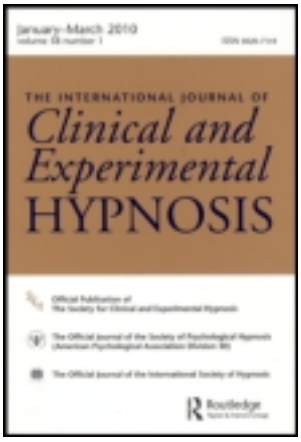

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EFFECTS OF HYPNOTIC ANALGESIA AND VIRTUAL REALITY ON THE REDUCTION OF EXPERIMENTAL PAIN AMONG HIGH AND LOW HYPNOTIZABLES

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Abstract: This research compared a no-treatment control condition and 3 experimentally induced pain treatment conditions: (a) virtual reality distraction (VRD), (b) hypnotic analgesia (HA), and (c) HA + VRD in relieving finger-pressure pain. After receiving baseline pain stimulus, each participant received hypnosis or no hypnosis, followed by VRD or no VRD during another pain stimulus. The data analysis indicated that, overall, all 3 treatments were more effective compared to the control group, irrespective of whether it involved hypnotic analgesia, virtual reality distraction, or both (hypnosis and virtual reality). Nevertheless, the participants responded differently to the pain treatment, depending on the hypnotizability level. High hypnotizables reported hypnotic analgesia, but low hypnotizables did not show hypnotic analgesia. VR distraction reduced pain regardless of hypnotizability.

The efficacy of hypnosis as a pain management technique has long been documented in the literature (Jensen & Patterson, 2006; Montgomery, DuHamel, & Redd, 2000; Patterson & Jensen, 2003; Patterson, Questad, & Boltwood, 1987). Recently, the effect of hypnosis on pain relief has been assessed for various clinical conditions such as chronic pain management in children with cancer (Tomé-Pires & Miró, 2012), reducing the postoperative pain and the side effects of anesthesia (Lew, Kravits, Garberoglio, & Williams, 2011), reducing birth-related pain and anxiety (Abbasi, Ghazi, Barlow-Harrison, Sheikhvatan, &

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Mohammadyari, 2009; Dufresne et al., 2009), and chronic back pain (Elkins, Jensen, & Patterson, 2007; Tan, Fukui, Jensen, Thornby, & Waldman, 2009). Nash and Tasso (2010) drew attention to two randomized clinical trials that also showed the efficacy of hypnosis in reducing pain among women with metastatic breast cancer (Butler et al., 2009) and among women with temporomandibular disorder (Abrahamsen, Zachariae, & Svensson, 2009). Following a review of the specialized literature regarding the efficacy of hypnotic analgesia in the chronic and acute pain in adults, Stoelb, Molton, Jensen, and Patterson (2009) reached the following conclusions: (a) hypnotic analgesia is more effective compared to no-treatment/standard care; (b) hypnosis is frequently more effective in reducing pain compared to nonhypnotic interventions (i.e., education, supportive therapy); and (c) the efficacy of hypnosis in pain relief is similar to the efficacy of the interventions containing hypnotic elements, such as progressive muscle relaxation.

A meta-analysis carried out by Montgomery and colleagues (2000) revealed that the average participant treated with hypnosis achieved more pain reduction than 75% of individuals in standard treatment and no-treatment control conditions. This review included both clinical and experimental pain studies.

One new hypothesis is that, by adding a virtual reality (VR) component to hypnosis, we might have the ability to increase the intervention efficacy for the individuals with low hypnotizability as well (Thompson, Steffert, Steed, & Gruzelier, 2010). Indeed, technological development has allowed for new approaches as well as combining nonpharmaceutical remedies for pain relief in support of the people undergoing various painful medical procedures. For example, clinical trials and laboratory research have demonstrated that virtual reality, hypnosis, as well as their combined version, virtual reality hypnosis, are among the complementary methods effective in reducing chronic and acute pain (Hoffman et al., 2011; Hoffman, Patterson, & Carrougher, 2000; Hoffman et al., 2004; Oneal, Patterson, Soltani, Teeley, & Jensen, 2008; Patterson, Hoffman, Garcia-Palacios, & Jensen, 2006; Patterson, Jensen, Wiechman, & Sharar, 2010; Patterson, Tininenko, Schmidt, & Sharar, 2004; Patterson, Wiechman, Jensen, & Sharar, 2006).

