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Beliefs About Expectations Moderate the Influence of Expectations on Pain Perception

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Abstract

Background Expectations congruently influence, or bias, pain perception. Recent social psychological research reveals that individuals differ in the extent to which they believe in expectation biases and that individuals who believe in expectation biases may adjust for this bias in their perceptions and reactions. That is, idiosyncratic beliefs about expectations can moderate the influence of expectations on experience.

Purpose Prior research has not examined whether idiosyncratic beliefs about expectations can alter the degree to which one's expectations influence pain perception. Using a laboratory pain stimulus, we examined the possibility that beliefs about expectation biases alter pain responses following both pain- and placebo-analgesic expectations.

Methods Participants' beliefs about expectation biases were measured. Next, participants were randomly assigned to receive either a pain expectation or a placebo-analgesia expectation prior to a cold-pressor task. After the task, participants rated their pain.

Results Beliefs about expectation biases significantly influenced pain reports. Specifically, pain reports were more influenced by provided expectations the less participants believed in expectation biases (i.e., pain expectations resulted in more pain than analgesia expectations).

Conclusions Beliefs about the expectation bias are an important and under-examined predictor of pain and placebo analgesia.

Keywords Beliefs · Cold pressor · Correction · Expectations · Pain

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Introduction

Expectations are predictions for future events [1]. Although expectations often reside outside of conscious awareness, many of the expectations that individuals hold are quite overt—such as expectations about medical treatments given by healthcare professionals. Furthermore, a diverse and voluminous literature indicates that expectations often lead individuals to experience what they expect to experience [1–4]. For example, individuals anticipating that a drug will reduce the pain caused by a medical procedure often report less pain after taking the drug, even when the drug is actually inert [2]. However, whether or not such expectation effects manifest depends upon a variety of individual-difference and situational factors [5–9]. Of current focus, Handley, Albarracín, Brown, Li, Kumkale, and Kumkale [10] recently suggested that individuals vary in the degree to which they believe that expectations (e.g., alcoholic drinks make one happy) bias actual experiences (e.g., how happy an alcoholic drink makes one feel). Furthermore,

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these authors reasoned that beliefs about expectation biases shape individuals' experiences after an expectation is consciously presented.

Ample research shows that individuals typically wish to reduce bias in their judgments [11]. Specifically, experiments indicate that when individuals become aware of a factor they believe biases their judgments (e.g., expectations) and they are motivated to arrive at accurate judgments, they often correct against the unwanted bias [11–13]. Yet, it is difficult for individuals to fully determine how much factors, such as expectations, influence their judgments. As a result, individuals sometimes over-correct against perceived bias [13]. Consequently, Handley et al. [10] reasoned that individuals who believe that expectations bias them may tend to correct or over-correct against the influence of expectations, reducing or even reversing this influence. For example, consider an individual who receives an explicit expectation that a stimulus will provoke considerable pain and another individual who receives no pain expectation for the same stimulus. Commonly, the individual who receives the pain expectation will be influenced by that expectation and perceive greater pain from exposure to the same stimulus. Yet, if that individual believes that expectations influence experiences, he or she may correct (or even over-correct) for the influence of the pain expectation during the painful stimulus. As a result, this individual may perceive pain comparable to (or even less than) that perceived by the individual who was provided no pain expectation. However, some individuals tend not to believe that expectations bias experiences. As such, these individuals may correct little or not at all for explicitly provided expectations, and thus, they have experiences biased by (i.e., consistent with) their expectations. Thus, this meta-cognitive variable may be an important moderator of expectation effects.

