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PAIN-REDUCTION STRATEGIES IN HYPNOTIC CONTEXT AND HYPNOSIS: ERPs and SCRs During a Secondary Auditory Task

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Abstract: Pain-rating scores were obtained from 10 high, 10 medium, and 10 low hypnotizable subjects who were holding a painful cold bottle in their left hands and were exposed to pain reduction treatments while they were performing a secondary oddball task. All subjects received suggestions of dissociative imagery and focused analgesia as cognitive strategies for pain reduction. The following measures were obtained for tone targets of the auditory oddball task: (a) reaction time; (b) P300 peak amplitude of the event-related potentials; (c) skin conductance levels and skin conductance responses. Focused analgesia produced the most pain reduction in high, but not medium or low, hypnotizable subjects who showed shorter reaction times, higher central and parietal P300 peaks, and higher skin conductance responses. These findings were discussed vis-à-vis the dissociated-control model assuming that capacity demands of hypnotic suggestion are low.

It is generally accepted that hypnotically induced analgesia is highly effective in relieving pain, but the level of experienced hypnotic analgesia varies greatly across individuals. In terms of individual differences in experiencing hypnotic analgesia, it appears that hypnotic susceptibility is a rather stable individual trait that reliably accounts for responsiveness to hypnotic-analgesia suggestions (Hilgard & Hilgard, 2004).
1975). However, the mechanism by which these analgesic effects are differentially achieved still remains obscure. Three main models are usually put forward to explain pain relief in hypnosis.

The first is referred to as the neodissociation model of hypnosis (Hilgard, 1977). According to this model, hypnotic analgesia is the product of a dissociation phenomenon; i.e., pain is registered but remains dissociated from conscious awareness by an amnesia-like process.

The second model derives from the neodissociation model of hypnosis and focuses on the experience of nonvolition that usually accompanies hypnotic suggestions (Bowers, 1981; Weitzenhoffer, 1978). According to Bowers (1990, 1994), because subsystems of control are activated more or less directly by hypnotic suggestions without executive initiative, hypnotized subjects frequently experience suggested analgesia as effortless or nonvolitional. This model suggests that the more that pain is effectively reduced by dissociated control, the more high-level cognitive resources remain available for the execution of a secondary task (Bowers, 1994).

The third model is known as the social-cognitive theory of hypnosis (Spanos & McPeake, 1974). This model argues that hypnotic analgesia is mediated in the same way as pain reductions that are reached by subjects instructed to use various cognitive-behavioral strategies (Turk, Meichenbaum, & Genest, 1983). This model (Spanos, 1986; Spanos, Kennedy, & Gwynn, 1984; Spanos, Radtke-Bodorik, & Ferguson, 1979) asserts that hypnotic analgesia is similar to nonhypnotic analgesia and suggests that pain is reduced by motivated subjects coping with painful stimuli. Typically, the coping strategy consists of distracting attention from the pain by using “goal-directed fantasies.” Spanos and co-workers explain the experience of involuntariness as being a result of goal-directed fantasies (Spanos et al., 1984). These authors claim that high hypnotizable subjects reduce pain more than low and medium hypnotizable ones because they are better at mobilizing and sustaining cognitive strategies.

The rationale of this study is based on the neuropsychological theory of attention and information processing (Kahneman, 1973; McCaul & Malott, 1984; Pribram & McGuinness, 1975, 1992; Schneider & Shiffrin, 1977), suggesting that conscious mental activity, such as mental imagery, is very resource-demanding and that not attending the sensation of pain is a difficult task that is likely to consume most of the individual’s available cognitive capacity by making it hard to successfully perform a secondary, unrelated task. Consequently, if we assume that hypnotic analgesia involves the conscious distraction of attention from a painful stimulation, then there may be a rather high cognitive loading with little cognitive capacity left for performing a concurrent, demanding cognitive task.
Both social-cognitive and neodissociation models of hypnotic analgesia suggest that active cognitive efforts are required to reduce pain. In contrast, the dissociated control view of hypnotic analgesia implies that pain reduction involves minimal cognitive effort so that high-level cognitive resources remain available to perform a secondary task.

Previously, we explored the electrocortical mechanisms of different analgesia suggestions on pain perception in high, medium, and low hypnotizable persons (De Pascalis, Magurano, & Bellusci, 1999; De Pascalis, Magurano, Bellusci, & Chen, 2001). Somatosensory event-related potential (SERP) and autonomic responses to both target and standard painful stimuli were analyzed (using an oddball paradigm) in high, medium, and low hypnotizable subjects using different pain-reduction strategies in hypnosis (deep relaxation, dissociative imagery and focused analgesia). The pain rating and SERP findings obtained with the oddball paradigm in this study confirmed the findings previously reported by Zachariae and Bjerring (1994). In all three groups (high, medium, and low hypnotizable), the P3 peak to standard and target stimuli was reduced across all hypnotic conditions. However, during focused analgesia, high hypnotizable subjects also reported shorter reaction times to target stimuli and faster habituation of skin conductance responses (SCRs) compared to the moderately and low hypnotizable ones. These findings suggest that the operation of an inhibitory process is responsible for reduced pain and distress sensations. However, in terms of behavioral and physiological measures, focused analgesia—which requires attention to be focused on the hand receiving painful stimulations and imagining a glove as an obstructive hallucination of incoming stimuli—was the most effective in reducing pain.