Virtual reality hypnosis (VRH) should be distinguished from virtual reality distraction (VRD), however. VRH makes use of immersive virtual reality to facilitate a hypnotic induction, while VRD uses the same technology to distract a patient during pain (but does not in itself involve hypnosis). Immersive virtual reality (VR) in general is a computer-based technology involving the use of two distinct concepts: the *sense of presence* in the virtual environment and the concept of *immersion* (Slater & Wilbur, 1997). Thus, the concept of presence in VR has been defined *as the illusion of being in the three-dimensional environment* generated by the computer. Immersion is a measurable

objective description of the sensory input that a private system offers to a participant.

Many studies not involving hypnosis have supported the efficacy of distraction through virtual reality as a means of reducing the pain associated with invasive medical procedures (Hoffman et al., 2011; Hoffman, Patterson, Carrougher, & Sharar, 2001; Hoffman et al., 2004). Many of the early studies on this topic have used SnowWorld, a three-dimensional computer-generated world where patients "float" slowly through a snowy three-dimensional canyon and throw snowballs at snowmen and other virtual objects. Hoffman et al. (2011) carried out a summary of the clinical trials and laboratory research aimed at analgesia through virtual reality distraction. Attention distraction through virtual reality led to a reduction by 35% to 50% in the pain associated with wound care procedures in burn patients.

As mentioned above, VRH is a method of combining hypnosis with virtual reality; this method has been used in clinical studies both for exploring acute pain relief (Patterson et al., 2010; Patterson et al., 2004; Patterson, Wiechman, et al., 2006) and for the problems associated with chronic pain (Oneal et al., 2008).

Patterson and colleagues developed the technique of using virtual reality as a means of hypnotic induction (Milling, 2008). The inductive scenario begins with the three-dimensional image of an ice canyon from the top of which the patients float until they reach the bottom while receiving relaxation suggestions. The studies using virtual reality hypnosis induction have been case-series designs involving limits such as the absence of a randomized distribution and a control group and/or small sample sizes. Another variation of virtual reality hypnosis is to use conventional audiotape suggestions with no VR and afterward let participants use VR distraction (throwing snowballs). Using this approach, Patterson, Hoffman, et al. (2006) conducted a laboratory study on 103 healthy volunteer students for whom they assessed the individual and combined effects of VR distraction and the audio suggestions (not during virtual reality) of posthypnotic analgesia on acute pain (i.e., brief thermal pain stimulations). More precisely, in the Patterson et al.'s study, with eyes closed, participants listened to audio suggestions for relaxation to explore whether hypnotic suggestions can intensify the VRD. The hypnotizability level was established as low, average, or high, and the participants were randomly distributed into four experimental conditions: audiotaped hypnosis with posthypnotic suggestions for pain relief; VR distraction (VRD); combined VR distraction and audiotaped hypnotic suggestions; and a control condition with none of the treatments. After the painful stimulation at baseline, the experimental procedure involved two stages. In the first stage, all participants either listened to an audiotape with posthypnotic suggestions or to a control audiotape; in the second stage, there was the stimulation of the thermal pain with or without VRD. The

results indicated the fact that posthypnotic suggestions were effective only for the high hypnotizable participants, while VRD reduced pain independently of the hypnotizability level. Combining audio hypnosis with VRD reduced the pain and unpleasantness more than VRD alone.

Overview of The Current Study

Based on Patterson, Hoffman, et al. (2006), we wanted (a) to check the stability and generalizability of the results regarding hypnosis and VR in pain control and (b) to explore whether these results generalize to other pain paradigms, besides thermal pain. VRD and hypnosis can be combined in various ways. The aim of this study was to verify the individual and combined effect of VR distraction and hypnotic suggestions delivered continuously while participants were experiencing the pain stimulus in experimental conditions. The virtual environment (SnowWorld) was not used to induce hypnosis; instead, classical "audio only" induction was used, and later, the VR distraction was applied after the subject was under hypnosis. In other words, after participants were hypnotized by audiotape, they put on a VR helmet and threw virtual snowballs at snowmen and other objects in the virtual world (VR distraction). Our research involved comparing the no-treatment control condition and three experimentally induced pain treatment conditions: (a) virtual reality distraction (VRD), (b) hypnotic analgesia (HA), and (c) HA + VRD in relieving finger-pressure pain.

The specific objectives of our research were the following: (a) to examine the effects of the various treatments on the amount of pain reduction, depending on the hypnotizability level of the participants, while they were experiencing concomitantly the painful stimulus; and (b) to examine hypnotic suggestions for their effect in amplifying the sense of presence in the virtual reality. In most of the previous studies involving VR and hypnosis, participants mainly scored in the medium range of hypnotizability (Patterson, 2010). We separated screened participants and limited inclusion to those with high versus low hypnotizability scores in order to verify if there was a differential analgesic effect between the two categories of participants and thus to explore the impact of the hypnotizability on the experimental conditions.

