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Pain, Posture, and Perception: Investigating the Role of Bodily Primes in Placebo Analgesia

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ABSTRACT

Most studies on placebo mechanisms rely on Expectancy Theory, which suggests that conceptual expectations can bring about physiological change. However, the exact processes underlying this effect remain unclear. Perceptual Symbol Systems (PSS) Theory, grounded in Embodied Cognition Theory, offers a more specific explanation: mental representations grounded in sensory-motor systems may directly evoke bodily responses. This study tested whether embodied primes, based on PSS Theory, elicit stronger placebo responses than traditional expectancy-based suggestions. Using a within-subjects design, 71 university students underwent a cold pressure task under three conditions: (1) verbal suggestion of an analgesic cream, (2) visual priming with a photo of a person looking upward, and (3) combined visual-motor priming, where participants also looked upward themselves. The placebo response was measured by changes in pain intensity and heart rate. Results showed that both embodied conditions (visual and visual-motor priming) produced stronger placebo responses than the verbal suggestion condition, as indicated by lower pain intensity and reduced heart rate ($F(2,140)=5.83$; $p<.01$). However, the difference between the two embodied conditions was not statistically significant in terms of pain ratings. Notably, visual-motor priming led to a greater reduction in heart rate than visual priming alone ($F(6,330)=1.99$; $p=.06$), suggesting a subtle additive effect of motor engagement. These findings support the role of unconscious embodied processes specifically, perceptual and motor representations in modulating placebo responses. They offer a promising direction for understanding how non-verbal bodily cues may influence the complex perception of pain.

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Introduction

In the scientific literature, self-healing processes are commonly viewed as a form of *Placebo Response* (Alling, 2015). Most of the models describing this response (except for classical conditioning) consider the individual's awareness to be an essential factor during the experience of a treatment. . Healing as a response to a therapeutic intervention on the biological or psychological level would only occur when the patient is aware of the received treatment (Benedetti, Maggi, Lopiano, Lanotte, Reinero, Vighetti, & Pollo, 2003; Miller & Kaptchuk, 2008; Price, 2015).

Expectancy Theory as a comprehensive model explaining the placebo response is rooted in cognitive approaches highlighting the importance of the patient's awareness of receiving the treatment and introduces *verbal suggestions/information* as a key element in initiating the placebo response (Di Blasi, Harkness, Ernst, Georgiou, & Kleijnen, 2001; Stewart-Williams & Podd, 2004). For example, in a series of placebo analgesia studies in patients with Irritable Bowel Syndrome (IBS) (Price, 2015; Craggs, Price & Robinson, 2014; Vase, Norskov, Petersen & Price, 2011) a verbal suggestion was used telling patients they would receive pain analgesia shown to be effective. Placebo effects were higher in patients who received this verbal suggestions compared to those who did not (Craggs et al., 2014; Vase et al., 2011). Brain activity was compared between groups by MRI, and results indicated that only the group receiving the verbal suggestion showed a significant decrease in brain activity for pain perception (Craggs et al., 2014).

Apparently, awareness of receiving a treatment plays a key role in initiating placebo responses, and, thereby, likely self-healing processes and increases treatment effectiveness. However, recent approaches in cognitive sciences, including Embodied Cognition Theory (ECT), suggest that self-healing processes in the body can potentially be initiated without any accompanying conceptual or verbal message (Leitan, Williams & Murray, 2015). According to ECT, no explicit expectation or thought is necessary in order to induce a healing process. Cognitive and affective processes are situated in physical context (e.g. bodily posture and movement) (Barsalou, 1999; Leitan et al., 2015; Frenkel, 2008).

Perceptual Symbols Systems (PSS; Barsalou, 1999) theory a subset of ECT, suggests a model in which concepts, such as healing, are "modal" representations. By activating a concept via priming cues (e.g. a straight and upward posture), "simulation" of that concept can be initiated as a neural reconstruction of its experience in modal centers of the brain (Barsalou, 1999); simulation, in turn, may then be realized on a behavioral level (e.g. subjective pain relief).