In the present study, high, medium, and low hypnotizable subjects were administered a continuous painful stimulus. They were administered both dissociative imagery and focused analgesia protocols to cope with the pain while they were engaged in an auditory target detection task (De Pascalis et al., 1999, 2001). On the basis of the dissociated-control model of hypnosis (Bowers, 1990, 1994), high hypnotizable subjects were expected to reduce the pain sensation of cold by using a minimal cognitive effort and thus be free to direct their attention to auditory target detection. On the other hand, medium—and to a greater extent—low hypnotizables were expected to attempt to reduce pain by a conscious use of cognitive strategies requiring a high level of cognitive effort, thus reducing their performance on the auditory oddball task.

In keeping with a large body of the literature, it may be assumed that the P300 amplitude in sensory discrimination tasks can be considered as a direct indicator of the resources that are still available for stimulus evaluation (e.g., Mecklinger, Kramer, & Strayer, 1992; Mulder, 1986).
That is, for a subset of mechanisms of conscious processing (e.g., Isreal, Chesney, Wickens, & Donchin, 1980; Isreal, Wickens, Chesney, & Donchin, 1980; Sirevaag, Kramer, Coles, & Donchin, 1989). These variations in resource allocation, which depend on changing experimental conditions, that is, “resource trade-offs,” can be predicted by energetic models of information processing (e.g., Gopher, 1986; Wickens, 1986). For instance, if—under identical conditions—the mental load in these tasks is increased with regard to a component of conscious processing other than stimulus evaluation—for example, rehearsal—or in relation to compensatory control, then the P300 amplitude can be expected to decline (e.g., Mecklinger et al., 1992). In these cases, the P300 amplitude can be considered to be an indirect and inversely proportional effort indicator; that is, an indicator for subsets of conscious processing other than stimulus evaluation or for compensatory control (compensatory effort).

Among autonomic activities, SCR has been identified as an expression of the elicitation and habituation of the orienting response (OR) (Barry & Sokolov, 1993; Sokolov, 1963). Furthermore, SCR has been successfully used in differentiating between high and low susceptible hypnotic subjects in the basic attentional processing of orienting (e.g., De Pascalis et al., 1999; Gruzelier, 1998; Gruzelier & Brow, 1985). In Gruzelier and Brow’s study, high susceptible subjects showed a reduction in orienting and/or faster habituation under hypnosis, whereas low susceptibles showed retarded habituation under hypnosis. The SCR has also been used successfully as a measure of the subjective impact of pain stimuli under hypnosis (e.g., Edmonston, 1968; Laidlaw, Booth, & Large, 1996; Velden & Wolk, 1987; Wickramasekera, 1996).

In the present study, ERPs and SCRs were elicited by target auditory stimuli of a secondary oddball task performed while high, medium, and low hypnotizable subjects used cognitive strategies of dissociative imagery and focused analgesia in a hypnotic context and hypnosis. On the basis of information-processing models of attention, shorter reaction times, higher SCRs, and greater P300 peaks to the target stimulus of the secondary task could indicate that greater resources are available for stimulus evaluation during a given hypnotic analgesia condition, since the pain reduction strategy involves a minimal cognitive effort in this condition.

Overall, the aims of the present investigation were to evaluate: (a) whether individual differences in hypnotic susceptibility reliably account for individual differences in tonic pain reduction; (b) whether, in high hypnotizable individuals, dissociative imagery should be less effective in pain reduction than focused analgesia; (c) whether high hypnotizables, as compared to medium and low hypnotizables, should display greater ERP peaks and behavioral SCRs to auditory targets,
while engaged in pain reduction strategies in hypnosis; and (d) the capacity of the hypnotic context to evoke analgesic effects of cognitive-attentional strategies even in the absence of hypnotic induction.

**Method**

**Subjects**

From a group of 82 right-handed women (aged 20–28, $M = 22.9$, $SD = 2.6$), 10 high hypnotizable, 10 medium hypnotizable, and 10 low hypnotizable subjects were selected using the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C; Weitzenhoffer & Hilgard, 1962). Subjects were considered to be highly hypnotizable ($n = 10$, $M = 9.8$, $SD = 0.3$) when their scores on the SHSS:C were one standard deviation above the group mean of a larger sample tested in our laboratory ($N = 82$, $M = 6.3$, $SD = 3.2$); an equivalent but opposite deviation designated the low hypnotizable subjects ($n = 10$, $M = 2.7$, $SD = 0.4$). The medium hypnotizable group was composed of subjects who showed hypnotizability scores one standard deviation within the group mean ($n = 10$, $M = 6.9$, $SD = 1.1$). Three different female hypnotists carried out the assessment of hypnotic susceptibility. All subjects were naive volunteers, and care was taken to ensure that they had no awareness of the relevance of hypnotic ability to their participation in the experiment. Subjects who were in their menstrual period were invited for electrophysiological recordings on another occasion.

