain is that which results from tissue damage or stimuli that would cause tissue damage if it were to continue (Melzack & Wall, 1973; Williams, 1999). Acute pain is also usually short-lived, can be severe, and is typically associated with medical procedures such as surgery, wound care, dental care, or childbirth (Patterson & Sharar, 2001). Although acute pain can often be reduced with opioid analgesics (e.g., morphine and its derivatives), even the most powerful analgesics do not control acute pain in every patient (Melzack, 1990). For example, most patients with severe burn injuries report severe-to-excruciating pain during wound care or debridement, even when they have received strong drugs for pain (Perry, Heidrich, & Ramos, 1981; Ptacek, Patterson, & Doctor, 2000). Further, opioid analgesics have a number of negative side effects and can potentially increase the length of hospitalization and other medical costs (Cherny et al., 2001; Lang et al., 2000).

A number of controlled studies have demonstrated that both virtual reality distraction (VRD; Hoffman, Doctor, Patterson, Carrougher, & Furness, 2000; Hoffman et al., 2001; Hoffman, Sharar, et al., 2004) and posthypnotic suggestions (PHSs) for analgesia (Montgomery, DuHamel, & Redd, 2000; Patterson & Jensen, 2003) are effective nonpharmacological treatments for acute pain. An exciting feature of both VRD and PHS is that these interventions can be studied in controlled laboratory conditions, and the resulting knowledge can be used to better understand the mechanisms of effects or to improve clinical applications of these treatments (Hilgard & Hilgard, 1975; Hoffman, Richards, et al., 2004; Hoffman, Sharar, et al., 2004; Rainville, Duncan, Price, Carrier, & Bushnell, 1997).

The essence of immersive VR is the participant's illusion of going inside the 3-D computer-generated virtual world, a perceptual phenomenon known as *VR presence*. A primary mechanism hypothesized for the efficacy of VRD analgesia is distraction. Pain requires conscious attention to process. VR ideally lures attention into the computer-generated world, leaving less attention available to process incoming nociceptive signals. Consistent with this hypothesis, in one recent study some participants (those who received high-tech VRD) used VR hardware (VR helmet, headphones, and head-tracking system) designed to elicit a strong illusion of VR presence. Others (those who received low-tech VRD) used VR hardware designed to elicit a less compelling sensation of VR presence (see-through VR glasses, no headphones, no head tracking). Healthy volunteers who received high-tech VRD during a brief thermal pain stimulus reported a stronger illusion of presence in VR and more reduction in pain than did study participants who received low-tech VRD. These findings were interpreted to suggest that the participant's illusion of going into the virtual world had an impact on the amount of distraction, reducing the amount

D. R. Patterson and M. J. Jensen, Department of Rehabilitation Medicine, University of Washington School of Medicine; H. G. Hoffman and A. Garcia Palacios, Human Interface Technology Lab, University of Washington.

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Correspondence concerning this article should be addressed to David R. Patterson, Department of Rehabilitation Medicine, University of Washington School of Medicine, 325 9th Avenue, Box 359740, Seattle, WA 98104-9740. E-mail: davepatt@u.washington.edu

of attentional resources available to process the conscious sensation of pain (Hoffman, Sharar, et al., 2004). These and other results summarized by Hoffman, Sharar, et al. (2004) appear to implicate, at least indirectly, an attentional mechanism for VRD analgesia.

Although there is not yet consensus concerning how hypnosis reduces pain experience, one fairly consistent finding is that hypnotizability plays a role in hypnotic pain control (Hilgard & Hilgard, 1975; Patterson & Jensen, 2003), particularly in experimental studies of induced pain. Hypnotizability is an empirical quantification of a person's response to hypnotic suggestions. A frequent finding reported on the use of hypnosis for experimentally induced pain (e.g., cold-pressor or thermally induced) is the relationship between hypnotizability and the amount of pain reduction; participants scoring at the high range of hypnotizability tend to show substantial reductions of pain in response to hypnotic suggestions, whereas those scoring low on hypnotizability measures tend to show minimal reductions that are equivalent to placebo (Hilgard & Hilgard, 1975; McGlashan, Evans, & Orne, 1969). In a series of studies, Miller and Bowers (1986, 1993) demonstrated that hypnotizability influenced the amount of posthypnotic analgesia but did not have an effect on nonhypnotic pain control interventions. High hypnotizables showed a greater reduction in cold-pressor pain than did low hypnotizables, but high hypnotizables and low hypnotizables did not differ in response to stress inoculation training. Miller and Bowers concluded from these results that the hypnotic and nonhypnotic forms of pain control involved different mechanisms; specifically, high hypnotizables invoked the "effortless" strategies for pain control postulated in the dissociated control theory of hypnosis (Miller & Bowers, 1986, 1993; see Kihlstrom, 1998, for a review). The experimental design used by Miller and Bowers offers a useful paradigm to determine whether VRD and posthypnotic pain control techniques involve different mechanisms.

Certainly, attentional mechanisms figure prominently into both hypnosis and VRD. However, in VRD, participants are presented with multisensory, external stimuli designed to lure their attention away from pain. They are not encouraged to engage in any cognitive strategies to reduce their pain. In the case of hypnosis, participants are encouraged to engage in cognitive processes that are specifically designed to reduce pain intensity. Social–cognitive theorists might use expectation and contextual demands to maximize participant response to imagery and relaxation (Lynn & Rhue, 1991). Dissociated control theorists, as discussed above, posit that hypnotic suggestions allow patients to engage effortlessly in pain control strategies. In terms of hypnotic analgesia, different patients or participants may invoke one or both of these strategies on the basis of personality and situational factors (Patterson, 2001). Both theories, however, would agree that with hypnosis, participants must rely on their own imagination, coping strategies, and/or attentional capacities in some manner to reduce their experience of pain. In the case of VRD, however, there is far less of a demand for participants to engage in any internal cognitive processes. The literature has yet to demonstrate that such attentional processes toward pain differ between hypnosis and VRD. Also, to our knowledge, there have not been any investigations exploring whether hypnosis can potentiate VRD analgesia or vice versa.