Recent research in cognitive science examined the claims proposed by PSS. Leitan et al. (2015) used the priming paradigm for the embodied investigation of the healing response. In this experimental study, after priming the concept of healing by using an associated symbol (i.e. upright posture and looking upward), participants were asked to classify words as either healing-related or unrelated. Results indicated that participants responded faster to healing-related words than to unrelated words. Using the same priming technique, Leitan (2013) showed that observing healing symbols (Leitan, 2013; Leitan et al., 2015) visually may activate the embodied concept of healing resulting in perceptual changes (e.g. pain relief). Researchers introduced posing a straight bodily state as a proper behavioral way for pain and tension resilience (Michalak, Mischnat, & Teismann, 2014; Michalak, Troje, Fischer et al., 2009).

Nair, Sagar, Sollers, Consedine, & Broadbent (2015) showed that in a stressful experimental environment, priming an upright posture may result in increased self-esteem and motivation, improved attitude and reduced fear comparison to a slumped posture. Moreover, the results indicated that those who assuming a slumped posture tended to use more negative emotional words, more first person singular pronouns, and less positive emotional language. Furthermore, following embodied priming of the concept of “power” psychological tensions was significantly reduced (Nair, Sagar, Sollers, Consedine & Broadbent, 2015; Hung & Labroo, 2011). Other similar studies showed that even holding a “painkiller” medication--as a symbol of healing--in one’s hand may increase pain tolerance and reduce perceived pain intensity (Rutchick & Slepian, 2013). Also, based on PSS theory, the perceptions, actions, proprioceptions, introspections and emotions which happen during the processing of a concept can be considered as “embodiments” of that concept (Barsalou, 1999; Leitan et al., 2015). This claim is supported with the study of Valentini, Martini, Lee, Aglioti & Lannetti (2014) which showed visual exposure to facial expressions of positive emotions (which usually occur simultaneously with pain relief) has been shown to enhance analgesic placebo effects (Valentini, et al., 2014).

Embodied approaches may make use of a powerful interaction between sensorimotor and cognitive systems outside of conscious cognition (Balcetis & Cole, 2009). What distinguishes this theory from traditional cognitive theories is the notion that somatic experiences can affect or even induce psychological states and, as a result, influence behavior (Barsalou, 1999; Barsalou, Niedenthal, Barbey, & Ruppert, 2003). All aforementioned processes occur independent of conscious awareness and may serve as support of an alternative explanations of placebo responses. However, there is a lack of research comparing embodied priming and verbal suggestion for placebo analgesia. The aim of the current study is to investigate the effectiveness of embodied priming of a healing symbol compared with a verbal suggestion on the response to a placebo intervention for pain. The research question was: does embodied priming using a healing symbol (upright bodily posture) induce a stronger placebo response compared to a verbal suggestion?

Method

Setting and Participants

Undergraduate students (N = 88) of Tehran University were invited to participate in the study. Participants were screened for any physical injury or recent disease (heart-disease, diabetes, Reynaud disease, extreme blood pressure, epilepsy, and arthritis) or acute or chronic pain conditions in hand/wrist, or neck, pregnancy, and for taking any pain medications on the day of the experiment. Subjects with any of these conditions were excluded in order to reduce risks and biased results. Thirteen students were excluded because they rated their average pain as ≤ 3 when taking their hands out of the cold water. As a result, data of 71 participants (44 female, 27 male) were analyzed for pain intensity. Among these, the heartbeats of 56 individuals were recorded using Photo plethysmography (PPG).

Experimental Design and Procedures

We conducted a within-subject study using three experimental conditions: (a) verbal priming to receive a treatment shown to be effective (placebo analgesia), (b) priming using a visual healing symbol, or (c) visual-motor priming using the healing symbol and applying a symbolic healing posture. We assessed perceived pain intensity and stress arousal by heart rates at four time points. The three experimental conditions were assigned in random order.

Cold-pressor. To induce pain on the subject’s right hand, a standard cold-pressor device was used. Water temperature was set to 6 C$^{\circ}$. A water pump secured constant-temperature cold water flow through the tank with a built-in thermostat, thermal sensors, and digital display (Chemia Rahavard Company, 2013).