**Manipulations and Instrumentation**

**Painful stimulation.** Tonic pain was induced using a standardized cold-bottle test (CBT, i.e., holding a Coca-Cola bottle that had been chilled to $-10^\circ C$) reported by Chen and colleagues (Chen, Chang, & Arendt-Nielsen, 2000). Specific focal EEG changes were identified by 3D topographic mapping by Chen and colleagues, during tonic pain from the CBT. These EEG changes were identified in the increases of the right frontal delta-1 Hz and bilateral frontal and temporal beta-26 Hz EEG-peak powers to tonic painful stimulation. These EEG changes were consistent with other previous EEG changes observed in healthy subjects using a cold-pressor test (Chen, Dworkin, Haug, & Gehrig, 1989; see review by Bromm & Lorenz, 1998).

Following this testing procedure, in the present study subjects were required to hold a 250 ml cold bottle ($-10^\circ C$) of 5.6 cm diameter, filled with water, with their left hand for a time period of 183 seconds.

**Conditions.** Subjects were administered three treatments for pain control during (a) a hypnotic-context condition without hypnotic induction and (b) after they had received a hypnotic induction. Treatments in the hypnotic-context condition were administered first. These
treatments were selected from a number of previous psychophysiological studies on hypnosis in which verbal suggestions of relaxation, dissociative imagery, and focused analgesia proved to be effective in reducing pain (De Pascalis et al., 1999, 2001; Zachariae & Bjerring, 1994).

**Hypnotic context.** Verbal suggestions were given continuously during each of the following three pain-treatment conditions:

1. Relaxation (no-analgesia): Continuous suggestions to enter a progressive deeply relaxed condition in which the body is experienced as becoming heavy and relaxed. No suggestions were given to reduce pain sensitivity.

2. Dissociative imagery: Suggestions to engage in pleasant visual imagery of the site in which a building was located and to then imagine floating out of one’s body and going up into the air, crossing the corridor of the building, going out along the street and enjoying looking down on people and buildings; suggestions to imagine that the body had been left behind on the ground and that the body was going into a deep sleep with no feeling of pain.

3. Focused analgesia: Suggestions to focus on sensations in the hand and arm and experience that both hand and arm were becoming numb and analgesic like a glove covering the hand and wrist.

**Hypnosis.** During hypnosis, subjects received the same three pain treatments (relaxation/no-analgesia, dissociative imagery, and focused analgesia) as those administered in the preceding hypnotic-context condition.

In the hypnotic-context condition, subjects were informed that they would be engaged in some cognitive-attentional strategies known to be hypnotic in nature and effective in reducing pain. Before starting each of the three treatments, either in the hypnotic context or hypnosis, subjects were required to rest for 2 minutes with their eyes closed. Subjects were also required to keep their eyes closed during each treatment condition. To avoid undesired task-order effects, the sequence of the three treatments was randomized across hypnotic-context and hypnosis conditions. Scripts had been prepared for all three treatments to ensure that all subjects were given identical suggestions. After each treatment, which lasted 3.2 minutes, subjects were told that their hand and arm would regain normal sensitivity.

**Cognitive load test.** Subjects were binaurally presented 82 tone pips through insert headphones using a fixed interstimulus interval (ISI) of 2.2 seconds. Stimuli were presented according to an oddball paradigm, 65 (80%) standards and 17 (20%) targets. Target and standard stimuli were pure sine tones presented at 1200 and 800 Hz, respectively, at a constant intensity of 70 dB SPL. All tones were presented for 100-ms duration to both ears with a 20-ms rise and fall time. Subjects were
instructed to keep their eyes closed and to press a hand-held response button with the dominant hand as quickly as possible whenever the target tone was presented. Target presentation order was pseudorandom and met the criteria that no two targets were presented in succession. Immediately after detecting each target, subjects were required to verbally rate the pain sensation.

Physiological monitoring.

