

The Placebo Effect and the Relation Between Blood Pressure and Pain Sensitivity

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ABSTRACT. The goal of this study was to explore the relation between blood pressure and pain sensitivity and examine how the presentation of a placebo expectation affected this relation. We hypothesized that participants given an expectation that a cream would reduce pain would report less pain than participants not given this expectation. The results indicated that the hypothesis was correct; participants given the placebo expectation experienced less pain than participants in the control condition. We found negative correlations between blood pressure and pain, such that participants with lower blood pressure experienced the greatest pain. The introduction of the placebo expectation did not affect this relation. Similarly, the introduction of the placebo had no effect on blood pressure. This research contributes to the understanding of responses to acute pain.

A placebo is often used in clinical trials to test the effectiveness of a new type of drug or treatment (Friedman & Dubinsky, 2008). Individuals presented with a placebo, and the instruction that it has the ability to alter symptoms, expect that the inert treatment will relieve their ailments. When this expectation causes an individual to experience a change in symptoms, the phenomenon is known as the placebo effect.

Research on the placebo effect emphasizes the importance of the expectation element. It is not the inert treatment, such as a pill or cream that results in a change in symptoms; the change occurs because of the patient's expectation that the treatment will result in altered symptoms (Benedetti, 2008). Without the expectation, the inert treatments would have no effect on individuals, either physiologically or psychologically. A variety of methods have been used to study the

placebo expectation, such as sham caffeine pills or modified acupuncture (Geers, Wellman, Fowler, Rasinski, & Helfer, 2011; Wasan et al., 2010). These methods alone have shown no effect on individuals; however, when paired with the expectation that energy will be increased or pain will be relieved, individuals experienced effects consistent with their expectation.

In placebo research and literature, the placebo effect does not always occur as expected (Benedetti, 2008). In some cases, individuals presented with a placebo expectation experienced no change in symptoms. Geers, Weiland, Kosbab, Landry, and Hefler (2005) discussed the search for a "placebo-responder" personality, but personality alone does not predict placebo responding. The goal of our research was to determine if a physiological characteristic, rather than personality, can determine how individuals respond to a placebo expectation.

The placebo effect has been used to treat many types of ailments, including both chronic and acute pain. Typically, chronic pain, such as migraines or back pain, tends to be long lasting. In contrast, acute pain tends to be sharp in feeling and lasts only a short period (Speciali, Peres, & Bigal, 2010). A recent study (Whalley, Hyland, & Kirsch, 2008) examined the relation between the placebo

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expectation and acute pain. To induce acute pain, participants received pricks on both hands. One hand received a placebo cream with the participant given the expectation that the cream would reduce pain, whereas the other hand remained untreated. Participants rated the hand treated with the cream as being less painful than the hand left untreated; that is, the expectation of pain relief resulted in participants experiencing less pain.

Although these results (Whalley et al., 2008) show that the introduction of a placebo analgesic can effectively reduce laboratory induced pain, research indicates that the introduction of a placebo can have various effects, depending on the context in which it is presented. For example, if the expectation presented is that the placebo will cause negative symptoms, such as headache or nausea, individuals will often believe that the placebo is making them ill (Geers, Helfer, Weiland, & Kosbab, 2006).

Thus, although the placebo expectation can both induce negative symptoms and relieve ailments, our study focused only on the latter. The purpose of this study was to determine whether the introduction of a placebo reduced pain. Before it is possible to use a placebo to reduce pain, it is first necessary to induce a state of acute pain. The use of the cold pressor task to study the relation between pain and the placebo effect is common practice (Bennett & Boehm, 1997) and involves participants placing their hand in a container with ice water and then rating their pain.

In addition to being used to study the placebo effect, the cold pressor task is also commonly used to study the relation between pain and physiological responses, such as blood pressure (Streff, Kuehl, Michaux, & Anton, 2010). Important for the present research is the relation between resting blood pressure and pain sensitivity. Individuals differ in their resting blood pressure levels, and individuals with low resting blood pressure tend to have greater pain sensitivity than individuals with high resting blood pressure (Duschek, Schwarzkopf, & Schandry, 2008). For example, using the cold pressor task, Helfer and McCubbin (2001) studied the relations among sex, pain sensitivity, and blood pressure. In this study a significant negative correlation was found between resting systolic blood pressure and sensitivity to pain; this result did not differ for men and women.