Physiological evaluation of heart rate. To assess the heart rate, an electrode was placed on the middle finger of the subject’s left hand. Heartrate data were registered by a computer using Khaje-Nasir Modern Technologies Company (VER2013) software.

Placebo cream. An inactive cream was used described to participants as an analgesic topical cream. Both participants and the research assistant were blind to its lack of activity.

Numeric Rating Scale (NRS). Perceived pain during the experiment was assessed by the Numeric Rating Scale representing the level of pain (Jensen, Karoly, O'Riordan, Bland, & Burns, 1989). The scale consists of pain rating on a scale from 0 (no pain) to 10 (maximum pain). The level of perceived pain intensity was verbally indicated by the participants and recorded by the research assistant.

Procedure

Participants signed informed consent. The whole procedure was explained to the subject, and he would have the chance to ask questions. To reduce the novelty effect, subjects were exposed to the test procedure before the assessments and asked to place their hand in the cold water and remain at the position until the pain is no longer bearable; then, the hand was taking out of water. After 5 minutes of rest the experiments were conducted.

Participants underwent three experimental conditions which took about one hour. Before cold-pressure exposure, they were asked to rate their baseline pain if any. This was followed in random order by: healing induction by visual priming, visual-motor priming, and verbal suggestion. Time interval between conditions was 5 minutes. However, if after this interval subjects rated their pain intensity as more than 1, the interval was extended until they rated pain intensity as 0.

In visual priming condition, participants were sitting at a table facing a white wall, on which the visual stimuli were projecting, while the research assistant stood behind them. The digital thermostat showed the temperature of the water in the center of the container as 6 C°.

According to perceptual symbols system theory, reaching the concept of *healing* could be related to activation of embodied simulations of that concept (Barsalou et al., 2003). That is, embodied visual priming of healing, like a straight posture, can trigger the simulation of healing concept when there is a need to heal (for example while experiencing pain), and therefore, results in healing.

Moreover, using motor priming in accordance with visual priming could increase the chance for reaching the simulated concept, and as a result would enhance the probability of feeling healed on a behavioral level (Simmons & Barsalou, 2003). For example, posing an upright gesture, in addition to a visual priming of straight posture when there is a need to heal (like while feeling pain), is expected to increase the chance for reaching the healing concept, and enhance the feeling of being healed.

In each three conditions, participants were instructed to place the right hand down to the wrist into the water with his fingers extended without touching the container walls. The NRS scale of pain intensity was projected onto the wall, and participants were asked to rate their pain at the first immersion. Pain ratings were recorded by a research assistant, who was unaware of the experimental conditions and their purposes. The subjects would keep their hands in the water until the pain was no longer bearable. From the initial pain rating to the moment of taking the hand out of water, subjects kept looking at the projected visual healing symbol (described below). Immediately after exiting the hand, subjects would place it on the table, and rate pain intensity again with four subsequent ratings every 30 seconds between rating participants were asked to look at the presented visual stimuli.

Visual Priming Condition: Based on Leitan et al. (2015), the stimulus provided in the visual priming condition was an image of an upright standing person looking upwards. The stimulus was projected onto the center of the screen, and subjects were asked to focus on the image, and not to look around. The gender on the image matched that of the subject (Figure 1).

Visual-Motor Priming Condition: The same visual stimulus was used again in the visual-motor priming condition. In addition participants were asked to move their head to look upwards.

Verbal Suggestion Condition: Subjects were told that "a medical company sponsoring our study asked us to evaluate the effectiveness of an analgesic topical medicine as part of our experiments. We are putting this cream on your hand before you place it in the water". In the verbal condition only, participants were asked to look at a Celtic cross) projected on the wall in front of them.

Heartrates were recorded continuously using the PPG sensors.

Following the experiments, subjects were appreciated and debriefed. Participants were informed of the general purposes and were promised to receive more detailed information and the results at an upcoming seminar. At the Psychology and Educational Sciences Faculty of the Tehran University.