We hypothesized that, consistent with Miller and Bowers's work (1986, 1993), the amount of pain reduction from PHSs would be moderated by hypnotizability. In contrast, on the basis of our contention that VRD is nonhypnotic and primarily relies on a distraction mechanism, we predicted that VRD would not be moderated by hypnotizability. The present study was designed to elucidate the mechanisms underlying these two approaches and to determine whether hypnotic suggestions could in some way potentiate VRD.

Method

Participants

The participants in this study were 103 undergraduate psychology student volunteers (40 men and 63 women) from the University of Washington. Their ages ranged from 18 to 40 years. The mean age was 19 years, and all but 4 of the participants were 20 years or younger. We obtained both written and verbal informed consent using a protocol approved by the University of Washington's Human Subjects Review Committee. Students received course credit for their participation.

Measures

The primary outcome measure was a rating of worst pain intensity. Secondary outcome measures included ratings of (a) pain unpleasantness, (b) time spent thinking about pain during the stimulus, and (c) amount of "fun" experienced during the study procedures. To assess these domains, we instructed participants as follows after each pain stimulus: "Please indicate how you felt during the past 30-second pain stimulus by making a mark anywhere on the line. Your response doesn't have to be a whole number." They were then asked to make a mark on a 10-cm graphic rating scale (GRS) that provided numerical and verbal descriptor cues. The specific instructions and verbal descriptors associated with each GRS used in the study are described below.

Primary outcome variable: Worst pain intensity. We assessed worst pain intensity by giving participants instructions to "Rate your WORST PAIN during the most recent pain stimulus (pain intensity)." Although participants were instructed to make a mark on the 10-cm line to indicate the severity of worst pain, they were also allowed to indicate their pain intensity by marking one of the numbers (0–10). The ranges of numbers associated with each of the verbal descriptors on the GRS (0 for *no pain*, 1–4 for *mild pain*, 5–6 for *moderate pain*, 7–9 for *severe pain*, and 10 for *excruciating pain*) were selected on the basis of research that suggests that they represent reasonable cutoffs for mild, moderate, and severe pain ratings, on average (Jensen, Smith, Ehde, & Robinson, 2001; Mendoza et al., 2004; Serlin, Mendoza, Nakamura, Edwards, & Cleeland, 1995). GRSs of pain intensity have been shown to be valid through their strong associations with other measures of pain intensity, as well as through their ability to detect treatment effects (Jensen & Karoly, 2001).

Secondary outcome variables: Pain unpleasantness, time spent thinking about pain, and amount of fun during the procedures. Although worst pain intensity was the primary outcome variable, we also wished to examine the effects of VRD and hypnosis on three secondary outcome domains: pain unpleasantness, the amount of fun experienced, and time spent thinking about pain during the painful stimulus. Pain unpleasantness was assessed, given evidence that pain unpleasantness is conceptually distinct, and can under certain circumstances also be statistically distinct, from the domain of pain intensity (Gamsa, 1994; Gracely, McGrath, & Dubner, 1978). Although the rationale for assessing amount of fun experienced during an experimental pain stimulus may not be readily apparent, preliminary data suggest that VRD can be associated with increased levels of fun even during painful stimuli (Hoffman, Sharar, et al., 2004) and burn wound debridement (Hoffman, Patterson, et al., 2004). A rating of time spent thinking about pain was included as a measure of a cognitive component of pain, a domain that is underassessed in pain outcome studies

(Jensen, 2003). Previous studies indicate that VRD can have an impact on this pain domain and that the GRS used in this study is sensitive to these effects (Hoffman, Sharar, et al., 2004; Hoffman, Patterson, et al., 2004).

GRSs similar to those used to assess worst pain intensity were used to assess pain unpleasantness, fun (if any) associated with the painful procedures, and time spent thinking about pain. The verbal descriptors associated with the pain unpleasantness rating were *not unpleasant at all*, *mildly unpleasant*, *moderately unpleasant*, *severely unpleasant*, and *excruciatingly unpleasant*. The verbal descriptors associated with the fun rating were *no fun at all*, *mildly fun*, *moderately fun*, *pretty fun*, and *extremely fun*. Finally, the verbal descriptors associated with the time spent thinking about pain rating were *none of the time*, *some of the time*, *half of the time*, *most of the time*, and *all of the time*.

Hypnotizability. General hypnotizability was assessed using the Stanford Hypnotic Clinical Scale (Hilgard & Hilgard, 1975). This scale consists of a standard induction followed by five suggestions designed to elicit specific classic hypnotic responses, including hand lowering, coughing or throat clearing, amnesia, age regression, and having a suggested dream. The Stanford Hypnotic Clinical Scale has demonstrated its validity through positive association with other measures of hypnotizability (Hilgard & Hilgard, 1975). For purposes of analyses examining the impact of hypnotizability on response to the interventions, we divided participants into three groups, with low being 0–1 ($n = 21$), medium being 2–3 ($n = 56$), and high being 4–5 ($n = 26$) on the basis of Hilgard and Hilgard's (1975) classification system (for normative tables).