The Present Research

In the current experiment, participants performed

the cold pressor task with or without the expectation that a hand cream would reduce the pain caused by the task. Based on the findings of Montgomery and Kirsch (1996), we hypothesized that participants given the expectation that the cream would reduce pain would report less pain than participants not given this expectation. Additionally, we hypothesized that women would be more sensitive to pain and have lower blood pressure, as supported by previous research (Helfer & McCubbin, 2001). Furthermore, we assessed whether the relation between blood pressure and pain sensitivity would differ based on whether participants received given a pain relief expectation. Research has indicated that a relation exists between blood pressure and pain sensitivity (Duschek et al., 2008). Because the introduction of a placebo expectation should have an effect on pain (Whalley et al., 2008), we reasoned that the introduction of a placebo would also have an effect on the relation between blood pressure and pain sensitivity. The possibility that a placebo expectation would alter the association between blood pressure and pain sensitivity has not been examined in previous research.

Method

Participants

Participants consisted of 80 undergraduate students who earned partial course credit in their general psychology classes for their participation. Our inclusion criteria consisted of nonsmokers and individuals who were not taking medication causing cardiovascular effects. Due to these criteria, we excluded five participants. Of the 75 remaining participants (33 men, 42 women, *M* age = 18.93 years, age range: 18–24), 57 identified themselves as being White/Caucasian, seven as Black/African American, two as Asian American, one as American Indian/Alaskan Native, one as Hispanic American, and seven as multiethnic. We randomly assigned participants to either the placebo condition or the control condition, with 37 participants in the placebo condition and 38 in the control condition.

Materials

Participants completed a health history form, a demographic questionnaire, and the short form of the McGill Pain Questionnaire (MPQ; Melzack, 1987). The MPQ includes three subscales: a present pain intensity scale, a visual analogue scale, and a list of pain descriptors. The present pain intensity scale ranges from 0 (*no pain*) to 5 (*excruciating*). The visual analogue scale measures pain severity

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with the anchors: *no pain* and *worst possible pain*. Between the two anchors of the visual analogue scale is a 100-mm line on which the participants make a vertical mark to indicate their pain rating. The third component of the short-form MPQ is a list of pain descriptors. These 15 pain descriptors divide into two subscales: four *affective* (e.g., fearful, punishing) and 11 *sensory* (e.g., throbbing, shooting). Each descriptor is given a rating from 1 (*none*) through 4 (*severe*) to indicate how accurately each word described the pain experienced.

The experimenter applied the same hand cream to all participants; the cream has been used in prior studies focusing on the placebo effect and pain. It consists of a moisturizing cream with the addition of iodine and oil of thyme (Montgomery & Kirsch, 1996). Although participants in the placebo condition were given the expectation that it would reduce their pain, the cream used in this study was inactive.

Apparatus

Systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were measured in millimeters of mercury (mmHg) using a GE Dinamap monitor (Carescape V100, 2008).

Procedure

All procedures were reviewed for ethical consideration and approved in advance by the Adrian College Research Committee. Participants completed the study individually. After obtaining informed consent, the experimenter attached a blood pressure cuff to the participant's nondominant arm. Participants then completed the health history and demographic questionnaire. While answering the questions, they had a 10-min resting period. During this time SBP, DBP, and MAP were measured every 2 min.

To give the researchers the appearance of medical professionals, the experimenter entered the room in a lab coat and used gloves to apply the cream to the participant's entire dominant hand. The experimenter told participants in the placebo group that the cream was a drug called Trivaricane, stating that "Most people would find this task painful. But your pain will be reduced because of the Trivaricane." The experimenter told participants in the control group that the cream was a hand cleanser: "I need to make sure your hand is free of dirt and oils. To do this, I need to apply this hand cleanser." After applying the cream, participants

immersed their dominant hand in a container filled with ice and water at 4°C for a maximum of 2 min. The methodology for the cold pressor task was based on its successful use in previous studies (e.g., Bennet & Boehm, 1997; Helfer & McCubbin, 2001). SBP, DBP, and MAP were measured once per minute for the duration of the cold pressor task. If participants asked to withdraw their hand early, the time was recorded. After the cold pressor task, participants completed the MPQ. After completing this questionnaire, the experimenter debriefed participants and thanked them for their participation.