Current aims, experiment overview, and hypotheses

Few experiments have examined beliefs in expectation biases and, to our knowledge, none within a pain context. In the current experiment, we examined whether individuals' beliefs about expectation biases moderate the influence of expectations on pain reports. We examined the relationship under two different laboratory conditions in which participants engaged in the cold-pressor task by submerging their hand in ice water for 2 min. Specifically, half of the participants' were randomly assigned to a condition in which they were lead to anticipate that an upcoming task produces a great deal of pain (*pain-expectation condition*). This condition approximates commonplace medical contexts in which patients are told that a procedure will cause pain (e.g., “This is going to hurt, but please remain as still as possible”). The remaining participants were lead to anticipate reduced pain due to an administered (placebo) analgesic prior to the same painful task (*analgesia-expectation condition*). Blood pressure and heart rate were measured before and during the pain task, and afterward, participants rated their pain using the McGill Pain Questionnaire Short-Form (MPQ-SF; [14]). As no prior experiments have examined the relationship between beliefs in expectation biases and pain, we examined all scales of the MPQ-SF.

Given the results and theorizing of Handley et al. [10], we anticipated that the less participants believed in expectation biases, the more their pain perceptions would be influenced by the provided expectations (i.e., pain expectations would result in more pain than analgesia expectations). However, the more participants believed in expectation biases, the more they may correct or over-correct against the provided expectations. As a result, these participants should perceive pain that is not influenced by the provided expectations or even perceive pain that is opposite to the provided expectations if they over-correct against expectations (i.e., analgesia expectations would result in more pain than pain expectations).

Method

Participants

Sixty-seven healthy university students without chronic pain participated individually in return for partial course credit. All participants engaged in the cold-pressor task, for which they were requested to submerge their hand in ice water for exactly 2 min. Only participants who engaged in the task for the full 2 min were retained for analysis. This retention criterion was established a priori to (a) ensure that analyzed pain reports pertained to an *identical experience* (i.e., a 2-min task rather than a shorter task) and (b) to increase the likelihood that retained participants took the experiment seriously (thus completing the task per instructions) and reported earnestly on their experiences. Seventeen individuals did not complete the pain task, and one remaining participant failed to complete all items assessing beliefs in expectation biases, leaving 49 participants for analysis (23 female and 26 male). Non-retained participants were significantly older (M=22.06) than retained participants (M=19.08, SD=1.61; ages ranged from 18 to 26 years), $t(65)=2.54$, $p<.05$, but were comparable on gender composition, $\chi^2(1)=2.3$, $p>.05$. Importantly, the retention criteria did not influence the samples with regard to the two predictor variables (i.e., random sampling and random assignment were preserved even though some participants were not retained). Specifically, participants retained and not retained for analyses held comparable beliefs in expectation biases, $t(63)=-0.81$, $p>.40$, and the

17 individuals who were not retained were evenly distributed across the pain-expectation (eight individuals) and analgesia-expectation (nine individuals) conditions. Forty retained participants categorized their ethnicity as "White," two as "Black," three as "Asian," and four as "other." The Institutional Review Board of the University of Toledo approved all procedures in advance.

Procedure

Participants completed a pre-screening questionnaire packet earlier in the semester. Embedded within this packet were five items measuring beliefs that expectations influence experiences. Three of these items were the same as those used by Handley et al. [10], such as "In general, people are likely to experience the mood (good or bad) they expect to experience." Two new items were added to assess beliefs regarding the influence of *medically related* expectations on experiences. These items included "In general, medications given by doctors (e.g., antibiotics) are very effective for me" and "If one expects to feel pain, one will probably experience pain." Participants responded to each item on a five-point scale anchored at 0 (*not at all true*) and 4 (*very true*). The sum of these items created a reliable (*Cronbach's* α=0.68) measure of participants' beliefs in expectation biases.

Participants completed the study individually in a laboratory room. After reading and signing an informed consent document detailing the procedures of the experiment, participants relaxed during a 10-min baseline period in which blood pressure (mmHg) and heart rate (bpm) were recorded every 2 min using a GE Medical Systems Dinamap Pro Series 100 Vital Signs Monitor.