Experimental Thermal Pain Model

Controlled thermal pain stimulation was applied using a commercially available Peltier thermode (Medoc Advanced Medical Systems U.S., Durham, NC; http://www.medoc-web.com) designed to provide noxious heat, noxious cold, and nonnoxious thermal stimulation over a range of 0 °C to 50 °C (Becerra et al., 1999; Coghill et al., 1994; Edwards, Fillingim, & Ness, 2003; Kwan, Crawley, Mikulis, & Davis, 2000; Talbot et al., 1991). The highest temperature used in the present study was 48 °C (only 9 participants chose to go this high). The noxious heat stimulus temperature was individually determined for each participant immediately prior to the study phase, using the psychophysical method of ascending levels as follows. A 30-s heat stimulus (always 44 °C for the first stimulus, which all participants found tolerable) was delivered through a thermode attached to the dorsal surface of the right foot, and after each stimulus, the participant was asked to rate the stimulus using a 0–10 graphic rating scale. With the participant's permission, the temperature for the next stimulus was increased by 1 °C (e.g., to 45 °C) and then rated, and this sequence was continued until the participant reported a stimulus that was painful but tolerable. To avoid excessive pain, stimulus increments of less than 1 °C were sometimes administered at the researcher's discretion as participants approached severe pain. In general, an attempt was made to achieve either a pain unpleasantness or worst pain rating of 7 out of 10, but a number of participants chose to stop before achieving a pain rating of 7. Individualized stimulus temperatures that were rated as painful but tolerable ranged from 44 °C to 48 °C ($M = 46.4$ °C) and were associated with baseline ratings of worst pain ranging from 2 to 10 out of 10 ($M = 6.7$; 97% of participants rated baseline pain between 5 and 8). The noxious baseline temperature selected (30-s thermal stimulus without distraction) also served as the pain stimulus temperature during a second thermal stimulus.

Conditions

Hypnosis condition: Audiotaped induction and PHS for analgesia. Participants who were assigned to receive audio PHSs via headphones were asked to close their eyes and were given a hypnotic induction while being asked to imagine themselves drifting through a snowy canyon as the audiotaped hypnotic induction progressed. An audiotape of D. R. Patterson's voice instructed participants to become increasingly comfortable and relaxed as they counted from 1 to 10. At the bottom of the canyon, upon reaching 10, the participants were offered the following suggestions for analgesia:

> Your entire body is warm and relaxed with one exception. Your right foot is relaxed, and you notice a sense of coolness and numbness starting in your toes. It is as if you are dipping your toes and foot into some nice, cool water. You immerse your foot in that water up to the ankle. Just like in a cool river. Just like that river you saw at the bottom of the canyon. As you move your foot and toes down into the cool river, you get a sense of tingling and coolness in your toes, moving up into your foot, all the way up to your ankle. Your foot is becoming very cool and pleasantly numb now, up to the ankle.
>
> Just noticing your right foot's sense of coolness and numbness. And meanwhile, interestingly, the rest of your body is getting warmer and warmer, deeply relaxed. Your foot is becoming cooler and number. And you may even get the sense of your foot being detached from your body in a very comfortable way.
>
> Whatever your experience of your foot, you do notice how comfortable it is, and how it feels however it wants. So your foot may be very cool or very numb, or maybe it feels like it is no longer a part of your body. Maybe it feels all of these things. As long as it feels comfortable, whatever it experiences is fine. As your foot experiences one thing, the rest of your body and mind are drifting through this very pleasant place. You may get the sense that you are indeed drifting. Just noticing things that you can see and notice how pleasant you feel. You continue to feel pleasant as you remain in this very comfortable place.
>
> Now, as you remain in this interesting place, drifting along, with your right foot becoming even more comfortable. In a little while we will be turning on the heat machine to your right foot again. At the time we turn on the heat machine, you will continue to feel the sensation of comfort or whatever else you presently experience in your right foot. In fact, when we turn on the heat machine attached to your right foot, your right foot will feel even more comfortable than it does now. Turning on the heat machine will be a signal for your foot to become cool, numb and comfortable.

The participants were instructed to imagine themselves returning up the canyon and to become increasingly alert as the audiotaped voice counted from 10 to 1.

VRD condition: VRD analgesia. Study participants assigned to the VRD condition were administered VRD using a Dell 530 workstation with dual 2 GHz CPUs, 2 GB of RAM, an NVIDIA GeForce 6800 Ultra video card (Santa Clara, CA; http://www.nvidia.com), the Windows 2000 operating system, and SnowWorld (http://www.vrpain.com), created using MultiGen-Paradigm Vega VR-world-building software (MultiGen-Paradigm, 2000; http://www.multigen.com). A Polhemus Fastrak position tracking system (Colchester, VT; http://www.polhemus.com) was used to monitor the position of the user's head. When in VR, participants followed a predetermined path, "gliding" through an icy 3-D virtual canyon (SnowWorld). Participants aimed with their gaze direction (head orientation) and pushed a keyboard button to shoot virtual snowballs at virtual snowmen, igloos, robots, and penguins (see Figure 1). This VRD condition included head tracking (e.g., participants saw the sky when they looked up, a canyon wall when they looked to the left, and a river when they looked down); sound effects (e.g., a splash when a snowball hit the river); and animated green, blue, or white colored explosions. Participants in the VRD condition wore an NVIS nVisor SX high-resolution helmet (Reston, VA; http://www.nvisinc.com) that completely blocked their view of the real world.

