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Anger Management Style Moderates Effects of Attention Strategy During Acute Pain Induction on Physiological Responses to Subsequent Mental Stress and Recovery: A Comparison of Chronic Pain Patients and Healthy Nonpatients

JOHN W. BURNS, PHD, PHILLIP J. QUARTANA, PHD, and STEPHEN BRUEHL, PHD

Department of Psychology, Rosalind Franklin University of Medicine and Science (J.W.B.), North Chicago, Illinois; Department of Psychiatry and Behavioral Sciences (P.J.Q.), Johns Hopkins University School of Medicine, Baltimore, Maryland; and the Department of Anesthesiology (S.B.), Vanderbilt University School of Medicine, Nashville, Tennessee

Abstract

Objectives: To examine whether high trait anger-out chronic low back (CLBP) patients would show exceptionally large symptom-specific lower paraspinal (LP) responses, compared with healthy nonpatients, during pain induction, a subsequent mental stressor, and recovery when they were urged to suppress awareness of pain and suffering.

Methods: CLBP patients ($n = 93$) and nonpatients ($n = 105$) were assigned randomly to one of four attention strategy conditions for use during pain induction: sensory-focus, distraction, suppression, or control. All participants underwent a cold pressor, and then performed mental arithmetic. They completed the anger-out (AOS) and anger-in (AIS) subscales of the Anger Expression Inventory.

Results: General Linear Model procedures were used to test Attention Strategy Condition $\times$ Patient/Nonpatient Status $\times$ AOS (or AIS) $\times$ Period interactions for physiological indices. Significant interactions were found such that: a) high trait anger-out patients in the Suppression condition seemed to show the greatest LP reactivity during the mental arithmetic followed by the slowest recovery compared with other conditions; b) high trait anger-out patients and nonpatients in the Suppression condition seemed to show the slowest systolic blood pressure recoveries compared with other conditions.

Conclusions: Results extend previous work by suggesting that an anger-out style moderates effects of how attention is allocated during pain on responses to and recovery from a subsequent mental stressor. Results provide further evidence that trait anger-out and trait anger-in among CLBP patients are associated with increased LP muscle tension during and after pain and mental stress.

Keywords

attention strategies; acute pain; trait anger-out; symptom-specific reactivity; chronic pain patients

INTRODUCTION

Anger and how anger is managed are related to acute and chronic pain severity (1–7). Actual (“state”) anger suppression seems related to subsequent pain intensity in healthy controls and to observable pain behaviors among chronic low back pain (CLBP) patients (8,9). Findings suggest that the trait-like tendency to express anger (anger-out) may affect acute and chronic pain sensitivity through deficits in endogenous opioid functioning (1) and through disruptions in personal relationships (5). Results also indicate that effects of trait anger-out on pain intensity and physiological reactivity may be heightened under conditions in which people with a strong inclination to express anger are prevented from doing so (10–13). In the work of Burns et al. (12), subjects scoring high on trait anger-out who attempted to suppress thoughts and feelings of anger during interpersonal provocation reported greater pain during subsequent pain induction than high anger-out subjects who did not attempt to suppress feelings of anger. This “mismatch” of people who prefer to express anger to a situation in which they must suppress may have sustained their anger, and thus left them more vulnerable to the next noxious event (i.e., pain).

Although interpersonal harassment provokes anger, so too do events that stimulate pain. Findings indicate that acute pain induced under controlled laboratory settings not only elicits general emotional distress and suffering but incites angry and aggressive responses as well (4,14–16). To the degree anger-related emotions are aroused during pain, people will need to manage, regulate, or cope with these feelings. It may well be the case that people who are predisposed to express their anger may facilitate recovery from pain by expressing the irritation, annoyance, and aggravation invoked by the pain. Conversely, habitual anger expressors may have more difficulty dealing with pain and its aftermath if by force of circumstance, they must suppress their irritation.

Findings concerning attention and cognitive processing of pain offer some intriguing possibilities about connections between anger regulation during pain and subsequent responses. Results suggest that distinct ways of attending to and interpreting painful stimuli may exert profoundly different effects on pain intensity, distress, and physiological reactivity both during and after pain induction. Specifically, we have argued that a given attention strategy used during a noxious (painful) event affects reactions to later events to the extent that it serves to magnify, sustain, or reduce the emotional arousal incurred during the initial event (17). Directing attention away from pain through distraction or focusing attention on innocuous sensory aspects of pain seem related to lower pain intensity and emotional distress (18,19). However, attempting to suppress awareness of pain and suffering during noxious stimulation seems to have the paradoxical effect of amplifying pain intensity and emotional distress (8,20,21). These findings have also shown that various attention strategies employed during pain will influence the magnitude and direction of responses to subsequent events, stressful or otherwise.

