EFFECTS OF EMOTION ON PAIN REPORTS, TOLERANCE, AND PHYSIOLOGY

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Effects of Emotion on Pain Reports, Tolerance, and Physiology

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Running Head: EFFECTS OF EMOTION ON PAIN

Abstract

The specific effects of particular emotional states on laboratory pain were tested by examining verbal report, overt behavior, and psychophysiological responses of 80 student volunteers (50% female). Participants were assigned to one of four Velten-style emotion induction conditions (i.e., depression, anxiety, elation, or neutral). Sex of experimenters was counter-balanced. Pre and post physiology (i.e., electrocardiogram, corrugator and trapezius electromyogram) and verbal report baselines were recorded. Pressure pain tolerance and severity ratings were measured before and after the emotion-induction procedure. As predicted, depression condition subjects showed reduced pain tolerance and increased pain severity ratings compared to a neutral induction controls. A complex pattern of gender-related effects was found in physiological and verbal report variables. Findings indicated that depression significantly influenced pain responding across all three systems (verbal report, physiology, and overt behavior). Furthermore, pain responding also was influenced by the gender of the subject and experimenter. Pain responding is complex and influenced by a variety of factors, including emotion, making prediction and control of pain quite challenging.

Effects of Emotion on Pain Reports, Tolerance, and Physiology

Over the years, researchers and clinicians alike have become aware that the personal experience of pain is much more complex than the effects of tissue damage alone (Beecher, 1959). Emotions, in particular, have received recognition as important mediators in pain perception and response (Melzack & Wall, 1982). Clarifying the relative effect of emotions on the experience of pain, however, has proven to be extremely difficult. To date, no theory has been able to adequately capture the complex relationships between emotions and pain (Turk, 1994). The research literature on this topic is also quite convoluted and, at this time, appears to only provide clues as to the processes involved. Some researchers have even suggested that the study of pain and emotions like anxiety and depression are empirically confounded because of methodological difficulties (Gross & Collins, 1981; Turner & Romano, 1990). Despite these impediments, researchers continue to attempt to determine the extent of the impact that feelings like depression, anxiety, and more recently happiness, can have on the experience of pain.

Clinical Pain

Depression

Depression in particular has received considerable attention in the clinical pain literature (Lautenbacher &

Krieg, 1994; Romano & Turner, 1985; Ward, 1990). Most researchers agree that at least 50% of chronic pain patients are clinically depressed (Turk & Holzman, 1986). They also concur that 30% to 100% of depressed patients complain of pain (Romano & Turner, 1985). Cognitive distortions commonly seen in depressed patients have also been noted in chronic pain patients (Flor, Behle, & Birbaumer, 1993; Smith, O'Keeffe, & Christensen, 1994). The association between depression and pain is so strong that Blumer and Heilbronn (1982) even proposed that chronic pain with unknown etiology was simply masked depression as part of a "pain-prone" personality. There is also some indication that the same neurotransmitters that are found in abnormally high amounts in some depressed patients may also mediate pain perception (Romano & Turner, 1985). Moreover, antidepressant medication is known to alleviate chronic pain in some patients as well (Monks, 1990). The findings in this area suggest a complex interaction between pain and depression which is only beginning to be understood.

Anxiety

Anxiety and pain also appear to share a complex relationship in both acute pain (Chapman & Turner, 1990) and chronic pain (Bonica, 1990; Lautenbacher & Krieg, 1994) clinical populations. Severe pain often produces anxiety and/or fear so compelling that patients avoid previously desirable activities in the hope of preventing another pain

episode (McCracken, Gross, Sorg, & Edmands, 1993; Taegtmeyer, Beck, Bennett, & Berisford, 1989). When the need is sufficiently compelling (e.g., dental care), some patients endure their fear of pain to seek treatment (Vassend, 1993). Hendler (1982; 1984) suggested that the effects of chronic pain on the psychology of the individual follows four stages (i.e., acute pain, subacute pain, chronic pain, and subchronic pain) similar to those proposed by Kubler-Ross (1970) with regards to the process of dying. In the latter stages of chronic pain syndromes (i.e., at least 6 months of pain), previously stable patients often report increased symptoms of general anxiety (Hendler, 1982) and fear that they have an undiagnosed physical illness (Pilowsky, 1978).

Interestingly, these symptoms are similar to those experienced by some anxiety patients (Beck, Berisford, Taegtmeyer, & Bennett, 1990; Beck, Taegtmeyer, Berisford, & Bennett, 1989). Barlow (1988) reported that 38% to 76% of patients with a diagnosis of panic disorder with agoraphobia complained of pain during panic attacks. Panic disorder patients also commonly fear that they have an undiagnosed medical illness and feel compelled to avoid previously common activities to prevent another panic attack (Barlow, 1988). In addition to these findings, preoperative state anxiety has also been found to be predictive of postoperative pain and duration of hospitalization (Boeke,

Duivenvoorden, Verhage, & Zwaveling, 1991). Klepac (1975) demonstrated that in some cases, increasing pain tolerance can reduce dental fear and avoidance. Treatments that reduce anxiety, like biofeedback (Belar & Kibrick, 1986), stress inoculation (Klepac, Hauge, Dowling, & McDonald, 1981; Meichenbaum & Turk, 1976), progressive muscle relaxation (Syrjala, 1990), and self-hypnosis (J. Barber, 1986; T. X. Barber, 1985), have been shown to successfully reduce pain. These data have led many to conclude that the more anxious a patient is, the more pain he or she is likely to feel (Bonica, 1990; Lautenbacher & Krieg, 1994).

Combinations of Anxiety and Depression

Clinical observations have also documented the common tendency of pain patients to show symptoms associated with both depression and anxiety (Romano & Turner, 1985). Both emotions are associated with increased pain reports (Kuch, Cox, Evans, Watson, & Bubela, 1993). Ward, Bloom, and Friedel (1979) reported 100% of depressed patients who admitted to being moderately anxious also complained of pain symptoms. In addition to mood and anxiety disorders, some chronic pain sufferers are diagnosed with somatization disorder, previously known as Briquet's syndrome. Liskow and colleagues (Liskow, Othmer, Penick, DeSouza, & Gabrielli, 1986) reported that in women diagnosed with Briquet's syndrome, 87.2% also met the criteria for major depressive disorder. Of that same sample, 44.9% of the

patients were diagnosable with panic disorder. These data suggest there is a substantial subset of various patient populations that experiences depression, anxiety, and pain together.

Positive Emotion

Traditionally, clinical observations of positive emotions like happiness are not reported in the pain literature. Recently, however, increasing attention has focused on the potential benefits of positive emotions (e.g., happiness) and laughter in the general healing process and longevity. Happiness was found to be significantly positively correlated with longevity (Palmore, 1969; Veenhoven, 1984) and self-perceived positive health (Veenhoven, 1984). Periods of laughter have been reported to decrease pain and other somatic complaints (Ljungdahl, 1989), reduce "discomfort sensitivity" (Cogan, Cogan, Waltz, & McCue, 1987), and enhance immune system functioning (Dillon, Minchoff, & Baker, 1985-1986). Conversely, attitudes inconsistent with happiness, like depression, were reported to be consistently followed by periods of increased somatic complaints in a longitudinal study by Brenner (1979). These studies together suggest that happiness and laughter are associated with better perceived health and fewer health complaints, like pain.

Pain Theories

Gate-Control Theory

Although there are considerable data to indicate that emotions have significant effects on pain perception, few theoretical formulations, to date, have attempted to explain these phenomena. In 1965, Melzack and Wall published the Gate-Control Theory of Pain and became the first to place emotions in a prominent role in a comprehensive theory about pain. Their proposed theory suggested that the brain could evaluate current pain in terms of a complex array of factors including past experience and current emotional state. Theoretically, these central nervous system processes were believed to modify how much pain the person experienced and the person's behavioral response to the pain. However, the Gate-Control Theory, although strong in providing specific physiological explanations for various aspects of pain, was still noticeably vague regarding exactly how emotions affected pain experiences. Since that time, other theorists have attempted to clarify the influence of emotions on pain (and vice versa), but with limited success.

Parallel Processing Model

Leventhal and Everhart (1979) proposed a Parallel Processing Model of pain distress which elaborated upon the Gate-Control Theory. These authors theorized that there are several types of pathways which together generate the perceptual experience of pain. Primary among these pathways

are informational (e.g., location and type of pain) and emotional/motivational (i.e., distress) channels. These types of perceptual information are independent of each other, are processed simultaneously (i.e., in parallel), and can be elaborated in different ways by each individual.

The Perceptual-Defensive-Recuperative Model

Bolles and Fanselow (1980) proposed the Perceptual-Defensive-Recuperative (PDR) Theory. Their theory suggests that anxiety and pain inhibit one another, interacting in unique ways during each of three stages (i.e., perceptual, defensive, and recuperative) of responses. During the perceptual phase, the subject perceives the presence of a potentially-traumatic stimulus which activates species-specific defense behaviors. In the defensive phase, fear inhibits pain of any injuries to allow the fullest defensive action possible. Pain will inhibit subsequent anxiety, during the recuperative phase, to encourage quiescence and thereby promote healing.

Bioinformational Theory

Recently, researchers have begun exploring the usefulness of applying the Bioinformational Theory of emotion by Lang (e.g., 1987) to the experience of pain (McNeil & Brunetti, 1992). This theory suggests that memories for emotional experiences are stored in propositional networks in three ways: stimulus information, responses associated with the stimulus, and meanings

attached to the experiences. A network is activated when relevant stimuli are processed by the individual. Level of responding to the stimulus is proportionate to the degree of activation created in the associated propositional network(s).

Evaluation of Pain Theories

Although each of these theoretical formulations uniquely contribute important perspectives about the effect of emotions on pain, none provides specific hypotheses that are relevant to all emotions in general. As noted earlier, the Gate-Control theory is important because it provides specific hypotheses about physiological mechanisms of pain, but does not elaborate equally well regarding the role of emotions. Leventhal and Everhart (1979) contribute more specificity to the emotional/motivational pathways hypothesized by Melzack and Wall (1982), but they also fail to provide sufficient specificity to drive empirical research. Only Bolles and Fanselow (1980) provide definitive hypotheses about the role of emotions and their effect on the experience of pain. Their theory, although providing promise in the area of anxiety and fight and flight defensive responses, does not generalize well to other situations or emotional states (e.g., depression). Lang's Bioinformational theory, although interesting, has never been formally extended to the experience of pain. Unfortunately, there is no comprehensive theory which, at

this time, addresses the effects of emotions on pain perception.

Pain Research Methodology

Clinical Pain Research

These theories are important in part because they help to organize and describe clinical observations. Clinical data are vital to pain research because they represent the actual effects of pain on humans. They provide data about the patient's view (e.g., verbal descriptions of suffering), the clinician's perspective (e.g., observations of pain behaviors), and sometimes, even provide clues about physiological mechanisms (e.g., surgical interventions) involved in the mediation of pain. There are, however, many ethical and methodological limitations to clinical pain research (Melzack, 1983). For example, often it is difficult to isolate a single source of pain with certainty, in seriously ill or injured patients who often have multiple physical ailments. It is also not ethically appropriate to perform unnecessary surgeries on pain patients just for the advancement of science. Furthermore, important components of clinical research like observations of pain behaviors have been found to account for only 10-16% of the variance in pain ratings (Teske, Daut, & Cleeland, 1983), and thus provide only limited additional knowledge of pain experiences (Turk & Flor, 1987). Because of these and other limitations on clinical research and the complexity of the

relationship among pain and emotions, basic research is also needed to provide the additional perspective that a more precisely controlled laboratory environment can provide (Melzack, 1983).

Laboratory Pain Research

Basic research settings can provide reliable, quantifiable laboratory pain techniques that are useful parallels to those found in formal medical settings (Melzack, 1983). It is important, however, to determine which of the many laboratory pain techniques are most applicable to clinical problems (Klepac & Lander, 1983). To evaluate which laboratory techniques are the most similar to clinical pain, various aspects of clinical pain must first be understood. Melzack and Dennis (1978) suggest that clinical acute pain has a well defined cause, is characterized by a rapid onset phasic component, and then a subsequent tonic component that persists until healing has occurred. Examples of acute pain are a burned finger or a ruptured appendix. Melzack and Dennis (1978) argue that chronic pain states (e.g., low back pain) "may begin as acute pain and pass through both the phasic and tonic phases. The tonic pain, however, may persist long after the injury has healed" (p. 13). Based on these approximate definitions of clinical pain, many researchers have concluded that tonic pain like cold pressor (Lovallo, 1975), tourniquet pressure (Sternbach, 1983), and algometer

pressure (Rainwater & McNeil, 1991) pain all create the feeling of dull aching pain similar to chronic pain and late stage acute pain. Radiant heat (Hardy, Wolff, & Goodell, 1952) and electric tooth pulp stimulation both provide different types of quick shooting pain similar to phasic acute pain seen in sudden injuries. All of the previously mentioned devices provide reliable laboratory-induced pain which seems to effectively mimic different aspects of clinical pain (Rollman, 1983; Wolff, 1983). Electrical stimulation (other than tooth pulp stimulation), on the other hand, is generally considered to "have a unique quality rarely encountered in clinical pain states" (Wolff, 1983, p. 10). Many researchers believe that tonic pain is the aspect of clinical pain which is the most difficult to understand, most like problematic clinical pain, and most susceptible to emotional/motivational factors (Melzack & Dennis, 1978). For these reasons, tonic pain is considered the most useful parallel to apply to many clinical pain problems.

Ethical Issues

Even though laboratory-induced pain can mimic clinical pain, laboratory procedures also have many limitations. Some researchers believe that there are three primary differences between laboratory and clinical pain: intensity, duration, and control (Beecher, 1959). Due to ethical issues, laboratory pain is necessarily short term and mild

(Sternbach, 1983), and therefore more consistent with mild, acute pain. Chronic pain, by definition, lasts for months or even years. Pain of this duration is just not practical or ethically possible to simulate in the laboratory. Also, due to the need for informed consent, subjects have the right to stop laboratory pain when they want, preventing what some feel to be the true "suffering" seen in clinical settings (Wolff, 1978). Fortunately, pain has such strong motivational properties that even mild laboratory pain elicits fearful anticipation and escape behavior reminiscent of that seen in clinical settings (Chapman, 1983). The necessary limitations of laboratory pain, however, make the eventual application of basic research findings to the clinical setting important to assure the generalizability of the resulting conclusions (Melzack, 1983).

Pain Measures

There are many pain measurement techniques currently available for use in clinical and laboratory research. These techniques range from pain intensity ratings using simple visual analogue scales (Huskisson, 1983), to multidimensional verbal report questionnaires and interviews (Melzack, 1975), to observations of pain behaviors (Fordyce, 1990). Other measures available include: pain threshold and tolerance times, signal detection theory indices, physiological measures, and verbal report questionnaires and checklists (Rollman, 1983). Whereas some of these

techniques are favored by clinicians and are easier to implement in clinical settings (e.g., observations of pain behaviors), there is some overlap between laboratory and clinical measures. All of these techniques, whether used in the clinic or in the laboratory, are very sensitive to instructional and setting variables; findings vary tremendously as a result.

Particularly common measures are pain threshold, pain tolerance, and pain intensity ratings. Pain threshold is the point at which the subject just begins to feel pain (Wolff, 1978). Pain tolerance is the level of pain at which the subject chooses to escape from or terminate pain. Both of these measures are generally used more often in laboratory research. In comparing threshold and tolerance, pain tolerance has been shown to be more reliable, frequently cited in the literature, and the most applicable to clinical problems (Wolff, 1978). Pain intensity measures are also popular in both clinical and laboratory research. Because of their common usage and clinical relevance, pain tolerance and intensity ratings will be the preferred measures to be reviewed in the following sections. Pain threshold measures are generally seen as less reliable and less useful as analogues to clinical situations (Chapman, 1983; Wolff, 1978). The literature using this technique, however, is far more extensive than that currently available for either pain tolerance and intensity measures. For this

reason, pain threshold studies will only be reviewed as they are seen to contribute information otherwise missing from the pain tolerance and intensity literature.

Laboratory Pain

Depression

Pain tolerance. Evidence is mixed, but emotional states in basic laboratory research may have effects on induced pain tolerance measures, like some emotional experiences have on clinical pain. Little research has directly addressed the effect of depression on laboratory pain tolerance. As a result of this deficit, the few studies cited here must be interpreted cautiously because they were not originally designed to address this question. In one study (Kopp & Gruzelier, 1989) that examined electrodermal activity in anxiety patients, higher levels of depression were found to be associated with lower electric shock pain thresholds. Along a similar line, Belanger, Melzack and Lauzon (1989) found that more depression was associated with lower perceived pain tolerance (i.e., subject's own report of pain tolerance) in women having voluntary abortions. Boureau, Luu, and Doubrere (1991), however, reported no significant correlations between pain tolerance or threshold measures and depression in a mixed chronic pain population or a healthy control group. Clearly, more research is needed in this area to directly address these questions.

Pain severity. More research has been completed concerning the effects of depression on self reported pain intensity ratings. In particular, preexisting depression was found to account for more of the variance in predicting reported pain intensity during first-trimester abortions than any other variable (Belanger et al., 1989). Doan and Wadden (1989) found that depressed chronic pain patients reported greater pain intensity than did non-depressed pain patients. They concluded that, "depression may well impair the patients' tolerance for, and ability to cope with continuous pain . . ." (Doan & Wadden, 1989, p. 82). Boureau et al. (1991) reported similar results in another mixed chronic pain population. Some theorists have suggested that depression is associated with maladaptive cognitive strategies like catastrophizing (e.g., Beck, Rush, Shaw, & Emery, 1979). Keefe, Brown, Wallston, and Caldwell (1989) found that a significant history of catastrophizing was associated with higher pain intensity ratings and greater disability. Similarly, in a sample of significantly depressed subjects with moderate anxiety, Ward et al. (1979) indicated that as patients' depression responded to anti-depressant medication, their reported pain severity decreased. These findings suggest a pattern of severity of depression being associated with higher pain intensity ratings.

Anxiety

Pain tolerance. Anxiety has been reported to have mixed effects on laboratory-induced pain. Many researchers have found that anxiety is associated with reduced pain tolerance (Chen, Dworkin, Haug, & Gehrig, 1989; Malow, West, & Sutker, 1987). Other studies, however, have suggested that anxiety either does not change pain tolerance (e.g., Cornwall & Donderi, 1988; Malow, 1981) or that anxiety increases pain tolerance (e.g., Carter, McNeil, & Reed, 1991). As a result of this lack of consensus, it is important to examine various aspects of this extensive literature in depth.

Types of anxiety. Some researchers have recommended that the type of anxiety is important in determining its effects on pain tolerance (Dougher, Goldstein, & Leight, 1987; Wiesenberg, Aviram, Wolf, & Raphaeli, 1984). These studies suggested that anxiety about pain decreases pain thresholds, whereas unrelated anxiety increases pain thresholds. These attempts at clarification of this aspect of the literature have unfortunately met with only limited success. In partial support of Wiesenberg et al. (1984), McNeil, Rainwater, and Aljazireh (1986), and Rainwater (1989) found that pain fearful subjects were both more apt to avoid experiencing pain and viewing video presentations depicting pain than controls. The Wiesenberg et al. hypothesis (1984), however, is not consistent with many of

the other studies previously cited (e.g., Carter et al., 1991b; Cornwall & Donderi, 1988; Malow et al., 1981, 1987).

Types of laboratory pain. Others have suggested that the type of pain stimulus used (i.e., tonic or phasic) is important in determining the effect anxiety has on induced pain. For example, Bobey and Danielson (1970) showed that anxiety did not change tolerance of tonic pain (i.e., pressure), but did decrease pain tolerance to phasic pain (i.e., radiant heat). These results are consistent with some of the findings cited above (e.g., Cornwall & Donderi, 1988; Malow et al., 1981, 1987), but not the Carter et al. (1991b) results.

Anxiety-like states. Some researchers have suggested that it is not emotions like anxiety per se which affect pain responding, but instead cognitive states (e.g., attention) that can, at times, resemble anxiety (Friedman, Thompson, & Rosen, 1985). This research group (Friedman et al., 1985) found that subjects in their perceived threat condition showed greater pain tolerance to cold pressor than the control group. Other cognitive states like excitement (Melzack & Casey, 1968), attention (Arntz, Dreessen, & Merckelbach, 1991), and distraction (Hodes, Howland, Lightfoot, & Cleeland, 1990; McCaul & Haugtvedt, 1982; McCaul & Malott, 1984) have also been found to reduce pain responding. More recently, however, several researchers have suggested that distraction and attention may not be as

effective in reducing the distress associated with pain as previously thought (Leventhal, 1992; McCaul, Monson, & Maki, 1992). The difficulty in evaluating emotion and cognition research is identifying which semantic labels (e.g., anxiety, perceived threat, distraction) are in fact similar or different from each other. Then, an equally important problem is determining which of these differences is pertinent to the particular research being planned.

Pain severity. Although the effects of anxiety on pain tolerance and pain threshold still are not obvious, the influences on pain intensity ratings are somewhat clearer. The way anxiety affects pain reports seems to differ based on the subject's pain sensitivity (i.e., pain tolerance) and type of anxiety. For example, Belanger et al. (1989), Chen et al., (1989), and Kopp and Gruzelier (1989) all found that higher anxiety measures were associated with higher pain sensitivity (i.e., lower pain tolerance) and higher pain intensity ratings. Al Absi and Rokke (1991) reported that subjects who were anxious about cold pressor pain reported more pain during a cold pressor task than subjects who were in low anxiety conditions and subjects who were anxious about shock pain. Schumacher and Velden (1984) found that anxiety increased reports of pain particularly at higher shock pain intensity levels. Most studies also found that pain reports increased in severity over the course of the

time an individual was exposed to pain (al Absi & Rokke, 1991; Boureau et al., 1991; Chen et al., 1989).

Positive Emotional States

Pain tolerance. Only a few articles have explored the effects of positive emotional states, like happiness or pleasure, on pain tolerance. The literature has, however, consistently shown that positive emotional states increased tolerance of laboratory-induced pain. Whipple and Komisaruk (1988) found that genital self-stimulation in women elevated pain thresholds, producing an analgesic effect that was distinct from a distraction process. Stevens, Heise, and Pfost (1989) also found that pleasure raised pain tolerance for pressure pain, as compared to anger. Their data suggested that it was the specific emotion experienced by the subject and not the intensity of that emotion that changed pain tolerance.

Pain severity. At this time, there are no known data on the effect of positive emotion on pain intensity ratings.

Sex and Gender Related Responses

Pain tolerance. Another important and sometimes controversial area in pain tolerance research has been sex and gender related responding[1]. In the past, there has been the popular belief that women have lower pain tolerances than men. In a short review by Otto and Dougher (1985), considerable evidence has accumulated to support this contention across many types of pain (e.g., electric shock,

focal pressure, and thermal stimulation). The pain threshold literature has been less conclusive (Otto & Dougher, 1985). Sex and gender associations in pain tolerance, however, in the more recent literature, are less conclusive. Several recent studies have found no differences in pain tolerance (Carter et al., 1991b; Jensen, Andersen, Olesen, & Lindblom, 1986; Ohrbach & Gale, 1989). Otto and Dougher (1985) found that higher pain tolerance was associated with higher levels of masculinity in male subjects only. No such relationship was found for female participants. They also reported, however, that sex or gender differences in pain tolerance still remained even after masculinity/femininity and social desirability were statistically controlled. Another study reported gender of the experimenter can influence pain tolerance performance. Levine and De Simone (1991) found that male subjects reported less pain in front of female experimenters than male experimenters. Female subjects tended to report higher pain in the presence of male experimenters. This latter finding, however, was not statistically significant (Levine & De Simone, 1991). Otto and Dougher (1985) did not find that sex of the experimenter affected pain tolerance in their study. They did suggest, however, that the variability in the sex-associated data could be due to personality factors in the different populations used. There are no known reports of sex or gender related

responding in clinical pain populations (Ohrbach & Gale, 1989). There are also no known studies which suggest that women have higher pain tolerances than men. It is clear that more studies, using contemporary methodologies, need to address the possible effects of sex and gender in research. New studies should, at least, consider the possible complexities sex and gender can bring to the interpretation of any findings.