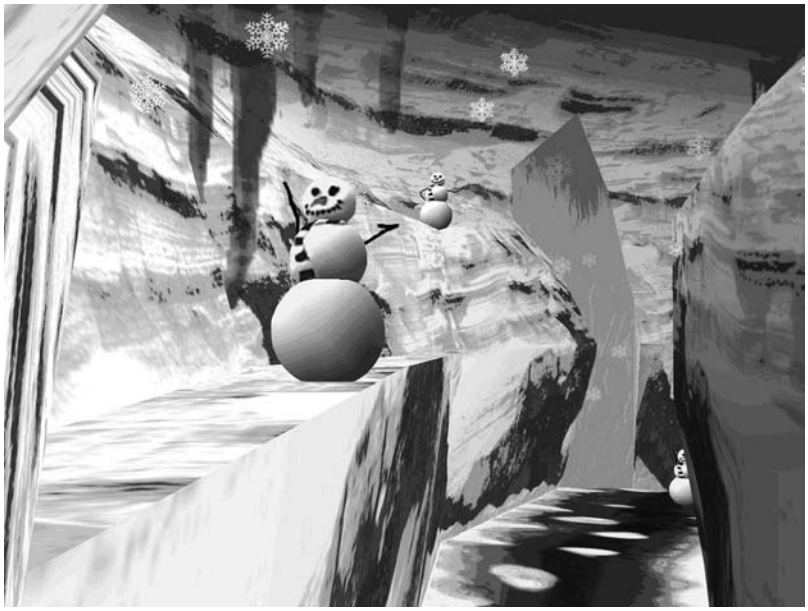

Figure 1. A snapshot of what patients see when interacting with SnowWorld. Image by Stephen Dagadakis. Copyright 2006 by Hunter Hoffman. Reprinted with permission.

Study Design and Procedures

The study participants were randomly assigned to one of the following four mutually exclusive experimental conditions: No PHS + No VRD (control), No PHS + Yes VRD, Yes PHS + No VRD, or Yes PHS + Yes VRD. The research assistant administering the outcome ratings was not present during the intervention procedures and was therefore blind to experimental condition. After the baseline pain stimuli and ratings and prior to the painful stimulation, all participants listened to either a PHS or a control tape (Phase 1), and all participants were given the 30-s painful stimulation again either during VRD or without VRD (Phase 2).

Audiotape prior to painful stimulation (Phase 1). Participants assigned to the PHS condition (i.e., the Yes PHS + No VRD group and the Yes PHS + Yes VRD group) received the following instructions prior to the audio posthypnotic analgesia intervention:

> You will now get a brief intermission during which you will listen to a relaxation audiotape. You will imagine yourself floating slowly down an icy canyon and you'll count each number from one to ten as you pass them on the way down. At the bottom, you will hear suggestions that you feel relaxed and comfortable. You will then be asked to imagine yourself floating back out via the icy canyon, back to where you started. There will be no pain stimuli during the intermission. After the intermission, you will receive one additional 30-second thermal pain stimulus and will then rate how painful you found that stimulus.

They then listened to the PHS audiotape. Suggestions for posthypnotic analgesia were provided as described above.

The participants who were not assigned to the PHS condition (i.e., the No PHS + No VRD group and the No PHS + Yes VRD group) received the following instructions during Phase 1:

> You will now get a brief intermission during which you will listen to a relaxation audio tape called *Relaxing Sounds From Nature*. Please close your eyes, make yourself comfortable, and listen to the tape until it stops in about 25 minutes. There will be no pain stimuli during the intermission. After the intermission, you will receive one additional 30-second thermal pain stimulus and will then rate how painful you found that stimulus.

They then listened to the control audiotape *Relaxing Sounds From Nature*.

Painful stimulation (Phase 2). During Phase 2, all participants received 30 s of painful stimulation under one of the two conditions: VRD or no VRD. Participants assigned to receive VRD during Phase 2 donned the VR helmet and experienced the VR technology for a total of 2 min. This included a 1.5-min acclimatization period in VR, after which participants received their second 30-s pain stimulus while still in VR. Participants assigned to receive no VRD did not wear a helmet or go into VR. After the Phase 2 thermal pain stimulus, a research assistant not involved with the pain stimulation or VR treatment entered the room and administered subjective pain ratings using the series of 10-point graphic rating scales described above.

Poststimulation Measures

After the 30 s of painful stimulation and after the pain ratings were administered, participants' hypnotizability was assessed in another room by a second (different) trained research assistant who was also blind to treatment condition.

Data Analysis

Percentage change in the primary (worst pain intensity) and one of the secondary (pain unpleasantness) outcome ratings and absolute change in the other two secondary outcome ratings (time spent thinking about pain and fun) from the initial thermal pain testing to the second thermal pain testing were used as the dependent variables in this study. Percentage change rather than absolute change was used for the two pain ratings (intensity and unpleasantness) because research has indicated that baseline pain has a biasing impact on the meaning of change scores (Farrar, Young, LaMoreaux, Werth, & Poole, 2001; Jensen, Chen, & Brugger, 2003); this research has consistently demonstrated that higher initial pain levels require larger decreases than do lower initial levels to have the same meaning to the person experiencing pain. Moreover, recent research has also indi-

cated that the use of percentage change reduces, and can even eliminate, this biasing impact of initial pain levels (Hanley et al., 2006). Percentage pain intensity change scores also have the advantage of having specific meanings; a 30% or greater decrease in pain intensity is generally regarded as being clinically meaningful to patients (Farrar et al., 2001). Absolute change in time spent thinking about pain and fun were used as the dependent variables for the analyses involving these domains because (a) there are no data to indicate that initial or baseline levels of these variables influence the meaning associated with absolute change and (b) there are no data that indicate that specific percentage changes in these variables are associated with specific meanings.

Following computation of percentage change and absolute scores in the outcome variables, a series of four univariate analyses of variance (ANOVAs) were computed to test the effects of PHS and VRD on the outcome variables. In these analyses, PHS condition (Yes, No), VRD condition (Yes, No), and hypnotizability scores (high = 4–5; low–medium = 0–3) were the independent variables.

Results

Primary Outcome: Worst Pain Intensity

An ANOVA with the percentage change in worst pain intensity as the dependent variable indicated a nonsignificant trend for a PHS Condition × Hypnotizability interaction, $F(2, 94) = 3.04$, $p = .052$, as well as a significant main effect for VRD condition, $F(1, 94) = 14.58$, $p < .001$. No other significant effects or trends were found.