To the extent that angry feelings are elicited during pain, distraction from pain or focus on nonemotional, sensory information presented by pain may therefore serve to avoid to some degree the arousal of anger during pain, and thereby help minimize detrimental effects on responses during and after an acute pain episode. In contrast, attempts to suppress awareness of pain during painful stimulation may ironically augment anger-related thoughts and feelings, and thus may have especially deleterious effects on perceptions of and reactions to later events. Effects of these attention strategies on responses to current and subsequent events may further depend on the typical way a person manages anger. Distraction and sensory focus may contribute to optimal responses for high and low anger expressors alike. However, the detrimental effects of suppression may become more dramatic among people who usually express anger because this attention strategy represents a kind of regulation that is inconsistent—a mismatch—with their preferred style.

Further, aberrant muscle tension reactivity during pain and stress may have implications for pain and distress among patients with chronic musculoskeletal pain, whereas this may not be the case for healthy nonpatients. A “symptom-specificity” model proposed by Flor and colleagues (22–24) suggested that patients with a variety of musculoskeletal disorders may show abnormal stress-induced muscular activity that is specific to their disorder. Results indicate that CLBP patients reveal strong contractions of low back muscles (i.e., lower paraspinals, LP) during physical and psychological stress, whereas they do not necessarily show such contractions at more distal muscle sites (22–28). Such symptom-specific reactivity may underlie pain aggravation at the site of injury (29,30), and results suggest that LP (but not trapezius) reactivity to stress is predictive of everyday pain severity among CLBP patients (31). Burns (17) also reported that CLBP patients who attempted to suppress awareness of pain showed greater LP tension increases than patients in distraction or sensory focus conditions during pain—a difference that was magnified during a later mental arithmetic stressor and recovery. To the degree LP tension affects chronic pain aggravation (31), suppressing pain-related thoughts during pain may pose a special danger to CLBP patients in that such tension may be maintained or even increased during subsequent events.

Pulling the attention strategy, anger management, and symptom-specificity findings together, we propose that CLBP patients who prefer to express anger may reveal exceptionally high levels of symptom-specific LP muscle reactivity during and after an event in which they are forced to suppress awareness of pain and suffering. We sought to conduct preliminary tests of these speculations with an extant data set collected in a study of CLBP patients and healthy nonpatients, who underwent a cold pressor pain induction task and then performed mental arithmetic (17). Participants underwent pain induction under one of four attention strategy conditions: distraction, sensory focus, suppression, or control. For the present study, we examined whether anger management style moderated effects of attention strategy during pain on cardiovascular and symptom-specific physiological responses to a subsequent mental stressor, using the participants and procedures reported in Burns (17). To the degree distraction and sensory focus prevent attention from being directed fully to negative emotional aspects of pain, these strategies may ameliorate cardiovascular responses to the subsequent mental arithmetic stressor among both high and low anger-out participants because sustained feelings of pain-evoked anger and distress will be minimized. Suppression of pain-related thoughts, however, was expected to lead to

maintained or even increased cardiovascular arousal during later mental arithmetic from levels attained during cold pressor for high anger-out participants. These mismatch effects on cardiovascular indices were expected for both high anger-out patients and nonpatients.

However, if CLBP patients are prone to experience reactivity specific to their disorder (i.e., in muscles of the lower back), then high anger-out patients who attempted to suppress pain-related thoughts during the cold pressor were expected to exhibit continued or increased LP muscle tension during later mental arithmetic, whereas high anger-out nonpatients were not expected to reveal such effects. Stable or increased trapezius muscle tension (i.e., a distal muscle site) was not expected to distinguish high anger-out CLBP patients from high anger-out nonpatients.

Finally, we explored the potential moderating role of trait anger inhibition (anger-in). Past findings suggest that trait anger-in predicts LP reactivity to interpersonal harassment among CLBP patients (32,33), but we offer no specific hypotheses regarding interactive effects on physiological reactivity of anger-in by attention strategy used during pain.

METHODS

Participants

Healthy controls ($n = 105$) were recruited through advertisements and e-mail postings at a university, and CLBP patients ($n = 100$) were recruited through advertisements and postings at pain clinics and multidisciplinary pain programs from September 2001 to June 2003. This study was approved by the Institutional Review Board of the first author's institution. Participants were paid \$40. Exclusion criteria for all participants were the following: a) current cardiovascular disorder; b) current use of medications that affect cardiovascular function (i.e., β blockers); c) chronic pain due to malignant conditions; d) current alcohol or substance abuse problems; e) a history of psychotic or bipolar disorders; f) daily use of opioid analgesic medication; and g) inability to understand or speak English well enough to comprehend the attention strategy instructions or to participate in the mental arithmetic. A further exclusion criterion for healthy controls was chronic pain from any source within the past year. Inclusion criteria for CLBP patients were the following: a) musculoskeletal pain of the lower back stemming from degenerative processes, muscular or ligamentous strain, or disk herniation as determined by a neurosurgeon or neurologist; and b) pain duration of at least 6 months.