Multiple Stressors

Most of the studies cited thus far have examined one emotion or stressor at a time. Another important area that has received little attention to date is the effect of multiple emotional states and stressors. Myrtek and Spital (1986) published a study using cold pressor, mental arithmetic, and physical exercise as stressors. They found that multiple stressor conditions produced synergistic effects on numerous physiological measures as compared to single stressor conditions. Ceiling effects were documented in the verbal reports of tension, suggesting that discomfort levels quickly rose to the highest point on the scale provided. Fernandez, Nygren, and Thorn (1991) have suggested that an "open-transformed scale" for verbal report ratings can be useful in preventing ceiling effects in phenomena that change in a continuous fashion (e.g., stress and pain). This type of scale measures changes without designating the absolute number of increments used by the

subject. Multiple emotional states have been documented as to their synergistic or "summation" effects as well as "subtraction" effects (Rachman & Lopatka, 1986). Examples of multiple emotional states that have begun to receive attention in the literature include: fear of sadness (Taylor & Rachman, 1991) and fear of fear (Taylor & Rachman, 1992). More studies need to address the issues of overlapping stressors and emotions because of the common occurrence of these sorts of events in vivo.

Multiple Emotional States

The variability in research techniques and populations studied have made generalizations based on the data presented difficult. Clear conclusions might be easier to draw if consistent methodologies were used more often. Along this line, only a few studies have examined the effects of multiple emotions on pain tolerance and pain intensity ratings using the same experimental paradigm. Zelman, Howland, Nichols, and Cleeland (1991) recently published an article which answers this need. In this project, subjects participated in an initial cold pressor pain task during which pain tolerance data were collected. The subject was also prompted every five seconds for ratings of pain intensity on a one to ten scale. Subjects were randomly assigned to one of three Velten (1968) emotion-induction conditions (i.e., depressive, neutral, and elative). Then, subjects participated in a final cold

pressor trial. Depression was found to be associated with decreased pain tolerance. The elation condition increased pain tolerance. No differences in pain intensity ratings were indicated.

The Zelman et al. (1991) article has several procedural advantages and disadvantages. The emotion induction procedure is a major advantage. It allows for the induction of several different emotional states using parallel methodology. During this mood induction technique, subjects read statements reflecting the content associated with specific emotions (e.g., "I'm discouraged and unhappy about myself"). This procedure avoids potential weaknesses associated with other emotion-induction techniques (e.g., video or music), because many more aspects of the stimulus materials can remain controlled (Zelman et al., 1991). For example, during the Velten emotion-induction procedure, it is clear to the subject what mood he or she is supposed to experience. With video or music presentations, the emotion that is being induced may not be obvious to the subject. As a result, the responses from subjects to the same horror movie vignette may range from fear, excitement, or even to sadness. A few of the areas that Velten emotion-induction procedures attempt to control for across conditions are: number of statements, amount of time each statement is presented, the length of the procedure, and number of high and low emotion-provoking statements. It is difficult to

control other types of emotion-induction procedures at this level. It still remains to be demonstrated that the areas that Velten conditions control for are, in fact, the important variables involved in emotion induction in humans. The results of this methodology were also reported to be robust even for subjects who did not expect their pain tolerance to change based on the emotion induction procedure (Zelman et al., 1991). This study also used a well established tonic pain induction procedure that is reliable (i.e., cold pressor). They used manipulation checks to verify the effectiveness of the emotion-inductions and attempted to control for ceiling effects in pain intensity ratings by allowing subjects to give ratings beyond their scale if they so chose.

The Zelman et al. (1991) study could be strengthened in a variety of ways. First, the article did not state whether the sex of the experimenter was considered. As noted earlier, several studies have suggested that subjects report pain differently when in the presence of a same or different sex experimenter (Bobey & Danielson, 1970; Levine & De Simone, 1991). Equal numbers of male and female subjects would be useful in examining the relation of sex and gender in pain responding, which has been shown to be an important topic in the literature (Clark & Yang, 1983). The addition of physiological measures would provide added data

concerning the effectiveness of the mood induction procedures.

Also, a better way of dealing with subjects who never escape from the pain task and thus have maximum pain tolerance scores needs to be found. The Zelman et al. (1991) study did not use subjects who had maximum pain tolerance times. This ceiling effect correction resulted in a reduction in the number of male subjects used. This adjustment to the subject data may make their sample less representative of the general population in pain responses.

The lack of differences between conditions in pain severity ratings may be due to the difficulty subjects have been found to experience with determining final rating values on closed scale rating systems (Fernandez et al., 1991). Rating systems with anchors at each end have been found to suffer from ceiling effects on the first trials in which subjects get to a rating of 10 before they have reached pain tolerance. Research has found that they often compensate for this inaccuracy on subsequent trials making comparison of the two trials at times inaccurate (Fernandez et al., 1991).

Goals of the Current Study

The goals of the present project were to evaluate the influences of emotion on the expression of pain. Based on the literature reviewed, the Zelman et al. (1991) paradigm was determined to have considerable merit to accomplish this

task. For this reason, the present study replicated the study by Zelman et al. (1991), extended that paradigm to explore anxiety in relation to pain, included physiological dependent measures, and added a variety of paradigm improvements based on the current state of the literature. Replication of previous research is important in verifying the usefulness of methodologies as well as confirming results. For this reason, it was important to keep the basic methodology similar to that in the Zelman et al. (1991) study, although some extension and improvement was in order. The Velten emotion induction procedure is a commonly used induction technique and was maintained in the present study, as much like the Zelman et al. (1991) study as possible. To avoid ceiling effects in pain tolerance measures, particularly with males, an algometer (pressure pain) was used with a weight sufficiently heavy to prevent frequent long pain tolerance times. Slightly lower demand instructions were used (i.e., instructing the subjects to stop when they "begin to feel uncomfortable") to help solve this problem. Unlike the Zelman et al. (1991) study, the present study replaced the data of subjects who did not escape from the pain tasks, thus keeping the sex ratio the same.

To try to avoid ceiling effects in pain severity ratings, an "open-transformed scale" developed by Fernandez et al. (1991) was used. This technique simply involves

asking the subject to indicate when she or he notices an increase in her or his pain. The experimenter notes the timing of these ratings, which are then algebraically transformed to produce scores of one to ten across certain time intervals. This rating method appears to be more natural for subjects and shows promising test-retest reliability (Fernandez et al., 1991).

As previously noted, additional research is needed to explore the effects of anxiety and depression on pain. Therefore, an anxiety condition was added to the Zelman et al. (1991) paradigm. The previously mentioned improvements of control for experimenter sex, equal number of male and female subjects, and a better solution for ceiling effects in pain tolerance, were incorporated into the present design.

Collecting data across various response modalities and many types of measures strengthens any conclusions ultimately drawn from those data. Lang (1968) suggested that three response systems should be measured: overt motoric behavior, verbal report, and physiology. The Zelman et al. (1991) study already includes verbal report (e.g., pain intensity ratings) and overt behavior (e.g., pain tolerance) measures. Physiological measures would, however, add an important dimension to this project.

Statement of Hypotheses

The current study hypothesized differences among emotion induction conditions in pain response. Specifically, laboratory-induced depression and anxiety were expected to increase reports of distress, pain intensity ratings, physiological responding, and decrease pain tolerance compared to the neutral and elation conditions. Elation was predicted to produce decreased distress reports, pain intensity ratings, physiological responding, and increased pain tolerance compared to the other three conditions. Sex and gender were expected to influence all measures. It was anticipated that men would report less distress, display less pain escape, and be less physiologically responsive than women.

Method

Subjects

Participants were 80 undergraduate students (40 males and 40 females) in psychology classes at Oklahoma State University. The average age of participants was 20.4 years (SD = 3.4) ranging from 18 to 39 years. Ethnic distribution of the subjects included 1 African American, 4 Asian Americans, 67 Caucasians, 1 Hispanic, and 7 Native Americans. All subjects received course extra credit points or a monetary payment of $5 for participation.

Subjects were recruited via experimenters giving oral presentations about the study to psychology classes that

were offering extra credit to research participants. Volunteers completed sign-up sheets following the presentation and were later contacted by telephone for individual appointment times.

A variety of criteria were used to determine which volunteers were eligible for participation. Much of this information was collected using a medical and social history interview. First, in accordance with university research guidelines, subjects were not allowed to participate if they were under the age of 18 or pregnant. Second, volunteers were not included who were actively in treatment for a psychological disorder. Third, subjects who reported significant depression or anxiety on standardized verbal report instruments during initial screening during participation were excluded. Fourth, subjects were excluded if health problems prevented safe application of focal pressure to the dominant hand (e.g., diabetes mellitus, history of hand fractures). Fifth, subjects' data were replaced if they indicated any medical problems that would compromise physiological recording of ECG or EMG data (e.g., cardiac irregularities). Sixth, participants' data were not included if they escaped the pain task in less than 10 s, because insufficient physiological data would be available for statistical calculations. Seventh, subjects who did not escape from either pain task were excluded due to their tendency to demonstrate a response set of nonavoidance

(Zelman et al., 1991). Eighth, subjects' data were replaced if an experimenter error or equipment malfunction compromised the data's integrity. Finally, volunteers' data were not used if either the subject or a member of the data collection team significantly deviated from the experimental protocol.

Based on these criteria, the data from 32 subjects were replaced. Of these subjects, 13 (10 males) did not escape either pain task, 8 scored above the depression or anxiety cut-offs, 1 escaped a pain task before 10 s had elapsed, and 1 was excluded due to noncompliance with procedural instructions. The remaining subjects (n = 9) had unusable data due to experimenter error or equipment malfunction.

Materials

An informed consent statement was used as an outline to discuss with subjects the purpose, costs, and benefits of the study. (See Appendix A for details.)

A short medical/social history interview was devised specifically for this study. (See Appendix B.) Information was obtained regarding demographic variables, previous pain history, and medical conditions which might prevent participation in the study. This interview was also used to collect information necessary for other research not reported in this document (e.g., Pain Stroop Test).

Self Report Instruments

The Beck Depression Inventory (BDI; Beck & Steer, 1987) is a 21 item questionnaire which measures the presence and severity of the affective, motivational, cognitive, and psychomotor aspects of depression. Each item is rated on a 4-point Likert-type scale (0 - 3) with a total score range of 0 - 63, with higher scores indicating more depression. In an extensive review article (Beck, Steer, & Garbin, 1988), the BDI test-retest reliability alpha coefficients ranged from .60 to .83 for nonpsychiatric populations. Concurrent validity alpha coefficient ranges between the BDI and other measures of depression (for nonpsychiatric populations) ranged from .55 to .86.

The trait version of the State-Trait Anxiety Inventory Form-Y (STAI; Speilberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) measures chronic anxiety. This questionnaire consists of 20 face valid items which the subject rates on a 4-point Likert-type scale (1 - 4). Scores range from 20 to 80, in which higher scores are indicative of more anxiety. According to Speilberger et al. (1983), the stability coefficients for the STAI-trait ranged from .65 to .86 across trials with retest intervals ranging in length from 1 hour to 104 days. Furthermore, correlations between the STAI-trait and other anxiety measures for student and patient populations ranged from .52 to .83.

The Emotion Assessment Scale (EAS; Carlson et al., 1989) is a 24 item questionnaire in which specific emotional states are rated along separate visual analogue scales (e.g., anxiety). This questionnaire provides subscale scores for eight emotions: Anger, Anxiety, Disgust, Fear, Guilt, Happiness, Sadness, and Surprise. To maintain the integrity of the questionnaire, the entire EAS was given to each subject during each trial of the study. Only the Anxiety, Fear, Happiness, and Sadness subscales, however, were used in analyses. The validity correlations (Carlson et al., 1989) between the EAS subscales and related questionnaires were as follows: Anxiety .78 (STAI-trait), Fear .55 (STAI-trait), Sadness .65 (BDI), Happiness -.36 (BDI) and -.38 (STAI-trait).

The Self-Assessment Manikin (SAM; see appendix to Hodes, Cook, & Lang, 1985; Lang, 1980) is a computer-controlled video character, displayed on a video monitor, which the subject manipulates using an input control device to give ratings in three dimensions: Valence (e.g., happy - sad), Arousal (e.g., aroused - calm), and Dominance (e.g., in control - controlled). These ratings were quantified on a 21 point (0 - 20) scale, with higher scores indicating positive valence, more arousal, or greater dominance.

Pain severity ratings were collected using an "open transformed" scaling procedure (Fernandez, 1990). Subjects put a tally mark on sheet of paper when they perceived pain

threshold and every "just noticeable" increase in their pain until tolerance was reached. Physiological recording software was modified to record the cumulative time of each key stroke made by the computer operator corresponding to the subject's rating marks during the pain task. The test-retest reliability coefficient for this procedure is .96 (Fernandez, 1990). (See Appendix D for full details.)

Pain and Emotion Induction

Laboratory-induced pain was created using a noninvasive device, the algometer. The algometer produces an "aching" pain resembling that found in clinical settings. It is also easy to use, reliable, and safe. A 750 g weight applied focal pressure to the second phalanx of one finger. The subject's hand fit into the device and was secured to prevent movement. A dull Lucite edge was then lowered onto the finger and the weight was applied, causing pressure and then pain. The device used was based on a model introduced by Forgione and Barber (1971), and modified by Rainwater and McNeil (1991).

Laboratory-induced emotion was produced using a Velten-style emotion-induction technique (Velten, 1968). A group of 50 ranked statements was used for each of the four emotion conditions: anxiety, depression, elation, and neutral. (See Appendix C.) Each statement was shown for 15 s, in order from least to most emotion-provoking, on a Panasonic 20 in (51 cm) video monitor. The subject was

instructed to "read each statement, think about it carefully, and try to experience the emotion suggested by the statement" (Zelman et al., 1991). The anxiety induction was successfully used in previous research (Orton, Beiman, LaPointe, & Lankford, 1983) and was designed to elicit feelings of anticipation of danger or unpleasantness, and castastrophizing. The depression, neutral, and elation inductions were previously used in Zelman et al. (1991). The depressive statements suggested sadness and pessimism. The elation induction was intended to produce feelings of self-efficacy and optimism, whereas the possible effects of reading statements was assessed by use of the neutral statements.

A shortened version of the elation statements (i.e., every odd numbered statement) was viewed at the end of the study by subjects assigned to the anxiety and depression conditions. A similar short positive emotion induction was found effective in countering the aftereffects of negative emotion-induction conditions (Frost & Green, 1982).

Laboratory and Apparatus

The study was conducted in a three room laboratory. A conference room was equipped with a large table and chairs and was used for debriefing. A control/equipment room contained an IBM PC/XT microcomputer equipped with a Scientific Solutions Labmaster interface board and specialized software (Cook, Atkinson, & Lang, 1987). This

equipment was used to time the procedures, to control a Coulbourn Instruments (CI) Precision Signal Generator (F81-06), a CI Audio Mixer-Amplifier (S82-24), a CI Selectable Envelope Shaped Raise/Fall Gate (S84-04), and to collect the electrocardiogram (ECG), electromyogram (EMG) and SAM data. Medi-Trace Ag-AgCL pre-gelled disposable foam electrodes (#GC-11) were attached to the subject's skin surface to the right (negative) and left (ground) of the sternum just below the clavicle and on the left side of the chest at the last palpable rib (positive) to collect ECG data. A CI System Power Supply was connected to a High Gain Bioamplifier/ Coupler (S75-01), a Schmitt trigger device (CI Bipolar Comparator [S21-06] and CI Retriggerable One Shot [S52-12]) which were used to filter, amplify and digitize the ECG signal. The computer recorded the time interval between cardiac R-waves.

Two channels of analog EMG data were recorded; they measured tension in the corrugator supercilii (i.e., "knits" the eye brows) and the trapezius (i.e., shoulder) muscles. For the corrugator data, two 4 mm Beckman electrodes fixed with adhesive collars (Sensor Medics #650454) and filled with electrode electrolyte gel (TECA #822-201210) were used to collect data. One was placed "directly above the brow on an imaginary vertical line that traverses the endocanthion (inner commissure of the eye fissure). The second electrode is positioned 1 cm lateral to, and slightly superior to, the

first on the border of the brow" (Fridlund & Cacioppo, 1986; p. 571). One Bio-Medical Instruments (BMI) 8 mm disposable electrode (#DS-02) was also filled with gel and placed near the hair line on the nondominant hand side of the forehead as a ground. The trapezius recordings were made by using three of the 8 mm BMI disposable electrodes. These were filled with gel and affixed in a row on the nondominant hand side of the spinal column at the approximate level of the first thoracic vertebra. One electrode was medial to the spine, another was lateral to the first electrode and medial to the spine of the scapula. The grounding electrode was placed between the other two.

CI Bioamplifiers (S75-01) recorded EMG data falling between the cutoff values of 90 and 1000 Hz. Initial EMG signals were processed by CI Contour-Following Integrators (S76-01) set at a 0.1 s time constant with a sampling rate of 10 Hz. Electrode impedance was kept below 10 kiloohms as measured by a Grass Instruments Electrode Impedance Meter (#EZM5). For consistency in EMG research, the guidelines provided by the Society for Psychophysiological Research (Fridlund & Cacioppo, 1986) were followed.

In the sound-attenuated subject room, a video monitor was used to present the emotion-induction statements and SAM. A Realistic cassette recorder was used to play audiotaped procedure instructions. The room also contained

a table, a large recliner, and two desk chairs. Rooms were linked via a one way mirror and an intercom system.

Procedure

Teams of two experimenters conducted the study. One experimenter operated the computer from within the control/equipment room. The other experimenter was with the subject instructing and assisting him or her with procedures. Sex of the experimenter in direct contact with the participants was counterbalanced across subject sex and conditions. Unfortunately, a systematic error resulted in slightly unequal cell sizes for this three way interaction (i.e., $n = 4$ and $n = 6$ rather than two cells with $n = 5$). All other factor combinations were properly balanced. (See Appendixes E and F for a procedure summary flow chart and complete variable list.)

Instructions and Initial Assessment

Upon arrival at the laboratory, the subject was nonsystematically assigned to an emotion-induction condition, escorted to the subject room, and seated in the recliner. The subject was introduced to the study and an informed consent statement was discussed and signed. The medical/social history interview was completed. Heart rate and muscle tension monitoring equipment was then attached. The subject completed a standard battery of questionnaires including the BDI and STAI. The subject was also instructed in the use of the SAM and EAS rating systems.

For the protection of participants, the BDI and STAI were used to determine if subjects were suitable to experience the emotion induction procedure which might aggravate preexisting psychological difficulties. For this reason, the BDI and STAI were completed first by the subject and scored immediately. The experiment was aborted if subjects' BDI scores were over 19, suggesting possible moderate to severe depression (Beck, 1978). The cutoff scores for the STAI were set at the 95th percentile (i.e., raw scores of 54 for men and 59 for women), suggesting significantly more anxiety than average. If the subject had a STAI score higher than the cutoff score, then the experiment was aborted.

Preinduction Baseline

The subject was instructed, via audiotape presentation, to relax with eyes closed for 5 min while baseline heart rate and muscle tension data were collected. For this procedure, the room lights were dimmed and the experimenter left the room. At the end of the baseline period, a 1 s 1000 Hz tone sounded and the subject was instructed to give affective ratings (i.e., SAM and EAS) based on how she or he felt at the end of the rest period.

Pain Task 1

The experimenter reentered the room, turned up the lights, seated the subject in one of the desk chairs behind a table, and presented audiotaped pain task instructions.

These instructions included assurances that the pain device would cause no physical damage; they were patterned after the "low demand" instructions developed by Miller and Bernstein (1972). The subject were instructed to say "stop" when she or he felt fairly uncomfortable, and that this verbalization would indicate that the experimenter should discontinue the task. The index finger of the subject's nondominant hand was placed in the algometer. The task was timed from the onset of the pain task until the subject "stopped" the task, or until a 5 min time limit was reached. Pain tolerance time was recorded as the amount of time the subject chose to remain in the pain task.

From the start of the pain task until the subject "stopped" the procedure, the subject put a tally mark on a piece of paper with a pencil when she or he "first noticed pain and at every noticeable increase in her or his pain after that." The computer operator, seated behind the one way mirror, pressed a key on the computer every time the subject made a mark.

Following discontinuation or the end of the time limit, a 1 s 1000 Hz tone sounded and the subject was instructed to give SAM and EAS ratings based on how she or he felt at the point just before stopping the pain task, or at the point just before the tone sounded. Heart rate and muscle tension data were collected continually during the pain task.

Emotion Induction

The subject was then exposed to one of four emotion induction conditions, (i.e., anxiety, depression, elation, or neutral). The subject received audiotaped condition specific instructions that asked him or her to "read each statement, think about it carefully, and try to experience the emotion suggested by the statement" (Zelman et al., 1991). In these instructions, the emotion to be experienced was specifically named four times. After the instructions, the experimenter left the room. Each of 50 statements was shown for 15 s on the video screen. Following the completion of this procedure, the subject was instructed to give SAM and EAS ratings based on how she or he felt at the end of the emotion induction.

Pain Task 2

The experimenter reentered the room and the pain task was repeated. The instructions and procedures were the same as those used for the first pain task, with the addition of instructions for the subject to continue feeling the way suggested by the emotion induction Velten statements. The middle finger of the subject's nondominant hand was placed in the algometer. Pain intensity ratings were also recorded as before. Following discontinuation or the end of the 5 min time limit, a 1 s 1000 Hz tone sounded and the subject was instructed to give SAM and EAS ratings based on how she or he felt at the point just before stopping the pain task,

or at the point just before the tone sounded. Heart rate and muscle tension data were collected continually throughout this pain task.

Postinduction Baseline

The subject was seated again in the recliner and instructed, via audiotape, to relax with eyes closed while ECG and EMG data were collected. The experimenter left the room after dimming the lights. At the end of the 5 min period, a 1 s 1000 Hz tone sounded and the subject was instructed to give affective ratings (i.e., SAM and EAS) based on how she or he felt at the end of the rest period.

Short Positive Emotion Induction

The experimenter reentered the room and detached the ECG and EMG electrodes. A short (i.e., 6 minute) positive mood induction was then completed by the anxiety and depression condition participants. The audiotaped instructions informed the subject that the pain tasks were now over and encouraged the subject to read the statements listed on the video screen to assist in overcoming any negative after effects of the previous procedures.

Debriefing

After all procedures were completed, the subject was then escorted to the conference room and seated at the table. The subject was interviewed about his or her experiences in the study using a structured format. The interview included questions regarding the subject's

feelings, reactions to the experiment, and an explanation of the expected results of the study.