1. ERPs. EEG recordings were made using an Electro-cap (Blom & Anneveldt, 1982) with pure tin electrodes placed on frontal (F3, F4), temporal (T3, T4), central (C3, C4), and parietal (P3, P4) sites. Linked earlobes served as reference with a forehead ground. Electrode impedance was kept below 5 KΩ and raw EEG signals were recorded (0.5–70 Hz bandpass) using an eight-channel EEG machine (ERA-9 – OTE Biomedica Italiana). Eye movement (EOG) was recorded using a separate amplifier in a bipolar arrangement, superior orbit referenced to the outer canthus of the right eye. The EEG was acquired at a sampling rate of 256 Hz per channel with a 12-bit resolution. For each instruction condition, 82 epochs (65 for standard and 17 for target stimuli) of 2000 ms (512 points per epoch per channel) were recorded on hard disk. For each recording epoch, the signal was off-line processed within a time interval of 751 ms using a prestimulus baseline period of 106 ms. Epochs were rejected if: (a) there were any muscle artifacts or stimulus contaminations; (b) eye-movement slow potential variations were greater than 70 μV; and (c) false positive and false negative button pressing on standard nontarget stimuli were detected. The ERPs to target stimuli were subjected to statistical analysis. The EEG was low-pass filtered at 8.5 Hz (FIR filter 3 dB, 12 dB/octave roll off). For target tones, the most reliable ERP peak was measured. This was recognized as the P300 component of the ERPs, peaking at about 330 ms (337 ± 21.5 ms). The P300 peak-amplitude measure was obtained as the baseline to a local maximum of a positive peak in a window of 218–452 ms latency range.

2. Skin conductance. Skin conductance (SC) was recorded with Ag/Acl electrodes on the volar surfaces of the medial phalanges of the second and third digits of the right hand, with 0.05 M NaCl in an inert viscous ointment base as electrolyte. SC was detected by a constant voltage (0.5 V) applied to the electrodes so that an SC value of 10 μS corresponded to an observed current of 5 μA (Fowles et al., 1981). The SC was digitized and recorded by a SATEM Biolab 104SC system using a sampling rate of 10 Hz. An epoch of 4.2 seconds was used to measure the amplitude of SCR to target stimuli.

SCRs were scored as measures of phasic electrodermal activity when they were greater than 0.3 μS compared to prestimulus levels and when they occurred with onset latencies between 1.0 and 2.0 seconds (inclusive) (Barry, 1990; Dawson, Schell, & Filion, 1990).

Two different types of scores were obtained for data analysis: (a) the peak amplitude of phasic SCR as a function of stimulus repetition, and
(b) skin conductance level (SCL) as the mean score obtained in the 1-second period immediately prior to each stimulus onset. These values were range corrected by dividing each of the 18 values of each subject by the level existing prior to the first stimulus presentation. These scores were considered as a measure of arousal level at each stimulus presentation (tonic-orienting response). Within each subject, the 17 values of the SCR were regressed on the corresponding values of SCL. In order to remove the effect of tonic arousal (SCL) on phasic arousal (habituation scores) (SCR), the residuals of this regression procedure were taken as the phasic SC corrected for within variations in arousal levels and used as data scores. The SCR values were subjected to a square-root transformation to improve the skew commonly associated with small responses in the electrodermal activity and then normalized within-subject by dividing each subject’s response by that obtained with the initial stimulus presentation.

Measures of behavior. During the cognitive-load test, the following behavioral measures were obtained: (a) reaction time (RT) response (button-press) to the tone target in milliseconds; (b) rate of correct tone target detection and false alarm. Sensory pain-rating scores were also obtained by asking the subjects to verbally rate the pain sensation (Chen & Rappelsberger, 1994, 1998) on a 0–10 Pain Intensity Scale (0 = no sensation, 1 = barely cool but no pain, 2 = cool but no pain, 3 = cold but no pain, 4 = slight pain, 5 = mild pain, 6 = moderate pain, 7 = moderately strong pain, 8 = strong pain, 9 = very strong pain, 10 = unbearable pain) for each delivery of the target tone.

Procedure

At least 1 week and no later than 2 weeks after the administration of the SHSS:C, selected subjects—on the basis of their hypnotic susceptibility—were again invited to the lab for an electrophysiological recording session. Subjects participated individually in a 90-minute session (from 1 to 3 p.m.), and they were informed of the nature of the cold-painful stimulation. Prior to this moment, subjects were not aware they would be treated with painful stimuli, nor were they aware that hypnosis or hypnotizability was relevant to the experiment. Written consent was required if they agreed to continue with the study, which was carried out by following the ethical norms of the Italian Association of Psychology. Two subjects declined. Subjects who reported cardiovascular or neurological problems were excluded from the experiment. After the electro-cup was mounted and electrode impedance tested, the electrophysiological recordings started with baseline eyes-closed recordings (2 minutes) and the suggestion of three treatments for pain reduction in a hypnotic-context condition (including resting periods lasting 15.6 minutes overall). An auditory oddball task was also given, as a secondary task, during each treatment condition. After the
hypnotic-context condition, hypnosis was induced for the second time using the Stanford Hypnotic Clinical Scale (SHSC; Morgan & Hilgard, 1978–1979). During hypnosis in the eyes-closed condition, the subjects were asked to perform the same treatments with the same resting periods as the ones they previously experienced in the hypnotic-context condition. The effectiveness of the first selection of the subjects with the SHSS:C was confirmed by the distribution of the SHCS scores ($N = 30$, $M = 2.9$, $SD = 1.2$; Highs, $n = 10$, $M = 4.4$, $SD = 0.2$; Mids, $n = 10$, $M = 2.9$, $SD = 0.6$; Lows, $n = 10$, $M = 1.4$, $SD = 0.3$). The hypnotic induction lasted about 7 minutes and hypnoizability testing lasted approximately 18 minutes. The hypnotist was blind to the hypnotizability level of the subjects.