Data screening and statistical analysis

Setting time periods for healing from pain severity and feeling of pain: Before applying the analyses, 5 variables related to pain severity, at the moment of, and at 30, 60, 90, and 120 seconds after taking the hand out of cold water, transformed to variables of subjective pain healing. Since our goal was to evaluate pain relief after taking the hand out of water, the rating differences of time periods of 30, 60, 90, and 120 seconds with the hand-exiting moment were calculated. This results in four variables representing the level of healing from the moment that the hand was out of water to each of these time periods. Four variables of relief from pain severity includes, pain severity from hand-exiting moment to 30 seconds after that, from hand-exiting moment to 60 seconds after that, from hand-exiting moment to 90 seconds after that, and pain severity from hand-exiting moment to 120 seconds.

By the means of PPG records, the same method was used to calculate the heart rate healing. That is the heart signals of each subject over 5 time-periods were extracted, and by the same calculations 4 heart-rate healing values ultimately were heart rate healing from hand-exiting moment to 30 seconds after that, from hand exiting moment to 60 seconds after that, from hand-exiting moment to 90 seconds after that, and heart rate healing from hand-exiting moment to 120 seconds after that.

To investigate the effect of experimental conditions (intra-subject comparison) on pain severity and heart rate, repeated measures of ANOVA was used. Statistical analyses were done using SPSS-16 software.

Figure 1. Posing a straight looking upwards gesture as an embodied visual-healing symbol (Leitan et al., 2015)

Results

Data analysis for 13 participants reporting pain severity of less than 3 when taking their hands out of cold water was omitted reducing the sample to 71 subjects. Heart rate data were available for 56 subjects.

Means and standard deviation of pain intensity and heartrate for the three conditions are presenting on Table 1.

Table 1 Mean and SD for Pain Intensity and HR for three Conditions; Comparisons between the conditions using Repeated-measures of ANOVA

Dependent Variables	Condition	Means and standard deviations				Condition Effect	Conditions*time Effect
		30 sec*	60sec	90sec	120sec	F-value (df), p-value	F-value (df), p-value
Healing as indicated in pain intensity (VAS) (N=71)	Verbal Suggestion (1)	2.92 (1.53)	4.76 (2.69)	5.59 (3.11)	5.96 (3.33)	5.831 (2, 140), p<.01	.91 (6, 420), p=.48
	Visual Priming (2)	3.34 (1.99)	4.99 (1.97)	5.94 (2.02)	6.36 (2.07)		
	Visual-Motor Priming (3)	3.33 (1.77)	5.28 (1.77)	6.16 (1.84)	6.50 (1.90)		
Healing as indicated in Heart Signals (N=56)	Verbal Suggestion (1)	.40 (1.53)	.84 (2.69)	.95 (3.11)	1.05 (3.33)	.55 (2, 110), p=.57	1.99 (6, 330), p=.06
	Visual Priming (2)	.65 (2.10)	.86 (2.46)	.95 (2.89)	.92 (3.42)		
	Visual-Motor Priming (3)	.44 (1.87)	1.02 (3.01)	1.40 (3.38)	1.56 (3.60)		

* Time interval after hand removal from cold water

Repeated Measures of ANOVA analysis showed that there were differences between three condition in pain intensity ratings (F (2, 140) = 5.83; p<.01). Pairwise comparisons showed a difference between the average of pain severity at visual-motor condition and expectation condition (p< 0.001) which was found to be in favor of the visual-motor condition. Expectation condition revealed a less average healing than visual condition (p<0.05), however, no difference was found between visual and visual-motor conditions in pain intensity relief (p=0.29).

