IMPACT OF WRITTEN EMOTIONAL DISCLOSURE AND GENDER ON CAPSAICIN-INDUCED INFLAMMATION, ALLODYNIA, AND SPONTANEOUS PAIN

A Thesis

by

JERRELL SMITH

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2008

Major Subject: Psychology

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Approved by:

Chair of Committee,	Mary W. Meagher
Committee Members,	James M. Grau
	Louis G. Tassinary
Head of Department,	Leslie C. Morey

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ABSTRACT

Impact of Written Emotional Disclosure and Gender on Capsaicin-Induced Inflammation, Allodynia, and Spontaneous Pain.

(December 2008)

Jerrell Smith B.S., Texas A&M University

Chair of Advisory Committee: Dr. Mary W. Meagher

Prior research has shown that affective valence and arousal interact to alter pain perception. One personally relevant method of inducing affective states is the written emotional disclosure procedure. The current study examined the immediate effects of written emotional disclosure on secondary hyperalgesia, flare, and spontaneous pain in healthy undergraduate men and women. Fifty-five men and women undergraduates participated in an IRB approved experiment in which they wrote about a traumatic or neutral event fro twenty minutes. After writing, the participants underwent pain perception testing for area of secondary hyperalgesia, flare, and spontaneous pain.

Results indicated that women writing about a traumatic experience rated their spontaneous pain as more intense than those writing about a neutral topic, whereas males did not. In addition, men showed greater physiological arousal and area of flare than women. These findings suggest that men and women experience different affective and pain modulatory reactions to written emotional disclosure, though the underlying mechanisms remain to be elucidated.

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1. INTRODUCTION

In 1961 Robert Melzack observed that our perception of pain is not a "fixed response to a noxious stimulus. Its perception is modified by our past experiences, our expectations, and, more subtly by our culture" (Melzack, 1961). In 1965 Melzack and Wall expanded on this realization and proposed their "Gate Control Theory" of Pain (Melzack & Wall, 1965). They posited that pain perception was not proportional to tissue damage rather incoming nociceptive signals are modulated by neural pathways that descend from the brain to the spinal cord allowing higher psychological processes to either inhibit or amplify the incoming nociceptive signal before pain is experienced at the conscious level.

Since Melzack and Wall's Gate Control theory, research has shown that our perception of pain is subject to modification by several psychosocial factors, one of interest being emotion. It has been found that negative affect tends to increase pain while positive affect tends to decrease it (Zelman, Howland, Nichols, Cleeland, 1991; Janssen, 1996; Meagher, Arnau & Rhudy, 2001; Rhudy & Meagher, 2001; Zautra, Johnson, & Davis, 2005). Furthermore, studies from our laboratory have shown that the relationship between negative affect and pain perception is influenced by arousal. For instance, it has been found that higher arousal combined with negative affect (e.g., fear) produces a decrease in pain perception (Rhudy & Meagher, 2000; Rhudy & Meagher, 2003;

This thesis follows the format of *Health Psychology*.

Rhudy, Grimes, & Meagher, 2004), whereas low to moderate arousal combined with negative affect (e.g., anxiety) produces an increase in perceived pain (Rhudy & Meagher, 2001).

Although previous studies from our laboratory have used acute thermal pain models to study affective pain modulation, recent work has begun to investigate how stress influences pain perception using the capsaicin pain model. The capsaicin test provides a clinically relevant model of the process of central sensitization that underlies many forms of pathological pain. Similar to other forms of central sensitization, the secondary hyperalgesia observed after capsaicin depends on NMDA-receptor mediated glutamatergic transmission and tachykinin co-transmission (Anderson, Felsby, Nicolaisen, & Bjerring, 1996; Coderre & Katz, 1997).

At the site of capsaicin application (primary zone) the sensory changes include thermal and mechanical hyperalgesia (increased experience of pain due to a stimulus that is normally painful) and spontaneous pain. In contrast, the surrounding area of secondary hyperalgesia (secondary zone) is characterized by mechanical hyperalgesia. Secondary hyperalgesia refers to the increase in pain sensitivity that occurs in undamaged skin surrounding an injured region. It involves increased sensitivity to noxious and non-noxious mechanical stimuli but not to heat stimuli. Mechanical hyperalgesia can take 3 forms: (1) Static mechanical hyperalgesia is found in the primary zone and is mediated by sensitized C-nociceptors and can be elicited by continuous stimulation with a blunt probe. (2) Dynamic mechanical hyperalgesia, or allodynia (pain due to stimulus that is normally not painful), is mediated by central

mechanisms and can be evoked by stimulation with small von Frey hairs or by light brushing of the skin in both the primary and secondary zones. Under conditions of prolonged C-nociceptive discharge from the primary zone, A-beta fiber afferents in the secondary zone appear to stimulate sensitized wide dynamic range neurons in the spinal dorsal horn. (3) Punctate mechanical hyperalgesia is mediated by A-delta and C-fibers and can be elicited in both the primary and secondary zones by stimulation with firm von Frey hairs. The spread of punctate hyperalgesia to the secondary zone is thought to involve central sensitization. Secondary hyperalgesia is caused by the sensitization of central nociceptive neurons due to noxious input from the periphery.

The central mediation of secondary hyperalgesia is supported by the finding that hyperalgesia can be evoked by stimulation of afferent fibers even after peripheral nociceptors have been anesthetized (Torebjork, Lundberg, & LeMotte, 1992). Although a barrage of injury-related nociceptive afferent discharge normally triggers secondary hyperalgesia, it can also be induced in the absence of tissue damage by intense discharges of nociceptive C-fibers that are stimulated by topical capsaicin (LaMotte et al., 1992).

Also relevant to the capsaicin pain model is the effects of the level of arousal on the area of flare seen at the site of application. Flare is a result of the activation of nerve fibers at the site of stimulation (Lutgendorf et al., 2000) and is visible in the tissue surrounding the site of capsaicin application as a reddening of the skin. Previous work has shown that flare resulting from the application of capsaicin is affected by relaxation and the degree of sympathetic arousal the participant is experiencing (Lutgendorf et al.,

2000). Lutgendorf and colleagues found that participants trained in relaxation techniques showed a significantly smaller area of flare. Although participants in the stress condition and control condition showed no difference in area of flare, a significant positive correlation was found between stress-induced norepinephrine levels and flare. More work needs to be done to determine whether or not more personally relevant or noxious stressors would affect flare size.

In general women report higher levels of pain intensity than men do (Fillingim, 2003; Riley et al., 1999), though, as our laboratory has shown, this relationship is influenced by more than gender. Using the capsaicin model, we recently found that noise stress increased the area of secondary hyperalgesia in men (Grimes, Creech, Chokshi, Angermiller, Villa, Yates, & Meagher, 2003). The pattern of results observed in women depends on the phase of the menstrual cycle, with women exhibiting a similar pattern of stress-induced increases in secondary hyperalgesia to men during the luteal phase, but not during the ovulatory or follicular phases (Grimes, 2005).

In addition to noise stress our laboratory has also conducted research using a form of affect induction known as written emotional disclosure developed by Pennebaker and colleagues (Pennebaker & Beall, 1986). This procedure generally involves writing about a traumatic experience over a 20 to 30 minute time period over several days and also usually includes a control group instructed to write about an emotionally neutral topic such as what they do in a typical day.

A great deal of research has investigated the various components of written emotional disclosure and its effects. Most notable among these findings are positive

health outcomes for individuals writing about an unpleasant and personally meaningful situation 1 to 3 months after the writing has occurred (Chung & Pennebaker, 2008; Hughes, Uhlmann, & Pennebaker, 1994; Epstein, Sloan, & Marx, 2005; Pennebaker & Beall, 1986; Norman, Lumley, Dooley, & Diamond, 2004; Pennebaker & Roberts, 1992; Pennebaker & Francis, 1996; Smyth, 1998; Pennebaker, Zech, & Rime, 2001; Sloan & Marx, 2004; Sloan, Marx, Epstein, & Lexington, 2007; Smyth, 1999; Smyth & Helm, 2003). These positive health outcomes include: reduced health care utilization, decreased disease severity in rheumatoid arthritis and asthma suffers, and improved immunological surveillance (Pennebaker & Beall, 1986; Smyth, Stone, Hurewitz, & Kaell, 1999; Spera, Buhrfeind, & Pennebaker, 1994; Greenberg, Wortman, & Stone, 1996; Esterling, Antoni, Fletcher, Magulies, & Schneiderman 1994; Pennebaker, Kiecolt-Glaser, & Glaser, 2004).