Patients who reported occasional use of opioid analgesic medication were asked not to take these substances on the morning they were scheduled to participate. Two patients were dropped from analyses because they admitted taking opioid medications just before the study. One patient withdrew during the cold pressor, and physiological data from four patients were lost due to equipment failure. The final CLBP sample was 93 patients (Table 1). Women comprised 53.8% ($n = 50$) of the CLBP sample, and 53.3% ($n = 56$) of the healthy sample. Male/female ratios were approximately equal across attention conditions.

Design Overview

Participants were randomly assigned to sensory focus, distraction, suppression, or control conditions (17). All participants underwent a cold pressor, and then performed mental arithmetic in a fixed order. A 10-minute resting baseline preceded the cold pressor, the mental arithmetic task followed immediately after the cold pressor (within 10 seconds), followed by a 5-minute recovery period. The between-subjects factors were Condition (sensory focus, distraction, suppression, control) and Status (patient, nonpatient), and the within-subjects factor was Period (baseline, cold pressor, mental arithmetic, 1-minute recovery, 3-minute recovery, 5-minute recovery). Blood pressure, heart rate (HR), and trapezius and LP muscle tension (i.e., electromyography, EMG) were assessed continuously.

Measures

Recording EMG—EMG activity was recorded from left and right LPs (L2-L4), and left and right trapezius muscles. Silver/silver chloride 8-mm electrodes were spaced 15 mm apart for bipolar recording, as recommended by Fridlund and Cacioppo (34). Sites were prepared with vigorous alcohol abrasion. Interelectrode impedance was kept <10 kilohms. Bioamplifiers with bandpass filters (Coulbourn Instruments, Whitehall, Pennsylvania) were used to record EMG. Raw EMG signals were amplified by a factor of 100,000. The sampling rate was 10/second, and signals were passed through narrow bandpass filters (100–250 Hz). Signals were integrated and “smoothed” with contour-following and cumulative integrators (Coulbourn Instruments). In accordance with the recommendations by Fridlund and Cacioppo (34), the time constant for integration was 100 ms. Data were collected through A/D conversion using Wingraph software.

Recording Cardiovascular Indices—Systolic blood pressure (SBP), diastolic blood pressure (DBP), and HR were measured (Dinamap 1846 SX Monitor, Johnson & Johnson Medical Inc., Langhorne, Pa.). This instrument assesses blood pressure with the oscillometric technique. Data were collected through A/D conversion, using Wingraph software.

Anger Management Style—Tendencies to express and inhibit anger were tapped with the Anger Expression Inventory (35), which includes subscales to measure anger-out (Anger-Out Subscale, AOS) and anger-in (Anger-In Subscale, AIS), and for which Spielberger et al. (35) reported adequate internal consistency coefficients.

Tasks

Cold Pressor—Ice and water was placed in two containers. The water was stirred continuously, and temperature was monitored with a thermometer. Water temperature was maintained at 1°C to 3°C. One container was used for participants’ hands, and the other was used for their feet. Participants first immersed the left foot in the ice water up to the ankle. They were told to “try” to keep their foot in the water until they were told to stop. Unbeknownst to participants, the time limit was 90 seconds. Next, participants immersed their right hand in the ice water up to the wrist with the same instructions. Again, unbeknownst to them, a 90-second time limit was imposed. Foot and hand immersion were

used to increase the amount of time the typical participant was exposed to pain, and was presumably using the attention strategy to which they were assigned.

Mental Arithmetic—Participants performed serial subtraction by 7 starting from the number 4265. After 4 minutes, they were stopped. During the task, the experimenter spoke six standardized statements intended to urge participants to perform well and quickly (e.g., “You need to go faster”).