Results

Scores for the MPQ present pain intensity scale were the participants' ratings (0 to 5). Scores for the MPQ visual analogue scales were the measurement of the location of the vertical mark made by the participant on the 100-mm line. For example, a mark at the 55-mm spot on the line would indicate a score of 55. Scores for the sensory subscale were calculated by adding the ratings (1 to 4) assigned to each sensory descriptor by the participant. Scores for the affective subscale were calculated in the same manner. Mean pretask and task readings were calculated for SBP, DBP, and MAP separately. The mean resting readings were the averages of all five pretask measurements. The mean task readings were the averages of two measurements. All participants left their hand in the ice long enough to obtain at least two readings. To determine reactivity, the mean resting measurement was subtracted from the mean task reading for each of the three blood pressure measures (Jennings, Kamarck, Stewart, Eddy, & Johnson, 1992).

Separate 2 (condition: control, placebo) \times 2 (sex: male, female) ANOVAs were performed for responses to both subscales of the MPQ; resting SBP, DBP, and MAP; and SBP, DBP, and MAP reactivity. Analyses revealed a main effect of condition on responses to the MPQ sensory subscale, $F(1, 71) = 4.29, p = .042, \eta_p^2 = .06$, with participants in the control group experiencing significantly more severe pain than those in the placebo group (see Table 1 for means). A main effect also existed for sex on resting SBP, $F(1, 71) = 31.98, p < .001, \eta_p^2 = .31$, with men having significantly higher SBP than women during the pretask readings. A main effect of sex on resting MAP also occurred, $F(1, 71) = 9.24, p = .003, \eta_p^2 = .12$, with men having significantly higher MAP than women during the pretask readings. Reactivity to the task (as measured by

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TABLE 1

Means and Standard Deviations for Dependent Variables by Condition and Sex

	Control				Placebo			
	Male		Female		Male		Female	
	M	(SD)	M	(SD)	M	(SD)	M	(SD)
Resting SBP ^a	128.53	(11.25)**	112.76	(12.06)**	123.86	(7.97)**	112.19	(9.52)**
Task SBP	133.00	(13.45)	118.34	(8.76)	132.24	(9.68)	120.28	(15.22)
Resting DBP	64.30	(4.69)	65.50	(7.06)	64.65	(4.89)	64.82	(6.84)
Task DBP	69.72	(8.14)	72.41	(7.78)	73.47	(7.25)	73.18	(9.73)
Resting MAP ^a	88.72	(6.54)*	83.56	(7.90)*	87.05	(5.40)*	82.37	(7.28)*
Task MAP	131.28	(106.79)	90.16	(7.81)	96.21	(7.52)	91.48	(11.23)
MPQ Present Pain Intensity	2.19	(.98)	2.50	(.86)	2.12	(.93)	2.45	(.89)
MPQ Pain Intensity Scale	34.62	(19.53)	42.95	(19.01)	32.76	(22.61)	37.50	(21.57)
MPQ Affect Subscale	5.00	(1.37)	4.86	(1.32)	4.59	(.80)	4.85	(1.69)
MPQ Sensory Subscale ^b	19.00	(5.47)*	22.05	(7.54)*	17.12	(3.18)*	18.55	(4.62)*

Note. SBP = systolic blood pressure; DBP = diastolic blood pressure; MAP = mean arterial pressure; MPQ = McGill Pain Questionnaire.
^aAll male participants (both control and placebo conditions) compared to all female participants (both control and placebo conditions). ^bAll participants in control condition (both male and female) compared to all participants in placebo condition (both male and female).
 * $p < .05$. ** $p < .001$.

change from baseline) did not differ based on sex or condition.

Correlation analyses were performed between SBP, DBP, MAP, and subscales of the MPQ. Present pain intensity scores were found to be negatively correlated with resting SBP, $r(74) = -.27, p = .02$, and with resting MAP, $r(74) = -.25, p = .028$. Pain severity was negatively correlated with resting SBP, $r(74) = -.31, p = .008$; resting DBP, $r(74) = -.25, p = .031$; and resting MAP, $r(74) = -.30, p = .010$. The MPQ sensory subscale negatively correlated with resting SBP, $r(74) = -.30, p = .008$, and with resting MAP, $r(74) = -.29, p = .013$.