During the writing manipulation itself, experiments which measured physiological correlates have tended to observe increased skin conductance for participants writing about a traumatic topic when compared to participants writing about a neutral topic (Pennebaker & Roberts, 1992; Hughes, Uhlmann, & Pennebaker, 1994); Pennebaker & Francis, 1996; Creech, Grimes, & Meagher, 2003). Importantly, heightened physiological reactivity during the initial writing session has been shown to predict greater reduction in PTSD and depressive symptoms at follow up (Sloan & Marx, 2004).

Meta-analysis found that the effect size for the written emotional disclosure paradigm is comparable to other interventions, with the largest effect sizes being seen

on psychological health and physiological functioning (Smyth, 1998). The results provided further evidence supporting the relationship between participation in the writing exercise and overall health outcomes. This meta-analysis also provided information in regards to gender. In agreement with an earlier study by Pennebaker and Roberts the meta-analyses revealed larger effect sizes for men (Pennebaker & Roberts, 1992; Smyth, 1998).

This gender difference in effect size may be related to differences in hostility and avoidance of emotional expressiveness that vary with gender. Supporting this hypotheses, Pennebaker and colleagues found that people who scored high on a measure of hostility seemed to benefit more from the writing than those who scored lower and that, in general, people who do not naturally talk about their emotional state seem to benefit more than those who naturally do (Pennebaker, Zech, & Rime, 2001).

Recent work suggests that this effect may be a product of ambivalence toward and avoidance of emotional expressivity. A study of female chronic pain patients found that women who had a higher level of ambivalence toward writing about their emotions surrounding their pain had a greater reduction in disability and lower pain at the two month follow up than those who had a lower baseline of ambivalence (Norman, Lumley, Dooley, & Diamond, 2004). Another facet of these findings may be found in the greater physiological reactivity of some participants in the initial writing session, which was associated with greater reduction in PTSD and depressive symptoms at follow up (Sloan & Marx, 2004). Research with the written emotional disclosure procedure also indicates that individuals who are less likely to talk about traumatic or

unpleasant events seem to benefit more from the experience (Pennebaker, Zech, & Rime, 2001). Given that men tend to be socialized to be emotionally less expressive than women (Turner, 1994) they are more likely to fall into this category of non-disclosers.

Though many researchers have investigated the effects of written emotional disclosure on health outcomes, relatively less work has focused on the important question of what is the underlying mechanism of these effects. In an extensive review Sloan and Marx narrow down the field of hypotheses to three main contenders (Sloan & Marx, 2004). The first hypothesis, which was originally proposed by Pennebaker in 1988, attributes the positive outcomes to the un-inhibiting of emotions. From this perspective, inhibition of negative emotions requires an investment of energy, which pulls resources from other functions such as immunity (Pennebaker & Susman, 1988). A second account posits that we have cognitive templates that help explain how the world works and that traumatic events create dissonance between the way we believe things will work and our actual experience. Furthermore, writing about these traumatic situations and our emotions results in a "cognitive adaption", wherein our internal models are changed or adapted to incorporate the incongruous experience (Sloan & Marx, 2004). A third account takes a learning theory perspective, which suggests that the writing process allows for exposure to the conditioned stimuli associated with the initial traumatic situation. By writing about the event the participant's negative emotional associations, the conditioned response, is extinguished (Sloan & Marx, 2004)

The question of how written emotional disclosure produces it's positive effects has recently been investigated empirically by Sloan and colleagues by grouping subjects into one of three conditions an emotionally expressive group, a cognitive adaptation group, and a control group. Data supported the emotional expressivity hypothesis in that these participants showed improved health outcomes at a one month follow up (Sloan, Marx, Epstein, & Lexington, 2007). Although further research is needed to clarify the underlying mechanisms of the written emotional disclosure paradigm, the current evidence indicates that emotional expressivity plays an essential role.

The majority of research involving the written emotional disclosure paradigm has focused on broad health benefits after the writing sessions however, relatively little work has been done investigating the effects of written emotional disclosure on pain perception and modulation. Our own laboratory has recently used this paradigm in several experiments investigating both the immediate and long-term effects of the writing paradigm on pain perception.

Similar to previous studies we have found that writing about a traumatic experience increases both subjective and physiological ratings of arousal and subjective ratings of negative affect (Creech, Grimes, & Meagher, 2003). In an early study the effect of written emotional disclosure on thermal pain perception was assessed in women. Thermal pain thresholds were assessed after a 20 minute writing session using a radiant heat device, in which a heat stimulus was applied to the index finger and participants were asked to remove their finger as soon as they felt pain. Participants

writing about traumatic events showed decreased withdrawal times indicating increased pain sensitivity (hyperalgesia).

Recently our laboratory has examined the impact of written emotional disclosure on capsaicin-induced pain (Creech et al., 2007). In one experiment, capsaicin was applied to the forearm and the participants were asked to write about either a neutral or traumatic experience during a single 20-minute session. Spontaneous pain ratings were taken midway through, at the end of writing, and every 2 minutes for an additional 10 minutes post-writing. Manipulation checks indicated that the participants writing about trauma reported increased arousal and unpleasantness. Although participants writing about trauma did not show the expected increase in skin conductance, a significant change in heart rate was found after 20 minutes of writing with people in the trauma topic group having an increase in heart rate and neutral topic group members having a decrease. Trauma writers reported the pain they experienced from the capsaicin as significantly less intense and unpleasant than neutral writers. This finding suggests that written emotional disclosure of trauma induces a stress-induced analgesia when spontaneous pain is assessed during and immediately following a single session of writing.

Although we had successfully replicated findings that traumatic writing induces negative affect and, at least subjectively, an increase in arousal, further research was needed to examine the impact on pain perception and pain modulation. Initial work in this laboratory using the written emotional disclosure paradigm did not include measures of secondary hyperalgesia and flare. Thus, the present study examined the effects of

written emotional disclosure on several measures of capsaicin-induced pain, including spontaneous pain ratings, area of secondary hyperalgesia, and area of flare. This experiment was also designed to replicate and extend previous findings by examining whether gender alters the effect of written emotional disclosure on pain modulation. Experiment 1a examined the impact of written emotional disclosure on capsaicin-induced pain in healthy men, while experiment 1b used healthy women and evaluated whether menstrual cycle phase altered the impact of written emotional disclosure or the perception of capsaicin-induced pain.

These experiments were designed to test the following specific hypotheses derived from previous studies: 1) Written emotional disclosure will result in decreased spontaneous pain, and increased area of secondary hyperalgesia and flare for women writing about a traumatic event compared to those writing about a neutral topic; furthermore, that these effects will be most pronounced in participants in the luteal phase of the menstrual cycle. 2) Written emotional disclosure will result in an increase in spontaneous pain as well as area of secondary hyperalgesia and flare for men compared to those writing about a neutral topic. 3) Writing about a traumatic topic will result in greater spontaneous pain, area of secondary hyperalgesia and flare for men over women. The following experiments were designed to test these hypotheses.

2. METHOD

Participants

All experimental procedures were approved by the Texas A&M University Human Participants Institutional Review Board. The participants were undergraduate psychology students who received course credit for their participation. Participants were excluded for: circulatory, cardiovascular, or neurological problems; chronic pain; or tobacco, analgesic, anti-histamine, anti-depressant, anti-inflammatory, hormonal birth control, recent drug/alcohol use, or if they were less than 18 years old. To examine the presence of any medical problem or the use of medication/substance that may impact pain perception and inflammation, a health status questionnaire was presented to participants. The questionnaire inquires about demographic information, their current use of any medications, including hormonal birth control, and the presence of any medical abnormality/illness that may potentially impact pain perception or inflammation.