Additional Procedures

All subjects also completed a number of additional tasks that were not related to this research project. Subjects performed Stroop color naming tests using pain-related and neutral control words similar to others used in recent research (Carter et al., 1991a; Lunsford, Boone, Carter, Carter, & McNeil, 1991) based on original work by Stroop (1935). They also completed a color vision screening to test for color blindness, the McGill Pain Questionnaire (MPQ; Melzack, 1975), and the Attributional Style Questionnaire (ASQ; Peterson et al., 1982). The data obtained from these procedures were not reported as part of this dissertation. (For details about the placement of these extra tasks in the procedure, see Appendix E.)

Results

Data Reduction

Heart Rate

For each period within the experiment (i.e., prebaseline, pain task 1, pain task 2, postbaseline), a computer program (Cook et al., 1987) calculated medians for heart rate, in beats per minute, in 10 s segments. Consistent with previous research (Carter, 1990; Carter, McNeil, Ries, & Turk, 1993), cardiac activity was assessed at the time the pain task was stopped and just prior to

discontinuation. Heart rate scores for the pain periods were developed by deriving means, in beats per minute, from two values: the median of the 10 s interval in which escape occurred and the median of the 10 s interval just preceding that one. If the subject did not escape from the task, then the mean was calculated using the medians from the two final 10 s intervals during the pain task. Separate means for the pre and postbaseline rest periods were developed by using medians for the two final 10 s intervals in each respective 5 min baseline period.

Muscle Tension

To produce comparable information, data reduction procedures for EMG are similar to those outlined for heart rate. Medians were calculated, in microvolts, for 10 s segments for each period within the experiment. Then, means were computed using the median EMG values for the two 10 s periods at the end of the two baselines and around the time of escape for the two pain tasks. Values for each EMG channel were calculated separately.

Pain Severity Ratings

The rating system recommended by Fernandez et al. (1991) produced cumulative times starting at pain threshold and continuing in a naturalistic fashion until pain tolerance was reached. These cumulative times were transformed into pain ratings using an algorithm which was developed from interpolation formulas. (See Appendix D for

details.) This process produced values that estimated each subject's pain ratings on a zero to ten scale, as if ratings had been given every 15 s. On this scale, zero was assumed to equal no pain, one was equivalent to pain threshold, and ten was assumed to be the subject's "quit point" or pain tolerance.

For comparison with other research, these converted ratings were used to calculate change scores (pain trial 2 - pain trial 1). Because of the need to allow escape from the pain task as an overt behavioral measure of pain tolerance, the number of pain ratings decreased considerably over time. This design choice necessarily reduced statistical power for the pain severity rating variable. The number of ratings collected decreased over time (maximum time = 300 s) in the following manner: 15 s (N = 77), 30 s (N = 60), 45 s (N = 41), 60 s (N = 31), 75 s (N = 17), 90 s (N = 13), 105 s (N = 8), 120 s (N = 3), 135 s (N = 3), and 150 s (N = 1).

Design and Statistical Approach

Analyses followed a basic design of 4 (emotion induction condition: anxiety, depression, elation, neutral) x 2 (subject sex) x 2 (experimenter sex) for the between subject factors. Trial was added as a within subject factor. The number of trials analysed differed depending on the dependent variable and the type of analysis utilized. For the overt behavior dimension, pain tolerance time was the only dependent variable. For this measure, two trials

were analysed (pain task 1 and 2). All three dependent variables used in the physiological dimension (heart rate, corrugator and trapezius muscle tension) included four trials each (preinduction baseline, pain task 1, pain task 2, and postinduction baseline). Finally, for the verbal report dimension, five trials were analyzed (preinduction baseline, pain task 1, emotion induction, pain task 2, and postinduction baseline). Separate repeated measures analyses of variance (ANOVA's) were used to test each dependent variable within each system of data (i.e., overt behavior, verbal report, and physiology) across trials. Appendix G lists all F values and related statistics for each of these sets of analyses. For significant ANOVA's, Tukey's method of testing Honestly Significant Differences (HSD; $\alpha = .05$) was used for follow-up analyses.

For the dependent variables of overt behavior (i.e., pain tolerance time) and heart rate, special additional analyses were performed. These analyses are detailed in subsequent sections.

Statistical Analyses

Baseline Physiological Values

To test for possible baseline differences among conditions, separate one way (across the four emotion induction conditions) ANOVA's were completed separately for ECG and both EMG channels. No significant differences were found among conditions on any of the dependent variables

tested for the initial baseline period, all F's < 1.41, all p's > .10. Similarly, no differences were detected for any dependent variable for the first pain task, all F's < 1.49, all p's > .10. Furthermore, no differences were found for the post baseline, all F's < 0.75, all p's > .10.

Initial Questionnaire Values

No differences were noted among conditions in preexisting depression and trait anxiety. BDI results among conditions were as follows: Anxiety (M = 6.1, SD = 4.7), Depression (M = 4.2, SD = 4.4), Elation (M = 4.6, SD = 3.8), and Neutral (M = 4.7, SD = 4.7), $F(3,79) = .53$, $p > .10$. For the STAI-trait, results were as follows: Anxiety (M = 34.4, SD = 7.2), Depression (M = 34.1, SD = 7.1), Elation (M = 38.8, SD = 6.8), and Neutral (M = 34.7, SD = 12.0), $F(3,79) = 1.26$, $p > .10$.

Three Systems

To evaluate the degree of correlation among the three systems of data (i.e., verbal report, physiology, and overt behavior) during pain exposure, change scores were calculated for each dependent variable (pain task 2 - pain task 1). Separate Pearson Product-Moment correlation coefficients were then computed among each of these change scores. As enumerated in Table 1, correlations between verbal report measures (EAS and SAM) and physiology (ECG and the two EMG channels) ranged from -.23 to .30. Verbal report and overt behavior (pain tolerance time)

intercorrelations ranged from -.18 to .14. Correlations among physiological measures and overt behavior ranged from -.13 to .22. Correlations of $r(78) = +/- .22$ or greater are significant at or beyond $p < .05$. Given the large number of comparisons, however, the chance of Type I error is increased. Any significant correlations should be viewed with caution.

Insert Table 1 about here

Overt Behavior

The 4 x 2 x 2 x 2 (condition by subject sex by experimenter sex by trial) ANOVA calculated on pain tolerance time found only a subject sex main effect, $F(1,64) = 7.95$, $p < .01$. Males ($M = 88.3$, $SD = 52.3$) had greater pain tolerance than females ($M = 56.6$, $SD = 52.7$). The nonparametric Lilliefors Test for Normality (Conover, 1980) showed that the data for pain tolerance were not normally distributed, thus making it more difficult to show existing data patterns using parametric analyses, $T = .12$, $p < .01$. The Zelman et al. study (1991) also had similar difficulties with their pain tolerance data. To adjust for this problem, they transformed the pain tolerance data into ranks and calculated a nonparametric ANOVA on the ranks (i.e., Kruskal-Wallis test). To maintain comparability between this study and the Zelman et al. study (1991), a 4 x 2 x 2 x

2 (condition by subject sex by experimenter sex by trial) Kruskal-Wallis test was completed on these ranked data as well. These calculations revealed subject sex, H (1) = 13.64, $p < .0005$, and experimenter sex, H (1) = 4.19, $p < .05$ main effects, as well as a condition by trials interaction, H (3) = 2.84, $p < .05$. No other interactions were significant. The Kruskal-Wallis multiple comparison procedure at the .05 level was used as a follow-up for the interaction. As illustrated in Figure 1, pain tolerance in the depression condition decreased significantly following the emotion induction. Furthermore, pain tolerance for the depression condition was significantly lower in the second trial than that for the neutral or anxiety condition. The elation condition group had lower pain tolerance in the first trial than any other group. No other differences were found. The main effects revealed that women escaped the pain task more than men; there was more escape for male experimenters than for females. For the purposes of comparison, Table 2 lists the original unconverted pain tolerance means and standard deviations for the condition by trials interaction.

Insert Figure 1 and Table 2 about here

Physiology

Heart rate. The 4 x 2 x 2 x 4 (condition by subject sex by experimenter sex by trial) ANOVA calculated on the cardiac data found a significant subject sex main effect, $F(1,64) = 8.58$, $p < .005$. Men were found to have lower heart rates ($M = 69.2$, $SD = 9.7$) than women ($M = 74.6$, $SD = 8.4$). This 4 x 2 x 2 x 4 ANOVA also revealed a trials main effect, $F(3,192) = 34.35$, $p < .0001$, showing that the heart rate in the post baseline was significantly lower than that in the initial baseline.

Consequently, post baseline heart rate was used as a covariate in an additional covariance analysis that focused on the two pain tasks. Use of the post baseline as a covariate is supported by previous research (Collins, Carlson, & Jones, 1989). A 4 (condition) x 2 (subject sex) x 2 (experimenter sex) x 2 (trial: pain task 1 vs. pain task 2) ANCOVA revealed a significant trials main effect, $F(1,64) = 8.08$, $p < .01$, and a trend for a condition by trials by subject sex interaction, $F(1,64) = 3.40$, $p < .10$. The trials main effect results showed that when collapsed across conditions, heart rate was higher during the first pain task ($M = 74.3$) than the second ($M = 72.8$). As illustrated in Figure 2, and tested with Tukey's HSD at the .05 level, in the condition by trials by subject sex trend, during the second pain task, men in the depression condition had lower

heart rates than similarly assigned women. No other differences were noted for this ANCOVA.

Insert Figure 2 about here

Corrugator EMG. The ANOVA (4 x 2 x 2 x 4; condition by subject sex by experimenter sex by trial) for the Corrugator Supercilii EMG revealed a significant experimenter sex by trial interaction, $F(3,192) = 2.81$, $p < .05$, and a near significant condition by trial interaction, $F(9,192) = 1.74$, $p < .10$. No other interactions or main effects were significant. The experimenter sex by trial interaction was followed up with Tukey's HSD tests at the .05 level. For the experimenter sex by trial interaction, Figure 3 shows that Corrugator EMG activity dropped significantly from the first baseline to the first and second pain tasks only for subjects paired with female experimenters. Corrugator EMG activity during the final baseline was higher for those paired with female experimenters than those with male experimenters. There were no other significant differences. To follow-up the condition by trial trend, Tukey's HSD tests at the .05 level were conducted. As illustrated in Figure 4, the depression condition subjects showed a reduction in Corrugator Supercilii EMG activity from the first baseline to the two pain tasks. There were no differences between conditions on any particular trial.

Insert Figures 3 and 4 about here

Trapezius EMG. For the trapezius EMG data, a 4 x 2 x 2 x 4 (condition by subject sex by experimenter sex by trial) ANOVA showed a trial main effect only, $F(3,192) = 21.48$, $p < .0001$. This trial effect was followed up with Tukey's HSD tests at the .05 level. As illustrated in Figure 5, trapezius EMG values increased significantly from the first baseline to the two pain tasks, then decreased during the final baseline. No other differences were found.

Insert Figure 5 about here

Verbal Report

SAM. The 4 x 2 x 2 x 5 (condition by subject sex by experimenter sex by trial) ANOVA for SAM ratings showed significant condition by trial interactions for all three SAM dimensions: Valence $F(12,256) = 10.95$, $p < 0.0001$, Arousal $F(12,256) = 6.19$, $p < 0.0001$, and Dominance $F(12,256) = 2.44$, $p < 0.01$. There were no other significant interactions or main effects. Significant ANOVA's were followed up with Tukey's HSD tests.

For the Valence dimension, Figure 6 illustrates that subjects in the anxiety and depression conditions reported significant decreases in pleasure following the emotion

induction and the second pain task compared to both baselines. Participants in all conditions showed reductions in pleasure from baseline during the pain tasks. After the emotion induction, elation condition subjects reported more pleasure than subjects in any other condition. Neutral condition participants reported less pleasure than those in the elation condition following the emotion induction, but more than those in the depression condition. During the second pain task, only the difference between the elation condition and the depression condition participants was

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Insert Figure 6 about here

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maintained. There were no differences between conditions for Valence during other trials.

As illustrated in Figure 7, Arousal for all conditions increased from the first baseline during the pain tasks and decreased again during the second baseline. Subjects in the anxiety and elation conditions also indicated more Arousal during the emotion induction than they reported during

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Insert Figure 7 about here

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either baseline. After the emotion induction, subjects in the anxiety condition reported more Arousal than those in the depression or neutral conditions. Elation condition

participants showed more Arousal than depression condition subjects. The anxiety condition also prompted reports of more Arousal than the depression condition during the second pain task. No other differences between conditions were noted for Arousal on any trials.

For the Dominance dimension, Figure 8 reveals that subjects in the depression and anxiety conditions indicated significantly reduced feelings of Dominance following the emotion induction than those in either the elation or neutral conditions. No other significant differences among conditions or trials were found for Dominance.

Insert Figure 8 about here

EAS. The 4 x 2 x 2 x 5 (condition by subject sex by experimenter sex by trial) ANOVA on the Anxiety, Fear, Happiness, and Sadness subscales found a variety of interactions. Significant effects were followed up with Tukey's HSD tests at the .05 level.

Figure 9 illustrates the condition by subject sex by trial interaction involving the Anxiety subscale, $F(12,256) = 2.17$, $p < .05$. Women in the anxiety condition reported more Anxiety following the emotion induction than women in the depression condition and subjects of both sexes in the elation and neutral conditions. Only the anxiety condition women reported significant increases in anxiety from either

baseline. No other differences were found among conditions or trials.

Insert Figure 9 about here

A significant condition by subject sex by trials interaction was also found for the Fear subscale, $F(12,256) = 2.33$, $p < .01$. As shown in Figure 10, it follows a similar pattern as found for Anxiety. Specifically, women in the anxiety condition reported significantly more Fear following the emotion induction than participants in any other condition. There is also a significant increase from their reported baseline Fear levels.

Insert Figure 10 about here

The repeated measures ANOVA (4 x 2 x 2 x 5; condition by subject sex by experimenter sex by trial) also revealed another interaction involving the EAS Fear subscale, subject sex by experimenter sex by trial, $F(4,256) = 2.44$, $p < .05$. There was also a trend for the condition by experimenter sex by trial interaction, $F(12,256) = 1.68$, $p < .10$. Tukey's HSD tests at the .05 level were used as follow-up analyses. For the subject sex by experimenter sex by trial interaction, Figure 11 shows that women reported significantly more Fear to female experimenters than to male

experimenters, particularly following the first pain task and the emotion induction. There were also significant decreases in reported Fear in female subjects from the first pain task and the emotion induction to the second baseline.

Insert Figure 11 about here

The trend in the condition by experimenter sex by trial interaction shows a slightly different pattern of results. As illustrated in Figure 12 (and tested with Tukey's HSD tests at the .05 level), participants in the anxiety condition tended to report more fear to female experimenters than did subjects in the elation and neutral conditions after the emotion induction. This pattern of fear reporting in the anxiety condition subjects significantly increased from the first baseline and the pain task to its highest rate after the emotion induction, then droped significantly again following the second baseline.

Insert Figure 12 about here

This ANOVA (4 x 2 x 2 x 5; condition by subject sex by experimenter sex by trial) also demonstrated condition by trial and subject sex by trial interactions for the Happiness subscale of the EAS, $\underline{F}(12,256) = 10.13$, $\underline{p} < .0001$ and $\underline{F}(4,256) = 5.61$, $\underline{p} < .0005$, respectively. As revealed

in Figure 13, in the condition by trial interaction, subjects in all conditions showed significant drops in reported Happiness from the first baseline to the first pain task. Reports of Happiness remained low following the emotion induction for all conditions except the elation condition. Elation condition subjects reported significant increases in feelings of Happiness after the emotion induction compared to the first and second pain tasks. For the depression condition, reports of Happiness increased significantly following the final baseline. The subject sex by trial interaction, as shown in Figure 14, indicated that men reported more happiness at baseline than women. All subjects showed less happiness during the pain tasks than at baselines.

Insert Figure 13 and 14 about here

For the Sadness subscale, a significant condition by subject sex by trial interaction was found, $F(12,256) = 1.94$, $p < .05$. Figure 15 reveals that subjects of both sexes in the depression condition, and women in the anxiety condition, reported more Sadness following the emotion induction than participants in other conditions. Specifically, men in the depression condition reported more sadness than subjects in any other condition. These men also expressed significantly more Sadness following the

emotion induction than they reported following either baseline or pain tasks. Women in the depression and anxiety conditions reported more Sadness after the emotion induction than subjects in the other two conditions. These women showed significant increases in Sadness following the emotion induction as compared to either baseline. No other differences in the Sadness subscale were found.

Insert Figure 15 about here

Pain severity ratings. Separate 4 x 2 x 2 (condition by subject sex by experimenter sex) ANOVA's were used to analyze change in pain severity ratings across time intervals. For this calculation, pain severity ratings from the first pain task were subtracted from the ratings for the second pain task for every 15 s interval that the subject remained in the task (i.e., second pain task ratings minus first pain task ratings). This method was used to be consistent with Zelman et al. (1991). These ANOVA's revealed significant condition main effects for the first two 15 s periods of pain severity change scores. Pain severity rating F values for the 15 second mark (n = 77) and 30 second mark (n = 60) were, $F(3,61) = 4.20$, $p < .01$ and $F(3,44) = 3.49$, $p < .05$, respectively. A near significant subject sex main effect was also revealed for the first 15 second mark only, $F(3,61) = 3.08$, $p < .10$. ANOVA's for

later time intervals in the pain task (e.g., 45 s (n = 41) and 60 s (n = 31)) showed no significant main effects or interactions. Significant ANOVA's were followed up with Tukey's HSD tests.

As illustrated in Figure 16, for the first 30 s of the pain task, depression condition participants reported more change in pain severity ratings compared to subjects in the neutral condition. That is, depression condition subjects reported more pain during the second pain task (i.e., after the emotion induction) than subjects in the neutral condition. After the number of subjects remaining in the pain task dropped below 75%, this pattern was no longer present. Furthermore, when data were collapsed across conditions, during the first 15 s of the pain task, male subjects (n = 39) tended to report negative change (M = -0.3, SD = 1.3) in pain severity ratings while females (n = 38) documented positive change (M = 0.5, SD = 1.7). This finding suggests that men reported that the second pain task hurt less than the first pain task. Women, on the other hand, indicated that the second pain task hurt more.

Insert Figure 16 about here

Discussion

Effects of Emotion on Pain

Depression

As predicted, this study showed that depression influenced pain response by reducing pain tolerance and increasing pain complaints (i.e., severity ratings). The pain tolerance findings are consistent with those of the Zelman et al. (1991) study. The pain severity rating results were predicted by both the present study and the Zelman group, but only demonstrated in the present study's data. This latter finding has been observed in clinical settings (Belanger et al., 1989; Doan & Wadden, 1989; Keefe et al., 1989; Ward et al., 1979), but has not been well demonstrated in laboratory research. No study other than Zelman et al. (1991) has directly examined the effect of laboratory induced depression on pain tolerance and severity ratings. It is possible that the lack of pain rating results by Zelman et al. (1991) were compromised by methodological issues.

In light of the paucity of comparable laboratory based pain research on the affects of depression, clinical implications of the present study can be forwarded with caution. The depression findings are consistent with clinical observations that depression and pain are often associated in complex ways (Monks, 1990; Romano & Turner, 1985; Turk & Holzman, 1986). Depression appears to have

decreased pain tolerance. Furthermore, this relationship has been shown to be robust across many types of populations (Romano & Turner, 1985) and was seen in this study in a nonsystematically assigned sample. For this reason, its effects seem quite broad based and general and not specific only to patients with a "pain-prone" personality as hypothesized by Blumer and Heilbronn (1982).

Anxiety

Anxiety appeared to reduce pain tolerance, but not to statistically significant levels. Anxiety did not appear to influence pain severity ratings. This study was unable to provide findings strong enough to clarify the mixture of results found in the experimental and clinical anxiety and pain literatures. The general direction of the effect of anxiety on pain (i.e., to reduce pain tolerance) was consistent with that observed in clinical settings (Barlow, 1988; Beecher, 1959; Hendler, 1982; Klepac, 1975) and some of the experimental literature (Chen et al., 1989; Malow et al., 1987).

Several tentative hypotheses may provide possible explains as to the lack of anxiety condition findings. Methodological issues related to the anxiety emotion induction and related instructions may be implicated. Gender effects were more prominent in the reporting of Anxiety and Fear than in other EAS subscales, suggesting that the anxiety emotion induction may be more effective for

one gender (i.e., females) than another. Furthermore, the quiet Velten-style of induction may be more effective for the induction of depression than anxiety. The low demand instructions, allowing easy escape from pain, may have also contributed to increasing the subject's sense of control during the study and reducing feelings of anxiety. These methodological issues are discussed in more detail in later sections.

In addition to these methodological issues, it is also possible that the effects of anxiety and depression on pain are not parallel processes and therefore the effects of anxiety may not have been effectively evaluated using this paradigm. More anxiety and cardiac arousal were recorded during early trials of the study rather than in later ones, suggesting that anxiety may have played more of an anticipatory mediating role compared to depression. The experimental design used did not test for the effects of possible mediating emotional states, like anticipatory anxiety. Although these hypotheses are very tentative, they would be consistent with preliminary clinical data (Carter et al., 1994) that indicate anxiety and depression have different, but related functions in the development and maintenance of chronic pain problems.

Elation

The lack of elation condition findings for pain tolerance were unusual compared to the other published

studies. Whipple and Komisaruk (1988) and Stevens et al. (1989) both reported that pain tolerance increased during episodes of happiness. The Zelman et al. (1991) results supported this relationship as well.

Although it is difficult to definitively explain why the results of the present study do not coincide with that of other research, there is evidence for increased anxiety in the elation condition, possibly interfering with the efficacy of the positive emotion induction procedure. During the baseline pain trial, the elation condition participants demonstrated significantly less pain tolerance than any other group. This group, particularly the females, reported more fear and anxiety (i.e., on EAS subscales) during the first baseline and in response to this first pain trial than subjects in any other condition. Furthermore, they showed slightly more trait anxiety than participants in other conditions, but not at a statistically significant level. Based on the experimental hypothesis that anxiety reduces pain tolerance, this group responded in the predicted direction.

Although nonsystematic subject assignment is designed to evenly distribute idiosyncratic variability in a sample across all conditions, occasional irregularity does occur. It appears that an overrepresentation of anxious subjects may have been unintentionally present in the elation condition, resulting in the unusually low baseline pain

tolerance values. This higher anxiety group appears to have responded to the elation emotion induction differently than subjects from other studies. This possibility would make the response of the elation group to the emotion induction stimuli not representative of a normally distributed subject population and less generalizable to other research.

No previous research other than the Zelman et al. (1991) study has examined the effect of elation on pain severity ratings. Both that study and the present one found that elation did not affect pain severity ratings. Based, however, on the paucity of research in this area, additional studies are needed to clarify this issue.

Relationship of Sex and Gender to Pain

As predicted, sex and gender were found to strongly affect pain. These influences, however, were more complex than expected. Statistical differences associated with sex and gender were noted in every system of data. Men and women responded differently across the variables of verbal report of pain and emotions, escape from pain, and physiology.

As predicted, men persisted longer on the pain tasks and reported less pain than women. These pain tolerance findings are consistent with other research (Otto & Dougher, 1985). The pain severity rating findings seem logical given the pain tolerance results. Unexpectedly, subjects demonstrated longer pain tolerance for female experimenters

than for males. The experimenter gender results are similar to the conclusions of some other research (e.g., Levine & De Simone, 1991) and inconsistent with others (e.g., Otto & Dougher, 1985). Interestingly, none of these influences appeared to interact with the emotion manipulations or to change across trials. The strength of these findings is impressive.