In order to help interpret the significant VRD main effect and the marginal PHS Condition × Hypnotizability interaction, we computed the average percentage decrease in the worst pain intensity ratings for participants in each treatment condition separately for low, medium, and high hypnotizables (see Table 1). Concerning the VRD main effect, consistent and substantial decreases in pain were seen among all participants who received VRD, regardless of hypnotizability (overall percentage decrease in worst pain for VRD participants: $M = 29.0\%$, $SD = 24.6\%$), and a relatively low percentage decrease among those who did not receive VRD was also seen (overall percentage decrease: $M = 6.3\%$, $SD = 25.0\%$). Concerning the interaction, Table 1 shows that PHS had relatively very little effect, if any, on worst pain among low and moderate hypnotizables. However, for high hypnotizables, among both those who received VRD and those who did not receive VRD, PHS was associated with a greater decrease in pain. Across both VRD conditions among high hypnotizables,

Table 1
Change Scores for Low, Medium, and High Hypnotizability Participants in Each Treatment Condition

Hypnotizability classification	VRD Yes				VRD No			
	PHS Yes		PHS No		PHS Yes		PHS No	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Worst pain intensity								
Low	16%	32%	27%	21%	0%	13%	11%	28%
Medium	32%	29%	30%	19%	8%	30%	2%	17%
High	35%	28%	25%	24%	33%	31%	−8%	30%
Pain unpleasantness								
Low	16%	29%	30%	18%	9%	15%	−8%	21%
Medium	37%	40%	37%	15%	21%	23%	6%	20%
High	44%	27%	33%	18%	36%	34%	11%	16%
Time spent thinking about pain								
Low	4.10	2.84	4.00	1.00	0.77	1.42	0.75	0.96
Medium	4.09	2.38	5.00	1.96	1.54	1.62	0.89	2.21
High	4.56	2.35	5.64	1.97	4.00	1.41	1.63	0.48
Fun ratings								
Low	−3.16	3.30	−5.00	2.12	−0.13	2.05	0.50	1.00
Medium	−3.84	2.30	−3.63	2.01	−0.79	1.25	−0.53	1.64
High	−4.11	1.45	−5.03	2.47	−0.80	0.84	−0.53	0.55

Note. A larger positive percentage change in worst pain intensity and pain unpleasantness indicates a larger decrease in pain intensity and unpleasantness during the treatment session. Similarly, a larger positive change score in time spent thinking about pain indicates a larger decrease in time spent thinking about pain. In contrast, a larger negative change score in fun ratings indicates a larger increase in these ratings (i.e., more fun) during the treatment session. Sample sizes for low hypnotizability participant conditions: VRD Yes/PHS Yes = 5; VRD Yes/PHS No = 5; VRD No/PHS Yes = 6; VRD No/PHS No = 5. Sample sizes for medium hypnotizability participant conditions: VRD Yes/PHS Yes = 11; VRD Yes/PHS No = 14; VRD No/PHS Yes = 14; VRD No/PHS No = 17. Sample sizes for high hypnotizability participant conditions: VRD Yes/PHS Yes = 10; VRD Yes/PHS No = 7; VRD No/PHS Yes = 5; VRD No/PHS No = 4, VRD = virtual reality distraction; PHS = posthypnotic suggestion.

participants who received PHS reported a greater decrease in pain, on average (M = 34.3%, SD = 27.7%), than those who did not receive PHS (M = 12.7%, SD = 29.6%). Results also show a nonsignificant but predicted pattern for high hypnotizables: audio PHSs for analgesia combined with VRD reduced pain more (35% reduction) than did VRD alone (25% reduction).

Secondary Outcome Variables

The ANOVA results for percentage change in pain unpleasantness indicated a significant VRD × PHS Condition interaction, $F(1, 94) = 4.55$, $p < .05$, as well as significant main effects for VRD condition, $F(1, 94) = 15.20$, $p < .001$, and hypnotizability, $F(2, 94) = 4.14$, $p < .05$, and a nonsignificant trend for a main effect for PHS condition, $F(1, 94) = 3.89$, $p = .052$. The interaction can be explained by the fact that the PHS condition appeared to have a greater effect on pain unpleasantness among participants who did not receive VRD. In these participants, the mean percentage decrease in pain unpleasantness was 4.2% (SD = 19.5%) for those who did not receive PHS and 22.7% (SD = 25.1%) for those who did. Participants who received VRD reported large decreases in pain unpleasantness regardless of PHS condition: Among those who did not receive PHS the mean decrease was 34.4% (SD = 15.9%); among those who did receive PHS the mean decrease was 35.8% (SD = 33.6%). The PHS main effect trend can be explained by the larger percentage decrease in pain unpleasantness (M = 29.2%, SD = 30.1%) among participants who listened to the PHS tape than among those who listened to the control tape (M = 18.7%, SD = 23.4%). The VRD condition main effect can be explained by a larger percentage decrease in pain unpleasantness among those who participated in the VRD condition (M = 35.1%, SD = 26.1%) compared with those who did not (M = 13.1%, SD = 24.0%).

Finally, the hypnotizability main effect can be explained by the relatively large decreases in pain unpleasantness ratings among those participants with high hypnotizability (M = 34.5%, SD = 26.0%), by the less, yet still substantial, decreases among participants with medium hypnotizability (M = 23.5%, SD = 27.7%), and by the relatively low decreases in pain unpleasantness among participants with low hypnotizability (M = 11.7%, SD = 23.6%) across treatment conditions. Overall, these findings suggest that VRD is generally effective for reducing pain unpleasantness, regardless of hypnotizability, that VRD appears to be more effective than PHS, and that PHS appears to exert its effects primarily when VRD is not present. Average percentage change scores for pain unpleasantness for participants in all four experimental conditions are presented in Table 1, separately for low, medium, and high hypnotizables, and clarify the effects of VRD and PHS in greater detail. These results also show a nonsignificant but predicted pattern for high hypnotizables: Audio hypnosis combined with VRD reduced pain unpleasantness more (44% reduction) than did VRD alone (33% reduction).