Of the 30 participants who participated in Experiment 1a, no participants withdrew from the study nor were dismissed during testing because of equipment malfunction. However, two participants were removed from the analyses because they did not report any pain during the von Frey tests. Of these 30 participants, 22% self identified as Caucasian, 3% Latin, 3% African-American, 1% Asian and 2% other. Mean age was 19 years (SD=.893). Because of equipment failure discovered during analyses, which was not detectable during testing, 13 participants' heart rate and three participants' skin conductance level data, was not useable, leaving a total of 20

participants for heart rate analyses and 23 for skin conductance level analyses. This left an equal number of participants' data who wrote about a neutral topic versus a traumatic topic for heart rate analyses and three more participants who wrote about a traumatic topic than those who wrote about a neutral topic.

Of the 25 participants who participated in Experiment 1b, one participant withdrew from the study and no participants were dismissed during testing because of equipment malfunction. In addition, two participants were removed from the analyses because they did not report any pain to the von Frey tests. Of these 22 participants, 87% were Caucasian, 4.33% Hispanic, 4.33% African-American, and 4.33% Middle Eastern. Mean age was 19 years (SD=.683). Because of equipment failure discovered during analyses, which was not detectable during testing, nine participant's heart rate and no participant's skin conductance level data, was not useable, leaving a total of 16 participants for heart rate analyses and 22 for skin conductance level analyses. This left an equal number of participant's data who wrote about a neutral topic versus a traumatic topic for heart rate analyses and an equal number of participants who wrote about a traumatic topic versus a neutral topic for skin conductance level analyses.

Apparatus

All psychophysiological data acquisition was computer controlled by LabVIEW software and an AT-MIO-16DL DAQ board (both by National Instruments), which was also used for online data reduction. Physiological signal were collected using Grass Instruments Model 7E (Model 7DA driver amplifiers, Model 7P8 and Model 7P1 preamplifiers).

Skin conductance level (SCL) was recorded via two sensors (Grass F-EGSR) attached to the right clavicle and bottom left rib. Heart rate (HR) was measured using Grass Instruments F-E14D disposable cloth 7/8" by 7/8" electrodes attached to the right clavicle and left bottom rib of the participant with a third attached to their left ankle. Both SCL and HR were sampled at 50 Hz and recorded 1 minute immediately after the first informed consent, 20 minutes after the initial recording, 10 minutes into the writing task and at the end of the writing task. Tonic levels of skin conductance were assessed, whereas heart rate was examined in 5-second blocks of time and represented as beats per minutes (BPM). HR and tonic SCL were compared before and after treatment, as a means of assessing the impact written emotional disclosure had on autonomic activity.

A paper visual analog scale was used to measure pain reactivity. The measure consists of a solid line 9 cm in length. Labels are set at each end of the line with the anchors "No Pain" at the left end and "The Most Intense Pain Imaginable" at the right end. All recorded ratings were later transformed to a score on a 10-point scale by measuring, in centimeters, the distance from the left end of the line to the mark

indicating the participant's pain rating. This number was then multiplied by 10 and divided by 9 and rounded to the nearest 10^{th}.

In Experiment 1b, an OvuLens (Craig Medical Distribution, TOWN) saliva fertility prediction microscope was used to assess the participants' estrogen level to determine menstrual cycle phase. Participants were instructed on the proper use of the device, which consists of placing a saliva sample on the internal slide and focusing the microscope on the slide. When the estrogen level increases near the participants' ovulation period, the dried electrolyte crystals in the saliva form a fern-like pattern. When this fern-like pattern appeared, participants were indicated as being in the ovulatory phase of their menstruation cycle.

Measures

Self Report

Because we are interested in the effects of stress on pain reactivity, it is necessary to assess any preexisting emotional distress that may contribute to unwanted group differences. To do so, the Center for Epidemiological Studies-Depression Scale (CES-D; Radloff, 1977), a brief, 20-item questionnaire that taps into depression and anxiety symptoms was filled out prior to the experiment. Participants were instructed to read each item and rate the extent to which they felt that way at sometime during the past week. In addition, the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) was used to measure levels of subjective distress during the last month.

To assess the emotional impact of the writing paradigm and pain testing, participants filled out several questionnaires at the end of the experiment. The Self-

Assessment Manikin (SAM; Lang, 1980) is a measure with three pictogram scales indicating various levels of valence (ranging from "happy" to "unhappy"), arousal (ranging from "excited" to "calm"), and dominance (ranging from non-dominant to very dominant). Participants were asked to place an "X" on or between any of the figures to indicate their emotional response to their treatment condition.

To evaluate whether participants were aware of our hypothesis, they were given an exit questionnaire asking them what they believed the experiment to be studying. Those that gave answers indicating that they understood the hypothesis and purpose of the study were excluded. None of the participants in Experiment 1 guessed the hypothesis. In addition, the exit questionnaire consisted of a number of open-ended questions regarding their emotional reactions to the experiment.

Procedure

Figure 1 depicts the experimental procedure timeline, specifically when pain tests, capsaicin, and writing topics were presented as well as when psychophysiological data were recorded. For Experiment 1a all participants were greeted at the door by an experimenter and then taken to the experiment room where they were given informed consent for self-report forms, a pain rating practice procedure, recording of physiological measures and a baseline von Frey test. Participants were then presented with procedural information and instructed on the experimental tasks that are required (i.e., rating their emotional reactions and pain reactivity). To ensure that participants were able to rate changes in pain consistently, a cross-modality practice trial was employed where participants were asked to practice rating changes in perceived pressure being applied to

their arm via a blood pressure cuff using the paper VAS scale. The cuff was inflated to 100, then 200, then back to 100, and finally the pressure was brought back to 0. Proficiency in this task suggests that the subject will be likely to generate proportional pain ratings over time. After the practice, heart rate and skin conductance sensors were applied to their fingers. A grid with eight spokes radiating from the center was drawn in the center of their dominant volar forearm (see Figure 2) with each spoke consisting of ten pain application sites.

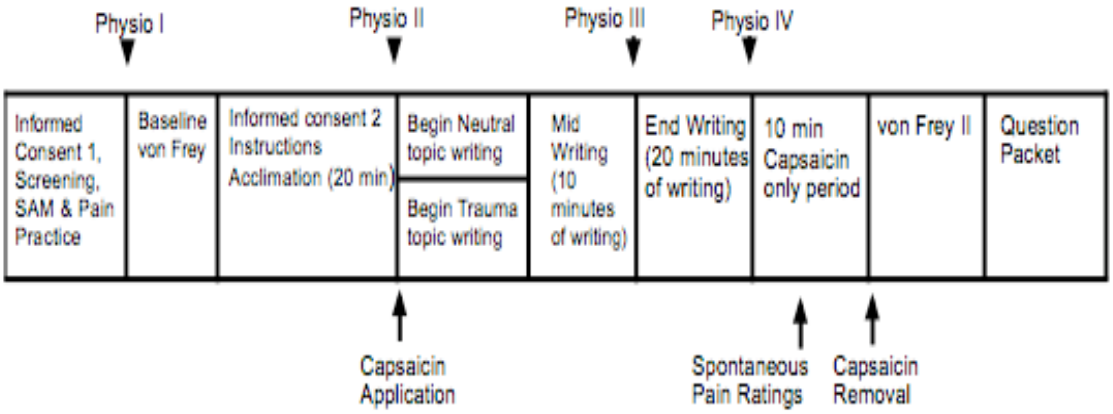

Figure 1. Depicts the procedure for Experiments 1a & 1b.

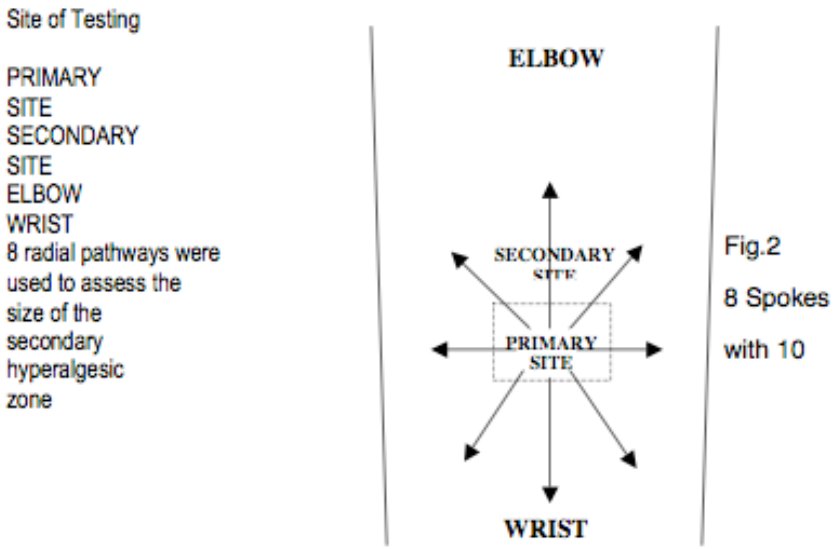

Figure 2. Testing began outside the area of secondary hyperalgesia and worked inwards toward the primary inflammatory site. Testing began at the wrist and was completed in a clockwise fashion.