Although it is difficult to definitely know why gender influences pain tolerance, there are a number of hypotheses that can be suggested. Differential socialization of men and women may be a factor. Social desirability and masculinity have both been shown to be associated with differences in pain tolerance (Levine & De Simone, 1991). Artifacts of the experiment itself, including experimenter gender, have been shown to influence pain (Levine & De Simone, 1991). It is also possible that biology is involved, specifically subject size. Pressure pain, like many other pain sources, assumes that one level of pressure is equal for all subjects, no matter how small or large their hands. No known research has examined the appropriateness of this assumption.

Effect of Sex, Gender and Emotion on Pain

Gender and sex were also noted to complicate the effects of depression and anxiety in cardiac and verbal report variables, making the results mixed. Negative emotional states of depression and anxiety were predicted to

produce increased physiological responding, with men being less responsive than women. Differential cardiac responding was present during the second pain task: Heart rate for depression condition men decreased compared to women. No differences were noted for the anxiety condition.

This finding is uncommon in the literature, but appears to be consistent with the verbal report data. Men in the depression condition reported significantly more sadness during the emotion induction and the second pain task than women. Velten-style depression inductions have been documented to produce behavioral slowing in some instances (Goodwin & Williams, 1982). It is possible that the observed cardiac slowing is another manifestation of this phenomenon. Interestingly, women were more verbally responsive to the anxiety condition than men, reporting greater distress, but no corresponding increase in cardiac responding was noted. Although a nonsignificant decrease in heart rate was noted in the neutral condition, no sex related relationships were noted. This differential cardiac and verbal report responding was associated with uniformly reduced pain tolerance times for both sexes in the anxiety and depression conditions, supporting the loose connection among the three systems and the unique pattern of each emotional state.

Methodological Issues

Gross and Collins (1981) noted the methodological difficulties of teasing apart the effect of emotions like anxiety from the experience of pain. It is likely that some of the variability of findings in the pain and emotion literature are due in part to dissimilar research techniques and experimental stimuli. Therefore, methodological variations in the current study need to be carefully compared to other research to clarify results.

Comparison To Zelman et al. (1991)

The present study was successful in partially replicating the results of the Zelman et al. (1991) study by using similar methodology. The general results (i.e., depression decreases pain tolerance), and the non-normal data distribution for pain tolerance times, were consistent with the Zelman et al. (1991) study findings.

Emotion induction. Furthermore, the emotion induction procedure appeared to be similarly effective in both studies, except that anxiety and fear were not measured or intentionally induced by the Zelman et al. (1991) study. Careful evaluation of EAS and SAM ratings indicate that each emotion induction condition produced a unique pattern of responding from subjects, suggestive of condition-specific emotion change. The changes elicited were mild in comparison to the depth of emotion possibly measured by

these scales, a finding also consistent with previous research (e.g., Carlson et al., 1989).

The Zelman et al. (1991) study found that induction of positive emotion (i.e., elation) reduced pain tolerance. Possible explanations for the present study's lack of findings for this condition have been previously discussed. Given the extreme variability of results in the pain literature and the number of variables that have been shown to complicate pain responding in humans, the similarity between the present study and the Zelman et al. (1991) findings still seems remarkable.

Type of pain. As an expansion upon the Zelman et al. (1991) ideas, the present study made several intentional methological changes (e.g., type of tonic pain, participant expectancies, and pain rating system) with mixed success. To reduce pain tolerance ceiling effects, the type of tonic pain induced was changed (i.e., cold pressor pain was changed to pressure pain). An algometer allows for some control over the general speed with which the pain builds by changing the pressure inducing weights. Lower demand instructions ("stop when you feel forced to remove your hand" was changed to "stop when you feel fairly uncomfortable") were issued to the subjects. Interestingly, not only did these procedural changes reduce ceiling effects somewhat, but they did not appear to change the similarity of results between the two studies.

Participant expectancies. Another difference between the present study and the Zelman et al. (1991) project was participant expectancies. A criticism of Velten-style emotion induction procedures is that effects may be produced through demand characteristics of the instructions, or the suggestibility of the subjects, rather than true emotion (Polivy & Doyle, 1980). The Zelman et al. (1991) study attempted to reduce subject expectancies as much as possible to avoid this criticism (e.g., not informing the subjects of the emotion being induced). Recent research (Kenealy, 1986; Slyker & McNally, 1991), however, indicates that genuine emotion change appears to be produced by emotion induction procedures whether subjects know what mood is being induced or not. Based on these findings, the present study intentionally informed the subjects what the target emotion was for their condition, so that the instructions and expectations were clear.

Based on postinduction verbal report checks, both studies appeared to have been successful in increasing reports of the various emotions. Furthermore, the pattern of responding in both studies was complex, suggesting that subjects may not have experienced one pure emotion. Some argue that emotions rarely occur in their pure form (Polivy, 1981). If subjects were merely responding to perceived expectations, then they would be expected to show a simple and pure pattern of verbal reports, rather than the complex

patterns seen in both the present study and the Zelman et al. (1991) project (Slyker & McNally, 1991). For this reason, it appears that more complex processes than subject expectation were operating in the current study. Furthermore, giving the subject clear instructions about the emotion induction process did not seem to compromise the current projects' findings.

Anxiety induction. To broaden the scope of the final conclusions, the present study added an anxiety emotion induction to the Zelman et al. (1991) paradigm. Although the anxiety induction increased reports of fear and anxiety (i.e., EAS) somewhat, other differences were not significant, as in the depression condition. Two possible reasons for this phenomenon may be gender differences in emotion reporting and the emotion induction methodology itself. First, women but not men reported significant increases in fear and anxiety (as measured by the EAS) following the anxiety emotion induction. The pattern of SAM ratings following the anxiety induction appears to be consistent with increased anxiety; no gender differences, however, were noted. The SAM responding pattern suggests that the anxiety emotion induction may have been effective, but that men were less likely to label their reduced valence, increased arousal, and decreased dominance as fear or anxiety. Furthermore, the effects of experimenter gender were more likely to complicate the reporting of fear than

any other emotion. Second, it is possible that the Velten style of emotion induction is more effective for the production of depression than anxiety (I. K. Orton, personal communication, January 5, 1992). The Velten procedure involves solitary, quiet, reflection on verbal statements. This setting seems less conducive to the development of the feelings of worry, panic and high physiological arousal associated with anxiety, compared to the sadness, loneliness and low arousal of depression. Despite these difficulties, the anxiety emotion induction deserves study as a comparison with the classic Velten emotion induction conditions (e.g., depression).

Utility of psychophysiology. EMG is less frequently recorded in experimental pain research even though psychophysiological technology (e.g., biofeedback) is commonly used in chronic pain treatment. Several channels of physiological measures were added to the Zelman et al. (1991) design, including ECG and EMG (i.e., trapezius and corrugator). Cardiac measures were effective in demonstrating interesting gender differences in the present study and suggesting otherwise unconsidered hypotheses. The EMG findings were generally less informative than other variables. Facial EMG (i.e., corrugator) was more responsive to experimental manipulations than trapezius recordings. Corrugator Supercilii EMG has been shown to be associated with expression of happiness and sadness

(Cacioppo & Petty, 1986; Schwartz, 1986). Usually, increased muscle tension is correlated with negative emotion and reduced muscle tension is associated with positive emotion. In this study, increased corrugator tension was associated most closely with reports of happiness and rest periods. A possible confounding factor involved with the corrugator recordings was that the baseline readings were taken while the subjects' eyes were closed and the pain task recordings were taken with eyes open. No significant changes resulted following the experimental manipulations. Trapezius EMG increased uniformly during the two pain tasks, suggesting that hand pain causes large muscle tension in the shoulder region on the same side of the body. No other differences were noted.

Pain rating systems. Contrary to the Zelman et al. (1991) findings, the present study found that emotion affected pain severity ratings. It is likely that this disparity in findings is attributable to differences in the pain rating systems of the two projects. The Zelman et al. (1991) "closed ended" rating system is commonly used in pain research (0 to 10 scale every 5 s), but has been shown to have lower reliability correlations and to be more susceptible to ceiling and practice effects (Fernandez, 1990). The present study used an "open transformed" pain rating technique developed by Fernandez and colleagues (1990; 1991). Although this system is more complex for the

researcher to use, the subjects appeared to have little difficulty with it. This study was the first known attempt to use the "open transformed" rating scale on quickly building pain (i.e., produced by an algometer). It appears to be as effective for this type of pain as well as the more slowly building pain used by Fernandez et al. (1991) (i.e., iscemic pain). As a result of the short endurance times, however, fewer pain ratings were reported before a high level of pain escape was observed. This phenomenon was associated with reduced power and nonsignificant results at an elapsed time of 45 s. For these reasons, these promising findings should be considered preliminary.

Related Issues

Three systems. This study is consistent with the body of literature (e.g., Hodgson & Rachman, 1974; Rachman & Hodgson, 1974), that the three systems of overt behavior, physiology and verbal report are only loosely related. The range of intercorrelations varied tremendously. Findings are suggestive of slightly stronger relationships during parts of the study involving pain and emotion, compared to resting baselines.

Repeated measures. Inherent in a repeated measures design is the readministration of experimental tasks and the associated learning processes. Although fatigue effects did not appear to have influenced the present study's results, learning about pain did occur. Variability across EAS and

SAM ratings appeared consistent with condition assignment, giving little indication of unusual responding patterns from individual subjects or across groups. Increased pain escape, however, across the two pain trials, was seen in most subjects. Furthermore, reports of anticipatory anxiety appeared to be reduced on the second pain trial compared to the first, suggesting that responses to novel pain may be slightly different than to familiar pain. Fortunately, pain learning would be expected to be uniform across similar pain induction techniques, thus not compromising the generalizability of the present study compared to other repeated measures pain designs.

Complexity of interactions. It was impressive to note how complicated pain and emotion interactions became when just a few variables, like sex of participant and experimenter, were analyzed. Many researchers avoid complicating pain research projects by using subjects of one sex and/or ignoring sex and gender issues. Although these factors make analyses much more complicated and difficult to interpret, pain has been shown to be mediated by a multitude of factors (Melzack & Wall, 1982). Clearly, prudence regarding the number of factors analyzed in pain reactions is important. It is possible, however, that by controlling too many factors, pain interactions may be oversimplified so completely that the research is no longer reflective of the reality of pain experiences. In this way, otherwise well

designed research could potentially lead to false conclusions.

Limitations

Aspects of the generalizability and interpretation of the present study's findings are limited by a variety of factors. First, while attempts were made to statistically and methodologically equalize baseline values, significant baseline differences persisted. Experimenter bias (experimenters were informed about subjects' condition assignment) and dissimilar groups may be possible contributors to these problems. Second, for ethical reasons, the degree and duration of the pain induced in laboratory research is limited. Furthermore, the laboratory is a highly predictable, controlled setting; subjects do not participate unless informed consent has been obtained. Therefore, the laboratory is necessarily artificial. The duration and intensity of clinical pain, on the other hand, is by nature less under the direct control of the researcher. Because of these fundamental differences, generalization of laboratory conclusions to clinical settings must be made with caution. Thirdly, the Velten-style emotion induction procedure was also completed in a controlled laboratory setting. These inductions appear to produce mild, transient changes in emotional state in many subjects. For this reason, generalizability is limited. Fourth, the subject population used in the present study was

relatively young, healthy, Caucasian and pain-inexperienced. Therefore, it is possible that a different subject pool might show an alternative pattern of results, making extension to a patient population tenable without appropriate replication. Fifth, in some of the analyses previously discussed, statistical power was limited by small cell sizes (e.g., $n = 5$). Particular caution should be taken when considering the ramifications of interactions involving three or more factors. Sixth, due to the exploratory nature of this research and the paucity of other research in this area, more statistical analyses were used than needed to simply test for hypothesized effects. Although this procedure may have enhanced the likelihood of type II errors, it increased the chance of finding meaningful differences. Finally, the present study extended aspects of experimental pain research into areas where little previous work had been published. Strong conclusions are best drawn from a body of literature and not from a single study. For this reason, additional work is needed in this area to clarify issues of generalizability.

Directions for Future Research

In general, the results of this study are rich and promising. As is typical with research, however, for each degree of clarification this study provided, additional issues arose that beg to be explored. As a result, the directions for future research are many. A primary

impediment to the organization of the pain literature and its application to clinical settings is the lack of testable theoretical models of pain. Such theories would incorporate existing knowledge and expand upon it, giving shape to an extensive literature and driving hypothesis development in future research. It appears that methodological differences may contribute to the discrepancies among studies, resulting in decreased clarity in the pain literature. The experimental pain literature would greatly benefit from some methodological consensus. Furthermore, pain has proven elusive to reliable measurement. By the simple act of measurement, the phenomenon being studied is sometimes unnaturally altered, resulting in inaccurate research conclusions. Alternative measurement techniques, like the "open transformed" rating system, need to be developed and evaluated carefully. Although the use of psychophysiology in pain research is uncommon, pain is, in part, an inherently physical sensation having a strong impact on the central and peripheral nervous systems. The use of psychophysiology, particularly in the channels which are used in pain biofeedback treatments (e.g., EMG, electrodermal measures, skin temperature), should be encouraged.

Sex and gender also appear to have a strong influence on pain. More research should focus on clarifying not only the existence of sex and gender differences, but determining

under what circumstances they occur and whether they are related to measurement, socialization, physiology, or other factors. Variables to consider in this type of research include physical size, masculinity/femininity, social interactional style, culture, experimenter effects, and differential report of emotions. Certainly pain is not a field where data collected with one set of subjects (e.g., Caucasian men) can be easily generalized to other populations. While this study did not attempt to tease apart sex and gender differences in pain, future research might address this issue.

Summary and Conclusions

In summary, the present study found that, even in a laboratory setting, pain and emotion clearly interact across all three response systems. Depression appeared to have a powerful affect on pain, precipitating more escape and pain complaints. These findings are in concert with observations of several influential pain researchers. Fordyce (1988) stated that it was suffering[2], not the pain and nociception itself, which was most highly associated with pain related disability. Implied in this statement is the notion that the meaning of the pain to the individual is crucial to prediction of his or her reactions to it (Leventhal, 1993).

Although the effects of anxiety on pain did not appear as pervasive as that of depression, anxiety and pain appeared to interact, but in a unique pattern. This

conclusion would be consistent with the findings of Kuch et al. (1993), who noted that anxiety was related to disability, but not highly correlated with pain perception. A possible role of anxiety is in the form of anticipatory anxiety. Most people have either direct or modeled experience with pain, and thus may experience the types of physiological arousal and emotional responsivity seen in the early parts of this study when concerned about possible pain contact. Furthermore, the present study showed that the effects of this type of preexisting negative emotion (i.e., anxiety) may be resistant to modification by positive mood states. Other research (Carter et al., 1994) supports the idea that preexisting anxiety is more persistent longitudinally and may possibly be more of an impediment to successful pain treatment than depression.

The fact that the pain/emotion interaction involved responding along all three emotion response systems (i.e., verbal report, physiology, overt behavior) posited by Lang (1968) is not surprising. Both pain and emotion can be powerful, overwhelming experiences which deplete the affective reserves of patients and elicit strong emotional reactions from friends and family members as well (Turk, 1994). Melzack and Wall (1982) conceptualized pain as including three primary facets; cognition, sensation, and motivation. Although some may argue that these two triads of factors may not be direct parallels, they are reminiscent

of each other, illustrating the similarity between pain and emotion. This commonality is one of the issues that makes research on this topic so challenging and complex (cf. Gross & Collins, 1981).

Sex and gender effects pervaded most aspects of the study, raising questions about the degree of responding related to physiological differences (i.e., sex) and social learning (i.e., gender; Deaux, 1993; Gentile, 1993; Unger & Crawford, 1993). Some differences may be related to basic physiological factors (e.g., physical size, musculature). On the other hand, reporting of emotion, particularly fear, was likely clearly complicated by gender issues and probable social learning factors. Interestingly, the sex differences in cardiac response were also influenced by experimental manipulation, suggesting some possible learned responses as well. Both biological and social factors are likely to influence pain and emotion interactions. Clearly distinguishing among them, however, will be difficult.

In conclusion, pain is a ubiquitous part of the human condition that has been studied for centuries. Nevertheless, it is not well understood. The variables that affect its manifestation and presentation are interactive and complex. The irony of pain is that those who experience it persistently are compelled to alleviate it at immense personal cost. Yet, those who rarely perceive it often perish from their difficulty learning about life's hazards.

The urgency for answers to help control the suffering is tremendous. The solutions to the problems of pain, however, continue to be elusive.

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Appendix A

INFORMED CONSENT STATEMENT

Project Title: The effects of emotion on pain tolerance and physiology.
Experimenters: Daniel W. McNeil, Ph.D., Leslie E. Carter, M.S., Cynthia L. Turk, and Barry J. Ries, M.A.

I, (print name) _____ hereby authorize and direct Daniel McNeil, Leslie Carter, Cynthia Turk, Barry Ries or associates of their choosing, to perform the procedures listed here.

A. Purpose: This study is designed to investigate thoughts and feelings about various emotions and pain.

B. Procedures: In participating in this experiment, you will be asked to do the following things:

1. Complete a series of interviews and questionnaires pertaining to your thoughts and feelings about different kinds of emotions.
2. Name the color of printed words while you are being timed.
3. Read statements listed on a video screen that should provoke elation, depression, anxious, or neutral feelings.
4. Endured a mildly painful task. You will be instructed as to how to stop this task at any time you wish.
5. During this procedure, recordings of heart rate and muscle tension reactivity will be completed using devices attached to the skin. These sensors will be attached using tape or other adhesives and are painless. The only sensation that will be felt is their presence on the skin. Risk of any type of electrical shock is extremely unlikely because of rigid safeguards.
6. Participate in a debriefing at the end of the study in which the purposes of the experiment will be discussed. At this time, any questions will be answered. Additionally, if you are interested in obtaining information about coping with various emotions or pain, you may inquire of the experimenter.

C. Duration of participation: Your participation will require 2 hours.

D. Confidentiality: All information that you provide will be kept confidential and will not be released except in the most extreme circumstances. Computer files of this

experiment's data will be numerically coded. Data from this experiment, including questionnaires, will be kept in a secure place. Results from this experiment may be presented at professional meetings or in publications. Your anonymity, however, will be preserved.

E. Risks: The risks in this study are minimal. Statements read on the video screen may potentially be anxiety or depression-provoking; mild pain will be experienced in another task.

F. Benefits: As a research participant, you will be exposed to the conduct of scientific psychological research and may gain insight into your own reactions to painful or anxiety-provoking objects or situations. In addition, you will be compensated as subsequently outlined. Through research like this, assessments and treatments can be developed to help people with problem pain, anxiety, or depression.

G. Compensation for participation: You will be receive: _____ 1 extra credit point in your PSYCH 1113 (Introductory Psychology) class for each hour or fraction of an hour in which you participate in this experiment or _____ Payment of $5.

Whether or not you choose to participate in this experiment, there are other ways that you can get extra credit in that class. You can be involved in other experiments or you can do projects (e.g., book reports) that your instructor can explain and allow you to complete.

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the risks and benefits in this study. I also understand the following statements:

I certify that I am 18 years of age or older.

My participation today is part of an investigation entitled "The effects of emotion on pain tolerance and physiology."

The purpose of these procedures is to examine thoughts and feelings about various emotions and pain.

I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty after notifying the project director.

I understand that I may contact this project's faculty investigator, Dr. Daniel W. McNeil, at 215 North Murray, Department of Psychology, Oklahoma State University, Stillwater, OK 74078-0250, 405/744-6027, should I desire to discuss my participation in this study and/or to request information pertaining to the study's outcome. Additionally, I understand that I may contact Beth McTernan, University Research Services, 001 Life Sciences East, Oklahoma State University, Stillwater, OK 74078, 405/744-5700.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form has been given to me. I hereby give permission for my participation.

_____ _____AM PM

Signature of Participant Date and Time

_____ _____

Signature of Witness Date

I certify that I have personally completed all the blanks in this form and have explained them to the subject before requesting the subject sign this consent form.

_____

Signature of Project Director or Authorized Representative

Appendix B

AX18 Medical/Social History

Name_____Date_____Subj#: AX18 _ _

Age___(*must be > 17) DOB___ Ethnicity_____ Gender: M F

==========

Y N 1. Wear glasses or contacts? (wear during mood induction)

Y N 2. Any past or present hearing problems? (Adjust audio?)
(explain_____)

Y N 3. Do you have difficulty distinguishing colors (e.g., color blindness)?
(explain_____)

Y N 4. Have you ever had a serious head injury?
(explain_____)

Y N 5. Have you ever had a period of unconsciousness?
(explain_____)

Y N 6. Do you have, or have you ever had a seizure disorder?
(explain_____)

Y N 7. Any current or past heart problems?
(explain_____)

Y N 8. Have you ever had rheumatic or scarlet fever?

Y N *9. (Females only) Are you presently pregnant, or do you have reason to believe you are pregnant?

Y N 10. Have you ever had any circulation problems in your hands or feet?
(explain_____)

Y N 11. Have you ever had bone, joint, or muscle problems?
(explain_____)

Y N 12. Have you had any experience with severe or prolonged pain at any point in your life?
(explain_____)

Y N 13. Have you ever witnessed anyone in severe or prolonged pain at any point in your life?
(explain_____)

Y N 14. Have you ever had any other type of serious or chronic health problem?
(explain_____)

15. How many hours of sleep did you get last night? _____

16. How many hours do you normally get?
_____

R L 17. Are you right or left handed?

18. Please describe the quantity and frequency of your use of the following medications over the past 30 days (include type and daily dosage):
a. prescription drugs_____
b. alcohol_____
c. recreational drugs_____
d. over-the-counter medication_____

Y N 19. Have you taken any medicine, alcohol or drugs in the last 24 hours?
(explain_____)

Y N 20. Have you used any caffeinated beverages or alcohol in the last 12 hours?
(explain_____)

****
Please place comments on back.
****

Appendix C

Emotion Induction Statements

Anxiety Emotion Induction Statements
(Orton, Beiman, LaPointe, & Lankford, 1983)

1. TODAY IS NEITHER BETTER NOR WORSE THAN ANY OTHER DAY.
2. HOWEVER, I FEEL A LITTLE UNSETTLED TODAY.
3. I'M WORRIED THAT MY PARENTS ARE UPSET WITH ME.
4. I'M NOT VERY CALM; I FEEL AGITATED AND JITTERY.
5. BEING AROUND CERTAIN PEOPLE UPSETS ME; I JUST GET MORE AND MORE NERVOUS.
6. I'M GETTING MORE UNCOMFORTABLE; I CAN FEEL MYSELF GETTING MORE JITTERY.
7. MY CONCENTRATION IS POOR; MY MIND KEEPS JUMPING FROM ONE THING TO ANOTHER; I FEEL SO INSECURE.
8. I'M REALLY FEELING UPSET AND NERVOUS; THIS WORRIES ME.
9. MY LIFE IS SO UNSETTLED -- I DON'T KNOW WHAT'S GOING TO HAPPEN NEXT.
10. I'M FEELING MORE AND MORE UPSET.
11. I FEEL LIGHTHEADED AND MY HEART SEEMS TO BE RACING.
12. MAYBE I'M NOT HANDLING THINGS AS WELL AS I THOUGHT; WHAT IF I'M NOT DOING WELL AT ALL? WHAT'S HAPPENING TO ME?
13. I'M FEELING MORE AND MORE JITTERY.
14. MY HEART SEEMS TO BE BEATING FASTER AND I'M FEELING MORE RESTLESS.
15. I JUST DON'T SEEM ABLE TO SETTLE DOWN.
16. I DON'T KNOW WHAT MIGHT HAPPEN TO ME TOMORROW.
17. MY HEART SEEMS TO BE BEATING MUCH FASTER THAN USUAL.
18. IT MAKES ME REALLY TENSE WHEN I THINK HOW I'VE TREATED SOME PEOPLE.