Statistical Analyses

MANOVAs were performed for RT, rate of correct and false alarm detections, pain ratings, and ERP data across the three treatments. The experimental design used was the following: 3 (hypnotizability: high, medium, low) x 2 (condition: hypnotic context, hypnosis) x 3 (treatment: no-analgesia, dissociative imagery, focused analgesia).

The use of MANOVAs in this study was to prevent the risk of falsely significant results as may be the case with repeated-measure ANOVAs if the sphericity assumption is violated (Vasey & Thayer, 1987). Post hoc comparisons of the means were carried out by Duncan’s Multiple Range Test. The significant effects that are considered essential for the questions addressed in this study are reported. The type I comparison-wise error rate was set at $\alpha = 0.01$ (Keppel, 1982, pp. 145–157).

RESULTS

Behavioral Responses

Pain ratings. MANOVA on pain-rating scores displayed the following significant effects: (a) hypnotizability, $F(1, 28) = 6.16$, $p = .019$; (b) Hypnotizability x Treatment, $F(2, 27) = 3.78$, $p = .035$; (c) time, $F(16, 13) = 6.84$, $p = .006$; (d) Hypnotizability x Time, $F(16, 13) = 2.78$, $p = .035$; (e) Hypnotizability x Treatment x Time, $F(16, 13) = 2.84$, $p < .01$. The first effect displayed significantly smaller pain ratings for high hypnotizables compared to medium and low hypnotizable subjects. For the second effect, post hoc comparisons of the means (Duncan’s test, $p < .05$) indicated that high hypnotizable subjects, in both the hypnotic context and hypnosis conditions, showed significant pain reductions across dissociative imagery and focused analgesia as compared to a no-analgesia condition, whereas medium and low hypnotizable subjects did not show significant pain reductions across treatments (see Figure 1). Post hoc comparisons of the means showed that there were different pain trends over time across treatments.
Figure 1. Mean pain ratings and standard errors during Tonic Cold Bottle Test in 10 high, 10 medium, and 10 low hypnotizable subjects (Highs, Mids, and Lows). Measures obtained with target tone onset during conditions of hypnotic context (Hc) and hypnosis (Hy) for no-analgesia (NoAnalg), dissociative imagery (Imag), and focused analgesia (FocAnalg) (*p < .05; **p < .01).
among high, medium, and low hypnotizable groups. In particular, the analysis of variance of trend contrasts showed that, within the time interval of 84–180 ms, high hypnotizable persons during focused analgesia in hypnosis produced significant pain reductions \( (p < .01) \) as compared to the same treatment in a hypnotic-context condition. Medium and low hypnotizable subjects did not show significant reductions in pain sensations among treatments and between hypnotic-context versus hypnosis conditions (see Figure 1).

The interactional effect of Hypnotizability \( \times \) Condition \( \times \) Treatment, that is, the most direct test of hypnotic analgesia, was not significant, \( F(2, 27) = 1.03, p = .372 \). However, the Hypnotizability \( \times \) Condition \( \times \) Treatment \( \times \) Time was marginally significant, \( F(16, 13) = 2.53, p = .054 \). Post hoc multiple comparisons of the means (Duncan’s multiple range test) in high hypnotizable subjects showed that, starting from 70 to 170 seconds after the painful stimulation, there were significantly more pronounced pain reductions \( (p < .05) \) in hypnosis during focused analgesia compared to dissociative imagery and to no-analgesia treatments. In contrast, in the hypnotic-context condition, these subjects did show similar pain reductions during dissociative imagery and focused analgesia treatments as compared to no-analgesia (see Figure 1).

To evaluate the relationship between hypnotic ability and pain reduction, correlation coefficients were calculated between SHSS:C scores and the reduction in pain ratings, obtained for each experimental treatment (in hypnotic context and hypnosis). Pain-reduction scores were obtained by subtracting the mean pain rating of each treatment from the one obtained for no-analgesia in the hypnotic-context condition. In the hypnotic-context condition, the correlation coefficients respectively between SHSS:C and pain reduction scores were positive and significant \( (r = .37, p = .040 \) for dissociative imagery; \( r = .45, p = .013 \) for focused analgesia). Similar relationships were found for treatments in the hypnosis condition \( (r = .25, p = .174 \) for no-analgesia; \( r = .38, p = .039 \) for dissociative imagery; \( r = .42, p = .022 \) for focused analgesia).