Method

Participants

The participants in this study were 120 students selected from almost 500 volunteers from two major Romanian universities. The selection was based on the results obtained in the Harvard Group

Scale of Hypnotic Susceptibility, Form A (Shor & Orne, 1962). The high hypnotizable participants (60 women) had scores between 8 and 12 ($M = 9.32$, $SD = 1.20$), while the low hypnotizable participants (60 women) had scores from 0 to 4 ($M = 2.78$, $SD = 1.22$). The students signed the informed consent and received credits for their participation (Enea & Dafinoiu, 2011). All subjects were females because most students who study psychology are women.

Apparatus

A Forgione-Barber Strain Gauge Pain Stimulator device (Forgione & Barber, 1971), used in various studies involving experimental pain induction (Milling, 2009; Milling, Kirsch, Meunier, & Levine, 2002; Milling, Shores, Coursen, Menario, & Farris, 2007) was employed for pain stimulation. Using this device requires the participant to position the left-hand index finger under a 231 g bar producing a pressure of 2.041 g force at the contact point.

Instruments

Harvard Group Scale of Hypnotic Susceptibility. The participants' hypnotizability level was assessed by means of the Romanian version of the Harvard Group Scale of Hypnotic Susceptibility, Form A (David, Montgomery, & Holdevici, 2003). The suggestions (in order) in the HGSHS:A are the following: head falling forward, eye closure, hand lowering, arm immobilization, finger lock, arm rigidity, hands moving together, communication inhibition, hallucination, eye catalepsy, posthypnotic suggestion, and posthypnotic amnesia. The scale has three dimensions (McConkey, Sheehan, & Law, 1980), described as consisting of cognitive items (e.g., a hypnotic hallucination of a fly), ideomotor items (e.g., suggestion that one's hands will move together), and challenge items (e.g., suggestions that one's arm is so stiff that it cannot bend, no matter how hard one tries).

Pain intensity rating. To assess the pain intensity during a minute, the numeric rating scale (NRS) was applied every 20 seconds, on an 11-point scale ranging from 0 (*no pain at all*) to 10 (*pain as intense as one can imagine*). There are three pain assessment scales, which are valid and reliable and adequate to be used in clinical and experimental research (McDowell, 2006): visual analogue scales (VAS), verbal descriptor scales (VDS), and numeric rating scales (NRS). A numeric rating scale was used for this study, since the participants were unable to mark the pain intensity on a visual analogue scale. After positioning the index finger into the pain-stimulation device, the computer played a recording through which, for one minute, the participants were required to report, every 20 seconds, a number from 0 to 10 that reflected pain intensity. Later, the sum of these ratings was computed, and it could vary from

0 to 30. Pain intensity was assessed twice: once at baseline and once during the intervention (postintensity).

Pain unpleasantness rating. Research has shown that pain intensity and unpleasantness are conceptually distinct (Gamsa, 1994; Gracely, McGrath, & Dubner, 1978; Patterson, Hoffman, et al., 2006); therefore, pain unpleasantness was assessed on a 6-point verbal descriptor scale (VDS): no pain, mild pain, moderate pain, severe pain, very severe pain, and worst possible pain. The scores 0, 2, 4, 6, 8, and 10 were assigned to each of the verbal descriptors, with *none* scored as 0 to *worst pain* scored as 10. Pain unpleasantness was assessed twice, once at baseline and once after the intervention.

Presence in virtual reality. To measure the sense of presence in the virtual reality, we used a 36-item version of the Presence and Reality Judgment Questionnaire (Baños et al., 2000). Each item can be scored from 0 (*not at all*) to 10 (*absolutely*) and we computed both a total score and separate scores for the five factors of the questionnaire. These are the following: Emotional Involvement, Reality Judgment and Presence, Interaction and External Correspondence, Influence of Formal Variables in Reality Judgment and Sense of Presence, and Satisfaction with the Experience. Cronbach's alpha was .88 for the version we used in the current study.

Procedure

The participants were screened with the HGSHS:A and distributed based on their hypnotizability level into low hypnotizable and high hypnotizable groups, were contacted by telephone and asked to participate in the research. The 120 participants selected were randomly distributed into the four experimental conditions: Group 1 = No Hypnosis, No VR Distraction; Group 2 = No Hypnosis, Yes VR Distraction; Group 3 = Yes Hypnosis, No VR distraction; and Group 4 = Yes Hypnosis, Yes VR Distraction. Each treatment condition was assigned 30 participants, 15 high hypnotizables and 15 low hypnotizables, and the experimenter was not aware of the hypnotizability level of the participants. The participants signed an informed consent form that stated that the study was aimed at comparing the effectiveness of various psychological methods in treating pain.