19. I'M REALLY FEELING UPTIGHT; I CAN FEEL MYSELF GETTING MORE AND MORE NERVOUS.

20. SOMETIMES MY LIFE IS SO OUT OF CONTROL THAT I CAN'T SLEEP; I JUST WORRY AND WORRY.

21. WHAT IF I GET SO NERVOUS I CAN'T SLEEP TONIGHT?

22. I PROBABLY WON'T BE ABLE TO SLEEP TONIGHT, I'M SO UPSET NOW.

23. I'M HAVING A HARD TIME GETTING MY BREATH; THINGS SEEM TO BE CLOSING IN ON ME.

24. WHAT IF SOMETHING SAD HAPPENED TO ME; I COULDN'T STAND IT; I'M SO WORRIED AND FRIGHTENED.

25. THIS IS TERRIBLE; I'M SO BENT OUT OF SHAPE I COULD CRY.

26. I'M SO WORRIED THAT SOMETHING TERRIBLE MIGHT HAPPEN TO ME.

27. I FEEL ALL JITTERY; I WANT TO RUN AWAY; THIS IS REALLY GETTING TO ME.

28. I FEEL LIKE I'M RUNNING; I'M GETTING MORE UPSET; I JUST KEEP GOING FASTER AND FASTER.

29. I'M SO NERVOUS THAT I DON'T KNOW WHAT I'LL DO NEXT.

30. I'VE GOT SO MANY THINGS TO DO, WHAT IF I DON'T GET THEM ALL DONE?

31. I'M REALLY AFRAID I WON'T DO WELL.

32. I AM SO NERVOUS RIGHT NOW I FEEL I'M GOING TO POP.

33. I CAN HARDLY SIT HERE.

34. THERE ARE SO MANY THOUGHTS RUNNING FASTER AND FASTER THROUGH MY HEAD.

35. I AM FEELING MORE AND MORE UPTIGHT; I DON'T KNOW IF I CAN STAY IN THIS PLACE MUCH LONGER.

36. I'M REALLY STARTING TO FEEL MORE UNCOMFORTABLE - WHAT IF I LOSE CONTROL?

37. I'M GETTING MORE AND MORE UPSET; I FEEL TERRIBLY WORRIED.

38. THE WAY I FEEL NOW, I DON'T KNOW IF I'LL EVER CALM DOWN.

39. I'M SO UPSET; WHAT WILL OTHER PEOPLE THINK OF ME?

40. I'M REALLY FEELING PRESSURED - IT'S GETTING HARD TO BREATHE.

41. I'M SO TENSE I'M BEGINNING TO FEEL DIZZY.

42. I REALLY FEEL SHAKY; MY ARMS AND LEGS ARE FEELING SO WEAK.

43. WHAT IF THERE'S SOMETHING WRONG WITH ME I DON'T KNOW ABOUT?

44. I DON'T KNOW IF I CAN TAKE THIS MUCH LONGER.

45. WHAT IF I LOST CONTROL OF MY FEELINGS?

46. I REALLY CAN'T STAND WHAT'S GOING ON.

47. I'M SO TENSE NOW I COULDN'T RELATE TO ANYONE NOW IF I HAD TO.

48. I FEEL LIKE CLIMBING THE WALLS.

49. THIS IS AWFUL.

50. IF THIS CONTINUES MUCH LONGER I'M GOING TO EXPLODE.

Depression Emotion Induction Statements
(Zelman, Howland, Nichols, & Cleeland, 1991)

1. TODAY IS NEITHER BETTER NOR WORSE THAN ANY OTHER DAY.

2. HOWEVER, I FEEL A LITTLE LOW TODAY.

3. I FEEL RATHER SLUGGISH NOW.

4. SOMETIMES I WONDER WHETHER SCHOOL IS ALL THAT WORTHWHILE.

5. EVERY NOW AND THEN I FEEL SO TIRED AND GLOOMY THAT I'D RATHER JUST SIT THAN DO ANYTHING.

6. I CAN REMEMBER TIMES WHEN EVERYBODY BUT ME SEEMED FULL OF ENERGY.

7. TOO OFTEN I HAVE FOUND MYSELF STARING LISTLESSLY INTO THE DISTANCE, MY MIND A BLANK, WHEN I DEFINITELY SHOULD HAVE BEEN STUDYING.

8. IT HAS OCCURRED TO ME MORE THAN ONCE THAT STUDYING IS BASICALLY USELESS, BECAUSE YOU FORGET ALMOST EVERYTHING YOU LEARN ANYWAY.

9. I DO FEEL SOMEWHAT DISCOURAGED AND DROWSY - MAYBE I'LL NEED A NAP WHEN I GET HOME.

10. I'M AFRAID THE FIGHTING IN IRELAND MAY GET A LOT WORSE.

11. THERE HAVE BEEN DAYS WHEN I FELT WEAK AND CONFUSED, AND EVERYTHING WENT MISERABLY WRONG.

12. I'VE HAVE DAYDREAMS IN WHICH MY MISTAKES KEPT OCCURRING TO ME - SOMETIMES I WISH I COULD START OVER AGAIN.

13. I FEEL TERRIBLY TIRED AND INDIFFERENT TO THINGS TODAY.

14. JUST TO STAND UP WOULD TAKE A BIG EFFORT.

15. I'M GETTING TIRED OUT. I CAN FEEL MY BODY GETTING EXHAUSTED AND HEAVY.

16. I'M BEGINNING TO FEEL SLEEPY. MY THOUGHTS ARE DRIFTING.

17. AT TIMES I'VE BEEN SO TIRED AND DISCOURAGED THAT I WENT TO SLEEP RATHER THAN FACE IMPORTANT PROBLEMS.

18. MY LIFE IS SO TIRESOME - THE SAME OLD THING DAY AFTER DAY DEPRESSES ME.

19. I COULDN'T REMEMBER THINGS WELL RIGHT NOW IF I HAD TO.

20. I JUST CAN'T MAKE UP MY MIND; IT'S SO HARD TO MAKE SIMPLE DECISIONS.

21. I WANT TO GO TO SLEEP - I FEEL LIKE JUST CLOSING MY EYES AND GOING TO SLEEP RIGHT HERE.

22. I'M NOT VERY ALERT; I FEEL LISTLESS AND VAGUELY SAD.

23. I'VE DOUBTED THAT I'M A WORTHWHILE PERSON.

24. I FEEL WORN OUT; MY HEALTH MY NOT BE AS GOOD AS IT'S SUPPOSED TO BE.

25. IT OFTEN SEEMS THAT NO MATTER <u>HOW</u> HARD I TRY, THINGS STILL GO WRONG.

26. I'VE NOTICED THAT NO ONE SEEMS TO REALLY UNDERSTAND OR CARE WHEN I COMPLAIN OR FEEL UNHAPPY.

27. I'M UNCERTAIN ABOUT MY FUTURE.

28. I'M DISCOURAGED AND UNHAPPY ABOUT MYSELF.

29. I'VE LAIN AWAKE AT NIGHT WORRYING SO LONG THAT I HATED MYSELF.

30. THINGS ARE WORSE NOW THAN WHEN I WAS YOUNGER.

31. THE WAY I FEEL NOW, THE FUTURE LOOKS BORING AND HOPELESS.

32. SOME VERY IMPORTANT DECISIONS ARE ALMOST IMPOSSIBLE FOR ME TO MAKE.

33. THINGS ARE EASIER AND BETTER FOR OTHER PEOPLE THAN FOR ME. I FEEL LIKE THERE'S NO USE IN TRYING AGAIN.

34. OFTEN PEOPLE MAKE ME VERY UPSET. I DON'T LIKE TO BE AROUND THEM.

35. IT TAKES TOO MUCH EFFORT TO CONVINCE PEOPLE OF ANYTHING. THERE'S NO POINT IN TRYING.

36. I FAIL IN COMMUNICATING WITH PEOPLE ABOUT MY PROBLEMS.

37. IT'S SO DISCOURAGING THE WAY PEOPLE DON'T REALLY LISTEN TO ME.

38. I'VE FELT SO ALONE BEFORE, THAT I COULD HAVE CRIED.

39. SOMETIMES I'VE WISHED I COULD DIE.

40. MY THOUGHTS ARE SO SLOW AND DOWNCAST I DON'T WANT TO THINK OR TALK.

41. I JUST DON'T CARE ABOUT ANYTHING. LIFE JUST ISN'T ANY FUN.

42. LIFE SEEMS TOO MUCH FOR ME ANYHOW - MY EFFORTS ARE WASTED.

43. I'M SO TIRED.

44. I DON'T CONCENTRATE OR MOVE. I JUST WANT TO FORGET ABOUT EVERYTHING.

45. I HAVE TOO MAY BAD THINGS IN MY LIFE.

46. EVERYTHING SEEMS UTTERLY FUTILE AND EMPTY.

47. I FEEL DIZZY AND FAINT. I NEED TO PUT MY HEAD DOWN AND NOT MOVE.

48. I DON'T WANT TO DO ANYTHING.

49. ALL OF THE UNHAPPINESS OF MY PAST LIFE IS TAKING POSSESSION OF ME.

50. I WANT TO GO TO SLEEP AND NEVER WAKE UP.

Neutral Emotion Induction Statements
(Zelman, Howland, Nichols, & Cleeland, 1991)

1. OKLAHOMA CITY IS THE LARGEST CITY IN THE WORLD IN AREA, WITH 631.166 SQUARE MILES.

2. JAPAN WAS ELECTED TO THE UNITED NATIONS ALMOST FOURTEEN YEARS AFTER PEARL HARBOR.

3. AT THE END APPEARS A SECTION ENTITLED "BIBLIOGRAPHY NOTES."

4. WE HAVE TWO KINDS OF NOUNS DENOTING PHYSICAL THINGS: INDIVIDUAL AND MASS NOUNS.

5. THIS BOOK OR ANY PART THEREOF MUST NOT BE REPRODUCED IN ANY WAY.

6. AGRICULTURAL PRODUCTS COMPRISED SEVENTY PERCENT OF THE INCOME.

7. SATURN IS SOMETIMES IN CONJUNCTION, BEYOND THE SUN FROM THE EARTH, AND IS NOT VISIBLE.

8. SOME STREETS WERE STILL SAID TO BE LISTED UNDER THEIR OLD NAMES.

9. SOME STATES SUPPLY MILK FOR GRAMMAR SCHOOL CHILDREN.

10. THE TYPOGRAPHY, PAPER AND BIND WERE OF THE HIGHEST QUALITY.

11. THE DESK WAS OLD, AND SCRATCHED INTO ITS SURFACE WAS A PROFUSION OF DATES, INITIALS, AND MESSAGES.

12. WHEN THE BANYAN BENT DOWN UNDER ITS OWN WEIGHT, ITS BRANCHES BEGAN TO TAKE ROOT.

13. THE HOPE DIAMOND WAS SHIPPED FROM SOUTH AFRICA TO LONDON THROUGH THE REGULAR MAIL SERVICE.

14. THE REVIEW WAS CONCERNED WITH THE FIRST THREE VOLUMES.

15. THE SHIP WAS ANCIENT, AND WOULD SOON BE RETIRED FROM THE FLEET.

16. SLANG IS A CONSTANTLY CHANGING PART OF THE LANGUAGE.

17. THERE IS A SMALL ARTICLE IN THE LOCAL NEWSPAPER WHICH INDICATED ACCEPTANCE OF THE KIDNAPPERS' TERMS.

18. THERE ARE SOME FORMS IN WHICH NO OATH IS REQUIRED.

19. INTRAMATICS FINDS MATES FOR THE LONELY.

20. 99.1% OF ALASKA IS OWNED BY THE FEDERAL GOVERNMENT.

21. TWO MEN DRESSED AS REPAIRMEN WILL APPEAR SHORTLY AFTER THE VAN PULLS UP.

22. THE WOOD WAS DISCOLORED AS IF IT HAD BEEN HELD IN A FIRE.

23. A LIGHT WAS NOTICED IN THE DARK OUTSIDE, AND IT MOVED EERILY TOWARDS THE HOUSE.

24. PAINTING IN A FEW OTHER NON-EUROPEAN COUNTRIES IS TREATED IN A SEPARATE VOLUME.

25. A RECENT STUDY REVEALED THAT ONE HALF OF ALL COLLEGE STUDENTS WERE UNABLE TO FIND SUMMER JOBS.

26. PROVOKED AROUSAL AND ORIENTATION ARE ACCOMPANIED BY STEEPER NEGATIVE SHIFTS.

27. THE NAMES OF THE CHRISTMAS MAILING LIST ARE ALPHABETICALLY ORDERED.

28. SIGNIFICANTLY, THESE CHANGES OCCUR DURING THE FULL MOON.

29. WEST SAMOA GAINED ITS INDEPENDENCE IN 1965.

30. THE MAGAZINE'S REPORT WAS SLANTED, AS USUAL.

31. THE MAP WOULD PROVE USELESS AS A BEGINNING GUIDE.

32. BLACK AND WHITE PICTURES ARE ARRANGED IN TEN SECTIONS.

33. NO MAN WORKED HARDER THAN ME.

34. POTTER WROTE NUMEROUS SATIRES ON SOCIAL CYNICISM.

35. BOEING'S MAIN PLANT IN SEATTLE EMPLOYS 35,000 PEOPLE.

36. THE DOORKEEPER WAS DRESSED IN READ.

37. DURING THE NEXT TEN YEARS, THE GROUP PARTICIPATED IN POLITICS.

38. THE ORGANIZATION DEPENDED ON THE PEOPLE FOR SUPPORT.

39. IN 1965, ELIZABETH MADE THE FIRST STATE VISIT BY A BRITISH MONARCH TO GERMANY IN 56 YEARS.

40. IT WAS THEIR SIXTH CONSECUTIVE BEST-SELLER.

41. IT ALL FITTED IN WHICH THE OFFICER'S STORY.

42. THE MERGER DID NOT CHANGE THE COMPANY'S POLICY.

43. THE MANSION WAS RENTED BY THE DELEGATION.

44. NINETY OCCUPATIONS WERE LISTED AS ELIGIBLE FOR THE GRADS IN BUSINESS.

45. UTAH IS THE BEEHIVE STATE.

46. CHANGES WERE MADE IN TRANSPORT OF LUMBER AFTER THE BORDER INCIDENT.

47. THE CHINESE LANGUAGE HAS MANY DIALECTS, INCLUDING CANTONESE, MADARIN, AND WU.

48. THINGS WERE BOOMING ONCE AGAIN IN THE LITTLE GOLD RUSH TOWN OF ANGEL.

49. AT LOW TIDE THE HULK OF THE OLD SHIP COULD BE SEEN.

50. A FREE SAMPLE WILL BE GIVEN TO EACH PERSON WHO ENTERS THE STORE.

Elation Emotion Induction Statements
(Zelman, Howland, Nichols, & Cleeland, 1991)

1. TODAY IS NEITHER BETTER NOR WORSE THAN ANY OTHER DAY.
2. I DO FEEL PRETTY GOOD TODAY, THOUGH.
3. I FEEL LIGHT-HEADED.
4. THIS MIGHT TURN OUT TO HAVE BEEN ONE OF MY GOOD DAYS.
5. IF YOUR ATTITUDE IS GOOD, THEN THINGS ARE GOOD, AND MY ATTITUDE IS GOOD.
6. I'VE CERTAINLY GOT ENERGY AND SELF-CONFIDENCE TO SPARE.
7. I FEEL CHEERFUL AND LIVELY.
8. ON THE WHOLE, I HAVE VERY LITTLE DIFFICULTY IN THINKING.
9. FOR THE REST OF THE DAY, I BET THINGS WILL GO REALLY WELL.
10. MY JUDGMENT ABOUT MOST THINGS IS SOUND.
11. I'M FULL OF ENERGY AND AMBITION - I FEEL I COULD GO A LONG TIME WITHOUT SLEEP.
12. MY JUDGMENT IS KEEN AND PRECISE TODAY - JUST LET SOMEONE TRY TO PUT SOMETHING OVER ON ME.
13. IF I SET MY MIND ON IT, I CAN MAKE THINGS TURN OUT FINE.
14. I FEEL ENTHUSIASTIC AND CONFIDENT NOW.
15. THERE SHOULD BE OPPORTUNITY FOR A LOT OF GOOD TIMES COMING ALONG NOW.
16. MY FAVORITE SONG KEEPS GOING THROUGH MY HEAD.
17. SOME OF MY FRIENDS ARE SO LIVELY AND OPTIMISTIC.
18. I FEEL TALKATIVE - I FEEL LIKE TAKING TO ALMOST ANYBODY.
19. I'M FULL OF ENERGY, AND AM REALLY GETTING TO LIKE THE THINGS I'M DOING ON CAMPUS.
20. I'M ABLE TO DO THINGS ACCURATELY AND EFFICIENTLY.

21. I KNOW GOOD AND WELL THAT I CAN ACHIEVE THE GOALS I SET.

22. NOW THAT IT OCCURS TO ME, MOST OF THE THINGS THAT HAVE DEPRESSED ME WOULDN'T HAVE IF I'D JUST HAD THE RIGHT ATTITUDE.

23. I HAVE A SENSE OF POWER AND VIGOR.

24. I FEEL SO VIVACIOUS AND EFFICIENT TODAY - SITTING ON THE TOP OF THE WORLD.

25. IT WOULD REALLY TAKE SOMETHING TO STOP ME NOW!

26. IN THE LONG RUN, IT'S OBVIOUS THAT THINGS HAVE GOTTEN BETTER AND BETTER DURING MY LIFE.

27. I KNOW THAT IN THE FUTURE I WON'T OVER-EMPHASIZE SO -CALLED PROBLEMS.

28. I'M OPTIMISTIC THAT I CAN GET ALONG VERY WELL WITH MOST OF THE PEOPLE I MEET.

29. I'M TOO ABSORBED IN THINGS TO HAVE TIME FOR WORRY.

30. I'M FEELING AMAZINGLY GOOD TODAY!

31. I AM PARTICULARLY INVENTIVE AND RESOURCEFUL IN THIS MOOD.

32. THINGS LOOK GOOD. THINGS LOOK GREAT.

33. I FEEL AN EXHILARATING ANIMATION IN ALL I DO.

34. I FEEL HIGHLY PERCEPTIVE AND REFRESHED.

35. MY MEMORY IS IN RARE FORM TODAY.

36. IN A BUOYANT MOOD LIKE THIS ONE, I CAN WORK FAST AND DO IT RIGHT THE FIRST TIME.

37. I CAN CONCENTRATE HARD ON ANYTHING I DO.

38. MY THINKING IS CLEAR AND RAPID.

39. MY LIFE IS SO MUCH FUN; IT SEEMS TO OFFER SO MANY SOURCES OF FULFILLMENT.

40. THINGS WILL BE BETTER AND BETTER TODAY.

41. I CAN MAKE DECISIONS RAPIDLY AND CORRECTLY; AND I CAN DEFEND THEM AGAINST CRITICISM EASILY.

42. I FEEL INDUSTRIOUS AS HECK - I WANT SOMETHING TO DO!

43. LIFE IS FIRMLY IN MY CONTROL.

44. I WISH SOMEBODY WOULD PLAY SOME GOOD LOUD MUSIC!

45. THIS IS GREAT - I REALLY DO FEEL GOOD. I AM ELATED ABOUT THINGS.

46. I'M REALLY FEELING SHARP NOW.

47. THIS IS JUST ONE OF THOSE DAYS WHEN I'M READY TO GO!

48. I FEEL LIKE BURSTING WITH LAUGHTER - I WISH SOMEBODY WOULD TELL A JOKE AND GIVE ME AN EXCUSE.

49. I'M FULL OF ENERGY.

50. GOD, I FEEL GREAT!

Appendix D

Pain Severity Rating Derivation

The open-scale pain rating system recommended by Fernandez (1990; Fernandez et al., 1991) produces cumulative times starting at pain threshold and continuing in a naturalistic fashion until pain tolerance is reached. The first rating of "just noticeable" pain (i.e., threshold) is assumed to be equal to a rating of one on a one to ten scale. Ten is assumed to be the "quit point" (i.e., tolerance) or point at which the subject chooses to discontinue the pain task. The Fernandez et al. (1991) article provides an algorithm which allows for transformation of the pain rating times, using basic proportions and interpolation processes, into ratings from one to ten given at certain times. (See Formula I later in this appendix.) These calculations allow the researcher to know specifically at what time in the pain task the subject would have given any integer value rating (e.g., for subject y a pain severity rating of five would have occurred 25 s into the pain task).

The Zelman et al. (1991) study, however, took ratings of one to ten every 5 s and analyzed their data in terms of the pain severity ratings at time 15 s, 30 s, etc. For comparison purposes, it was necessary to convert the Fernandez et al. (1991) algorithm to allow for transformation of data into ratings between one and ten at

given time intervals. This alternative formula is shown on the figure (Formula II).

The following instructions will help illuminate the exact use of these formulas. The Methods section of this document lists the instructions for completing these ratings with research personnel and subjects. For detailed use of Formula I, please refer to the original articles (Fernandez, 1990; Fernandez et al., 1991).

To use Formula II, perform the following steps:

1. Determine the total number of tally marks (RR) made by the subject.
2. Obtain the list of cumulative times (CT) associated with each mark.
3. Create a list of transformed ratings (TR) for each CT. Find the TR interval. The TR associated with the first CT is assumed to be 1. Add the TR interval to 1 to determine the second TR. Add the TR interval to the second TR to determine the next TR and so on until a TR corresponds to each CT. If this procedure is performed correctly the final TR should equal a value of 10.
4. Determine the cumulative times (CT_{int}) for which it is desirable to have pain rating correspond (e.g., 15 s, 30 s, 45 s, etc.).
5. Use Formula II to calculate the interpolated transformed ratings (TR_{int}) that correspond to each

CT_{int}. Determine the nearest upper and lower limits between which each CT_{int} and TR_{int} fall from the respective CT and TR value lists already calculated. Substitute the appropriate values into the formula for each occurrence desired.

Algorithms for transformation of open-scale pain ratings

Formula I

$$CT_{int} = CT_{ll} + \frac{(TR_{int} - TR_{ll})}{(TR_{ul} - TR_{ll})}(CT_{ul} - CT_{ll})$$

$$\text{Where } TR_{interval} = \frac{9}{(RR - 1)}$$

Formula II

$$TR_{int} = TR_{ll} + \frac{(CT_{int} - CT_{ll})}{(CT_{ul} - CT_{ll})}(TR_{ul} - TR_{ll})$$

$$\text{Where } TR_{interval} = \frac{9}{(RR - 1)}$$

Note:

RR	refers to the total number of reported ratings (i.e., tally marks) given by the subject through the time of pain escape.
TR interval	refers to the value used to calculate each transformed rating (TR).
CT_{ll}	refers to the nearest cumulative time that is less than the CT_{int} value.
CT_{ul}	refers to the nearest cumulative time that is greater than the CT_{int} value.
CT_{int}	refers to the cumulative time for which an interpolated transformed rating is desired
TR_{ll}	refers to the nearest transformed rating that is less than the TR_{int} value.
TR_{ul}	refers to the nearest transformed rating that is greater than the TR_{int} value.
TR_{int}	refers to the pain severity rating that corresponds to the desired CT_{int}.