Following the baseline period, we administered the context manipulation, which was slightly modified from procedures used successfully in other pain-expectation studies [15]. Participants were randomly assigned to the pain-expectation condition or the (placebo) analgesia-expectation condition by use of a random number generator. All participants were informed that they would soon take part in a very painful task in which they would place their hand in a container of water and crushed ice (the cold-pressor task). All participants then had an inert cream applied to their non-dominant hand. The cream contained a mixture of iodine, oil of thyme, food coloring, and lotion that created a light brown, medicinal-smelling cream. Individuals in the pain-expectation condition were told that the cream was a hand-cleaning product, and the experimenter applied the cream from a bottle labeled "Soft clean hand cleanser." Therefore, participants in this condition only expected pain, and no analgesic relief, from the upcoming pain task. In the analgesia-expectation condition, the experimenter went through the same procedure but additionally told participants "…we are studying the properties of a new pain-reducer called 'Trivaricane.' Trivaricane is a topical, local anesthetic that has been proven to be effective in studies at other universities. The drug is safe and, in essence, provides a numbing barrier between the pain receptors in your skin and a pain stimulus." The experimenter then opened a bottle labeled "Trivaricane: Approved for research purposes only" and applied the cream to the participants' non-dominant hand. The participants who were told that they received an analgesic cream were further told that the cream should start numbing their hand in about 30 s.

After the context manipulation, participants placed their non-dominant hand up to their wrist in a container of water and crushed ice at 4°C. Participants were instructed to keep their hand in the water for 2 min but were told they could withdraw their hand if it became unbearable. Blood pressure and heart rate were recorded every 30 s during the task.

Immediately after removing their hand from the ice water, participants completed a questionnaire containing the MPQ-SF [14]. The MPQ-SF includes a present pain intensity scale for which participants respond to the item "Which of the following best describes the pain you felt during the task?" on a six-point scale anchored from 0 (*no pain*) to 5 (*excruciating*). Next, participants completed a pain severity scale by responding to the question "how severe is the pain?" by placing a vertical line on a 100-mm horizontal line anchored at the left end with the label "no pain" and anchored at the right end with the label "worst possible pain." Finally, participants indicated on the MPQ-SF the amount of pain they experienced corresponding to four affective descriptors (e.g., Tiring–Exhausting, Sickening) and 11 sensory descriptors (e.g., Throbbing, Shooting) on four-point scales ranging from 1 (*none*) to 4 (*severe*). Participants' responses to the affective and sensory descriptors were independently averaged, creating affective and sensory scales (three individuals failed to complete all items for the sensory scale).

Results

Hierarchical regression analyses were used to examine all pain and physiological measures. In these regressions, context condition (dummy coded) and the continuous measure of participants' belief in expectation biases (centered) were included in the first step of the regression as predictor variables. In the second step, the Context Condition × Belief in Expectation Biases interaction term was entered.

Present pain intensity scale

The analysis of the present pain intensity scale revealed a significant main effect of beliefs in expectation biases, β=−0.442, p<.05, but no main effect of context condition (p>.05). This result indicates that beliefs about expectations can indeed alter pain reports. Furthermore, the Context Condition × Belief in Expectation Bias interaction was also significant, β=0.459, p<.05. Regression lines for the present pain intensity scale are plotted by condition at the top of Fig. 1, across the full range of the belief-in-expectation-biases scale. The nature of this interaction was examined with multiple-regression analyses following the guidelines provided by Aiken and West [16]. Specifically, simple effect tests were conducted to investigate differences between participants in the pain-expectation versus analgesia-expectation conditions at high (+1 SD) and low (−1 SD) levels of belief in expectation biases. As displayed in Fig. 1, the lower participants' beliefs in expectation biases were, the higher pain reports became in the pain-expectation condition relative to the placebo-analgesic condition, β=0.478, p<.05. However, the higher the participants' beliefs in expectation biases were, the lower pain reports actually became among participants in the pain-expectation relative to analgesic-expectation condition, although this difference was not statistically significant, β=−0.375, p=.07. These results support the idea that individuals correct, and perhaps over-correct, for the influence of explicitly provided expectations the more they believe in expectation biases.