The subject was then given final instructions and questions regarding the procedure were answered. A curtain was drawn and the subject's dominant forearm is placed on the experimenter's side of the curtain. The curtain is required to ensure that the participant is not receiving visual cues of inflammatory status or level of pain reactivity from the von Frey hair, which could impact pain ratings.

After informed consent the participant was then left in the room alone until the end of the 20 minutes acclimation period. During this time the experimenter prepared 300 µl of a 6.0% capsaicin solution to be topically applied to the dominant volar forearm via a 1.5 cm x 1.5 cm gauze pad (Culp, Ochoa, Cline, & Dotson, 1989; Simone, Baumann, & LaMotte, 1989). To impede evaporation, the site of application was covered with a dressing (Baron, Wasner, Borgstedt, Hastedt, Shulte, Binder et al., 1999). The pad and

dressing was left on the arm for a period of 30-minutes. After application the subject was given their topic and told to begin writing with instructions to write for the entire 20 minutes rewriting what they had already written if they ran out of things to write. The first 20 minutes of the capsaicin application phase were spent writing by the participant. During this time, participants were asked to rate their emotion using a SAM form at 10-minute intervals during writing and 2-minute intervals during the last 10 minutes of the capsaicin application. Participants were also asked to rate their experience of pain intensity at each of these intervals using a paper VAS scale.

At the end of the 30-minute capsaicin application phase the capsaicin pad was removed and the capsaicin residue was removed using vegetable oil applied to a cotton ball followed by a clean cotton ball. After this the experimenter conducted the von Frey pain test using the same procedure as before. After the final von Frey test was administered the participant was asked to fill out a post-testing questionnaire and then was walked through a debriefing explaining the goals of the experiment and educating the participant about the effects of the capsaicin solution.

In Experiment 2, participants were all women and the procedures differed from those in Experiment 1. Immediately after the first informed consent, in addition to the measures and procedures already mentioned, the subject was asked to provide a small globule of saliva. This globule was placed on the view screen of an OvuLens kit and later viewed by the experimenter to determine if the subject was in the ovulatory phase of her menstrual cycle. Each participant was also asked the date of her last menstruation

and how certain she was of this date on a scale of 1-10. All other procedures were identical to those in Experiment 1.

3. RESULTS

Manipulation Checks

Pre-existing Distress

To determine whether pre-existing levels of emotional distress or pain related self-efficacy contributed to any between group differences, CES-D and PSS scores were analyzed using a two-way ANOVA with writing topic and gender as between-group variables. There were no significant group differences on the CES-D for either writing topic [F (1, 49) = .1.073, MSE = 34.860, p > 0.05] or gender [F(1, 49) = .134, MSE = 4.438, p > 0.05]. Moreover, there were no significant group differences on the PSS for either writing topic [F (1, 49) =.451, MSE = 9.950, p > 0.05] or gender [F (1, 49) =.001, MSE = .024, p > 0.05]. These results suggest the groups were homogeneous on these variables, and thus any between-group differences cannot be attributed to pre-existing differences in emotional distress and pain related self-efficacy.

Affective Manipulation

Self-Report

To determine whether pre-existing differences in levels of SAM self report ratings contributed to any between group differences a series of two way ANOVAs were run with writing topic and gender entered as between-group variables. No main effects of topic or gender were found for SAM ratings [all Fs <1.062 p >.05]. In addition no interaction effects were found [all Fs <3.218 p >.05]. These results suggest that no between group differences can be attributed to pre-existing differences in SAM self report ratings.

Figure 3 depicts the effects of writing topic and gender on SAM valence over time. A series of two-way ANOVAs were conducted on SAM valence, arousal, and dominance ratings entering writing topic and gender as between subject variables and time as a repeated measure. A significant main effect for writing topic on SAM self report valence was found during the writing manipulation (collapsing valence ratings over times three and four) [F (1, 46) = 4.927, MSE = 32.339, p < 0.05]. In addition, a significant main effect for time on SAM self report valence was found [F (1, 3) = 23.232, MSE = 34.227, p < 0.05]. *Post hoc* analyses using Duncan's New Multiple Range test revealed that this was due to a significant difference between valence ratings at times three and four from valence ratings at times one and two though there was no significant difference between valence ratings at times one and two, ps < .05. This finding indicates that all participants experienced a subjective increase in unpleasantness as the experiment proceeded, which may be due to the gradual increase in capsaicin-induced pain over the session. There was also a significant 3-way interaction effect [F (1, 1) = 6.085, MSE=6.085, p<. 05]. *Post hoc* analyses using Duncan's New Multiple Range revealed that this was due to a significant difference at the middle of the writing manipulation [F (1,48) = 5.328, MSE=20.105, p<. 05]. Women writing about trauma reported an increase in unpleasantness from baseline that remained the same to the end of writing, while women writing about a neutral topic reported a significant increase in unpleasantness from the middle of writing to the end of writing. Men in both the neutral and trauma writing groups showed a significant increase from baseline by the middle of writing with the trauma writers reporting a higher degree of unpleasantness that

increased by the end of writing. Neutral writers showed a slight decrease in unpleasantness form the middle of writing to the end of writing.

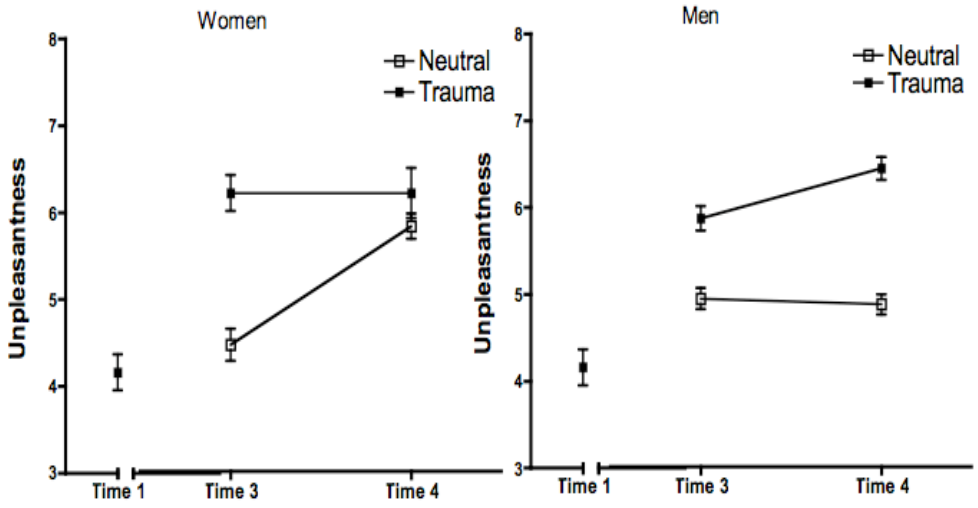

Figure 3. A significant three way interaction of writing topic, gender, and time was found.

Figure 4 depicts the effect of writing topic on SAM arousal ratings. An ANOVA revealed a significant main effect for writing topic on SAM self-reported arousal [F (1, 39) = 4.282, MSE = 33.144, $p < 0.05$], indicating that participants in the trauma writing condition reported increased levels of arousal. However, no other significant main effects or interactions were observed for writing topic, gender, or time on arousal [all F's < 4.282 $p > .05$]. Figure 5 depicts the effect of time on SAM dominance at times two, three, and four. Analyses revealed a significant effect of time on dominance [F (1, 46) = 4.071, MSE = 4.725, $p < 0.05$], suggesting that all participants experienced a subjective decrease in perceived social dominance as the experiment proceeded. It is possible that

the gradual increase in pain over the session may be decreasing perceived dominance. However, no other significant main effects or interactions were observed for writing topic, gender, or time on dominance [all F's < 4.071, p > .05].