The study involved three stages: *baseline, the preparation stage* for the treatment conditions, and the *intervention* stage.

At *baseline*, the left-hand index finger was positioned into the device for 1 minute and, every 20 seconds, the participant was required to rate the pain intensity and, later, the pain unpleasantness.

During the *preparation stage*, the participants experienced the treatment method with no painful stimulation. Thus, in the two groups that

received no hypnosis (i.e., Groups 1 and 2), participants listened to a relaxing, nonverbal audiotape for 20 minutes. In the two groups that received hypnosis (i.e., Groups 3 and 4), participants received the hypnotic analgesia treatment condition. The hypnotic analgesia treatment condition involves hypnosis induction, information on analgesia, and the advantages of hypnosis, followed by suggestions for deepening the hypnotic state and the *"glove anesthesia"* suggestion (Yapko, 2003).

During the *intervention stage*, all participants positioned their finger in the stimulator and, for 1 minute, they assessed every 20 seconds the pain intensity. Participants in Groups 2 and 4 began interacting with the virtual world 2 minutes before their painful stimulus. Participants in the no VR groups (Group 1 and Group 3) sat quietly for 2 minutes before their painful stimulus. The assessment of the pain unpleasantness followed the painful stimulation. The experimenter noted the pain intensity and unpleasantness ratings reported by the participant. The procedure ended with the application of *Presence and Reality Judgment Questionnaire* to the groups involving VR use.

Treatment Conditions

Virtual reality distraction (VRD). VRD was administered by means of the SnowWorld (Hoffman et al., 2001) virtual reality software (www.vrpain.com), which consisted of a three-dimensional ice canyon, where, as the participants moved forward, they met icemen, penguins, and mammoths. The participants wore helmets that blocked the view of the real world. When the participant aimed at and threw snowballs through a click of the mouse, the icemen and the penguins touched disappeared. VRD was administered using the following: a Dell XPS 1710 (Intel Core Duo T7600, 2.33 GHz; 2GB RAM; NVIDIA GeForce Go 7950 GTX); a tracker: InterSense Inertia Cube (IC3) position tracker (inertial-based tracking; sourceless 3-DOF (Degrees of Freedom) tracking with full 360-degree range; 180 Hz update rate; 4 ms of latency; USB interface). The participants wore a head-mounted display (HMD): Virtual Research Systems VR1280 HMD, on 3D mono mode (SXGA [1280 $\times$ 1024] resolution reflective FLCOS displays, 60 Hz; 60-degree diagonal field of view; operates in three-dimensional stereoscopic or mono modes; brightness and contrast adjustments; Inter Pupilary Distance adjustment [52-74 mm]; eye relief accommodated glasses; dual ratchet head band offers comfortable and secure fit; high-fidelity closed-cup Sennheiser stereo earphones).After baseline, in the preparatory stage, the 15 high hypnotizable participants and the 15 low hypnotizable randomly distributed in this condition were adjusted the VR helmet and were instructed on the VR use. To obtain the same experiment duration for this condition also, the participants listened to a relaxing song until the intervention stage. The acclimatization to the VR environment was carried out over a 2-minute period, when the participants were allowed

to experience the virtual world without any painful stimulation. The 1-minute painful stimulation was carried out concomitantly with the experimentation of the virtual world in the intervention stage.

Hypnotic analgesia suggestion (HA) condition. After measuring the pain intensity and unpleasantness at baseline, the participants randomly distributed to the hypnotic analgesia suggestion (HA) condition were given the induction from the Stanford Hypnotic Susceptibility Scale, Form C (SHSS: C; Weitzenhoffer & Hilgard, 1962). The recording on the computer contained all the possible reaction variants for a participant during induction. After the induction, the participants were provided information on analgesia and the advantages of hypnosis, followed by suggestions to further the state of hypnotic state and for experiencing the "*glove anesthesia*" suggestion (Yapko, 2003), for 2 minutes, without applying the painful stimulus. In the intervention stage, the "*glove anesthesia*" suggestion was accompanied by positioning the hand inside the device and exerting pressure for 1 minute. The suggestions of anesthesia were also administered during the painful stimulation:

> Now, for 1 minute, the device will produce pressure and you will rate the pain intensity every 20 seconds. Let us begin. A breeze passes over your hand, cooling it down . . . , cooling it . . . , and it gets colder . . . and colder . . . . Rate. The nice refreshing sensation in your hand gets more pleasant and stronger while the rest of the body remains comfortably warm . . . . Rate. And, during all this time, your hand gets more and more numb . . . colder and colder . . . . Rate. Your hand is no longer numb, you start feeling it normal again. Your hand is stretched. Keep your eyes closed and relax your hand.