Pain severity scale

Analysis of the pain reports on the pain severity scale produced no significant effects (all ps>.17).

Affective scale

The analysis of the affective scale of the MPQ-SF revealed a significant main effect of beliefs in expectation biases, β=−0.571, p<.01, but no main effect of context condition (p>.05). Furthermore, consistent with the present pain intensity scale, the anticipated interaction between context condition and belief in expectation biases was significant, β=0.332, p=.05. Regression lines for the affective scale are plotted by condition in the middle of Fig. 1 across the full scale of participants' beliefs in expectation biases. This interaction was explored with simple effect tests, as was done for the present pain intensity scale. Replicating findings for that measure, the lower participants' beliefs in expectation biases were, the higher pain reports became in the pain-expectation condition relative to the placebo-analgesic condition, β=0.498, p<.05. However, the higher the participants' beliefs in expectation biases were, pain reports became increasingly similar in both context conditions, β=−0.118, p>.50. Again, these results support the notion that individuals correct for the influence of explicitly provided expectations the more they believe in expectation biases.

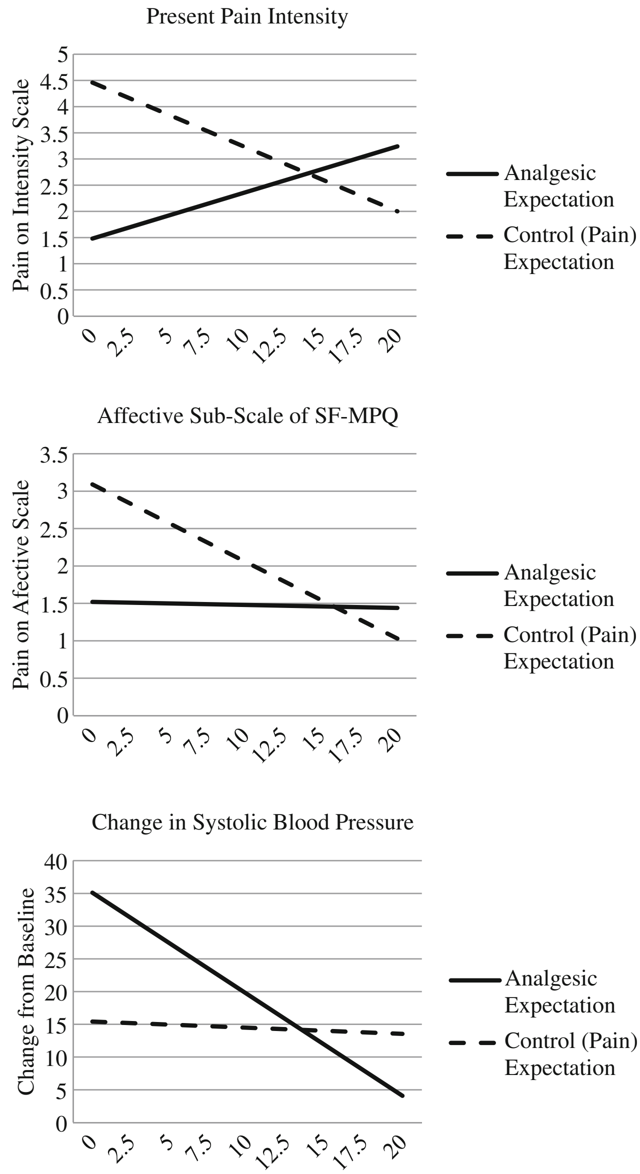

Fig. 1 Regression lines for the interaction between context condition and belief in expectation biases observed for the present pain intensity scale, affective scale of the MPQ-SF, and change in systolic blood pressure from baseline. *Note*. Regression lines are plotted across the range for belief in expectation biases (x-axis). Higher numbers of the x-axis indicate greater belief in the expectation bias

Sensory scale

The analysis of the pain reports on the sensory scale of the MPQ-SF did not produce any significant effects (all ps>.20).