The results indicate that hypnotic ability was related to pain reduction for subjects receiving pain reduction suggestions in a hypnotic context or receiving pain reduction suggestions during an explicit hypnotic treatment.

Reaction Time and Target Detection

RT scores shorter than 150 ms and longer than 900 ms were excluded from the data set. MANOVA analysis for this data set showed three significant effects. The first effect was for treatment, \( F(2, 26) = 8.85, p = .0012 \); the second was for Hypnotizability \( \times \) Treatment, \( F(4, 52) = 5.26, p = .011 \); the third effect was for Condition \( \times \) Treatment \( \times \) Hypnotizability, \( F(4, 52) = 2.61, p = .046 \). Post hoc comparison of the means (Duncan’s test) indicated a couple of things. First, in the
Figure 2. Reaction Time scores and standard errors to target tones during Tonic Cold Bottle Test in high, medium, and low hypnotizable subjects. Scores obtained during no-analgesia (NoAnalg), dissociative imagery (Imagery), and focused analgesia (FocAnalg) treatments in hypnotic-context (Hy-Context) and hypnosis conditions (*p < .05; **p < .01).
hypnotic-context condition, high hypnotizables had longer RTs during dissociative imagery and focused analgesia as compared to no-analgesia treatment. These differences were not significant for medium and low hypnotizables (see Figure 2). Second, in the hypnosis condition, highly and, to a lesser extent, moderately hypnotizable subjects displayed longer RTs during dissociative imagery and shorter RTs during focused analgesia as compared to no-analgesia treatment. RT trends across hypnotic-context and hypnosis treatments with respect to hypnotizability are shown in Figure 2. Two separate MANOVAs were performed for the rate of correct detection and false alarm scores. No significant effects were found for both correct and false alarm scores.

**ERP and SC Measures**

**P300 peak amplitude.** P300 peak amplitude scores to target tones displayed the following significant effects: (1) hemisphere, $F(1, 27) = 16.87, p = .0003$; (2) location, $F(3, 25) = 40.97, p < .0001$; (3) Hemisphere × Location, $F(3, 25) = 17.99, p < .0001$; (4) Treatment, $F(2, 26) = 4.09, p < .05$; (5) Treatment × Hemisphere × Hypnotizability, $F(4, 52) = 2.74, p < .05$; (6) Treatment × Location, $F(6, 22) = 14.96, p < .0001$; (7) Treatment × Location × Hypnotizability, $F(12, 44) = 2.67, p = .0087$; (8) Condition × Location, $F(3, 25) = 51.15, p < .0001$; (9) Condition × Location × Treatment, $F(6, 22) = 8.20, p < .0001$; (10) Condition × Hemisphere × Treatment, $F(2, 26) = 22.81, p < .0001$; (11) Condition × Hemisphere × Location, $F(3, 25) = 49.19, p < .0001$; (12) Hypnotizability × Condition × Hemisphere × Location × Treatment, $F(12, 44) = 12.09, p < .0001$. Post hoc comparisons of the means for the first three effects indicated that there were higher P300 peaks in the right compared to the left hemisphere and that this effect was more pronounced across central and parietal sites (6.4 vs. 5.6, 5.5 vs. 4.7, 7.5 vs. 6.1, and 7.8 vs. 6.5 μV, respectively for right vs. left hemisphere across frontal, temporal, central, and parietal sites). The fourth and fifth effect showed that there were (a) no P300 peak differences during no-analgesia treatment across high, medium, and low hypnotizables; and (b) an enhanced P300 peak amplitude in the right (but not in the left) hemisphere during focused analgesia treatments as compared to no-analgesia in high hypnotizable subjects and, to a lesser extent, in medium hypnotizable subjects. The hemisphere difference in low hypnotizable subjects was not significant across analgesia treatments. The sixth and seventh effects indicated that in high hypnotizable, and to a lesser extent in medium hypnotizable individuals, compared with low hypnotizable ones, there were no P300 peak differences during dissociative imagery, whereas during focused analgesia there were higher P300 peaks across central and parietal recording sites. The remaining significant effects indicated that (a) in high and medium hypnotizables, with respect to
low hypnotizable subjects, during focused analgesia in hypnosis, there were higher P300 peaks across central and parietal areas in the right hemisphere; (b) in high and medium hypnotizable subjects during focused analgesia in hypnosis there were higher central and parietal P300 peaks in the right hemisphere than treatments in hypnotic-context condition (see Figure 3). No P300 peak differences among hypnotizability groups were found during treatments in hypnotic-context conditions (see Figure 3).

Skin Conductance

MANOVA on skin conductance levels, measured prior to each target stimulus delivery, yielded only a significant effect for trial,
Normalized amplitudes of SCR scores as a function of trials (17 values, one for each trial) were analyzed using MANOVA. This analysis yielded a main effect for trial, $F(15, 13) = 3.16, p = .022$. No other effects were found to be significant ($p > .05$) for this measure.