Appendix E

Procedure Flow Chart

I. Instructions and Initial Assessment
   - A. Informed consent
   - B. Medical/social history interview
   - C. Physiological monitoring hookup
   - D. Pain Stroop 1
   - E. Questionnaires: FPQ-III, BDI, STAI, ASQ, and PASS
   - F. SAM and EAS instructions

II. Preinduction Baseline
   - A. ECG and EMG
   - B. SAM and EAS

III. Pain Task 1
   - A. ECG and EMG
   - B. Pain Tolerance
   - C. Pain Severity Ratings
   - D. SAM and EAS
   - E. Pain Stroop 2

IV. Emotion-Induction: (12 min) anxiety, depression, elation, neutral
   - A. SAM and EAS

V. Pain Task 2
   - A. ECG and EMG
   - B. Pain Tolerance
   - C. Pain Severity Ratings
   - D. SAM and EAS

VI. Postinduction Baseline (5 min)
   - A. ECG and EMG
   - B. SAM and EAS
   - C. Unhook physiological monitoring equipment

VII. Short Positive Emotion-Induction (6 min)

VIII. MPQ and color vision screening

IX. Debriefing

Appendix F

Variable List

Independent Variables:

A. Emotion Induction Condition
   (i.e., anxiety, depression, elation, and neutral)

B. Subject Sex (i.e., male or female)

C. Experimenter Sex

D. Trial

Dependent Variables:

A. Overt Behavior
   1. Pain Tolerance (seconds)

B. Physiology
   1. Heart Rate (beats per min)
   2. Corrugator Supercilii Muscle Tension (microvolts)
   3. Trapezius Muscle Tension (microvolts)

C. Verbal Report of Affect
   1. Self-Assessment Manikin (SAM) Ratings (0-20 points)
      a. Valence
      b. Arousal
      c. Dominance
   2. Emotion Assessment Scale (EAS; 0-10 cm)
      a. Anxiety
      b. Fear
      c. Sadness
      e. Happiness
   3. Pain Severity Ratings (0-10 points)

Appendix G

Results of ANOVA's and ANCOVA's for Major Analyses

G-1

F Values for Pain Tolerance Time Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	3, 64	1219.06	0.85	NS
Condition x Experimenter Sex x Trial	3, 64	762.50	0.53	NS
Subject Sex x Experimenter Sex x Trial	1, 64	449.63	0.31	NS
Condition x Subject Sex x Trial	3, 64	1059.55	0.74	NS
Condition x Subject Sex x Experimenter Sex	3, 64	1848.90	0.49	NS
Condition x Trial	3, 64	2462.17	1.72	NS
Subject Sex x Trial	1, 64	5.25	0.00	NS
Experimenter Sex x Trial	1, 64	1360.88	0.95	NS
Condition x Experimenter Sex	3, 64	4875.89	1.29	NS
Subject Sex x Experimenter Sex	1, 64	313.96	0.08	NS
Condition x Subject Sex	3, 64	9271.91	2.46	< .10
Trial	1, 64	3109.50	2.17	NS
Condition	3, 64	7300.46	1.93	NS
Subject Sex	1, 64	30004.88	7.95	< .01
Experimenter Sex	1, 64	14765.86	3.91	< .10

G-2
F Values for Cardiac ANOVA Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	9, 192	19.78	1.32	NS
Condition x Experimenter Sex x Trial	9, 192	13.31	0.89	NS
Subject Sex x Experimenter Sex x Trial	3, 192	22.44	1.49	NS
Condition x Subject Sex x Trial	9, 192	25.77	1.72	< .10
Condition x Subject Sex x Experimenter Sex	3, 64	906.47	3.63	< .05
Condition x Trial	9, 192	11.92	0.79	NS
Subject Sex x Trial	3, 192	20.48	1.36	NS
Experimenter Sex x Trial	3, 192	10.22	0.68	NS
Condition x Experimenter Sex	3, 64	122.61	0.49	NS
Subject Sex x Experimenter Sex	1, 64	8.71	0.03	NS
Condition x Subject Sex	3, 64	400.45	1.60	NS
Trial	3, 192	515.71	34.35	< .0001
Condition	3, 64	4.57	0.02	NS
Subject Sex	1, 64	2144.08	8.58	< .005
Experimenter Sex	1, 64	452.00	1.81	NS

G-3
F Values for Cardiac ANCOVA Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	3, 64	22.23	1.94	NS
Condition x Experimenter Sex x Trial	3, 64	13.15	1.15	NS
Subject Sex x Experimenter Sex x Trial	1, 64	3.53	0.31	NS
Condition x Subject Sex x Trial	3, 64	27.93	2.44	< .10
Condition x Subject Sex x Experimenter Sex	3, 63	44.53	1.14	NS
Condition x Trial	3, 64	13.63	1.19	NS
Subject Sex x Trial	1, 64	38.90	3.40	< .10
Experimenter Sex x Trial	1, 64	11.63	1.02	NS
Condition x Experimenter Sex	3, 63	37.91	0.97	NS
Subject Sex x Experimenter Sex	1, 63	144.65	3.70	< .10
Condition x Subject Sex	3, 63	38.85	0.99	NS
Trial	1, 64	92.54	8.08	< .01
Condition	3, 63	23.08	0.59	NS
Subject Sex	1, 63	0.10	0.00	NS
Experimenter Sex	1, 63	9.14	0.23	NS

G-4
F Values for Corrugator EMG Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	9, 192	2.41	0.76	NS
Condition x Experimenter Sex x Trial	9, 192	3.49	1.09	NS
Subject Sex x Experimenter Sex x Trial	3, 192	2.63	0.82	NS
Condition x Subject Sex x Trial	9, 192	1.96	0.61	NS
Condition x Subject Sex x Experimenter Sex	3, 64	5.60	0.50	NS
Condition x Trial	9, 192	5.55	1.74	< .10
Subject Sex x Trial	3, 192	1.24	0.39	NS
Experimenter Sex x Trial	3, 192	8.97	2.81	< .05
Condition x Experimenter Sex	3, 64	9.43	0.85	NS
Subject Sex x Experimenter Sex	1, 64	7.42	0.67	NS
Condition x Subject Sex	3, 64	3.11	0.28	NS
Trial	3, 192	16.65	5.22	< .005
Condition	3, 64	3.39	0.31	NS
Subject Sex	1, 64	1.00	0.09	NS
Experimenter Sex	1, 64	1.42	0.13	NS

G-5
F Values for Trapezius EMG Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	9, 192	2.37	0.61	NS
Condition x Experimenter Sex x Trial	9, 192	1.55	0.40	NS
Subject Sex x Experimenter Sex x Trial	3, 192	5.72	1.48	NS
Condition x Subject Sex x Trial	9, 192	1.91	0.49	NS
Condition x Subject Sex x Experimenter Sex	3, 64	3.72	0.38	NS
Condition x Trial	9, 192	4.97	1.28	NS
Subject Sex x Trial	3, 192	2.18	0.56	NS
Experimenter Sex x Trial	3, 192	0.68	0.17	NS
Condition x Experimenter Sex	3, 64	8.23	0.85	NS
Subject Sex x Experimenter Sex	1, 64	91.18	9.43	< 0.001
Condition x Subject Sex	3, 64	7.67	0.79	NS
Trial	3, 192	83.21	21.48	< 0.0001
Condition	3, 64	21.25	2.20	< 0.10
Subject Sex	1, 64	4.06	0.42	NS
Experimenter Sex	1, 64	4.15	0.43	NS

G-6
F Values for SAM Valence Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	12, 256	12.47	1.55	NS
Condition x Experimenter Sex x Trial	12, 256	3.09	0.38	NS
Subject Sex x Experimenter Sex x Trial	4, 256	6.98	0.87	NS
Condition x Subject Sex x Trial	12, 256	5.03	0.62	NS
Condition x Subject Sex x Experimenter Sex	3, 64	17.67	1.10	NS
Condition x Trial	12, 256	88.08	10.95	< .0001
Subject Sex x Trial	4, 256	11.57	1.44	NS
Experimenter Sex x Trial	4, 256	2.53	0.32	NS
Condition x Experimenter Sex	3, 64	4.79	0.30	NS
Subject Sex x Experimenter Sex	1, 64	9.88	0.61	NS
Condition x Subject Sex	3, 64	6.01	0.37	NS
Trial	4, 256	585.87	72.84	< .0001
Condition	3, 64	114.73	7.12	< .0005
Subject Sex	1, 64	17.00	1.05	NS
Experimenter Sex	1, 64	3.84	0.24	NS

G-7
F Values for SAM Arousal Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	12, 256	7.60	0.61	NS
Condition x Experimenter Sex x Trial	12, 256	7.62	0.61	NS
Subject Sex x Experimenter Sex x Trial	4, 256	21.41	1.72	NS
Condition x Subject Sex x Trial	12, 256	8.67	0.70	NS
Condition x Subject Sex x Experimenter Sex	3, 64	41.15	1.43	NS
Condition x Trial	12, 256	77.12	6.19	< .0001
Subject Sex x Trial	4, 256	3.67	0.29	NS
Experimenter Sex x Trial	4, 256	21.87	1.75	NS
Condition x Experimenter Sex	3, 64	2.65	0.09	NS
Subject Sex x Experimenter Sex	1, 64	107.10	3.72	< .10
Condition x Subject Sex	3, 64	13.86	0.48	NS
Trial	4, 256	1180.23	94.66	< .0001
Condition	3, 64	82.80	2.88	< .05
Subject Sex	1, 64	129.27	4.49	< .05
Experimenter Sex	1, 64	0.26	0.01	NS

G-8
F Values for SAM Dominance Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	12, 256	7.62	0.41	NS
Condition x Experimenter Sex x Trial	12, 256	12.90	0.70	NS
Subject Sex x Experimenter Sex x Trial	4, 256	6.22	0.34	NS
Condition x Subject Sex x Trial	12, 256	16.93	0.92	NS
Condition x Subject Sex x Experimenter Sex	3, 64	148.74	3.62	< .05
Condition x Trial	12, 256	44.97	2.44	< .01
Subject Sex x Trial	4, 256	5.40	0.29	NS
Experimenter Sex x Trial	4, 256	29.26	1.59	NS
Condition x Experimenter Sex	3, 64	34.80	0.85	NS
Subject Sex x Experimenter Sex	1, 64	12.47	0.30	NS
Condition x Subject Sex	3, 64	31.22	0.76	NS
Trial	4, 256	73.83	4.01	< .005
Condition	3, 64	91.75	2.23	< .10
Subject Sex	1, 64	41.87	1.02	NS
Experimenter Sex	1, 64	91.65	2.23	NS

G-9
F Values for EAS Anxiety Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	12, 256	1.19	0.78	NS
Condition x Experimenter Sex x Trial	12, 256	1.85	1.21	NS
Subject Sex x Experimenter Sex x Trial	4, 256	2.38	1.56	NS
Condition x Subject Sex x Trial	12, 256	3.31	2.17	< .05
Condition x Subject Sex x Experimenter Sex	3, 64	7.81	0.70	NS
Condition x Trial	12, 256	6.60	4.32	< .0001
Subject Sex x Trial	4, 256	1.26	0.83	NS
Experimenter Sex x Trial	4, 256	1.22	0.80	NS
Condition x Experimenter Sex	3, 64	9.09	0.82	NS
Subject Sex x Experimenter Sex	1, 64	15.32	1.38	NS
Condition x Subject Sex	3, 64	12.33	1.11	NS
Trial	4, 256	24.64	16.14	< .0001
Condition	3, 64	11.20	1.01	NS
Subject Sex	1, 64	1.53	0.14	NS
Experimenter Sex	1, 64	5.64	0.51	NS

G-10
F Values for EAS Fear Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	12, 256	1.39	1.34	NS
Condition x Experimenter Sex x Trial	12, 256	1.75	1.68	< .10
Subject Sex x Experimenter Sex x Trial	4, 256	2.54	2.44	< .05
Condition x Subject Sex x Trial	12, 256	2.43	2.33	< .01
Condition x Subject Sex x Experimenter Sex	3, 64	2.39	0.46	NS
Condition x Trial	12, 256	4.16	3.99	< .0001
Subject Sex x Trial	4, 256	1.49	1.43	NS
Experimenter Sex x Trial	4, 256	1.14	1.10	NS
Condition x Experimenter Sex	3, 64	0.82	0.16	NS
Subject Sex x Experimenter Sex	1, 64	14.61	2.83	< .10
Condition x Subject Sex	3, 64	4.25	0.82	NS
Trial	4, 256	17.00	16.31	< .0001
Condition	3, 64	5.49	1.06	NS
Subject Sex	1, 64	5.60	1.09	NS
Experimenter Sex	1, 64	8.21	1.59	NS

G-11
F Values for EAS Happiness Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	12, 256	0.46	0.24	NS
Condition x Experimenter Sex x Trial	12, 256	0.80	0.41	NS
Subject Sex x Experimenter Sex x Trial	4, 256	1.28	0.65	NS
Condition x Subject Sex x Trial	12, 256	1.26	0.65	NS
Condition x Subject Sex x Experimenter Sex	3, 64	4.57	0.63	NS
Condition x Trial	12, 256	18.96	9.71	< .0001
Subject Sex x Trial	4, 256	10.96	5.61	< .0005
Experimenter Sex x Trial	4, 256	1.28	0.65	NS
Condition x Experimenter Sex	3, 64	1.43	0.20	NS
Subject Sex x Experimenter Sex	1, 64	13.45	1.86	NS
Condition x Subject Sex	3, 64	4.03	0.56	NS
Trial	4, 256	99.47	50.94	< .0001
Condition	3, 64	26.87	3.72	< .05
Subject Sex	1, 64	24.63	3.41	< .10
Experimenter Sex	1, 64	2.41	0.33	NS

G-12
F Values for EAS Sadness Analyses

Source	Degrees of Freedom	Mean Square	F	p
Condition x Subject Sex x Experimenter Sex x Trial	12, 256	1.26	1.41	NS
Condition x Experimenter Sex x Trial	12, 256	0.91	1.02	NS
Subject Sex x Experimenter Sex x Trial	4, 256	1.60	1.79	NS
Condition x Subject Sex x Trial	12, 256	1.74	1.94	< .05
Condition x Subject Sex x Experimenter Sex	3, 64	3.58	0.79	NS
Condition x Trial	12, 256	11.27	12.60	< .0001
Subject Sex x Trial	4, 256	1.01	1.13	NS
Experimenter Sex x Trial	4, 256	1.61	1.80	NS
Condition x Experimenter Sex	3, 64	0.39	0.09	NS
Subject Sex x Experimenter Sex	1, 64	13.28	2.94	< .10
Condition x Subject Sex	3, 64	3.69	0.82	NS
Trial	4, 256	24.18	27.04	< .0001
Condition	3, 64	14.08	3.12	< .05
Subject Sex	1, 64	1.47	0.32	NS
Experimenter Sex	1, 64	12.50	2.77	NS

Footnotes

[1]For the purposes of the present document, sex will refer to biologically-based, physical sexual attributes. Gender will refer to the influence of socialization and learning sex roles. Furthermore, it is recognized that sex and gender are conceptually confounded, therefore terminology clearly noting "differences" may be inaccurate. For these reasons, attempts were made to improve upon sex and gender related terminology in this paper (Deaux, 1993; Gentile, 1993; Unger & Crawford, 1993).

[2]Suffering (Cassell, 1982) was defined as "a state of severe distress associated with events that threaten intactness of the person. It occurs when an impending destruction of the person is perceived; [and] . . . continues until the threat . . . has passed" (p. 640).

Table 1

Intercorrelations among the Three Systems of Data

	Physiology			Verbal Report						
				SAM			EAS			
	Heart Rate	Corrugator EMG	Trapezius EMG	Valence	Arousal	Dominance	Anxiety	Fear	Happiness	Sadness
Overt Behavior										
Pain Tolerance	0.15	0.22*	-0.13	0.14	0.00	0.13	-0.09	-0.18	0.04	-0.14
Physiology										
Heart Rate		0.25*	0.08	0.04	0.30**	0.01	-0.04	-0.09	0.17	0.00
Corrugator EMG			-0.25*	0.11	0.15	0.12	0.05	0.05	0.08	0.04
Trapezius EMG				-0.13	0.19	-0.23*	-0.07	-0.15	-0.10	-0.05
Verbal Report										
SAM										
Valence					-0.14	0.54***	-0.45***	-0.19	0.28**	-0.46***
Arousal						-0.15	0.35***	0.19	-0.01	0.24*
Dominance							-0.41***	-0.25*	0.11	-0.40***
EAS										
Anxiety								0.58***	-0.16	0.65***
Fear									-0.08	0.51***
Happy										-0.07

*p<.05. **p<.01. ***p<.001.

Table 2
Means (Standard Deviations)
for Pain Tolerance Times

Condition	Pain Task 1	Pain Task 2
Anxiety	91.3 (61.2)	73.9 (10.4)
Depression	80.3 (55.9)	53.3 (35.4)
Elation	55.5 (33.3)	57.2 (51.3)
Neutral	82.7 (68.5)	85.4 (65.8)

Figure Captions

Figure 1. Mean pain tolerance time across trials for each condition after nonparametric conversion. Pain tolerance data were transformed into ranks and a nonparametric ANOVA performed on the ranks (i.e., Kruskal-Wallis test). Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 2. Adjusted cardiac response means across the first and second pain trials for each condition and subject sex grouping. The second baseline was used as a covariate. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 3. Corrugator EMG response across trials for experimenter sex. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 4. Corrugator EMG response across trials for each condition. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 5. Trapezius EMG response across trials. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 6. SAM Valence ratings across trials for each condition. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 7. SAM Arousal ratings across trials for each condition. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 8. SAM Dominance ratings across trials for each condition. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 9. EAS Anxiety visual analog ratings across trials for each condition by subject sex group. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 10. EAS Fear visual analog ratings across trials for each condition by subject sex group. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

Figure 11. EAS Fear visual analog ratings across trials for each subject by experimenter sex category. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

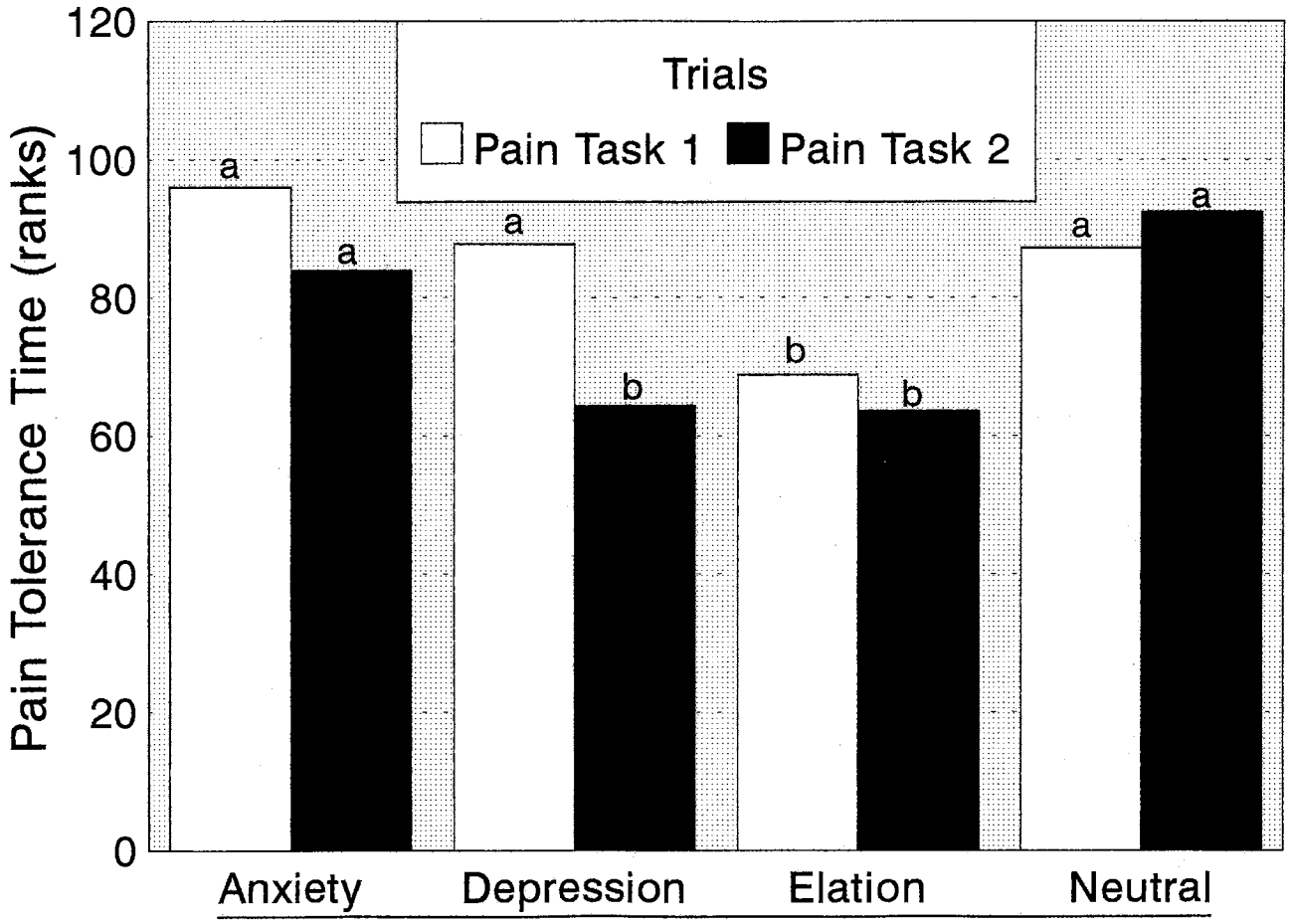
Figure 12. EAS Fear visual analog ratings across trials for each condition by experimenter sex group. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