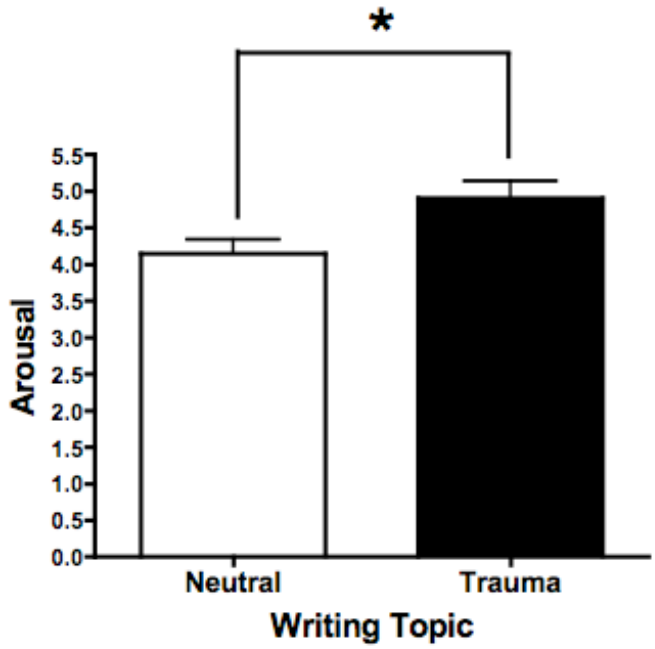

Figure 4. A main effect of writing topic on SAM self report measures of arousal was found.

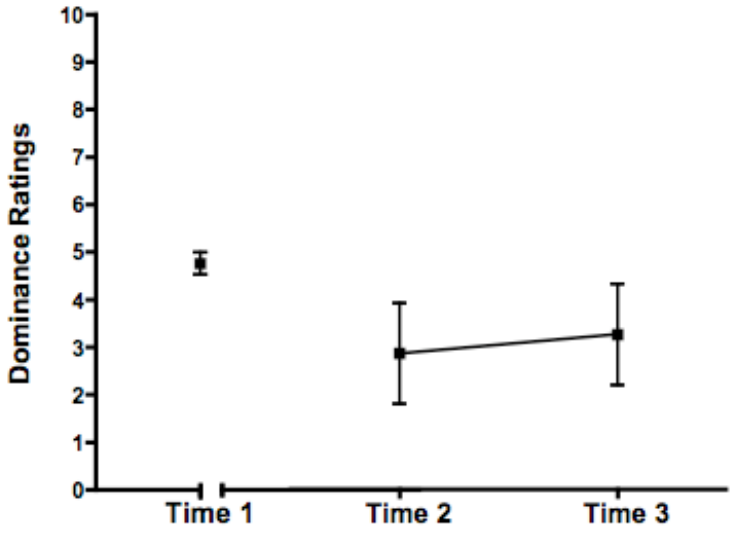

Figure 5. A significant effect of time on SAM self report measures of dominance for dominance ratings at times two, three, and four was found.

Heart Rate

Heart rate was recorded in 1-minute blocks immediately after initial informed consent, 20 minutes after the initial recording, midway through the writing (10 minutes of writing) and at the end of writing (20 minutes of writing). To determine whether any pre-existing differences in heart rate contributed to between group differences, baseline scores were analyzed using a series of two-way ANOVAs with writing topic and gender as between-group variables. No significant group differences were found for heart rate at baseline or at the 20 minute acclimation recording scores [all Fs <.846 p >.05].

Heart rate was analyzed in two ways: one by examining changes in heart rate in beats per minute from baseline, midway through the manipulation (10 minutes of

writing) and at the end of the writing manipulation (20 minutes of writing) and by analyzing heart rate measured in beats per minute at baseline, at the 20 minute acclimation point, midway through the manipulation (10 minutes of writing) and at the end of the manipulation (20 minutes of writing). The change scores were represented as difference in beats-per-min(BPM) and analyzed using a two-way ANOVA with writing condition and gender entered as between subjects variables and difference from baseline entered as a repeated within subjects variable.

Figure 6 depicts the effect of writing topic and gender over time on heart rate change from baseline scores. Change scores were calculated using the first baseline recorded when the subjects first entered the experiment room. An ANOVA revealed a significant main effect of gender on heart rate [$F(1, 1) = 4.433$, $MSE = 407.287$, $p < 0.05$], with men showing higher overall heart rate compared to women. Analyses of change scores also yielded a significant interaction effect between topic, gender, and time on heart rate change from baseline [$F(1, 1) = 5.275$, $MSE = 43.995$, $p < 0.05$]. *Post hoc* mean comparisons indicated that this interaction was attributable to men showing a decrease from baseline midway through writing and then an increase by the end of writing. Women showed an increase in rate from baseline midway through writing and at the end of writing.

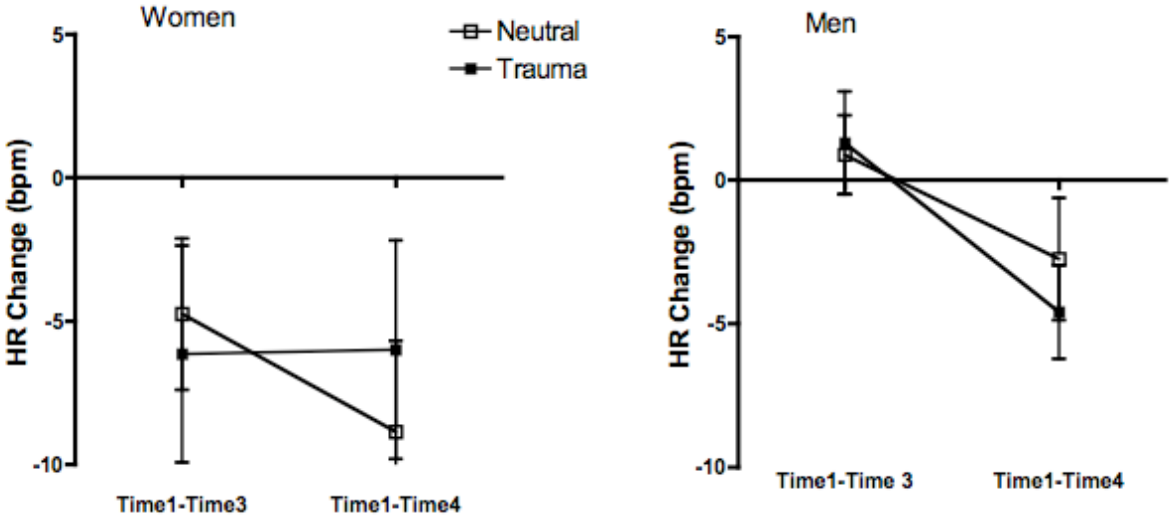

Figure 6. A three way interaction was found for writing topic, gender, and time on heart rate change from baseline. Points below the line represent decreases from baseline in heart rate and points above the line represent increases in heart rate from baseline.

Figure 7 shows the effect of time on raw heart rate. The raw heart rate scores were represented in beats-per-minutes (BPM) and analyzed using a two-way ANOVA with writing topic and gender entered as between subjects variables and heart rate entered as a repeated within subjects variable. A main effect for time was found for the raw heart rate data across times one, two, three, and four, [$F(1, 3) = 21.928$, $MSE = 182.891$, $p < 0.05$]. This finding indicates that all participants experienced a decrease in heart rate as the experiment proceeded, which may reflect either acclimation or increased attention to the capsaicin-induced pain or writing task over the session. No other main effects or interaction effects were found for raw heart rate data [all Fs <21.928 $p > .05$].