Physiological measures

Change scores on systolic blood pressure, diastolic blood pressure, and heart rate were created by subtracting average scores obtained during the 10-min resting baseline period from averaged scores obtained during the cold-pressor task. Separate analyses of these change scores only yielded an interaction between context condition and beliefs in expectation biases on systolic blood pressure change, $\beta=-0.379$, $p<.05$ (all other ps>.15). Regression lines for systolic blood pressure change are plotted by condition at the bottom of Fig. 1 across the full scale of participants' beliefs in expectation biases. This interaction indicated that the more participants believed in expectation biases, the lower their systolic blood pressure was in the analgesia-expectation condition compared to the pain-expectation condition, whereas the opposite was the case the less participants believed in expectation biases.

Exploratory measures

Several individual-difference measures were also examined to determine if the measure of belief in expectation biases isolates a unique psychological construct, or is redundant with other variables. Specifically, participants completed a revised self-motoring scale [17] which measures the extent to which individuals' reports derive from internal standards (low) or from social cues in the environment (high). The reports of high self-monitors tend to be influenced by the communications of others, and thus, they may demonstrate larger expectation effects. Additionally, we measured participants' level of dispositional optimism using the life-orientation test-revised [18]. Research indicates that optimistic individuals are more heavily influenced by expectations [6]. Furthermore, the current research demonstrated that expectations more heavily influence individuals the less they believe in expectations biases. Thus, it is possible that high self-monitors and more optimistic individuals might tend to believe that expectations do not bias them. Finally, we measured individual differences in the degree to which participants consider future consequences using the consideration-of-future-consequences scale (CFC; [19]). It is possible that the more individuals consider events in the future, the more they consider variables that might influence their future, like expectations. Thus, CFC and our measure of belief in expectation biases might be overlapping constructs. Importantly, none of these individual-difference variables correlated significantly with the measure of belief in expectation biases (correlations among all individual-difference variables appear in Table 1, along with descriptive statistics for each). Furthermore, the significant interaction between context condition and belief in expectation bias remained significant when simultaneously controlling for self-monitoring, optimism, and CFC in separate regression analyses for the pain intensity measure, $\beta=0.412$, $p<.05$, and affective scale, $\beta=0.419$, $p<.05$, but dropped to marginal significance for the systolic blood pressure measure, $\beta=-0.392$, $p=.06$. Thus, our individual-difference predictor variable was unique from these other measures (i.e., possesses discriminate validity).

Discussion

In this experiment, beliefs about expectation biases predicted pain reports on two pain scales. Moreover, the relationship between the type of expectation provided to participants and pain was moderated by beliefs in expectation biases. Essentially, the results indicated that participants' pain reports were more consistent with the provided expectations the *less* they believed in expectation biases (i.e., more pain was reported in the pain-expectation conditions than the analgesia-expectation conditions). However, participants' pain reports were less consistent with the provided expectations the *more* they believed in expectation biases (i.e., comparable pain was reported in both context conditions). These are the first data to demonstrate that beliefs in expectation biases can alter pain reports.

A plausible explanation for the obtained pattern of results derives from the bias-correction literature [11–13]. This research indicates that individuals attempt to undo or correct for factors *they believe* bias their decisions and perceptions. Individuals engage in bias correction when they are aware of factors they believe bias their judgments (e.g., expectations) and are motivated to correct for the unwanted influence. Given this, it seems likely that individuals who believe in expectation biases tend to correct or over-correct for the influence of pain- and analgesia-expectations, whereas

Table 1 Correlations, sample size, means, standard deviations, and actual ranges for all individual-difference measures