The procedure continued with the assessment of pain unpleasantness followed by deinduction.

HA + VRD. The participants in the hypnosis and virtual reality distraction condition followed the same procedural steps as the participants in the hypnotic analgesia suggestion condition. The difference consisted in the fact that in the preparation stage the participants experienced concomitantly hypnotic analgesia and virtual reality with no painful stimulation. In the intervention stage, while the participant worked the mouse with the right hand and watched the VR program, the left hand was placed under the device and the painful stimulus was applied. During the intervention, suggestions for increasing the sensation of presence in the virtual reality were concomitantly applied:

> Now open your eyes and, while you let yourself be involved in the virtual world wishing to obtain a good result in the game, you can easily keep your hand in this position and imagine your hand is in an anesthetic glove . . . . And since this is what happens, you begin noticing you

> feel this hand differently from the other one . . . the left hand is farther . . . from you . . . and while you are playing in the virtual reality, and while your attention is captured by the game, in your left hand you start feeling a chill, as if a cold breeze passed over your hand, cooling it down . . . chilling it . . . and it becomes colder and colder as you are travelling past the ice floes in the virtual world . . . the pleasant refreshing sensation in your left hand becomes stronger . . . colder . . . and while your hand becomes comfortably cold, you notice that a numb cold sensation becomes predominant . . . and you are more and more present in the virtual world. Now, for 1 minute, the device will produce pressure and I will to assess the pain intensity every 20 seconds. Let us begin. And while your left hand becomes colder and colder, with your right hand you throw snowballs at the icemen, obtaining a good score in the game . . . . Rate. The nice refreshing sensation in your left hand gets stronger and stronger . . . you get more and more focused in the virtual world . . . . Rate. You are more and more focused and present in the virtual world . . . and you obtain good results in the game. Rate. Now open your eyes. Your hand is no longer numb, you start feeling it normal again . . . relax your hand.

Then, we continued by recording the pain unpleasantness and deinduction.

No-treatment control condition. In the control condition, after assessing the pain intensity and the pain unpleasantness at baseline, the participants listened to a relaxing song in the preparation stage, followed by the application of the painful stimulus without any treatment in the intervention stage.

Results

Preliminary Analyses—Baselines

Pain intensity ratings yielded mean scores of 13.10 (SD = 5.65, range = 1–28) at baseline and 9.61 (SD = 5.54, range = 0–27) at postintervention. Pain unpleasantness ratings yielded mean scores of 3.15 (SD = 1.63, range = 0–8) at baseline and 2.18 (SD = 1.72, range = 0–8) at postintervention. Means and standard deviations for baseline and postintervention measures of pain intensity and pain unpleasantness by treatment condition and hypnotizability level are presented in Table 1.

A 2 × 4 (Hypnotizability x Treatment) analysis of variance (ANOVA) on baseline pain intensity ratings failed to show a significant main effect for the treatment condition or hypnotizability but yielded a significant interaction between the Hypnotizability × Treatment condition, $F(3, 112) = 3.291$, $p < .05$, $\eta^2_{\text{partial}} = .081$. Pairwise comparisons revealed that, in the low hypnotizable participants in the HA condition, pain intensity at baseline was significantly lower (M = 8.47), compared to

Table 1
Means and Standard Deviations for Baseline, Postintensity Pain Ratings, and Pain Unpleasantness Ratings by Condition and Hypnotizability Level

	Pain Intensity				Pain Unpleasantness			
	Baseline		Post		Baseline		Post	
Group/Treatment condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
High hypnotizable								
No-treatment control	12.13	6.66	12.60 *(13.19)*	7.17	3.07	1.83	3.47 *(3.5)*	2.06
HA	15.00	3.74	6.13 *(4.95)*	3.13	4.13	1.76	1.07 *(0.64)*	1.30
HA + VRD	14.27	5.68	8.47 *(7.74)*	4.17	2.93	1.28	1.20 *(1.29)*	1.47
VRD	14.73	4.70	10.80 *(9.78)*	3.91	3.73	1.64	2.80 *(2.54)*	1.65
Low hypnotizable								
No-treatment control	12.27	3.90	13.93 *(14.44)*	2.84	3.07	1.48	3.07 *(3.10)*	1.28
HA	8.47	5.01	8.33 *(11.20)*	7.06	2.00	1.30	2.67 *(3.16)*	1.63
HA + VRD	15.80	5.71	9.93 *(8.26)*	5.67	3.73	1.48	1.73 *(1.48)*	1.66
VRD	12.13	6.67	6.67 *(7.26)*	4.53	2.53	1.59	2.13 *(1.73)*	1.57

Note. Italic numbers in parentheses are the adjusted cell means.

the HA + VRD condition ($M = 15.80$). In the high hypnotizables, there are no differences in the pain intensity among the treatment conditions at baseline.