The ANOVA examining the effects on time spent thinking about pain showed a nonsignificant trend for a PHS × VRD Condition interaction, $F(1, 94) = 3.73$, $p = .057$, and a significant hypnotizability main effect, $F(2, 94) = 3.98$, $p < .05$. A significant VRD main effect that emerged, $F(1, 94) = 47.99$, $p < .001$, should not be interpreted, given the interaction that was found that included this variable. The interaction can be explained by the fact that, across the three hypnotizability groups, participants who received VRD but not PHS reported larger decreases in time spent thinking about pain (M = 4.98, SD = 1.85; see Table 1) compared with those who received both VRD and PHS (M = 4.27, SD = 2.37), PHS alone (M = 1.85, SD = 1.87), or neither (M = 1.03, SD = 1.83). The significant main effect for hypnotizability can be explained by a larger decrease in time spent thinking about pain among those with high hypnotizability scores (M = 4.28, SD = 2.22) compared with those with medium (M = 2.72, SD = 2.65) and low hypnotizability scores (M = 2.41, SD = 2.34), regardless of treatment condition.

The ANOVA examining the effects of treatment group on the fun ratings indicated a significant main effect for VRD condition, $F(1, 94) = 85.52$, $p < .001$. No other significant main or interaction effects emerged. This main effect can be explained by a larger increase in the rating of fun among those who received VRD (M = 4.04, SD = 2.20) than among those who did not receive VRD (M = 0.48, SD = 1.38; see Table 1 for a presentation of the mean changes in fun ratings during the intervention conditions relative to baseline, broken down by treatment condition and hypnotizability classification).

Discussion

The beneficial impact of PHSs for pain relief was primarily limited to participants with high hypnotizability scores, a finding that is consistent with what Miller and Bowers (1986, 1993) reported when hypnosis was compared with stress inoculation training. Consistent with our contention that VRD is nonhypnotic and primarily works by distracting attention, the amount of pain reduction from VRD was independent of how participants scored on a hypnotizability scale. The results suggest that hypnosis and VRD involve different mechanisms. They also replicate the earlier results that hypnotic analgesia is more than simply a placebo (demonstrated by an absence of an interaction between treatment condition and hypnotizability; Hilgard & Hilgard, 1975; McGlashan et al., 1969).

Our findings are also consistent with the notion that the cognitive processes involved in distraction during VR differ from those involved in hypnosis. Miller and Bowers (1993) found that hypnotic analgesia did not impair performance on a cognitively demanding secondary task (i.e., hypnosis did not reduce cognitive resources). In contrast, to illustrate how participants process information in VR, Hoffman, Garcia-Palacios, Kapa, Beecher, and Sharar (2003) asked healthy volunteers to listen to a string of numbers and indicate every time they heard three odd numbers in a row while in VR and without VR. Performance on the divided attention task (accuracy in identifying the consecutive odd numbers) dropped significantly while a participant was in VR compared with those in the control condition, and participants also estimated that the amount of time they were able to attend to the task of monitoring the numbers was significantly higher when they were not in VR. On the basis of the results of the current study, the ability of participants to become absorbed in the VR environment and to become distracted from pain does not appear to be related to hypnotizability.

A second goal of the present study was to explore whether hypnotic suggestions could in some way potentiate pain reduction from VRD. Hypnosis and VRD appeared to reduce worst pain

intensity and pain unpleasantness more effectively when the two treatments were combined, but only among high hypnotizables. The magnitude of this combined effect for high hypnotizables can be seen in Table 1, where PHS appeared to be associated with greater reductions in worst pain and in pain unpleasantness than did VRD alone, but only among high hypnotizables. For high hypnotizables, audio hypnosis combined with VRD reduced worst pain and pain unpleasantness more than did VRD alone. This result is encouraging in that it suggests that combining treatments may minimize acute pain, at least among individuals with high hypnotizability. However, this conclusion must be considered preliminary and in need of verification in additional research with larger sample sizes, given the lack of statistically significant three-way interactions that emerged in the analyses.

There were a number of limitations to our study. First, the five-item Stanford Hypnotic Clinical Scale was used to assess hypnotizability in this study. It is possible that the psychometrically stronger 12-item Stanford Hypnotizability Scale (form A or C; Hilgard & Hilgard, 1975) would have resulted in more reliable hypnotizability scores. Also, we should note that although pain reduction from posthypnotic analgesia suggestions showed a large enough effect size to warrant reporting, the magnitude of these effects was not particularly robust, especially relative to the VRD condition. This was likely because the hypnosis treatment relied on PHSs for its effects (i.e., participants were not undergoing hypnosis when they received the thermal pain stimulus), whereas the VRD occurred at the time of thermal pain stimulation. We did this in order to determine whether PHSs for analgesia could potentiate VRD (which it appeared to do only for high hypnotizables). However, because the hypnosis was presented prior to the onset of pain stimuli, it was not possible to compare directly the relative analgesic impacts of hypnosis versus VRD. It is likely that a hypnotic intervention (during hypnosis) would prove to be more powerful than PHSs for reducing perceived pain.