Attention Strategy Manipulations

Before the cold pressor, the experimenter gave instructions corresponding to the attention strategy conditions. For the sensory focus condition, instructions were: “While your foot and hand are in the ice water, it is very important that you think objectively about the sensations in your foot and hand. That is, concentrate on whether you feel coldness, wetness, tingling, or throbbing sensations. Stay objective and focus on the various sensations in your foot and hand. Please tell me what you’re supposed to do. Okay. Concentrate on sensations.” In the distraction condition, instructions were: “While your foot and hand are in the ice water, it is very important that you think about your bedroom at home. Picture it as clearly as you can: the arrangement of furniture, your possessions, pictures on the wall, colors, and so forth. Please tell me what you’re supposed to do. Okay. Concentrate only on your bedroom.” For the suppression condition, instructions were: “While your foot and hand are in the ice water, it is very important that you try as hard as you can to not think about any sensations or distress you may be having. In other words, you should suppress any thoughts and feelings about your foot and hand. Please tell me what you’re supposed to do. Okay. Put those thoughts right out of your mind.” For the control condition, instructions were: “While your foot and hand are in the ice water, it is very important that you think about anything you like. You might think about your foot and hand, or you might think of something else. Please tell me what you’re supposed to do. Okay. Think of anything you want.” Instructions for all conditions ended with the statement: “The physiological recordings being taken will allow the experimenter to determine whether you are trying to follow these instructions.”

Procedure

Participants were asked not to consume alcohol, caffeine, nicotine, or pain medications (opioid-based and otherwise) 4 hours before their appointments. Participants gave their written informed consent when they arrived at the laboratory. They were then seated upright in a chair, and the electrodes and blood pressure cuff were attached. After a 10-minute resting baseline, instructions for the cold pressor and for the mental arithmetic were delivered, followed by the attention strategy manipulations for the cold pressor. The cold pressor then began. After removing their hand from the ice water, participants were told, “Now start subtracting by 7 from 4269. Go!” The mental arithmetic task then began. After 4 minutes, they were stopped, and a 5-minute recovery period followed. The electrodes and blood pressure cuff were removed, and participants were thoroughly debriefed.

Data Reduction and Analyses

We decided a priori to include only those participants who kept both their foot and hand in the ice water for at least 70 seconds each. Only participants who underwent pain and used

their assigned attention strategy for between 140 and 180 seconds—thereby receiving a fairly standardized “dose” of the manipulations—were included in analyses. Only one person was dropped because of failure to achieve this criterion.

For LP and trapezius EMG, readings from left and right sites were summed and averaged. Baseline values for SBP, DBP, HR, and EMG were defined as the mean of readings taken during the last 3 minutes of the 10-minute resting period. Cold pressor and mental arithmetic values for SBP, DBP, HR, and EMG were defined as the mean of readings taken during the respective tasks. Recovery values were examined for the first, third, and fifth minutes after the mental arithmetic task, and were defined as the mean of readings taken during each of these periods.

Analyses revealing patterns of response over time for participants are presented in the work by Burns (17). The cold pressor and mental arithmetic task elicited significant changes from baseline for all physiological indices for patients and nonpatients alike.

Primary analyses focused on whether AOS and AIS further moderated Condition $\times$ Status $\times$ Period interaction effects on EMG and cardiovascular function during the cold pressor, mental arithmetic, and recovery. Change scores were computed by subtracting values recorded during cold pressor, mental arithmetic, and at 1, 3, and 5 minutes into recovery from baseline values. These baseline values were also statistically controlled in all analyses to give adjusted change score values that were unbiased by baselines. Given age effects on cardiovascular function, age was also controlled in all analyses. Using AOS as an example, General Linear Model procedures tested Condition (sensory focus, distraction, suppression, control) $\times$ Status (patient, nonpatient) $\times$ AOS scores (continuous) $\times$ Period (cold pressor, mental arithmetic, 1 minute, 3 minutes, 5 minutes) effects for simple changes from baseline in each physiological index with baseline values and age controlled. Significant complex interactions were pursued with increasingly simpler interaction tests, which aimed to examine AOS or AIS effects at each epoch. Mauchly's tests indicated that the assumption of sphericity was violated in all within-subject analyses, and therefore degrees of freedom for all analyses were corrected, using Greenhouse-Geisser estimates of sphericity.

RESULTS

Condition $\times$ Status $\times$ AOS Effects

LP Changes—The Condition (distraction, sensory focus, suppression, control) $\times$ Status (patient, nonpatient) $\times$ AOS scores (continuous) $\times$ Period (cold pressor, mental arithmetic, 1 minute, 3 minutes, 5 minutes) interaction was significant ($F(4,237.3) = 3.06; p < .001$) for LP change scores. To dissect this complex interaction, Condition $\times$ AOS scores $\times$ Period simple interactions were examined for patients and nonpatients separately. For patients, the Condition $\times$ AOS scores $\times$ Period interaction was significant ($F(3.7,99.4) = 2.96; p < .001$), whereas for nonpatients it was not ($F(5.8,184.1) = <1$). For nonpatients, no other effects involving AOS scores—two-way interactions or the main effect—were significant, suggesting that an anger-out style did not significantly affect their LP muscle tension. For patients, AOS $\times$ Period interaction effects were examined for each condition separately. The AOS $\times$ Period effect was significant only for patients in the Suppression condition