A 2 × 4 (Hypnotizability × Treatment) analysis of variance (ANOVA) on baseline pain unpleasantness ratings yielded a significant main effect for Hypnotizability, $F(1, 119) = 5.06$, $p < .05$, $\eta^2_{\text{partial}} = .04.$, explained by the fact that overall, the high hypnotizable patients reported a much more intense unpleasantness ($M = 3.46$) compared to the low hypnotizable participants ($M = 2.83$). There is also a significant effect of the interaction between the Hypnotizability × Treatment condition, $F(3, 112) = 5.28$, $p < .05$, $\eta^2_{\text{partial}} = .12$, explained by the fact that, at baseline, the low hypnotizable patients subsequently distributed in the HA group reported a significantly less intense unpleasantness ($M = 2.00$), compared to the participants that were to be distributed in the HA + VRD group ($M = 3.73$). In the high hypnotizables, there are no differences as regards to pain unpleasantness among the treatment conditions at baseline.

The existence of these differences at baseline justifies the use of the analysis of covariance (ANCOVA) method for their adjustment while verifying the efficacy of the treatment conditions in reducing pain intensity or unpleasantness.

Postinterventions

Pain intensity. A 2 (high hypnotizable vs. low hypnotizable) × 4 (treatment conditions) ANCOVA on postintensity ratings, with baseline intensity ratings as the covariate, yielded a significant main effect for covariate, $F(1, 119) = 83.89$, $p < .001$, $\eta^2_{\text{partial}} = .43$, a nonsignificant main effect for hypnotizability, $F(1, 119) = 3.71$, $p = .056$, and a significant main effect for the treatment condition, $F(3, 111) = 16.05$, $p < .05$, $\eta^2_{\text{partial}} = .303$. A least-significant-difference test on estimated marginal means with a Bonferroni adjustment for the number of statistical comparisons revealed that participants in the no-treatment control condition reported more intense pain (adjusted mean = 13.82) than those in the HA (adjusted mean = 8.07), HA + VRD (adjusted mean = 8.00), and VRD (adjusted mean = 8.52) conditions (see Table 1).

The Hypnotizability × Treatment condition interaction was significant, $F(1, 119) = 6.54$, $p < .001$, $\eta^2_{\text{partial}} = .15$. Pairwise comparisons indicated that highly hypnotizable participants in the no-treatment control condition (adjusted mean = 13. 19) and the VR (adjusted mean = 9.78) condition reported significantly more intense pain than those in the HAS (adjusted mean = 4.95) and HA + VR (adjusted mean = 7.74) conditions. Low hypnotizable participants reported significantly intense pain in the no-treatment control condition (adjusted mean = 14.44) and HA (adjusted mean = 11.20), compared with those in the HA + VR (adjusted mean = 8.26) and VR

(adjusted mean = 7.26) conditions. All the other pairwise comparisons were nonsignificant.

Pain unpleasantness rating. A 2 (high hypnotizable vs. low hypnotizable) × 4 (treatment conditions) ANCOVA on postintervention measures of pain unpleasantness, with baseline pain unpleasantness ratings as the covariate, yielded a significant main effect of the covariate, $F(1, 119) = 25.89$, $p < .001$, $\eta^2_{\text{partial}} = .18$, a significant main effect of the treatment, $F(3, 111) = 10.23$, $p < .001$, $\eta^2_{\text{partial}} = .21$, as well as a significant effect of the interaction between the Hypnotizability × Treatment conditions $F(3, 111) = 8.33$, $p < .001$, $\eta^2_{\text{partial}} = .18$. The treatment main effect can be explained by the fact that, generally, pain unpleasantness in the participants in the control group was significantly more intense (adjusted mean = 3.30), compared to the participants in the HA (adjusted mean = 1.90), HA + VRD (adjusted mean = 1.38), and VRD (adjusted mean = 2.14) conditions, whose pain unpleasantness was reduced. Among the treatment conditions, there are no significant differences in reducing pain unpleasantness (see Table 1).

The interaction between Hypnotizability × Treatment conditions could be explained by the fact that the highly hypnotizable participants from the control group (adjusted mean = 3.50) and from the VR group (adjusted mean = 2.54) reported a pain unpleasantness significantly more intense compared to those in the HA (adjusted mean = 0.64) and HA + VRD (adjusted mean = 1.29) conditions. In exchange, the low hypnotizable participants reported more intense pain unpleasantness in the control condition (adjusted mean = 3.10) and in the HA (adjusted mean = 3.16) condition, compared to the participants from the HA + VRD (adjusted mean = 1.48) and VRD (adjusted mean = 1.73) conditions. All the other pairwise comparisons were nonsignificant.