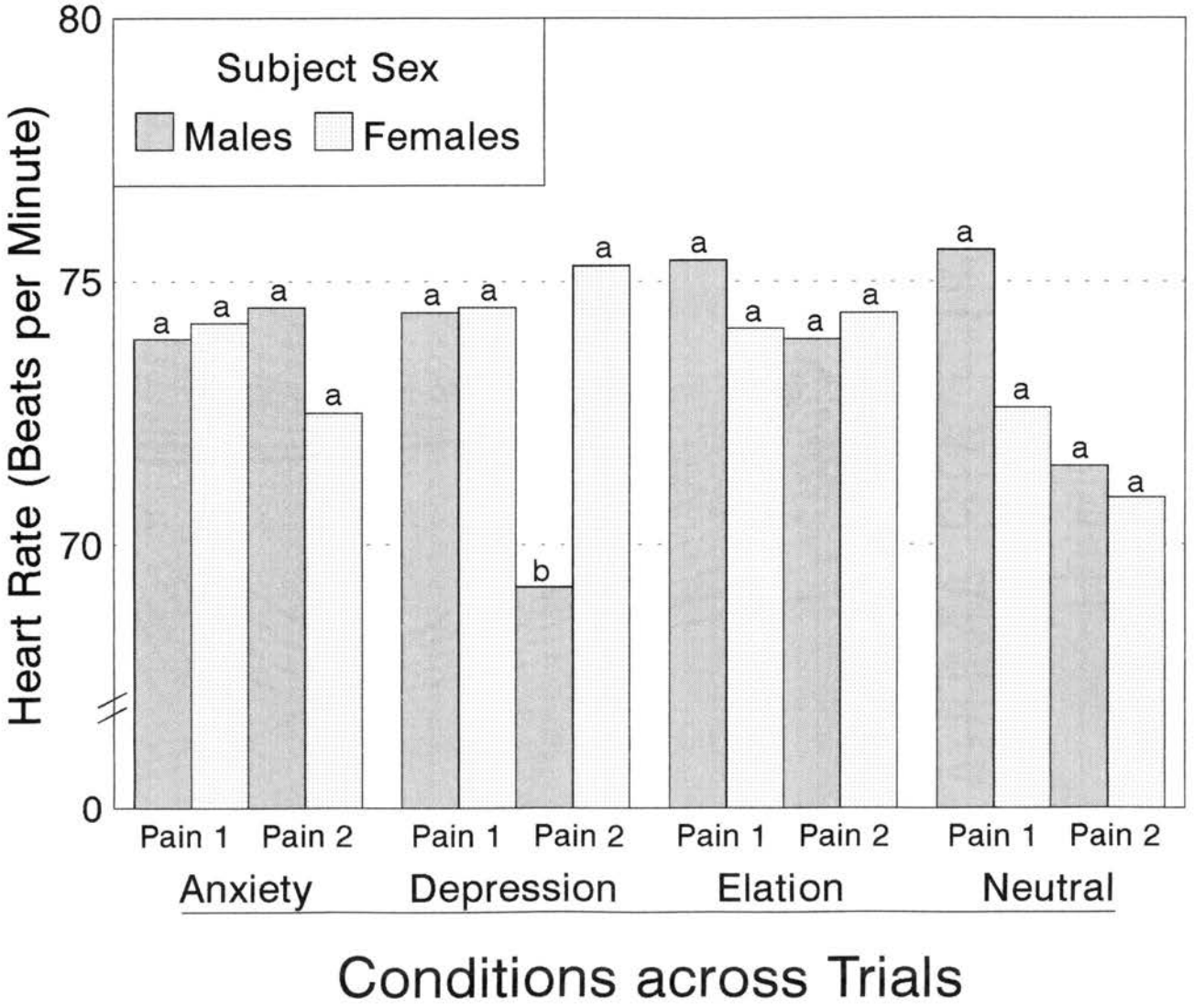
Figure 13. EAS Happiness visual analog ratings across trials for each condition. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

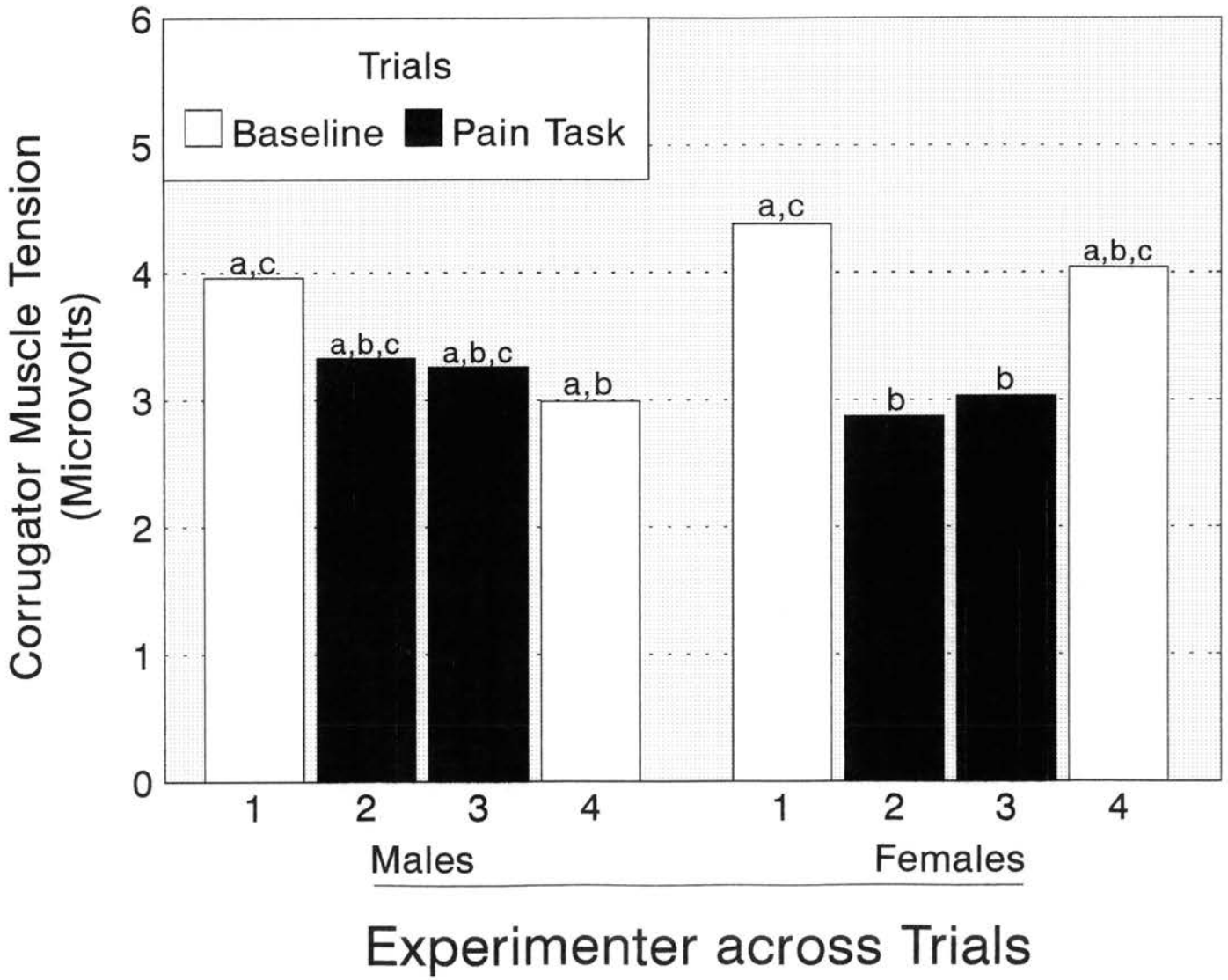
Figure 14. EAS Happiness visual analog ratings across trials for each subject sex category. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

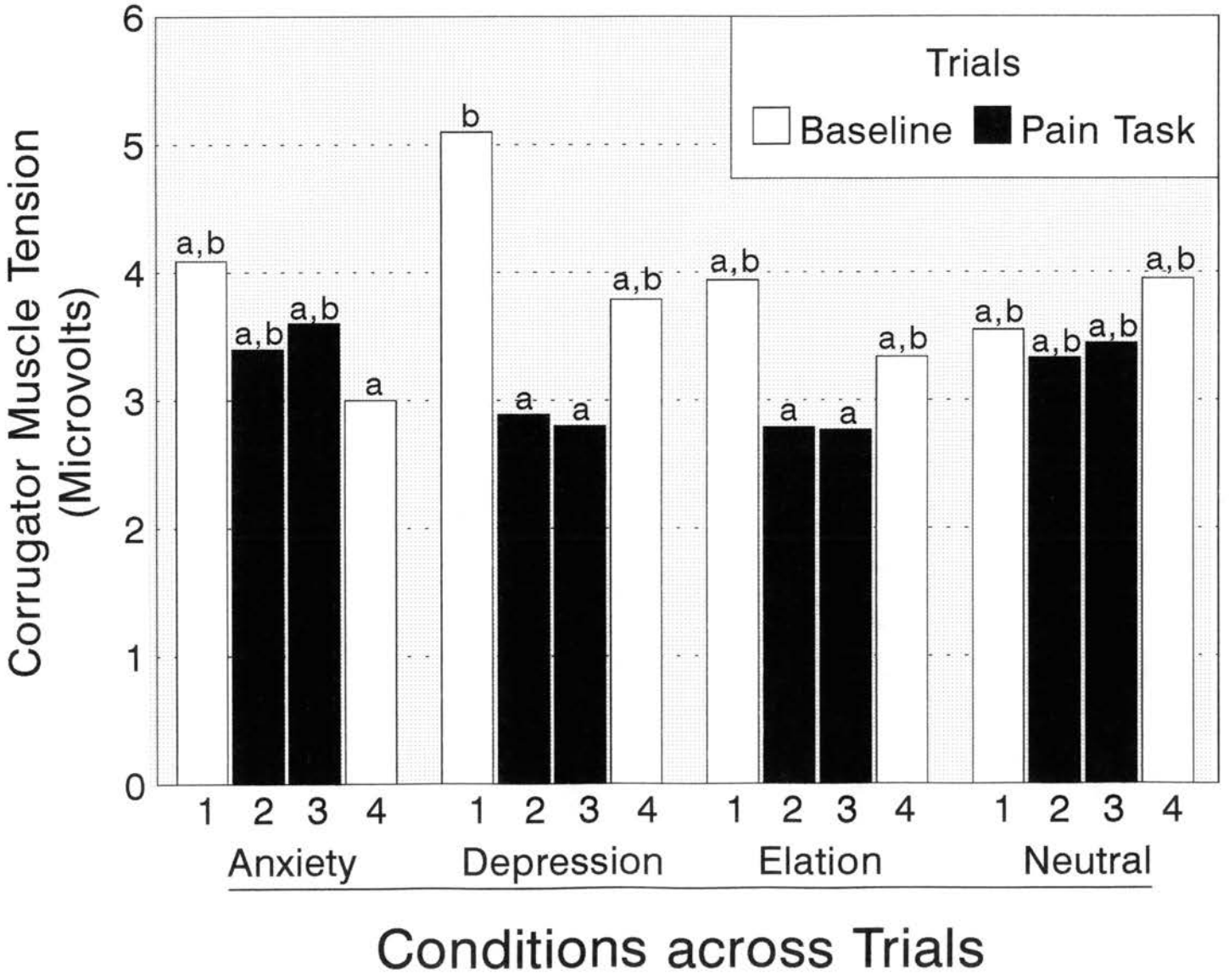
Figure 15. EAS Sadness visual analog ratings across trials for each condition by subject sex group. Bars that do not share superscripts are significantly different at or beyond $p < .05$.

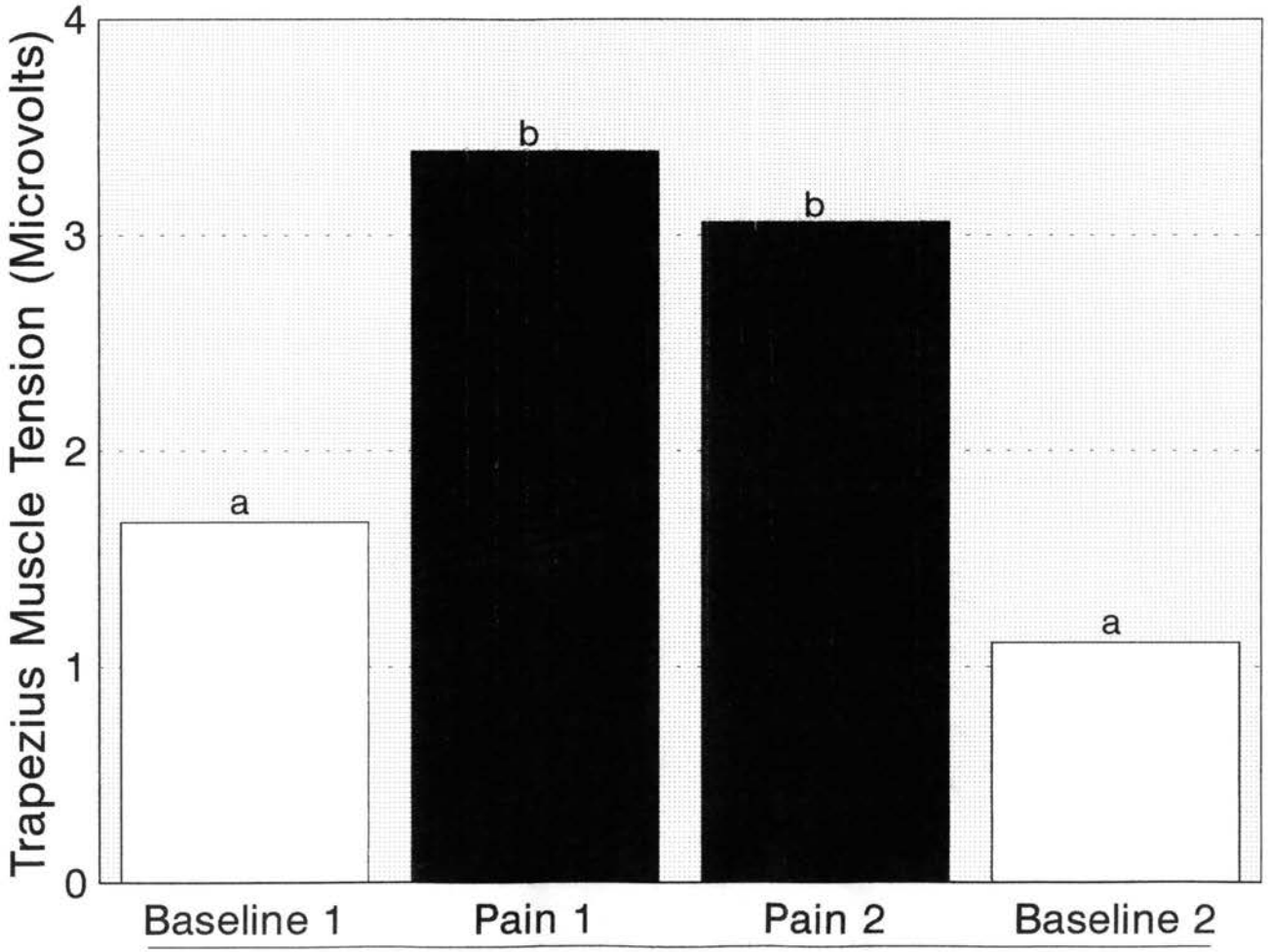
Figure 16. Change in pain severity ratings (pain 2 - pain 1) over time for each condition. Positive rating change values are indicative of higher pain severity ratings on the second pain trial. Significant differences are present only for the 15 s and 30 s intervals.

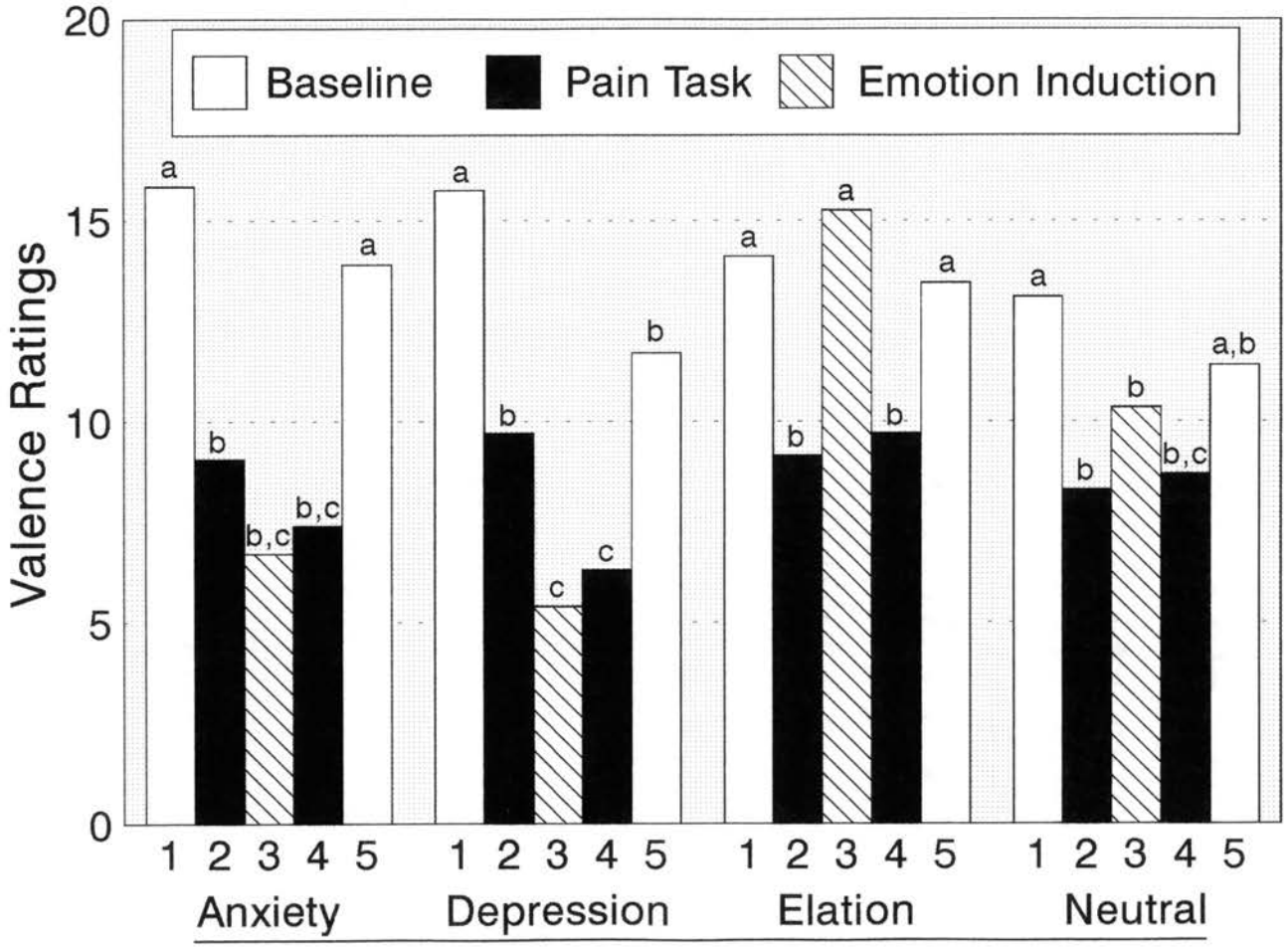

Trials
Pain Task 1
Pain Task 2
Pain Tolerance Time (ranks)
120
100
80
60
40
20
0
a
a
a
b
b
b
a
a
Anxiety
Depression
Elation
Neutral
Conditions
(after nonparametric conversion)

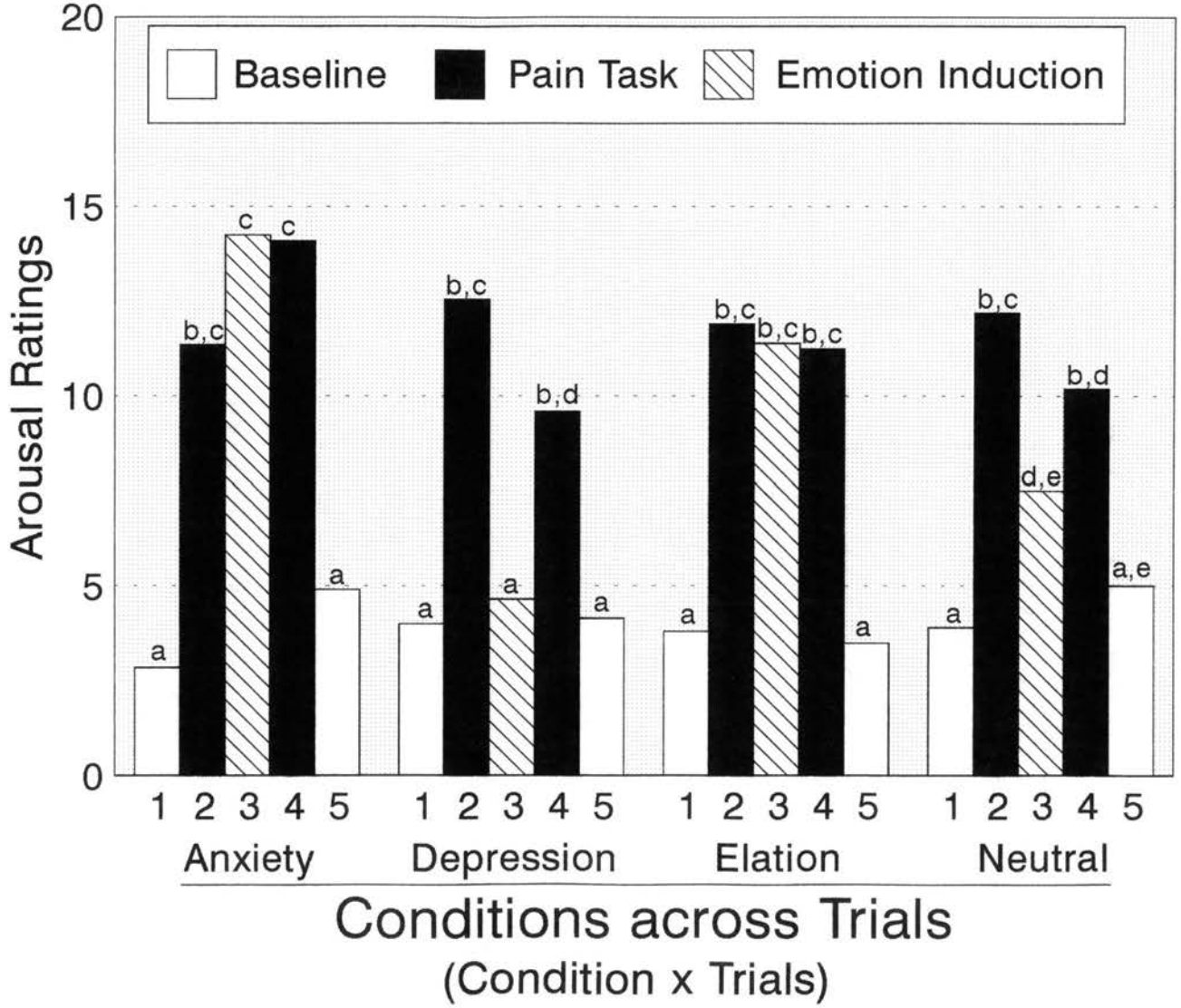

80
75
70
0
Heart Rate (Beats per Minute)
Subject Sex
Males
Females
a a a a
a a b a
a a a a
a a a a
Pain 1 Pain 2 Pain 1 Pain 2 Pain 1 Pain 2 Pain 1 Pain 2
Anxiety
Depression
Elation
Neutral
Conditions across Trials