($F(1.1,19.4) = 4.65; p < .002$). To illustrate these relationships for patients, regression equations, with AOS scores regressed on LP changes at each epoch (with baseline and age controlled), were solved for two hypothetical AOS values (+1 and -1 standard deviation (SD) from the AOS mean) for each condition separately. Values adjusted for baseline and participant age appear in Figure 1. Results suggest that high anger-out CLBP patients responded to mental arithmetic after attempts to suppress awareness of pain and distress with dramatic increases in LP tension and showed a prolonged recovery, whereas low anger-out patients in this condition and high and low anger-out patients in other conditions did not.

Trapezius Changes

The Condition $\times$ Status $\times$ AOS scores (continuous) $\times$ Period (see above) interaction was nonsignificant ($F(4,238.4) = 1.19; p > .10$) for trapezius change scores. Further, no other effects involving AOS scores—three-way or two-way interactions or the main effect—were significant for this physiological index.

SBP Changes

The Condition $\times$ Status $\times$ AOS scores $\times$ Period interaction was nonsignificant ($F = <1$) for SBP change scores. However, the Condition $\times$ AOS scores $\times$ Period interaction was significant ($F(10.2,600.9) = 2.08; p < .02$). To dissect this interaction, AOS scores $\times$ Period simple interactions were examined for each condition separately, collapsed across patients and nonpatients. The AOS $\times$ Period effect was significant for participants in the Suppression condition ($F(2.4,112.1) = 3.45; p < .02$), but not for those in the other three conditions ($F = >2.61; p < .10$). To illustrate these relationships, the procedure described above was used to compute SBP values for hypothetical AOS values (+1 and -1 SD from the AOS mean) for the Suppression condition with baseline SBP values and participant age controlled. Adjusted values appear in Figure 2. Results suggest that high anger-out patients and nonpatients in the Suppression condition showed a distinct pattern of response over time. Although high anger-out participants in the Control, Sensory, and Suppression conditions seemed to respond to mental arithmetic with similarly large increases in SBP—larger than those shown by low anger-out participants—high anger-out participants in the Suppression condition revealed a more prolonged recovery than their high anger-out counterparts in the other conditions.

DBP Changes

The Condition $\times$ Status $\times$ AOS scores $\times$ Period interaction was also nonsignificant ($F = <1$) for DBP change scores. With Greenhouse-Geisser correction, the Condition $\times$ AOS scores $\times$ Period interaction was only marginally significant ($F(8.7,519.4) = 1.79; p < .07$), and therefore was not pursued further. All other interaction and main effects involving AOS scores were nonsignificant ($F = <1.72; p > .10$).

HR Changes

The Condition $\times$ Status $\times$ AOS scores $\times$ Period interaction was significant ($F(8.8,519.5) = 1.98; p < .05$) for HR change scores. As above, Condition $\times$ AOS scores $\times$ Period simple interactions were examined for patients and nonpatients separately. For patients, the Condition $\times$ AOS scores $\times$ Period interaction was significant ($F(9.5,253.8) = 2.00; p < .04$),

whereas for nonpatients it was not ($F = <1$). For patients, AOS $\times$ Period interaction effects were examined for each condition separately, and only the effect for patients in the Suppression condition was significant ($F(2.5,44.7) = 2.66$; $p < .05$). To illustrate these relationships for patients, the procedure described above was used, and these values (adjusted for baseline HR and age) appear in Figure 3. Results suggest that high anger-out CLBP patients in the Suppression condition responded to cold pressor with relatively high HR reactivity, and continued to show elevated HR throughout recovery, whereas low anger-out patients in this condition showed relatively little HR reactivity and recovered quickly. High anger-out patients in the sensory focus and control conditions revealed larger cold pressor to mental arithmetic HR increases than the high anger-out Suppression patients but then recovered rapidly.

Condition $\times$ Status $\times$ AIS Effects

LP Changes—The Condition $\times$ Status $\times$ AIS scores (continuous) $\times$ Period interaction was nonsignificant ($F(12,716) = 1.13$; $p > .10$) for LP change scores, as was the Condition $\times$ AIS $\times$ Period interaction ($F = 1.49$; $p > .10$). The Status $\times$ AIS $\times$ Period interaction was significant ($F(1.9,345) = 2.55$; $p < .05$). To dissect this interaction, AIS scores $\times$ Period simple interactions were examined for patients and nonpatients separately. For patients, the AIS scores $\times$ Period interaction was significant ($F(1.8,146.9) = 2.71$; $p < .05$), whereas for nonpatients it was not ($F = <1$), suggesting that an anger-in style did not affect LP muscle tension in nonpatients. To illustrate these relationships for patients, the procedure described above was used, and values are shown in Figure 4 (adjusted for baseline LP values and age). Results suggest that high anger-in CLBP patients, irrespective of condition, responded to mental arithmetic after pain with increases in LP tension relative to low anger-in patients, and then showed a prolonged recovery.