Sense of presence in virtual reality. A 2 (level of hypnotizability) x 2 (HA + VRD vs. VRD) ANOVA on the sense of presence in virtual reality yielded no significant main or interaction effects. Analyzing the factors, in Emotional Involvement, the same analysis of variance yielded a marginally significant main effect for the treatment, $F(1, 59) = 3.907$, $p < .053$, $\eta^2_{\text{partial}} = .065$, pointing to the fact that, overall, in the HA + VRD condition, participants had the tendency to involve emotionally more ($M = 35.90$) than in the VRD ($M = 29{,}20$) condition. Moreover, in the Reality Judgment and Presence factor, the results showed a significant main effect for the treatment, $F(1, 59) = 4.588$, $p < .05$, $\eta^2_{\text{partial}} = .07$. The sense of presence was more intense in the participants from the HA + VRD ($M = 77.66$) condition, compared to the participants in the VR ($M = 64.56$) condition. The other main effects and interactions with the rest of the factors were nonsignificant.

Discussion

The current study is the first to show that VRD significantly reduced pain from a mechanical pain stimulus (pressure applied to the healthy volunteers' finger). Audio hypnosis also significantly reduced mechanical pain. As in a related study that used thermal pain, the present study found that VRD reduced pain regardless of the participant's hypnotizability, whereas analgesia from audio hypnosis was only significant for subjects with high hypnotizability scores. These results suggest that audio hypnosis, and virtual reality distraction differ in the mechanism of how they reduce pain.

The data analysis indicated that, overall, all three treatments were more effective compared to the control group, irrespective of whether it involved hypnotic analgesia, virtual reality distraction, or both (hypnosis and virtual reality). Nevertheless, the participants responded differently to the pain treatment, depending on the hypnotizability level. The results of the present study indicated that for the group that received hypnosis alone the highly hypnotizable participants showed hypnotic analgesia, but the low hypnotizable participants did not report hypnotic analgesia. In contrast, VRD reduced pain in participants, regardless of their hypnotizability. Therefore, these results seem to be consistent with what Patterson, Hoffman, et al. (2006) reported when comparing the effects of posthypnotic suggestion and virtual reality distraction on pain, noticing that VRD analgesia was effective independent of hypnotizability. Compared with Patterson, Hoffman, et al. (2006), in the current study, VRD and HA interventions were administered simultaneously with the pain stimulation and participants were prescreened with the Harvard Group Scale of Hypnotic Susceptibility. In the current study, hypnotic analgesia was moderated by hypnotizability, which was conceptualized as the change in suggestibility due to hypnosis (Weitzenhoffer, 1980). Individual's ability to experience dissociative phenomena, absorption, and fantasy-proneness are traits that correlate with hypnotizability (Heap, Brown, & Oakley, 2005).

However, although HA+VRD had the same efficacy with HA alone and VRD alone, it appears that their combination does not have an additive effect, and they might even interfere with each other. Future studies should better explore this effect.

Hypnotic pain reduction, which is significant for participants with high hypnotizability scores, could be explained by a division of consciousness in which pain is dissociated behind an amnesic barrier (Hilgard & Hilgard, 1994). Suggestions in the HA + VRD condition, overall, affected the participant's emotional involvement and they have tended to involve emotionally more than in the condition when they did not received the suggestions.

Pain requires attention to process (Chapman & Nakamura, 1999; Patterson, 2010) and VR proved to be a psychological pain control technique that has the ability to divert the attention from painful stimuli, both for high hypnotizable and low hypnotizable participants.

Another objective was to measure whether hypnotic suggestions could enhance the subjective experience of presence in the computer-generated world. As predicted, participants in the group that received hypnotic suggestions before interacting with the virtual world reported a stronger illusion of presence in VR (the illusion of going inside the computer-generated world, as if it was a place they visited).

One important limitation to our study is that the research used an experimental pain paradigm with the intention to generalize the results to clinical pain. The intensity of experimental pain is mild and time limited, while clinical pain, chronic or acute, is unpredictable and intense (Milling & Breen, 2003). Therefore, there are significant differences between experimental and clinical pain experiences and consequently in the patients' and participants' level of motivation to reduce the pain.

In conclusion, the results obtained showed that the treatment conditions were more effective than the no-treatment control condition in relieving finger-pressure pain. For the highly hypnotizable, the most effective conditions were HA and HA + VRD, while the low-hypnotizable responded better to the VRD and HA + VRD treatment. However, HA + VRD was not superior to VRD and HA and future studies should investigate the mechanisms of change involved in these outcomes.