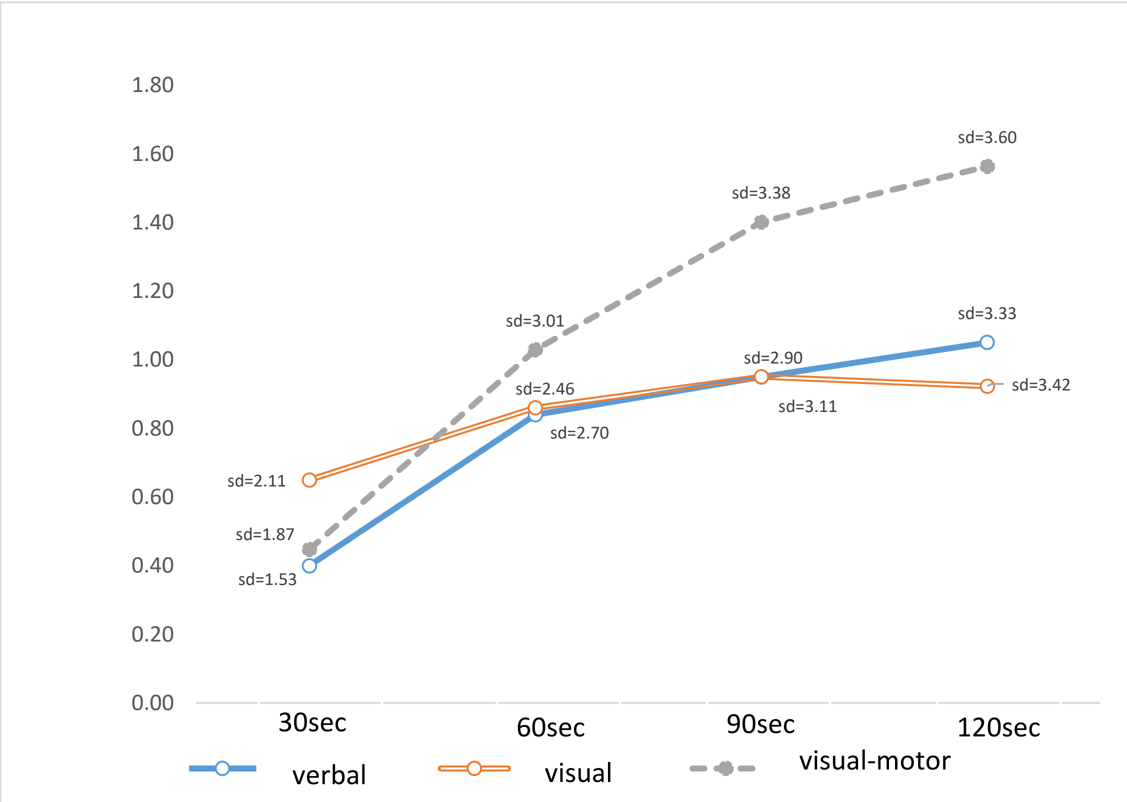

Figure 2. Heart-rate healing at three conditions of expectation, visual, and visual-motor conditions

Figure 2 shows over time (1.99 (6, 330), p=.06) (table 1) the effect of visual-motor priming becomes superior in inducing healing as reflected in heart rate signals.

Discussion and Conclusion

The results in line with previous studies (Kaptchuk, 2002; Miller & Kaptchuk, 2008) indicate that the pain relief were dependent on context, in our case depending on priming conditions with the embodied visual-motor priming having a pain intensity reducing effect superior to, using verbal suggestion. Furthermore, adding the motor modality to the visual modality (visual-motor condition), in comparison to the effectiveness of visual modality (alone), only was shown to be effective in reducing the heart rate signals, and the subjects reported no difference between visual and visual-motor priming conditions in the level of healing from pain intensity.

In summary, we studied the effects of verbal suggestion compared to embodied priming on pain relief following the cold pressure test. The results indicate a general difference between experimental conditions: visual-motor condition more effective than visual condition and expectation condition in pain relief following coldpressor test. In all of these conditions the subject would experience an ease of pain, however, for causing this, the visual-motor condition is found to be more effective than visual condition and visual condition than expectation condition regarding pain intensity healing. Though visual-motor priming could ease the pain more than visual priming, when compared, there was no significant difference considering reduction of the pain severity. Heart-rate signals reduction also seems to follow the same pattern at three conditions but it does show a considerable difference between healing through visual condition and visual-motor condition especially on final time-periods (60, 90, and 120 seconds) of the experiment.