The sample was separated into the control condition and the placebo conditions to test whether the relations between SBP, DBP, MAP, and pain persisted in the presence of a placebo expectation. In the control condition, there were negative correlations between pain severity scores and resting SBP, $r(37) = -.32, p = .049$; between MPQ sensory

scores and resting SBP, $r(37) = -.36, p = .025$; and between MPQ and resting MAP, $r(38) = -.40, p = .012$. In the placebo condition there were negative correlations between present pain intensity score and resting SBP, $r(36) = -.34, p = .041$; between pain severity and resting DBP, $r(36) = -.34, p = .041$; and between pain severity and resting MAP, $r(36) = -.35, p = .041$.

Fisher's z test was performed to test for differences between correlations in the two conditions. All z s were nonsignificant, $ps > .05$ —providing evidence that the relation between pain sensitivity and resting SBP, DBP, and MAP was not altered by a placebo expectation.

Discussion

Consistent with past research (Duschek et al., 2008), the results of this study indicated that individuals with high resting blood pressure were less sensitive to pain than individuals with low resting blood pressure. The results also showed that placebo expectation had an effect on individuals' perception of pain, using the common laboratory pain task, the cold pressor. When presented with the expectation of pain relief, participants experienced less pain than the participants not given this placebo expectation. Finally, the presentation of a placebo expectation did not affect the relation between individuals' blood pressure and their pain sensitivity.

Our initial hypothesis was supported; that is, the presentation of a placebo cream, accompanied by an expectation of pain relief, led to reduced pain sensitivity in individuals. The use of a placebo expectation to reduce pain has been successfully demonstrated by numerous previous studies (Wasan et al., 2010; Whalley et al., 2008). In addition, based on both prior research (Helfer & McCubbin, 2001) and the results of our study, there is a distinct negative relation between blood pressure and pain sensitivity. We chose to extend our research to another area of interest: resting blood pressure and pain sensitivity by combining these two areas of research (placebo effect and pain sensitivity; blood pressure and pain sensitivity) to explore a relatively unknown area of study. In this way, we determined that the relation between blood pressure and pain sensitivity is independent of the effects of a placebo expectation.

Based on these results, a variety of inferences can be made about the relation between blood pressure and pain sensitivity. For example, individuals who are hypotensive are extremely

sensitive to pain. In contrast, individuals who are hypertensive are much less sensitive to pain. These results coincide with the research of both Helfer and McCubbin (2001) and Duschek et al. (2008). Despite differences in resting blood pressure, the relation we found between blood pressure and pain sensitivity was not subject to gender differences—the relation was the same for both women and men.

With regard to the relation between the placebo effect and pain sensitivity, the implications are not limited to acute pain. We found that the presentation of a placebo expectation can be an effective means of reducing pain sensitivity in acute pain, but how does the introduction of a placebo analgesic affect chronic pain? Research shows that, similar to acute pain, the introduction of a placebo expectation can effectively reduce chronic pain, such as lower back pain (Charron, Rainville, & Marchand, 2006).

Our findings pertaining to the relations between blood pressure, pain sensitivity, and the placebo effect are central to determining what qualities make individuals placebo responders. However, our data suggest that the presentation of a placebo expectation had no effect on the relation between blood pressure and pain. From these findings, it can be inferred that physiological characteristics, such as blood pressure, are not a component in determining how an individual responds to the presentation of a placebo. The explanation for why some individuals respond to a placebo and others do not is still unknown. In addition, we determined that the relation between blood pressure and pain sensitivity was not altered by situational variables (e.g., experimental setting) or cognitive variables (e.g., expectations).

Although the results of the current study are promising in the area of placebo and pain research, a major procedural limitation did exist. Participation was limited to healthy, undergraduate students enduring temporary acute pain; we were not able to examine the effects on other populations. However, prior research has found that the placebo effect can be an effective means of reducing pain sensitivity in clinical settings involving other demographic groups, including the elderly (Bingel, Colloca & Vase, 2011) and individuals with Parkinson's (Lidstone et al., 2010).

The results of this study support the hypothesis that participants given the expectation that a cream would reduce pain report less pain than the participants not given this expectation. In the analysis of the relation between blood pressure and pain,

we found that the greatest pain was experienced by individuals with lower blood pressure. Furthermore, results indicate that the placebo effect does not change the relation between resting blood pressure and pain. The individual differences between participants in the magnitude of effect caused by the introduction of the placebo expectation are an aspect to be investigated in future research in this area.

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