Trapezius and Cardiovascular Changes

All interactions and main effects involving AIS scores were nonsignificant ($F = <1.86$) for trapezius, SBP, DBP, and HR changes.

DISCUSSION

Anger management style affects emotional responses to anger-inducing events, and these effects may be magnified when an individual is constrained or otherwise unable to use his or her preferred manner for dealing with anger. Pain itself seems to arouse anger and irritability in addition to general distress, and regulation of pain-induced anger may be an underappreciated determinant of recovery from pain and responses to subsequent events. We hypothesized that people characterized by a strong preference to express anger would be most reactive during pain and during a later stressful event if they were assigned to an attention condition that represented a conspicuous mismatch from this preference; namely, if they attempted to suppress awareness of pain and suffering. Further, we expected this vulnerability to be most manifest in CLBP patients through exaggerated symptom-specific, LP muscle tension responses. Hypotheses were generally supported.

A key finding was that an anger-out style moderated effects of the kind of strategy used to attend to pain on LP reactivity and recovery such that only high anger-out CLBP patients attempting to suppress—a putative mismatch situation—showed pronounced LP muscle tension changes. The anger-out effect was not significant among nonpatients. As shown in Figure 1, this effect seemed quite striking with low anger-out patients in the suppression condition showing LP reactivity and recovery comparable to the negligible changes shown by CLBP patients in the other conditions. These apparent mismatch findings are consistent with results documenting trait anger-out mismatch effects on cardiovascular reactivity (10,11) and even acute pain (12) among healthy normals. More specifically, present results are consonant with recent work showing trait anger-out mismatch effects on symptom-specific LP reactivity among CLBP patients (13). Of note, in the study by Burns et al. (13), the suppression/inhibition procedure differed from that used in the present study and was focused on anger aroused during harassment; yet, the moderating effects of an anger-out style on LP tension were similar across the two distinct methods.

There are at least two implications of these findings. First, to the extent that LP reactivity during stress is linked to exacerbation of everyday chronic pain severity among CLBP patients (31), patients who strongly prefer to regulate anger through expression may be at great disadvantage during situations in which they are unable to do so. Second, findings point to the potential importance of regulating negative emotions during painful episodes, especially to the degree that such regulation affects responses to events that follow pain. Although the present data set did not include self-reports of anger and distress during pain, other studies have documented the anger-eliciting effects of pain (4,14–16). The effects of trait anger-out on LP reactivity and recovery among CLBP patients who attempted to suppress during pain give indirect evidence of the potential importance of high anger-out patients being allowed to express in order to manage effectively anger and irritation during a noxious event. That anger has been shown to invoke larger LP responses than arousal of other negative emotions (31) speaks to the problematic nature of anger for CLBP patients in general. Poorly or inappropriately managed anger may further jeopardize patients' ability to achieve optimal adjustment to their persistent pain.

Findings that anger-out did not interact with patient/nonpatient status and/or attention condition to affect trapezius muscle reactivity further support a symptom-specific model for muscle tension. High anger-out patients attempting to suppress did not show evidence of differences in trapezius reactivity—muscles distant from the site of pain or injury—from low anger-out patients. A mismatched anger regulation style did not seem to affect substantially muscle tension in general but did so distinctly at a muscular site specific to CLBP.

For SBP, the moderating effects of trait anger-out on attention strategy seemed irrespective of patient/nonpatient status and thus also supported the symptom-specificity model. General autonomic arousal was not expected to differentiate high anger-out patients from high anger-out nonpatients. Consistent with past findings in which interpersonal harassment provided the stimulus (10–12), high anger-out people made to attend to thoughts and feelings about pain in a way incongruent with their preference (i.e., suppression) showed a pattern of reactivity and recovery that was distinct from those shown by high anger-out people in

other, presumably less incongruent conditions. Of note, and consistent with prior work (36,37), the mismatch effects for anger-out, suppression, and SBP responses seemed most clearly as a prolonged recovery.