Measure	1	2	3	4	n	Mean	SD	Actual range
1. Belief in expectation bias	—	-.136	-.059	.224	49	13.90	3.20	7–20
2. Self-monitoring		—	-.101	.240	48	10.08	2.05	5–14
3. Dispositional optimism			—	.019	49	13.90	4.46	1–23
4. Consideration of future consequences				—	48	40.06	6.83	23–53

Note. One participant failed to complete all items for the self-monitoring and consideration of future consequences scales. The p-values for all correlations involving the belief in expectation bias are>.125. The p-values for all other correlations are>.104.

individuals who tend not to hold this belief do not [10]. These results have implications for how individuals react to pain stimuli when they are provided an explicit expectation for the painful event. Also, the data may help to explain cases in which experimenter-provided placebo expectations produce less rather than more benefit [8]. Importantly, we hasten to add that not all of the results were consistent with this bias-correction interpretation. As this was the first examination of how beliefs in expectation biases influence pain perception, much more data are needed before firm conclusions can be made regarding the underlying mechanisms at work.

Limitations and future directions

Interestingly, the interaction observed for both the present pain intensity and affect scales was more heavily driven by participants in the pain-expectation condition. That is, there appears to be greater bias correction in the pain-expectation condition than the analgesia-expectation condition. This observation might shed light on possible factors that will determine the magnitude of bias correction within pain contexts. For instance, it is possible that participants who believed in expectation biases felt that the expectation was more biasing when they received the pain-expectation than when they received the analgesia (or mild pain) expectation. Thus, these participants may have felt the pain expectation requiring greater bias correction than the mild analgesic expectation. Alternatively, participants in the analgesic-expectation condition might have actually perceived two expectations: one for pain from the task and one for decreased pain perception from the cream. If participants corrected against both of these expectations to some extent, the observable relationship between beliefs in expectation biases and pain could be weakened. These and potentially other considerations could prove significant as research in expectation-based bias correction continues.

Furthermore, it is possible that future interventions could change individuals' beliefs in expectation biases. For instance, individuals could be educated that expectations actually do bias experiences, henceforth prompting them to correct against this bias. In this case, individuals could be less likely to experience unwanted, yet expected, symptoms. However, this would only be advisable if the intervention targeted beliefs about negative expectations; correcting against the influence of negative expectations can be beneficial, whereas correcting against positive expectations could be harmful.

It is important to discuss several issues regarding external validity. First, participants in this experiment were healthy young adults without chronic pain. This type of sample differs in numerous ways from clinical samples, and we must be cautious in extrapolating from these findings to clinical settings. Future research using clinical samples is required to determine the extent to which the current results generalize to clinical settings—and this is the next stage of our research agenda. Furthermore, here we examined laboratory pain rather than clinical pain. This laboratory-based design, with a greater emphasis on internal validity than external validity, was selected to provide a cleaner context for this initial examination into the relationships between beliefs in expectation biases and pain. As such, this study represents an “effect detection” study rather than an attempt at mimicking an actual clinical setting. Laboratory studies of this kind are critical in exposing factors that are important for clinical research and practice and, considering the high costs of clinical trial studies, provide the launching point for future clinical research. The results of the present study are the first to examine the influence of beliefs in expectation bias on pain and reveal that the issue is worthy of future inquiry with actual pain patients.

Finally, the MPQ-SF sensory scale and pain severity scale demonstrated no significant effects. It is not clear why these two measures produced no effects, whereas the present pain intensity scale and the affective scale did detect relationships between provided expectations and beliefs in expectation biases. Furthermore, for the physiological measures, we found an unanticipated interaction between context condition and beliefs in expectation biases on systolic blood pressure. Replication of this finding in future studies suggests that there is an interesting disconnect between the body's reaction to pain and the mind's meta-cognitive perception of pain and its causes. These data may prove valuable as further data regarding beliefs in expectation bias move forward. We hope that the developing research on beliefs in expectation biases addresses the aforementioned issues and more, increasing our ability to predict and manipulate the occurrence of pain and placebo analgesia.

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