In agreement with previous findings (Crawford, Knebel, Kaplan, & Vendemia, 1998; De Pascalis et al., 1999; Zachariae & Bjerring, 1994), hypnotic analgesia treatments significantly reduced pain ratings in highly hypnotizable persons. For these subjects, treatments in a hypnotic-context condition, defined as hypnotic, were effective in pain reduction (see Figure 1). The correlation between hypnotic ability and pain reduction was significant for both analgesia treatments.

In the hypnotic-context condition, highly hypnotizable persons displayed longer RTs during both pain treatments as compared to a control relaxation one. This difference was interpreted as reflecting the greater cognitive effort required, in the hypnotic-context condition, for generating a mental strategy of coping with pain. In the hypnosis condition, on the other hand, high and medium hypnotizable subjects displayed longer RTs during dissociative imagery and shorter RTs during focused analgesia, as compared with no-analgesia treatment (see Figure 2). This effect, particularly evident in high hypnotizable subjects, can be explained if we assume that, during focused analgesia in hypnosis, these subjects make less effective use of the control or effort system for pain reduction than do the other subjects. The reduction in effort released more processing capacity available for the auditory odd-ball task. This interpretation is in line with predictions deriving from the dissociated control model (Bowers, 1990, 1994). This model predicts that the more pain is effectively reduced by dissociated control, the
more high-level cognitive resources remain available for further information processing.

In sum, the combination of results of pain ratings and RT in high and, to a lesser extent, medium hypnotizable subjects indicates an interference between dissociative imagery and auditory target detection of the secondary task in both hypnotic context and hypnosis, leading to longer RTs. In contrast, the competition between focused analgesia and target detection is observed in the hypnotic context but not in hypnosis. Focused analgesia during hypnosis in high hypnotizable subjects had no discernable impact on RT. This provides evidence supporting the dissociated-control position. This is especially interesting in view of the larger analgesic effect found in focused analgesia compared to dissociative imagery (i.e., more analgesia with less interference on auditory target detection). These results suggest that focused analgesia and dissociative imagery, during hypnosis, operate through at least partially distinct mechanisms.

**P300 Peak Amplitude and SCR**

The P300 component of the ERP can be observed especially in vigilance tasks, signal detection tasks, tasks with feedback stimuli, language perception, and memory–search tasks. It is associated with so-called stimulus-evaluation processes, that is, the comparison of new information with a context-based expectation (e.g., Donchin & Coles, 1988). In this framework, P300 latency reflects the duration of such comparison processes, whereas amplitude represents the processing capacity allocated for stimulus evaluation. The P300 amplitude is thus an indicator of resource allocation for one subset of the computational processes and in this sense is a direct effort indicator as an energy supply for information processing.

On this basis, the finding of the present study that highly hypnotizable persons, compared with medium and low hypnotizable ones, reported significantly greater P300 peaks across right-central and parietal cortical regions during focused analgesia in hypnosis can be seen as indicating that, during this protocol, there was more available processing capacity (or less effort reactivity) for the secondary task than during treatments in baseline. This may also be inferred from a large body of literature in which the P300 amplitude is taken as an indirect and inversely proportional effort indicator or as a direct indicator of the resources that are available for stimulus evaluation (e.g., Mecklinger et al., 1992). This view is in line with Bowers’ (1990, 1994) predictions that, where pain reduction is actually achieved by dissociated control, more high-level cognitive resources remain available for fantasy and involved imagining or for performing a secondary task. Moreover, tone targets in high hypnotizable subjects (and, to a lesser extent, in moderately hypnotizable subjects) during Focused analgesia with hypnosis elicited higher P300 peaks over central and parietal regions only in the right hemisphere. This finding provides evidence of an altered brain
functioning with hypnosis and an association of focal right hemispheric change with hypnotic susceptibility. The finding appears in line with a number of previous studies indicating the enhanced activity of the right hemisphere in hypnosis (De Pascalis & Penna, 1990; Gruzelier, 1998; Levine, Kurtz, & Lauter, 1984; McCormack & Gruzelier, 1993) and with the idea that right hemisphere activity is involved in the regulation of the phasic arousal system whose function is to expand the attentional perspective to many new perceptual elements (Pribram & McGuinness, 1975, 1992; Tucker & Williamson, 1984). Positron emission tomography (PET) findings have also shown that the processing of pitch depends on right hemisphere structures (Zatorre, Evans, Meyer, & Gjedde, 1992; Zatorre & Samson, 1991).

Results obtained with SCR responses to tone targets appear in line with predictions deriving from the above-mentioned information-processing theories. These findings indicate that tone target detections in high hypnotizable subjects during focused analgesia in hypnosis produced more pronounced phasic-orienting responses than did stimuli in medium and low hypnotizable subjects.