The findings of this study suggest important avenues for future research. First, it would be of interest to compare the relative effectiveness of a hypnotic intervention that is provided during painful stimuli versus VRD. Having patients in a hypnotic state or in a context of hypnosis in which they are directly applying hypnotic pain control strategies during the painful stimulus would serve as a better comparison with VRD strategies. It would also be interesting to assess the effects of hypnosis when offered as a strategy to facilitate the effects of VR, in addition to (or instead of) suggestions for reduced pain. For example, we expect that, especially among high hypnotizables, participants who are given the suggestion that they will become deeply immersed in the virtual world and will feel less pain would show an even larger beneficial response to VRD than was observed in the participants in the current study (especially when they go into VRD during hypnosis instead of after PHSs).

We also suggest that our findings have some practical utility. The experimental literature and, more recently, the clinical pain literature, has indicated that participants and patients who score high on the tests of hypnotizability tend to show a better response to hypnotically based pain control than do low hypnotizables (Montgomery et al., 2000; Patterson & Jensen, 2003). Our findings provide additional support of the notion that hypnotic analgesia treatment may be best reserved for patients that have at least some hypnotic talent (although Montgomery et al., 2000, have pointed out that this represents the majority of patients). In contrast, VRD appears to be a useful pain control intervention to which even patients low in hypnotizability, and therefore a greater number of patients overall, can respond. It would follow that VRD may be particularly useful as an alternative for patients who struggle with hypnosis, if not as a first line nonpharmacological approach in the management of acute procedural pain.

References

Becerra, L. R., Breiter, H. C., Stojanovic, M., Fishman, S., Edwards, A., Comite, A. R., et al. (1999). Human brain activation under controlled thermal stimulation and habituation to noxious heat: An fMRI study. *Magnetic Resonance in Medicine, 41,* 1044–1057.

Cherny, N., Ripamonti, C., Pereira, J., Davis, C., Fallon, M., McQuay, H., et al. (2001). Strategies to manage the adverse effects of oral morphine: An evidence-based report. *Journal of Clinical Oncology, 19,* 2542–2554.

Coghill, R., Talbot, J., Evans, A., Meyer, E., Gjedde, A., Bushnell, M., et al. (1994). Distributed processing of pain and vibration by the human in the human brain. *Journal of Neuroscience, 14,* 4095–4108.

Edwards, R., Fillingim, R., & Ness, T. (2003). Age-related differences in endogenous pain modulation: A comparison of diffuse noxious inhibitory controls in healthy older and younger adults. *Pain, 101,* 155–165.

Farrar, J. T., Young, J. P., Jr., LaMoreaux, L., Werth, J. L., & Poole, R. M. (2001). Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain, 94*(2), 149–158.

Gamsa, A. (1994). The role of psychological factors in chronic pain. I. A half century study. *Pain, 57,* 5–15.

Gracely, R. H., McGrath, P., & Dubner, R. (1978). Ratio scales of sensory and affective verbal pain descriptors. *Pain, 5,* 5–18.

Hanley, M. A., Jensen, M. P., Ehde, D. M., Robinson, L. R., Cardenas, D. D., Turner, J. A., et al. (2006). Clinically significant change in pain intensity ratings in persons with spinal cord injury or amputation. *Clinical Journal of Pain, 22,* 25–31.

Hilgard, E. R., & Hilgard, J. R. (1975). *Hypnosis in the relief of pain.* Los Altos, CA: Kaufmann.

Hoffman, H. G., Doctor, J. N., Patterson, D. R., Carrougher, G. J., & Furness, T. A., III. (2000). Use of virtual reality as an adjunctive treatment of adolescent burn pain during wound care: A case report. *Pain, 85,* 305–309.

Hoffman, H. G., Garcia-Palacios, A., Kapa, V. A., Beecher, J., & Sharar, S. R. (2003). Immersive virtual reality for reducing experimental ischemic pain. *International Journal of Human-Computer Interaction, 15,* 469–486.

Hoffman, H. G., Patterson, D. R., Carrougher, G. J., Nakamura, D., Moore, M., Garcia-Palacios, A., et al. (2001). The effectiveness of virtual reality pain control with multiple treatments of longer durations: A case study. *International Journal of Human-Computer Interaction, 13,* 1–12.

Hoffman, H. G., Patterson, D. R., Magula, J., Carrougher, G., Zeltzer, K., & Sharar, S. (2004). Water-friendly virtual reality pain control during wound care. *Journal of Clinical Psychology, 60,* 189–195.

Hoffman, H., Richards, T., Coda, B., Bills, A., Blough, D., Richards, A., et al. (2004). Modulation of thermal pain-related brain activity with virtual reality: Evidence from fMRI. *Neuroreport, 15,* 1245–1248.

Hoffman, H., Sharar, S., Coda, B., Everett, J., Ciol, M., Richards, T., et al. (2004). Manipulating presence influences the magnitude of virtual reality analgesia. *Pain, 111,* 162–168.

Jensen, M. (2003). The validity and reliability of pain measures in adults with cancer. *Journal of Pain, 4,* 2–21.

Jensen, M. P., Chen, C., & Brugger, A. M. (2003). Interpretation of Visual Analog Scale ratings and change scores: A reanalysis of two clinical trials of postoperative pain. *Journal of Pain, 4,* 407–414.

Jensen, M., & Karoly, P. (2001). Self-report scales and procedures for

assessing pain in adults. In D. Turk & R. Melzack (Eds.), *Handbook of pain assessment* (2nd ed., pp. 15–34). New York: Guilford Publications.

Jensen, M., Smith, D., Ehde, D., & Robinson, L. (2001). Pain site and the effects of amputation pain: Further clarification of the meaning of mild, moderate, and severe pain. *Pain, 91,* 317–322.

Kihlstrom, J. F. (1998). Attributions, awareness, and dissociation: In memoriam Kenneth S. Bowers, 1937–1996. *American Journal of Clinical Hypnosis, 40,* 194–205.