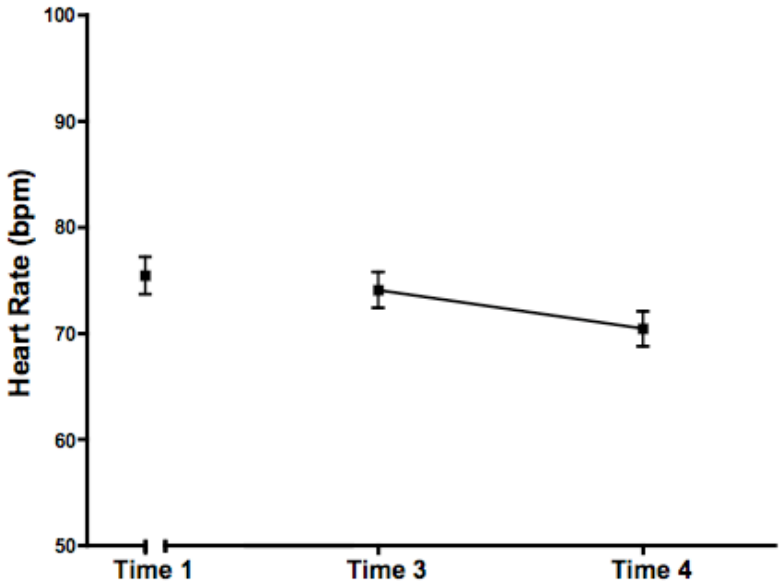

Figure 7. A main effect of time on the raw heart rate data across times one, two, three, and four was found. Because times one and two were not significantly different they are shown here averaged together as one baseline.

Skin Conductance

Skin conductance level (SCL) was recorded in 1-minute blocks immediately after initial informed consent, 20 minutes after the initial recording, midway through the writing (10 minutes of writing) and at the end of writing (20 minutes of writing). To determine whether any pre-existing differences in skin conductance level contributed to between group differences, baseline scores were analyzed using a series of two-way ANOVAs with writing topic and gender as between-group variables. No significant group differences were found for SCL at baseline or at the 20-minute acclimation recording scores [all Fs <1.390 p >.05].

Figure 8 depicts the graph of skin conductance level over time and figure 9 depicts skin conductance level for each gender. SCL was analyzed in two ways: one by examining changes in skin conductance level measured in micro Siemens (μS) midway through the manipulation (10 minutes of writing) and at the end of the manipulation (20 minutes of writing) and by analyzing skin conductance level midway through the manipulation (10 minutes of writing) and at the end of the manipulation (20 minutes of writing). The change scores were represented as difference in SCL and analyzed using a two-way ANOVA with writing condition and gender entered as between subjects variables and difference from baseline entered as a repeated within subjects variable. Analyses of change scores revealed no main effects or interaction effects [all Fs <. 394 p >.05]. No significant main effects of gender, topic, time or interaction effects were found [all Fs < 2.556 p >.05].

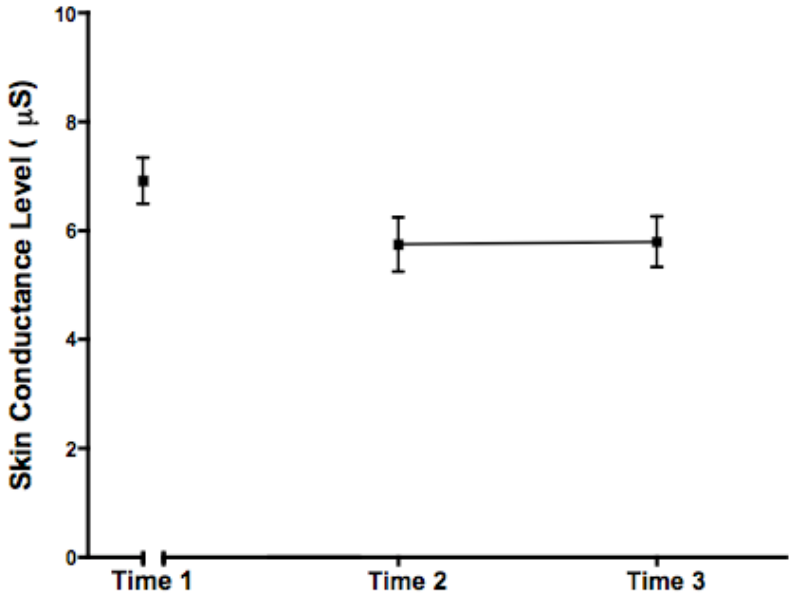

Figure 8. No significant effect of time on skin conductance level was found.

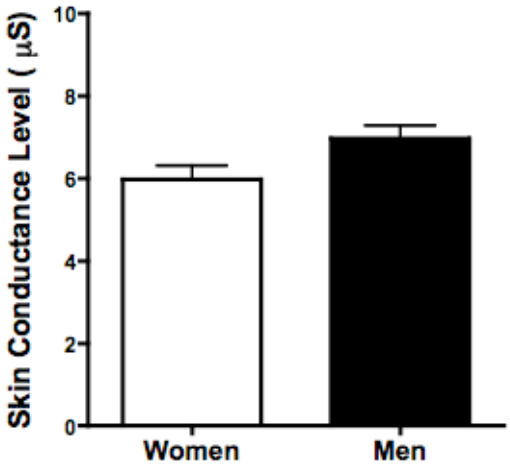

Figure 9. Though the effect of gender on skin conductance level was not significant men appeared to be slightly more aroused than women

Pain Reactivity and Secondary Hyperalgesia

Spontaneous Pain

Figure 10 illustrates the effect of writing topic and gender on spontaneous pain over time. Spontaneous pain intensity ratings were analyzed using a two-way ANOVA with writing topic and gender entered as between subject variables and all seven spontaneous pain intensity ratings entered as a within subjects variable. Significant main effects were found for writing topic [F (1, 46) = 4.420, MSE = 121.013, p < 0.05] and time [F (1, 6) = 14.283, MSE = 14.758, p < 0.05], however the main effect of gender was not significant [F <.175 p >.05]. Importantly, these effect were qualified by a significant interaction between writing topic and gender on spontaneous pain ratings [F (1, 46) = 6.400, MSE = 175.237, p > 0.05]. This interaction indicated that the effect of writing topic on spontaneous pain depended on gender, with women showing an increase

in spontaneous pain following trauma writing, whereas men did not show this pattern. When separate ANOVAs were run on the women and men, a significant main effect of writing topic on female spontaneous pain ratings was found [F (1, 20) = 8.873, MSE = 262.866, p > 0.05], but there was no effect of writing topic for men [F (1, 48) = .141, MSE = 4.469, p > 0.05].

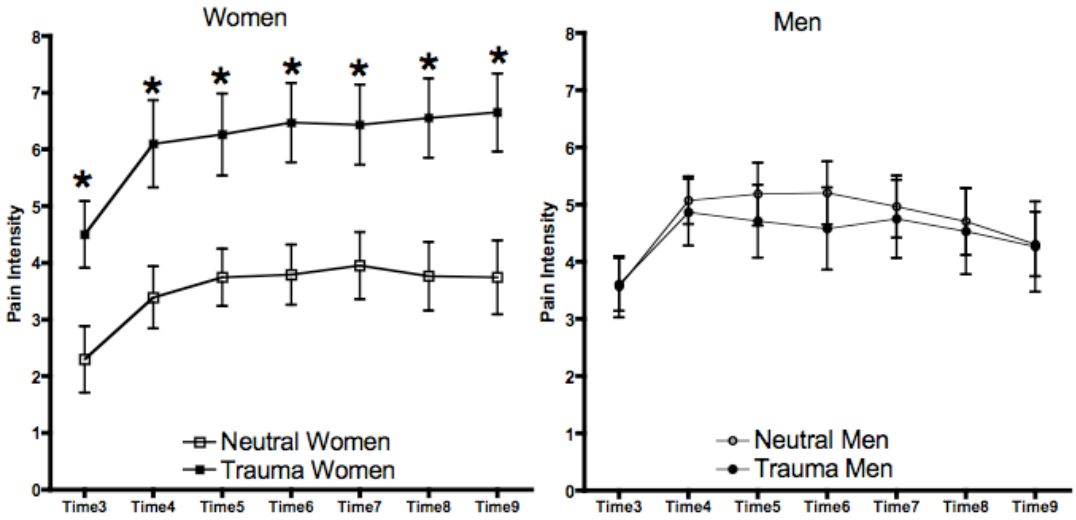

Figure 10. A significant topic by gender as well as a main effect of writing topic on sponatenous pain ratings in women was found. Women writing about trauma rated their pain as more intense than women writing about a neutral topic, men did not display this disparity.