One exception to the symptom-specificity model was our finding that trait anger-out interacted significantly with attention strategy to affect HR levels only among CLBP patients. As with LP reactivity, anger-out was related to HR changes only among CLBP patients in the suppression condition. Although patients and nonpatients showed similar patterns of anger-out effects for SBP changes, findings for HR may still be taken as suggesting that CLBP patients simply find any acute pain episode more distressing than nonpatients. Thus, mismatched anger-out patients may harbor more unexpressed feelings of anger and irritation than mismatched anger-out nonpatients. Overall, results for the cardiovascular indices complement but also extend prior findings by revealing intriguing effects of anger-out style on physiological reactivity begun during a painful stimulus.

Present results extend past findings in another way. Namely, that the effects of attempts to manage distress during pain had delayed effects on subsequent responses to another stressful stimulus depending on attention strategy used and on anger management style. Past results point to the emergence of rebound or delayed effects on health-related outcomes produced by deliberately trying not to think of a noxious event (8,20,21). Ironically, trying to suppress awareness or thoughts of a painful episode may make the negative emotional content of the event more accessible to consciousness, and, has been argued, color responses to the next stressful event (17,20). Inhibiting overt expression of pain-evoked distress and anger may delay recovery, but actively trying not to even think of an event, which also has the corollary effect of stymieing overt expression, may make matters worse for high anger-out individuals. Present and prior results showing that suppression during an initial event not only affects the rate of eventual recovery but also affects responses to a subsequent event helps illustrate “down-stream” effects of certain kinds of emotional regulation. Here, suppression among high anger-out CLBP patients during pain set the stage for problematic physiological responses to a later event that may have grave consequences for later functioning and well-being in the form of sustained muscle tension near the site of injury.

Because the present data set did not include an overt expression condition, we did not expect mismatch effects for high anger-in participants. Instead, we found that trait anger-in moderated effects of patient/nonpatient status on LP reactivity and recovery without regard to attention condition. These results are generally consistent with the few past findings regarding anger-in and LP reactivity (32,33). Taken together, accumulating findings imply that the habitual inhibition of anger may affect CLBP through the specific physiological mechanism of stress-induced LP reactivity. Here, the effect for trait anger-in emerged despite patients using very different strategies to attend to pain. The tendency to inhibit anger and irritation aroused during pain for patients characterized by high anger-in may override any situational features or demands. Such results speak to the substantial and detrimental influence this trait has on adjustment to CLBP.

Some limitations of the current study must be described. First, the original study was not specifically designed to examine effects of different ways to regulate anger and irritability

aroused during pain on physiological reactivity. Thus, we are left with indirect evidence only that high anger-out participants were in fact struggling to manage thoughts and feelings of an event—the cold pressor—that invoked these emotions. Second, the study did not include an expression condition, and so we could not examine moderation effects of trait anger management—anger-out or anger-in—on this kind of emotion regulation strategy. Expression would constitute a “match” situation for people characterized by high anger-out, and thus such a manipulation would have allowed us to test directly the notion that expression represents an optimal strategy for these people, leading to minimal reactivity and swift recovery. Third, the cold pressor provided only a laboratory analogue of clinical pain. Inferences about how suppressing awareness of pain can lead to delayed effects of sustained LP muscle tension during later events and recovery and thus further aggravate CLBP must be made with this caution in mind. Whether suppression of awareness of naturally occurring CLBP pain through movement or postural strain underlies a tendency to increase or maintain LP muscle tension during subsequent stressful events, especially among patients characterized by a strong preference to express anger, remains to be explored.

The particular way in which the information presented by painful stimulation is attended to, processed, and regulated has been shown in many studies to profoundly affect pain, suffering, and physiological reactivity (18–20). Individual differences in traits affecting appraisal of, and coping with painful events, such as catastrophizing, have been shown to further affect these associations (38–40). To our knowledge, this is the first study to provide hints that anger management style may modulate efforts to attend to or cope with pain, perhaps because pain itself may incite irritation, annoyance, and aggravation, and that these effects may be most acutely manifested in responses to later events and subsequent recovery rate. For patients with CLBP, the effective management of irritation and anger inspired by flare-ups of chronic pain, particularly among those with strong preferences to either express or inhibit, may have important consequences for achieving optimal adjustment to CLBP, and thus may be a ripe target for intervention.

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Glossary

CLBP	chronic low back pain
EMG	electromyography
AOS	anger-out scale
AIS	anger-in scale
LP	lower paraspinal muscles

SBP	systolic blood pressure
DBP	diastolic blood pressure
HR	heart rate

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Figure 1.