According to Perceptual Symbols System (PSS) Theory, posing an upright posture (as a healing symbol) while experiencing pain would initiate the simulation of healing concept on a behavioral level (Barsalou et al., 2003), reflected in the reports of pain severity and heart-rate index, supported by experimental studies (Leitan et al., 2015). In addition, based on PSS theory, using more modalities can initiate a more powerful simulation of a concept when compared to single modality and this would be reflected on a behavioral level. Therefore, we studied the visual modality alone, and its combination with motor modality, and then compare the findings. According to the results, by activating the simulation of healing concept, it is likely that a healing symbol (placebo) unconsciously play an important role in pain relief. Pain alleviation in visual-motor condition supports the claim that relief could be bodily and unconsciously manipulated. However, embodied induction of healing at visual condition was less effective than at combined condition of visual-motor, and visual priming alone, was not sufficient enough to make embodied priming more effective than verbal suggestion in order to induce healing state, Pain is a complex experience which includes physical, cognitive and emotional dimensions (Hirsch & Liebert, 1998). Neurologically, these dimensions relate to different parts of the brain. Although pain reduction levels in visual-motor condition compared to visual-condition was not statistically different, however, in the case of heart-rate regulation, these two conditions indicate a considerable and almost significant difference at some certain time periods. As shown earlier, the two conditions had similar pattern of reduction at the first seconds of taking the hand out of water. However, over the time up to 120 seconds, the differences between these conditions get higher. It seems adding motor modality to visual modality for activation of healing concept is not effective enough to make a difference between the two priming conditions considering making change to the level of pain. It is possible that visual modality functions better in the activation of healing concept than motor modality, therefore adding the latter may enhance the perception of relief, but it does not make a significant difference at the physical perception of pain reduction. Although there is no separate evaluation of the effectiveness of motor modality alone in this study, implicitly it could be concluded that visual priming can be sufficient enough to initiate simulation of the healing concept. The result may indicate that the modalities have different power in the process of concept simulation and its manifestation on behavioral level.

Latter finding support the notion that an unconscious simulation process may affect the perceived pain response. Based on the Perceptual Symbols System, the findings show this process can be clear on a conscious level of (perceived pain intensity) and its probable effect is on an unconscious neural level (which was reflected in heart-rate signals) (Benedetti, Carlino, & Pollo, 2011; Wager, 2005). As a result, the neural effect can enhance the perceived pain mitigation on a physical-sensory and heart-rate level. However, to support this interpretation additional studies are essential.

An alternative explanation could be that a straight gesture along with looking upwards may distract individuals from pain, as it has been shown that distraction from pain can successfully reduce pain (Van Ryckeghem et al. 2011). Another explanation could be that a straight body-gesture along with looking upwards may activate self-concepts such as pride, strength, and positive emotions, which may directly or indirectly affect the experience of pain (Leitan, 2013). Studies have shown that the position of head could manipulate the feelings of pride and positive emotions (Stepper & Strack, 1993), which, in turn, may affect the perception of pain (Berges, Seale & Ostir, 2011). Further research is needed to disentangle context effects from these potential mediators.

The results of this study support the role of embodied cognition and unconscious processes in producing pain relief responses. Placebo response may be produced in conscious ways in accordance with expectancy theory and unconsciously with embodied approaches (e.g. PSS). Our findings support the role of embodied mechanisms in the placebo response. This is consistent with Teasdale (1994), who suggests motor manipulations can function as an effective psychological treatment, and presenting straight body-gesture would help with the process of physical and psychological well-being.

The results of the current study should be considered along with its limitations. First, the current study had a relatively small sample size. Moreover, the sample of the study was selected from university students so the results cannot be generalized to other non-clinical or clinical samples (e.g. pain patients). Another method to strengthen the data would be to provide between-condition effect sizes with SD. Finally, study sample was selected from a non-patient population, and the results need to be evaluated in future studies, by studying a population of individuals who experience acute or chronic pain.

Declarations

Author Contributions

All authors contributed actively to the conception, design, and execution of the research.

Data Availability Statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Ethical considerations

All procedures performed in studies involving human participants were in accordance with the ethical standards of University of Tehran research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethic approval has been obtained before conducting the research.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this research.

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