The results concerning the efficacy of some treatments (e.g., hypnosis) in reducing experimental pain highlight differences between high and low hypnotizable persons (Enea & Dafinoiu, 2013), an important to topic for future research.

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Effekte hypnotische Analgesie und virtueller Realität in Bezug auf die Reduktion experimentellen Schmerzes bei sehr und weniger hypnotisierbaren Menschen

Violeta Enea, Ion Dafinoiu, David Opriş und Daniel David

Abstrakt: Diese Untersuchung verglich einen Kontrollzustand ohne Behandlung und 3 Behandlungsmethoden von experimentell hervorgerufenem Schmerz: (1) Zerstreuung mittels Virtueller Realität (virtual reality distraction = CRD), (2) hypnotische Analgesie (HA) und (3) HA + VRD zur Erleichterung von Schmerzen durch Druck auf einen Finger. Jeder Teilnehmer erhielt zu Beginn einen baseline Schmerzreiz und wurde dann entweder hypnotisiert oder nicht. Darauf folgend erhielten sie entweder VRD oder keine VRD während eines anderen Schmerzreizes. Die Datenanalyse deutet an, daß insgesamt alle drei Verfahren im Vergleich mit der Kontrollgruppe effektiv waren. Dabei war es nebensächlich, ob hypnotische Analgesie, Virtuelle Realität oder beide zusammen (Hypnose und Virtuelle Realität) beteiligt waren. Trotzdem reagierten die Teilnehmer in Abhängigkeit ihrer Hypnotisierbarkeit auf die Schmerzbehandlung unterschiedlich. Stark hypnotisierbare berichteten von hypnotischer Analgesie, während gering hypnotisierbare keine hypnotische Analgesie zeigten. Die Virtuelle Realität reduzierte den Schmerz unabhängig von der Hypnotisierbarkeit.

Stephanie Reigel, MD

Effets de l'analgésie hypnotique et de la réalité virtuelle sur la réduction de la douleur expérimentale parmi les patients présentant un degré élevé d'hypnotisabilité et un faible degré d'hypnotisabilité

Violeta Enea, Ion Dafinoiu, David Opriş et Daniel David

Résumé: Cette recherche visait à comparer un état de contrôle sans traitement et trois (3) états de traitement de la douleur induite expérimentalement: 1) distraction de la réalité virtuelle (DRV), 2) analgésie hypnotique (AH) et 3) AH et DRV pour soulager la douleur par pression des doigts. Après avoir reçu un stimulus douloureux de départ, chaque participant a été hypnotisé ou ne l'a pas été, puis a été soumis à une DRV ou ne l'a pas été durant un autre stimulus douloureux. L'analyse des données a révélé que, dans l'ensemble, les trois traitements se sont avérés plus efficaces comparé au groupe de contrôle, et ce, que le traitement suivi ait été l'analgésie hypnotique, la distraction de la réalité virtuelle ou les deux (hypnose et réalité virtuelle). Quoi qu'il en soit, les participants ont réagi de façon différente au traitement de la douleur, selon le niveau d'hypnotisabilité. Les sujets présentant un niveau élevé d'hypnotisabilité ont signalé une analgésie hypnotique, tandis que ceux présentant un faible niveau d'hypnotisabilité n'ont pas montré de signes d'analgésie hypnotique. La distraction de la réalité virtuelle diminuait la douleur, et ce, sans égard au degré d'hypnotisabilité.

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Efectos de la analgesia hipnótica y la realidad virtual en la reducción del dolor experimental entre sujetos poco y muy hipnotizables

Violeta Enea, Ion Dafinoiu, David Opriş, y Daniel David

Resumen: Este estudio comparó una condición control sin tratamiento y tres condiciones de tratamiento para dolor inducido experimentalmente: (1) distracción mediante realidad virtual (VRD), analgesia hipnótica (HA), y (3) HA + VRD para la disminución de dolor por presión en el dedo. Después de recibir el estímulo doloroso basal, cada participante recibió hipnosis o no hipnosis, seguido de VRD o no VRD durante un segundo estímulo doloroso. El análisis de datos indicó que, en general, los tres tratamientos resultaron más eficaces comparados con el grupo control, sin importar si se trataba de analgesia hipnótica, distracción mediante realidad virtual o ambos (hipnosis y realidad virtual). Sin embargo, la respuesta de los participantes al tratamiento para el dolor fue distinta dependiendo de su nivel de hipnotizabilidad. Aquellos altamente hipnotizables respondieron a la analgesia hipnótica, pero los poco hipnotizables no mostraron analgesia hipnotica. La distracción por realidad virtual redujo el dolor sin importar la hipnotizabilidad.

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