Attention Strategy Condition $\times$ AOS (anger-out scale) $\times$ Period for LP (low paraspinal) Changes among patients only (values adjusted for baseline LP and patient age). Contr/Lo = patients in control condition with hypothetical AOS values -1 standard deviation (SD) from mean; Contr/Hi = patients in control condition with hypothetical AOS values $+1$ SD from mean; Distract/Lo = patients in distraction condition with hypothetical AOS values -1 SD from mean; Distract/Hi = patients in distraction condition with hypothetical AOS values $+1$ SD from mean; Sensory/Lo = patients in sensory focus condition with hypothetical AOS values -1 SD from mean; Sensory/Hi = patients in sensory focus condition with hypothetical AOS values $+1$ SD from mean; Suppr/Lo = patients in suppression condition with hypothetical AOS values -1 SD from mean; Suppr/Hi = patients in suppression condition with hypothetical AOS values $+1$ SD from mean; LP Changes = simple change scores; CP = cold pressor; MA = mental arithmetic; R1, R3, and R5 = 1 minute, 3 minutes, and 5 minutes into recovery, respectively.

Figure 2.

Attention Strategy Condition $\times$ AOS (anger-out scale) $\times$ Period for SBP (systolic blood pressure) Changes collapsed across patients and nonpatients (values adjusted for baseline SBP and participant age). Contr/Lo = participants in control condition with hypothetical AOS values -1 standard deviation (SD) from mean; Contr/Hi = participants in control condition with hypothetical AOS values $+1$ SD from mean; Distract/Lo = participants in distraction condition with hypothetical AOS values -1 SD from mean; Distract/Hi = participants in distraction condition with hypothetical AOS values $+1$ SD from mean; Sensory/Lo = participants in sensory focus condition with hypothetical AOS values -1 SD from mean; Sensory/Hi = participants in sensory focus condition with hypothetical AOS values $+1$ SD from mean; Suppr/Lo = participants in suppression condition with hypothetical AOS values -1 SD from mean; Suppr/Hi = participants in suppression condition with hypothetical AOS values $+1$ SD from mean; SBP Changes = simple change scores; CP = cold pressor; MA = mental arithmetic; R1, R3, and R5 = 1 minute, 3 minutes, and 5 minutes into recovery, respectively.

Figure 3.

Attention Strategy Condition $\times$ AOS (anger-out scale) $\times$ Period for HR (heart rate) Changes among patients only (values adjusted for baseline HR and patient age). Contr/Lo = patients in control condition with hypothetical AOS values -1 standard deviation (SD) from mean; Contr/Hi = patients in control condition with hypothetical AOS values $+1$ SD from mean; Distract/Lo = patients in distraction condition with hypothetical AOS values -1 SD from mean; Distract/Hi = patients in distraction condition with hypothetical AOS values $+1$ SD from mean; Sensory/Lo = patients in sensory focus condition with hypothetical AOS values -1 SD from mean; Sensory/Hi = patients in sensory focus condition with hypothetical AOS values $+1$ SD from mean; Suppr/Lo = patients in suppression condition with hypothetical AOS values -1 SD from mean; Suppr/Hi = patients in suppression condition with hypothetical AOS values $+1$ SD from mean; HR Changes = simple change scores; CP = cold pressor; MA = mental arithmetic; R1, R3, and R5 = 1 minute, 3 minutes, and 5 minutes into recovery, respectively.

Figure 4.

Patient/Nonpatient Status $\times$ AIS (anger-in scale) $\times$ Period for LP (low paraspinal) Changes collapsed across attention strategy condition (values adjusted for baseline LP and participant age). Nonpat/Lo = nonpatients with hypothetical AIS values -1 standard deviation (SD) from mean; Nonpat/Hi = nonpatients with hypothetical AIS values $+1$ SD from mean; Patient/Lo = patients with hypothetical AIS values -1 SD from mean; Patient/Hi = patients with hypothetical AIS values $+1$ SD from mean. LP Changes = simple change scores; CP = cold pressor; MA = mental arithmetic; R1, R3, and R5 = 1 minute, 3 minutes, and 5 minutes into recovery, respectively.

TABLE 1

Sample Characteristics

Variable	Statistics					
	Patients (n = 93)			Nonpatients (n = 105)		
	Mean $\pm$ SD	%	n	Mean $\pm$ SD	%	n
Age	46.0 $\pm$ 14.9			29.0 $\pm$ 9		
At least 12 years of education		93.5%	87		100%	105
Ethnicity						
White		63.4%	59		61.9%	65
Hispanic		4.3%	4		9.5%	10
African American		31.2%	29		10.4%	11
Asian		2.2%	2		18.1%	19
Pain duration (months)	45.1 $\pm$ 46.5		—		—	—
Narcotic		22.6%	21		—	—
Nonsteroidal anti-inflammatory		53.8%	50		10.5%	11
Muscle relaxants		7.5%	7		—	—
Antidepressants		6.5%	6			

SD = standard deviation.