Area of Secondary Hyperalgesic Pain

To examine the impact on secondary hyperalgesia, the area of secondary hyperalgesia needed to be determined for each subject. To measure this area, each spoke along the grid was examined beginning from the center and radiating outward. The boundaries of secondary hyperalgesia were decided using previously published methodology (Huang, Ali, Travison, Campbell, & Meyer, 2000). Specifically, a boundary was defined as a 50% reduction in pain ratings for a given site relative to the

previous site on the spoke. To examine the effect of writing topic and gender on area of secondary hyperalgesia a two-way ANOVA was conducted using writing topic and gender as between subject variables. No significant main effects of writing topic, gender, time or interaction effects were found [all Fs <.1.589 p >.05].

Area of Flare

Figure 11 depicts the significant main effect of gender on area of inflammation. To examine the effect of writing topic and gender on area of flare a two-way ANOVA was conducted using writing topic and gender as between subject variables. A significant main effect of gender was found [F (1, 42) =44.396, MSE = 181998.060, p > 0.05], with women showing greater areas of flare compared to men. No other significant differences were observed [all Fs <44.396 p >.05].

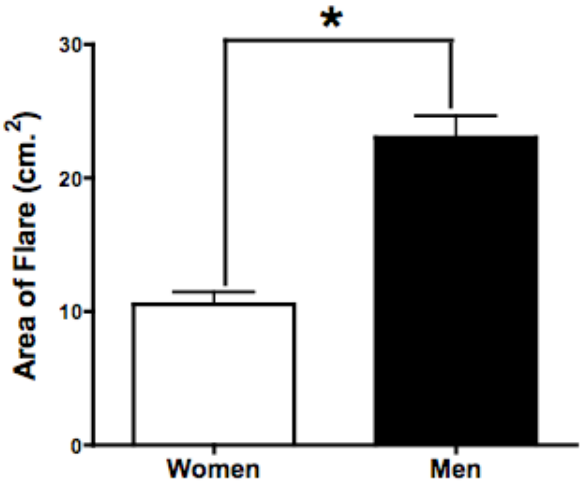

Figure 11. A significant main effect of gender on area of flare was found.

Effect of Menstrual Cycle on Pain

Figures 12 and 13 depict the data for the effect of phase of menstrual cycle on pain measurements. No significant effects were found [all Fs < 1.776 p >.05].

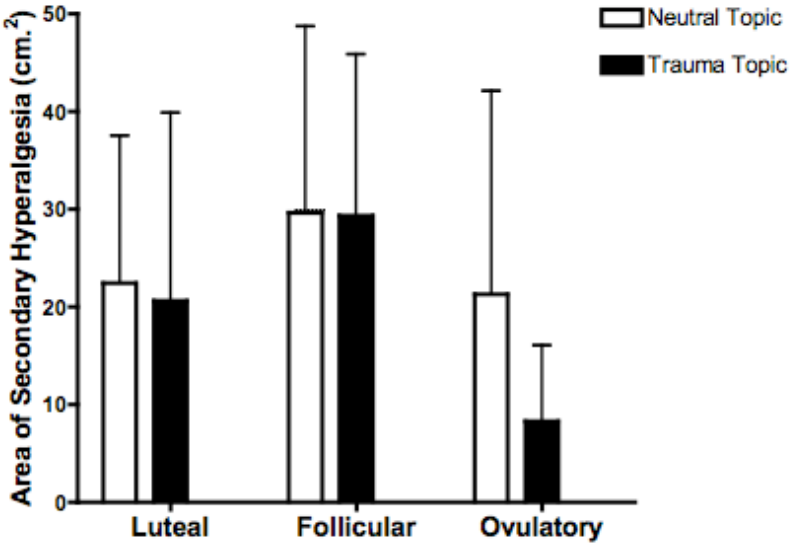

Figure 12. No significant effects were found for menstrual cycle phase on area of secondary hyperalgesia.

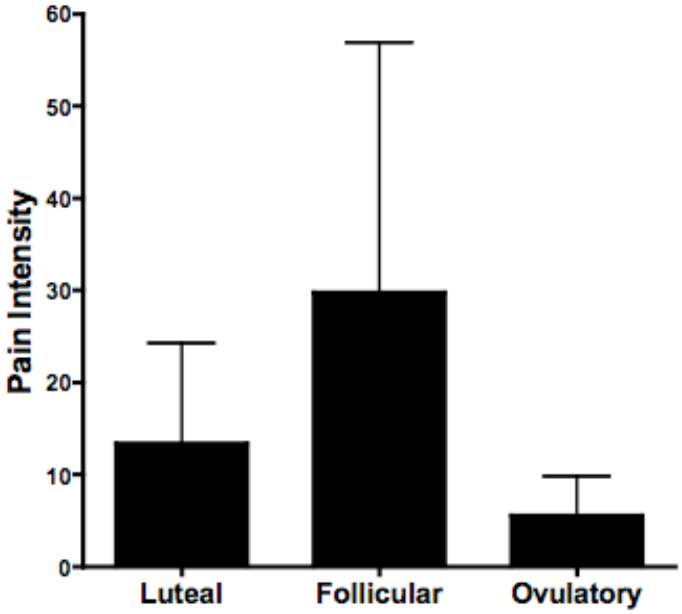

Figure 13. No significant effect of menstrual cycle phase was found for spontaneous pain ratings.

4. DISCUSSION & CONCLUSIONS

The present study examined the impact of written emotional disclosure and gender on capsaicin-induced pain and flare. The results indicated that written emotional disclosure alters spontaneous pain and that this effect is further modified by gender. Specifically, women writing about a traumatic topic rated their spontaneous pain as more intense whereas men showed no significant difference. Men did exhibit a significantly greater area of flare in response to the capsaicin solution compared to women. However, we did not observe any effects of written emotional disclosure or gender on area of secondary hyperalgesia.

Manipulation check data for self-reported valence revealed an interaction between gender, topic, and time. Women writing about trauma rated their experience as more unpleasant midway through writing than their neutral writing peers though this difference disappeared by the end of writing. Men writing about a trauma reported their experience as significantly more unpleasant than their neutral writing peers midway through and at the end of writing. Self-report data for arousal indicated that participants writing about trauma experienced the procedure as more arousing than did those writing about a neutral topic. All of the participants also reported feeling less dominant after the writing manipulation than they did at baseline. Because the capsaicin-induced pain began to peak at the onset of writing, either the increase in pain intensity and/or the writing process may have caused this decrease in dominance over the writing session. Collectively, these data confirm that writing about traumatic experiences led to increases

in self-reported negative affect and arousal, and that the experimental procedure alone decreased perceived dominance.

The physiological data provided further evidence that our experimental procedure was effective. The heart rate data revealed an interaction between writing topic, gender, and time. Specifically, women writing about the traumatic topic showed decreases in heart rate midway through writing but at the end of writing women writing about a neutral topic showed a significantly greater decrease than their trauma writing topic peers. Although men did not show a difference between the trauma and neutral writing conditions, men did show an increase in heart rate after 10 minutes of writing followed by a decrease in heart rate at the end of writing. In addition, a main effect of time was found on heart rate with an overall decrease in heart rate as the experiment progressed relative to the baseline condition. The changes observed in heart rate following writing may reflect changes in attention and autonomic activity induced by the process of writing alone and/or by increases in capsaicin-induced pain over the session.

In general, self-report data for this study were consistent with the results found in prior work. Participants writing about a traumatic experience rated the experiment as more unpleasant and arousing than did their neutral topic peers. In addition, participants reported feeling less dominant by the end of the procedure than they did at the beginning when writing about a traumatic topic. This is consistent with data from our own laboratory (Creech et al., 2007) and with data from other laboratories (Smyth, 1998). Our physiological findings were also generally consistent with prior work. Overall, participants showed a decrease in heart rate as the experiment progressed. Men in both

the neutral and trauma writing conditions showed an increase in heart rate from baseline after 10 minutes of writing but then a decrease from baseline after 20 minutes of writing. In contrast, women writing about a neutral topic showed a decrease from baseline after 10 minutes of writing and a greater decrease after 20 minutes of writing. Women writing about a traumatic topic showed an equal decrease from baseline in heart rate after both 10 and 20 minutes of writing. This may indicate that women begin to focus on the written emotional disclosure task sooner than men and were thus more subject to the psychophysiological and nociceptive effects it induced. Alternatively, women may be attending more to the capsaicin-induced pain, which is consistent with the finding that women reported greater levels of spontaneous pain. It is also possible that these decreases are merely a product of habituation to the task at hand. In terms of skin conductance level the current findings are not consistent with previous findings in that no significant differences were found between trauma writers and neutral writers (Pennebaker & Roberts, 1992; Hughes, Uhlmann, & Pennebaker, 1994); Pennebaker & Francis, 1996; Creech, Grimes, & Meagher, 2003). Skin conductance level results though not significant, when graphed, seem to indicate a slightly greater increase in arousal for men over women.