Kwan, C., Crawley, A., Mikulis, D., & Davis, K. (2000). An fMRI study of the anterior cingulate cortex and surrounding medial wall activations evoked by noxious cutaneous heat and cold stimuli. *Pain, 85,* 359–374.

Lang, E. V., Benotsch, E. G., Fick, L. J., Lutgendorf, S., Berbaum, M. L., Berbaum, K. S., et al. (2000). Adjunctive non-pharmacological analgesia for invasive medical procedures: A randomised trial. *Lancet, 355,* 1486–1490.

Lynn, S. J., & Rhue, J. W. (1991). *Theories of hypnosis: Current models and perspectives.* New York: Guilford Press.

McGlashan, T. H., Evans, F. J., & Orne, M. T. (1969). The nature of hypnotic analgesia and placebo response to experimental pain. *Psychosomatic Medicine, 31,* 227–246.

Melzack, R. (1990). The tragedy of needless pain. *Scientific American, 262,* 27–33.

Melzack, R., & Wall, P. (1973). *The challenge of pain.* New York: Basic Books.

Mendoza, T., Chen, C., Brugger, A., Hubbard, R., Snabes, M., Palmer, S., et al. (2004). Lessons learned from a multiple-dose post-operative analgesic trial. *Pain, 109,* 103–109.

Miller, M., & Bowers, K. (1986). Hypnotic analgesia and stress inoculation in the reduction of pain. *Journal of Abnormal Psychology, 95,* 6–14.

Miller, M. E., & Bowers, K. S. (1993). Hypnotic analgesia: Dissociated experience or dissociated control? *Journal of Abnormal Psychology, 102,* 29–38.

Montgomery, G. H., DuHamel, K. N., & Redd, W. H. (2000). A meta-analysis of hypnotically induced analgesia: How effective is hypnosis? *International Journal of Clinical and Experimental Hypnosis, 48,* 138–153.

MultiGen-Paradigm. (2001). MultiGen-Paradigm Vega Classic 3.7. [Computer software]. Santa Clara, CA: Author.

Patterson, D. R. (2001). Is hypnotic pain control effortless or effortful? *Hypnos, 28,* 132–134.

Patterson, D. R., & Jensen, M. (2003). Hypnosis and clinical pain. *Psychological Bulletin, 129,* 495–521.

Patterson, D., & Sharar, S. (2001). Burn pain. In J. Loeser (Ed.), *Bonica's management of pain* (3rd ed., pp. 780–787). Philadelphia: Lippincot, Williams & Wilkins.

Perry, S., Heidrich, G., & Ramos, E. (1981). Assessment of pain by burn patients. *Journal of Burn Care and Rehabilitation, 2,* 322–326.

Ptacek, J., Patterson, D., & Doctor, J. (2000). Describing and predicting the nature of procedural pain after thermal injuries: Implications for research. *Journal of Burn Care and Rehabilitation, 21,* 318–326.

Rainville, P., Duncan, G. H., Price, D. D., Carrier, B., & Bushnell, M. C. (1997, August 15). Pain affect encoded in human anterior cingulate but not somatosensory cortex. *Science, 277,* 968–971.

Serlin, R., Mendoza, T., Nakamura, Y., Edwards, K., & Cleeland, C. (1995). When is cancer pain mild, moderate or severe? Grading pain severity by its interference with function. *Pain, 61,* 277–284.

Talbot, J. D., Marett, S., Evans, A. C., Meyer, E., Bushnell, M. C., & Duncan, G. H. (1991, March 15). Multiple representations of pain in the human cortex. *Science, 251,* 1355–1358.

Williams, D. A. (1999). Acute pain (with special emphasis on painful medical procedures). In R. J. Gatchel & D. C. Turk (Eds.), *Psychosocial factors in pain: Critical perspectives* (pp. 151–163). New York: Guilford.

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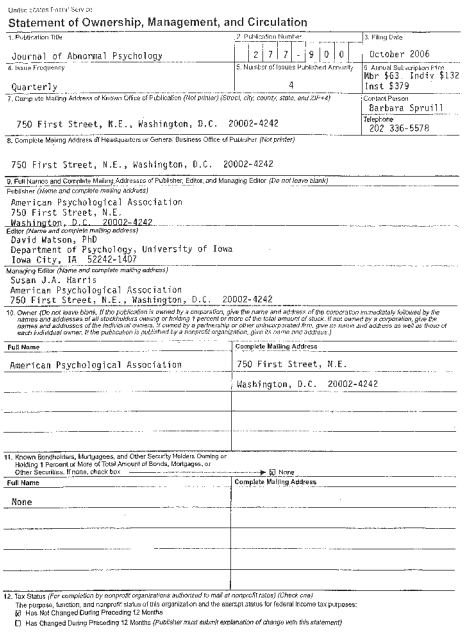

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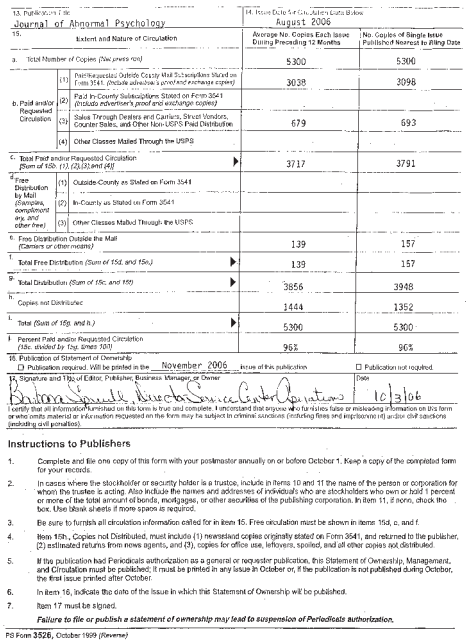

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