CONCLUSION

In terms of pain sensation, the results of the present investigation support the view that the operation of an inhibitory process was responsible for reduced pain sensation during hypnotic and hypnotic-context conditions. The present findings suggest that treatment of focused analgesia primes dissociated control in hypnosis by requiring a lower cognitive effort for pain reduction. This interpretation is in line with predictions deriving from the dissociated control model (Bowers, 1990, 1994), which predicts that the more pain is effectively reduced by dissociated control, the more high-level cognitive resources remain available for further information processing.

REFERENCES


Strategien der Schmerzreduktion in hypnotischem Kontext und unter Hypnose: ERP und SCR während einer zusätzlichen auditorischen Aufgabe.

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Zusammenfassung: 10 hoch-, 10 durchschnittlich- und 10 geringsuggestible Versuchspersonen beurteilten ihre Schmerzen beim Eintauchen der linken Hand in Eiswasser, während sie zusätzlich eine auditorische Oddball-Aufgabe absolvierten. Alle Versuchspersonen erhielten als kognitive Strategien zur Schmerzreduktion Suggestionen zu dissoziativen Imaginatio-
nen und fokussierter Analgesie. Folgende Variablen wurden für die auditorischen Zielreize bei der Oddball-Aufgabe erfasst: (a) Reaktionszeit, (b) P300-Amplitude des evozierten Potentials (ERP), (c) Hautleitwertniveau (SCL) und Hautleitwertreaktionen (SCR). Fokussierte Analgesie führte bei den hochsuggestiblen Versuchspersonen, aber nicht bei den durchschnittlich- oder geringsuggestiblen Versuchspersonen, zur größten Schmerzre-
duktion, wobei diese die kürzesten Reaktionszeiten, größere zentrale und parietale P300-Amplituden sowie größere Hautleitwertreaktionen aufwie-
sen. Diese Befunde werden diskutiert im Vergleich zu den Annahmen der Theorie der dissoziierten Kontrolle, die davon ausgeht, daß die Kapazitäts-
belastungen hypnotischer Suggestionen gering sind.

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Stratégies de réduction de la douleur dans un contexte hypnotique et hypnose: Potentiels Evénements-Connexes (ERPs) et RCP (SCRs) lors d’une tâche auditive secondaire.

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Résumé: Des scores d’évaluation de la douleur ont été relevés à partir de sujets hypnotisables – 10 fortement, 10 moyennement et 10 faiblement – alors qu’ils effectuaient une tâche douloureuse consistant à tenir une bouteille
froide dans leur main gauche puis alors qu’ils recevaient un traitement de réduction de la douleur lors d’une tâche secondaire sans importance. Tous les sujets ont reçu des suggestions d’imagerie dissociative ainsi qu’une suggestion d’analgésie ciblée comme stratégie cognitive de réduction de la douleur. Les mesures suivantes furent obtenues à partir des objectifs de la tâche secondaire auditive: (a) temps de réaction; (b) pic d’amplitude P300 sur les potentiels événements-connexes (ERP event-related potentiels); (c) niveaux de conductibilité de la peau et réponses de conductibilité de la peau (SCR skin conductance responses). La suggestion d’analgésie a produit la plus grande réduction de la douleur chez les sujets fortement hypnotisables mais pas chez les moyens ou faibles qui montraient des temps de réaction plus court, des pics P300 centraux et pariétaux plus élevés ainsi que des réponses de conductibilité de la peau plus élevées. Ces résultats ont été examinés par rapport au modèle de contrôle dissocié assumant comme faible la capacité de réponse à une suggestion hypnotique.

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Estrategias de reducción de dolor en la hipnosis y contexto de hipnosis: ERPs y SCRs durante una tarea auditiva secundaria

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Resumen: Obtuvimos puntuaciones de dolor de 10 sujetos con alta, 10 con media, y 10 con baja hipnotizabilidad mientras sostenían una botella fría dolorosa en la mano izquierda y se les administraban tratamientos para reducir el dolor mientras realizaban una tarea secundaria de eventos inusuales (oddball). Todos los sujetos recibieron sugestiones de imágenes dissociadas y analgesia enfocada, como estrategias cognoscitivas para reducir el dolor. Obtuvimos las siguientes medidas en la tarea auditiva de los tonos a escoger dentro de la tarea de eventos inusuales: (a) tiempo de reacción; (b) amplitud del pico P300 de los potenciales evocados (ERPs); y (c) niveles y respuestas de conductividad de la piel. La analgesia enfocada produjo la mayor reducción de dolor sólo en sujetos con alta hipnotizabilidad, que también mostraron tiempos más cortos de reacción, mayores picos P300 en las áreas central y parietal, mayores respuestas de conductividad de piel. Estos hallazgos se mencionan en relación con el modelo de control disociado, que asume que el uso de las capacidades durante la sugestión hipnótica es bajo.

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