Prior work in our laboratory suggested that women writing about a traumatic experience would rate their spontaneous pain as less intense than women writing about a neutral topic (Creech et al., 2003). In addition, we expected that men writing about trauma would have a weaker (compared to women) physiological reaction and that this moderate physiological response combined with the negative affect induced by the

trauma topic would result in an increase in spontaneous pain ratings by men compared to men in the neutral topic writing group. Interestingly, we found no differences in pain ratings among men.

In the current study we found that women writing about a traumatic topic actually showed an increase in pain sensitivity with women writing about a traumatic topic rating their spontaneous pain as significantly greater than those writing about a neutral topic. In addition, within women participants, we found no difference by phase of menstrual cycle, however we did not have sufficient numbers of subjects in each of the menstrual cycle phases to provide a fair test of this hypothesis. Although a definitive explanation for this difference across studies will require further investigation, several methodological changes across studies may account for this discrepancy.

First, it is important to note that there were differences in the procedure and in the informed consent and instructional script used to prepare the subjects for writing. In the study done by Creech and colleagues more extensive language was used concerning the confidentiality and anonymity of the participants writing sample. Although the same measures and precautions were applied in both studies, the wording was changed in the current study to conform to new IRB standards requiring more concise language and, in hindsight, careful enough attention was not given to this variation in language. It is possible that participants were less engaged and wrote about less personal or traumatic situations then they did in the prior study. We are currently conducting a content analysis of the participants' narratives to determine whether the participants used fewer affective descriptors in the present study relative to our prior studies using the original procedure.

It is also important to note that in the previous study participants were told they may or may not be asked to write about a traumatic experience whereas in the current study they were told they would be writing about a topic we would provide for them. Essentially in the previous study participants were aware of the possibility of being asked to write about something personally meaningful and traumatic for a full 20 minutes before baseline data were collected in which they could have been thinking about a personally meaningful and traumatic experience. It is likely that this 20 minute anticipatory period altered the temporal dynamics of the emotional response, such that the participants were experiencing a more intense negative affective state and heightened physiological arousal at the time of testing. This heightened emotional state may have activated descending inhibitory pathways resulting in a hypoalgesic effect for women writing about a traumatic experience. This may also offer insight in to why hypoalgesic effects were seen in the work done by Creech (Creech, et.al.,2007) and hyperalgesic effects in the work done by Grimes (Grimes,2005), which informed our hypothesis of disparate effects in women in the luteal phase.

In the current study, women assigned to the traumatic topic condition did not know what their topic would be until the writing phase of the task began, thus the onset of the negative affective state induced by trauma writing was delayed by 20 minutes. If one assumes an opponent process theory of affective dynamics (Solomon & Corbet, 1974), the delay in stimulus onset would be expected to alter the relative contributions of underlying A- and B-processes. Specifically, the delay would be expected to minimize the impact of an underlying opioid B-process, which have a slow onset and have been

hypothesized to mediate stress-induced analgesia. To resolve this issue, future studies would need to systematically vary the time when participants are informed they will write about trauma and the time of pain testing. We would predict that early notification will allow the relatively sluggish opioid B-process to grow in strength resulting in decreased pain consistent with Creech and colleagues (2007), while late notification would result in increased pain consistent with the present findings.

Finally, in an effort to collect a truer baseline measurement of physiological and self-report data we added an additional baseline measurement immediately after the participant entered the experiment rooms. We made this addition so that we would have data before the participants knew about the capsaicin we would use. However, it is unlikely that the addition of this baseline had a significant impact as the statistical analyses showed no significant difference between the true baseline and the baseline that was equivalent in timing to the one used by Creech and colleagues (2007). Further research must be done to disentangle these alternative explanations, especially the issue of the timing of when participants know they may be writing about personal and traumatic material and the extent to which the wording of assurances of confidentiality encourage or discourage active and meaningful engagement in the process.

The most influential factor in terms of what influenced our predictions concerning pain outcomes in this study was the interaction effect between arousal level and valence of affect. As cited earlier several studies conducted in our laboratory support the theory that negative affect combined with varying levels of arousal determine pain perception and modulation. We have found that moderate levels of arousal combined

with negative affect result in hyperalgesia, while negative affect combined with high levels of arousal result in hypoalgesia (Rhudy & Meagher, 2000; Rhudy & Meagher, 2001; Rhudy, Arnau, & Meagher, 2001; Grimes, & Meagher, 2004).

In regards to area of secondary hyperalgesia, we had predicted that men in the trauma-writing group would show an increased area of secondary hyperalgesia in comparison to men in the neutral-topic writing group. Furthermore, we predicted that men would have a larger area of secondary hyperalgesia and flare than women. Prior work in our laboratory using a noise stressor with men provided the basis for these predictions. (Grimes et al. 2003). However, the current study found no effects of either writing topic or gender on area of secondary hyperalgesia. The positive findings in our previous studies may be attributable to differences in the physiological and affective state induced by the noise. It is possible that 115 decibel bursts of white noise are more physiologically arousing and noxious to participants, and consequently more potent in their influence on centrally mediated pain processes such as area of secondary hyperalgesia. Future research must be done to tease apart the potency of these affect induction techniques and their effect on pain perception and modulation. Specifically, how aversive does the affect manipulation have to be in terms of physiological arousal and self-report ratings to induce changes in central sensitization.

We must also begin to closely investigate how our affect induction models alter the area of flare induced in the capsaicin model. In agreement with our predictions for flare size, which were the same as our predictions for area of secondary hyperalgesia, we observed that men showed a greater area of flare than did women. Research suggests that

flare area can be influenced by psychological factors such as relaxation or level of sympathetic arousal (Lutgendorf et al., 2000). It has also been reported that area of flare correlates with area of mechanical and heat hyperalgesia in the capsaicin pain model (Serra, Campero, & Ochoa, 1998). This raises the possibility that different mechanisms mediate the area of flare and area of hyperalgesia (as we found no difference in area of secondary hyperalgesia) and that there may also be sex differences in how these mechanisms are modulated. As mentioned above, Lutgendorf and colleagues found that area of maximum flare was predicted by indicators of increased sympathetic arousal such as systolic blood pressure, norepinephrine, and heart rate (Lutgendorf et al., 2000). It may be that the non-significantly higher arousal found in men was strong enough to induce a release of noradrenalin, which resulted in the increased flare size. This is consistent with research indicating that peripheral levels of norepinephrine mediate flare size (Drummond, 1995; Klede, Handwerker & Schmelz, 2003).

In summary, the current experiment was successful in inducing a negative and arousing affective state using written emotional disclosure. In addition, we found that written emotional disclosure has disparate effects by gender on spontaneous pain ratings. These findings combined with differences across studies raise important questions about the temporal aspects of the pain modulatory process. Future research must focus on how the timing of when participants know what they will be writing about relative to pain testing effects spontaneous pain ratings, secondary hyperalgesia, and flare.

Another factor that must be resolved in future studies is whether the language used in instructing participants as well as language used in describing procedures used to

protect privacy and confidentiality may alter the intensity of affect induction. It may be that if individuals feel safer in disclosing more intensely personal and meaningful traumas the impact on pain may be different. Yet another question that must be addressed is what underlies these gender differences, is it socialization or biology or, as so often is the case, both. Finally, replication of the disparity between area of flare and area of secondary hyperalgesia is needed to determine if this is a reliable finding or if it is merely chance.

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Clinical Experience

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2006-2008 Clinical Placement at the Bryan Women's Federal Prison, providing psychological education and Group Therapy to inmates. Bryan, Texas.

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