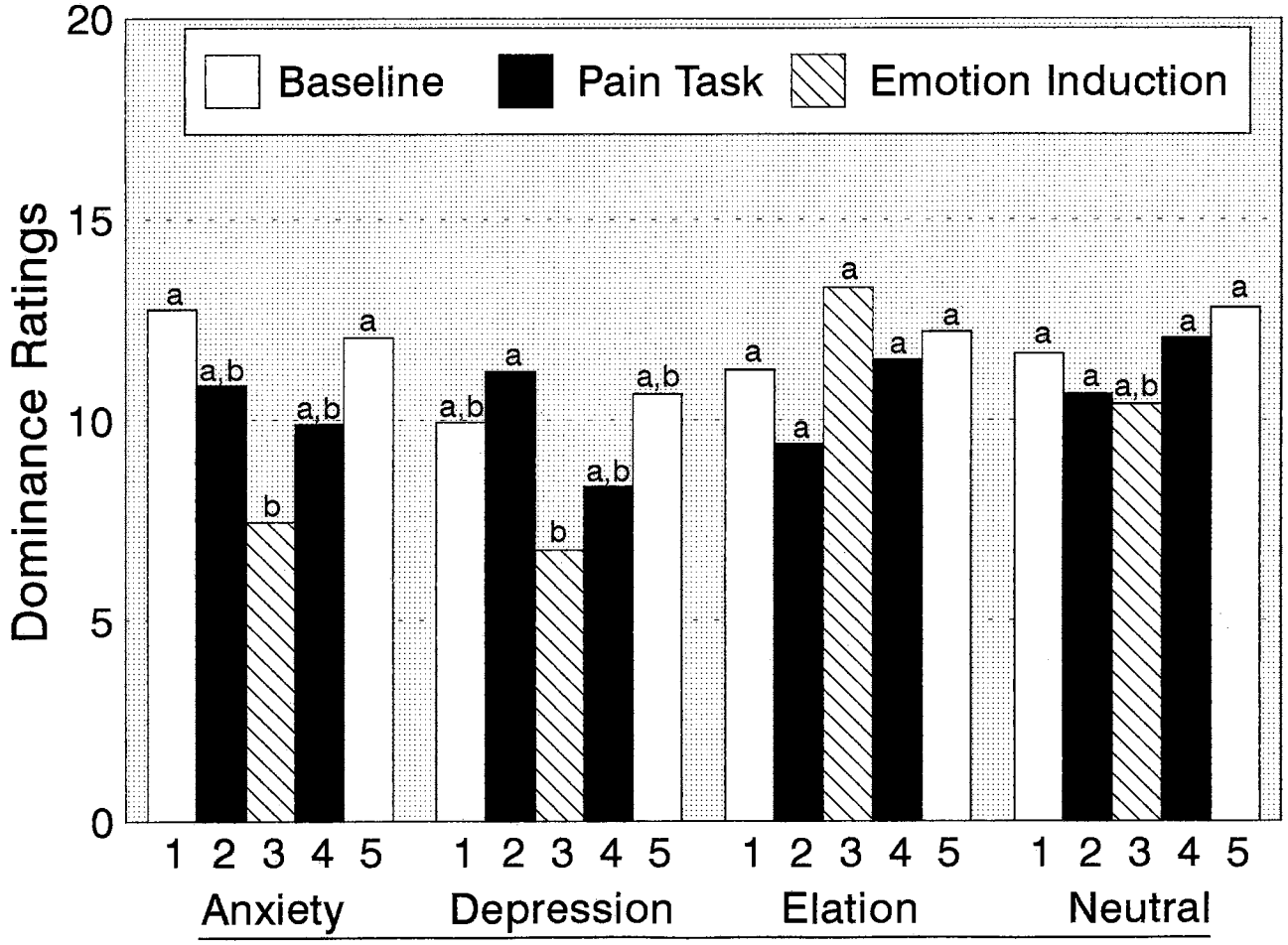

Trials
Baseline
Pain Task
Corrugator Muscle Tension (Microvolts)
0
1
2
3
4
5
6
a,c
a,b,c
a,b,c
a,b
a,c
b
b
a,b,c
1
2
3
4
1
2
3
4
Males
Females
Experimenter across Trials

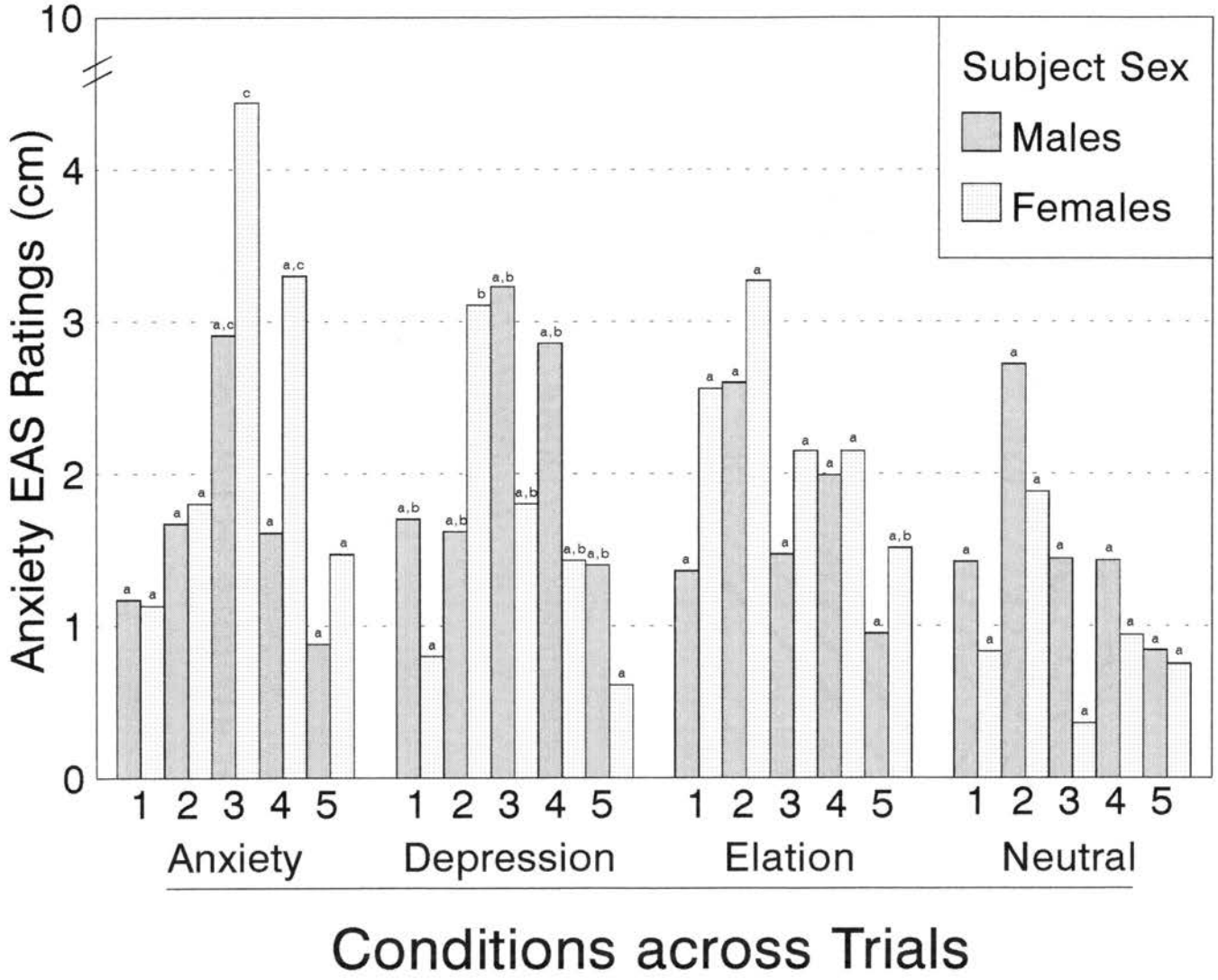

Trials
Baseline
Pain Task
Corrugator Muscle Tension (Microvolts)
0
1
2
3
4
5
6
a,b
a,b
a,b
a
b
a
a
a,b
a,b
a
a
a,b
a,b
a,b
a,b
a,b
1 2 3 4
Anxiety
Depression
Elation
Neutral
Conditions across Trials

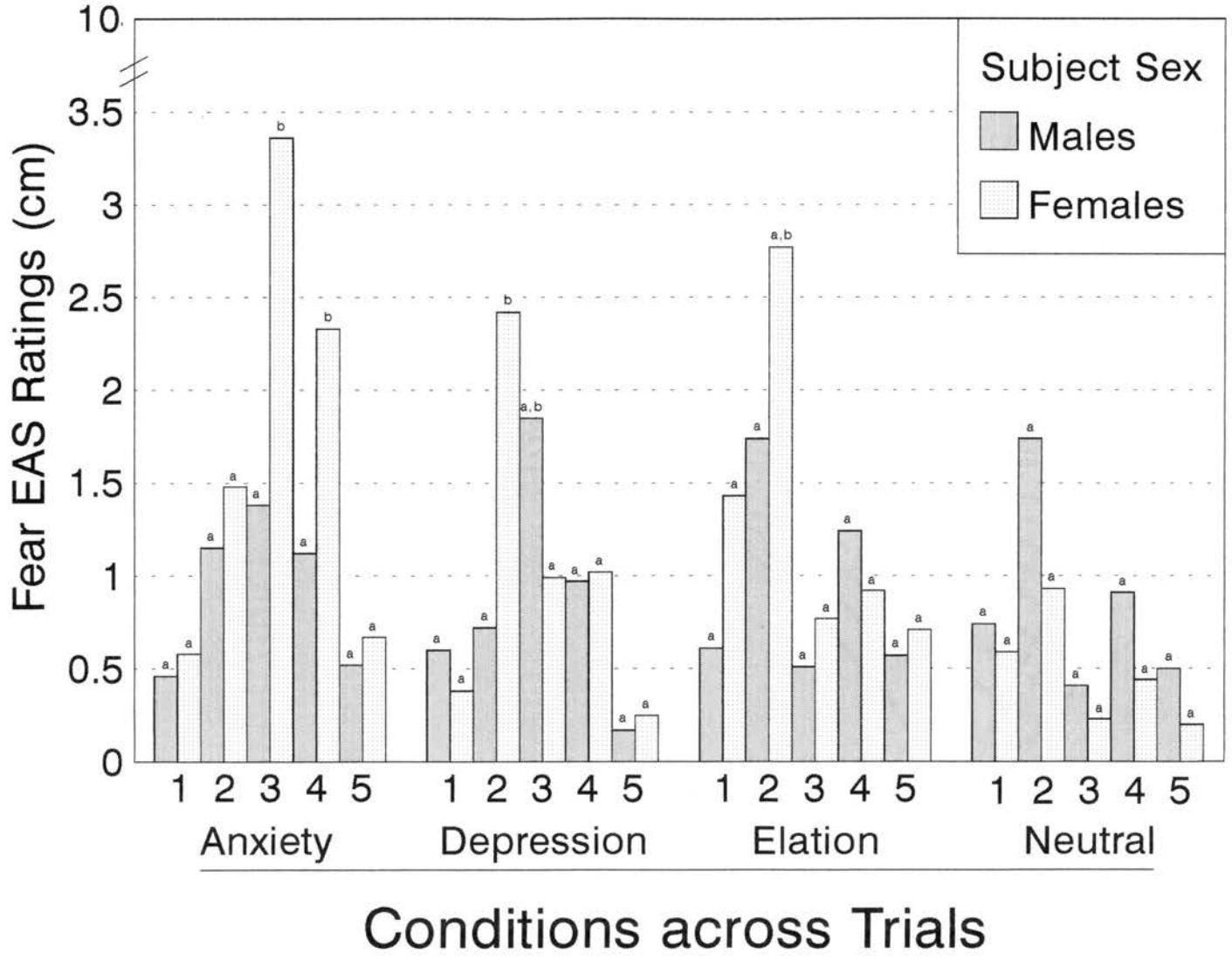

Trapezius Muscle Tension (Microvolts)
4
3
2
1
0
a
b
b
a
Baseline 1
Pain 1
Pain 2
Baseline 2
Trials


20
15
10
5
0
Valence Ratings
Baseline
Pain Task
Emotion Induction
a
b
b,c
b,c
a
a
b
c
c
b
a
b
a
b
a
a
b
b
b,c
a,b
1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
Anxiety
Depression
Elation
Neutral
Conditions across Trials
(Condition x Trials)

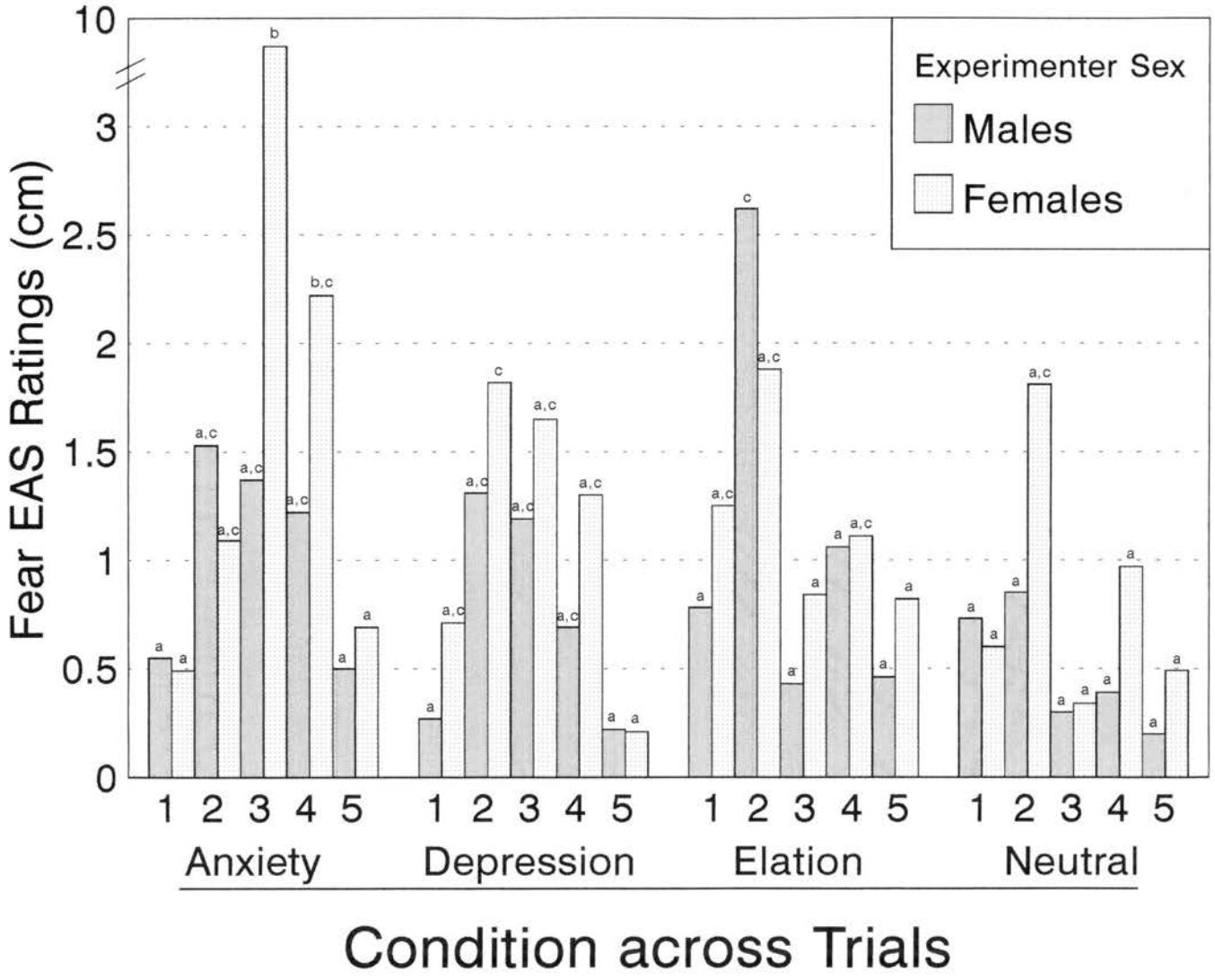

Baseline
Pain Task
Emotion Induction
Arousal Ratings
20
15
10
5
0
a
b,c
c
c
a
a
b,c
a
b,d
a
a
b,c
b,c
b,c
a
a
b,c
d,e
b,d
a,e
1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
Anxiety
Depression
Elation
Neutral
Conditions across Trials
(Condition x Trials)

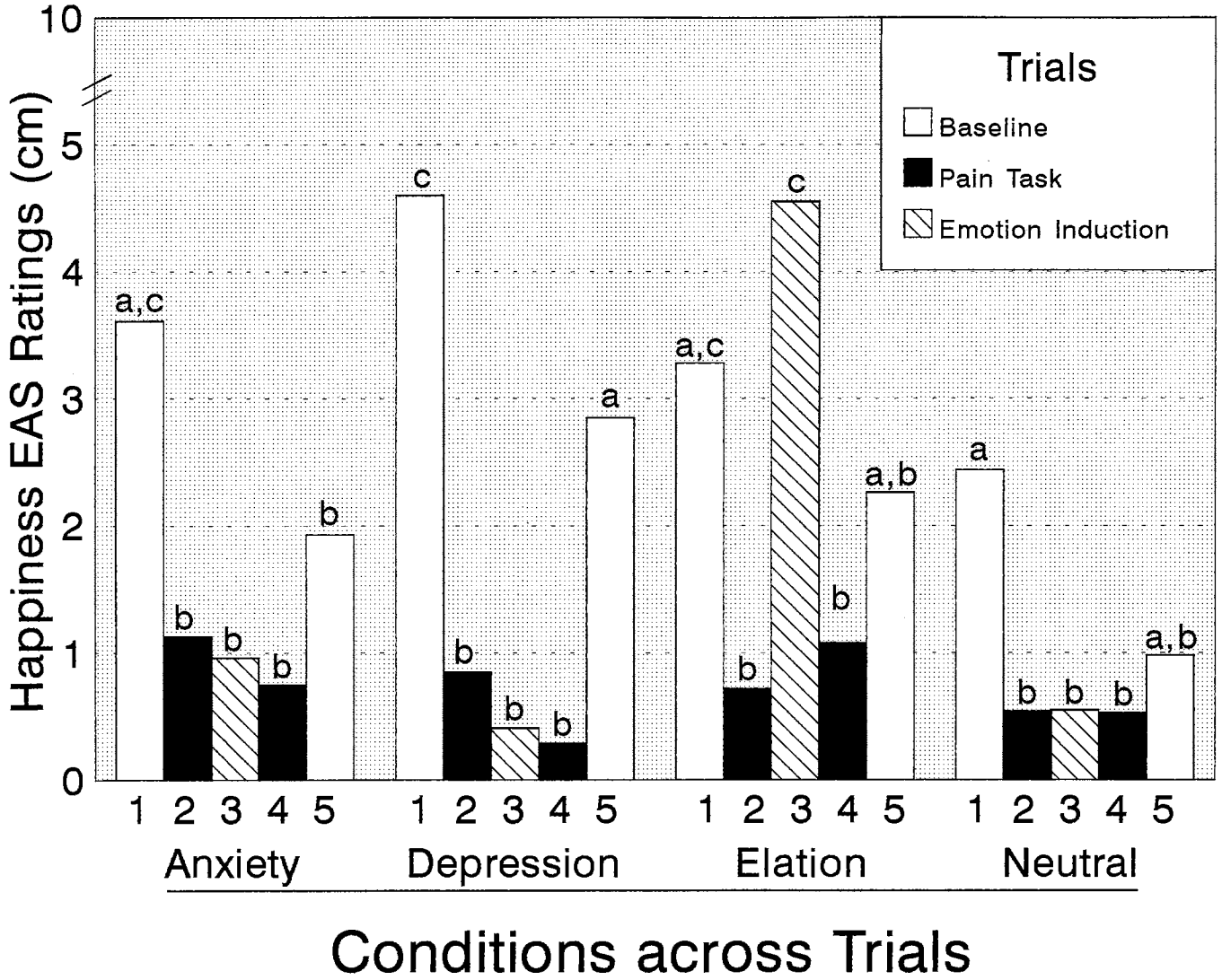

Baseline
Pain Task
Emotion Induction
Dominance Ratings
20
15
10
5
0
a
a,b
b
a,b
a
a,b
a
b
a,b
a,b
a
a
a
a
a
a
a,b
a
a
a
a,b
a
1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
Anxiety
Depression
Elation
Neutral
Conditions across Trials
(Condition x Trials)

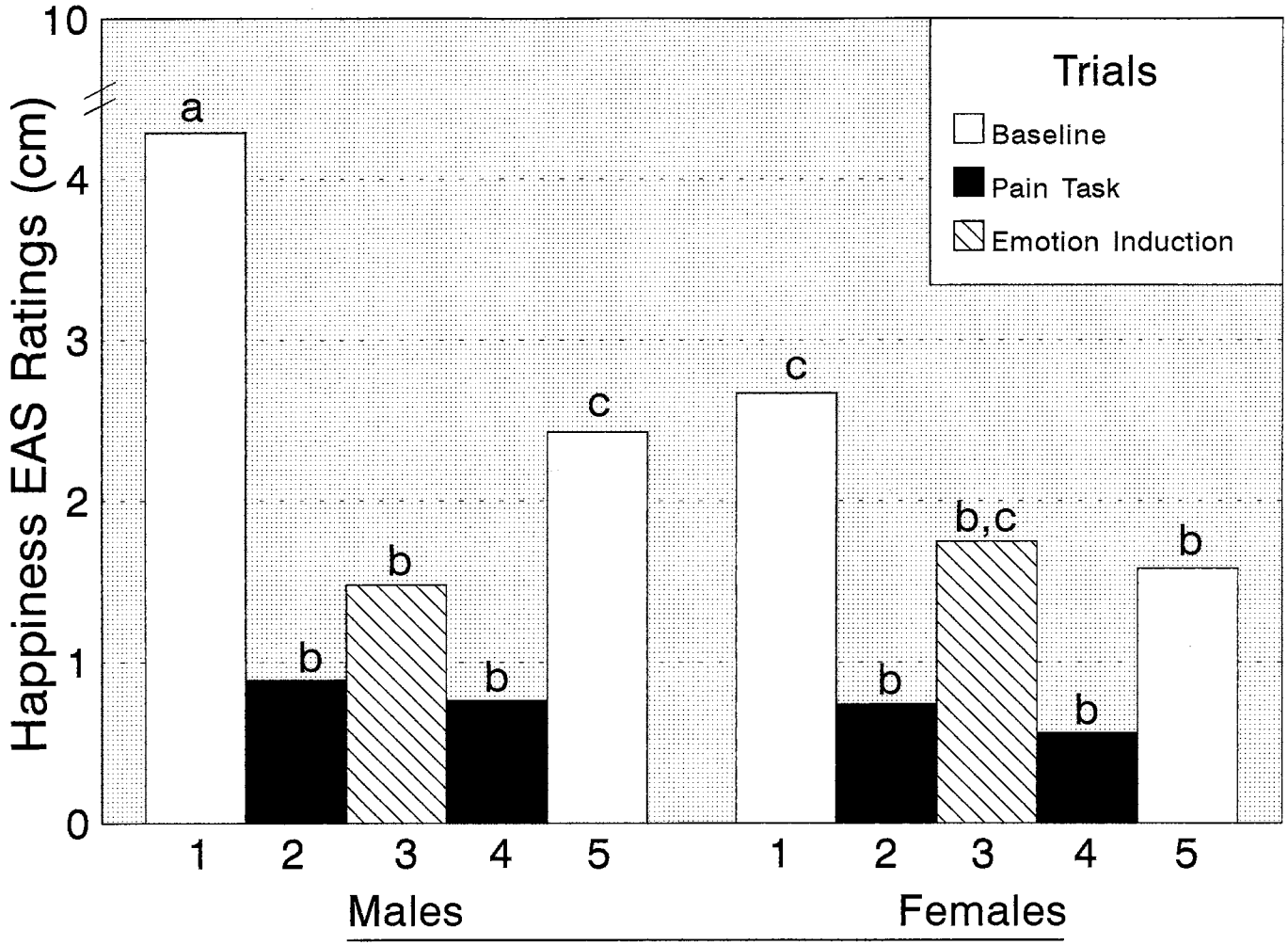

Anxiety EAS Ratings (cm)
10
4
3
2
1
0
Subject Sex
Males
Females
1 2 3 4 5
Anxiety
Depression
Elation
Neutral
Conditions across Trials

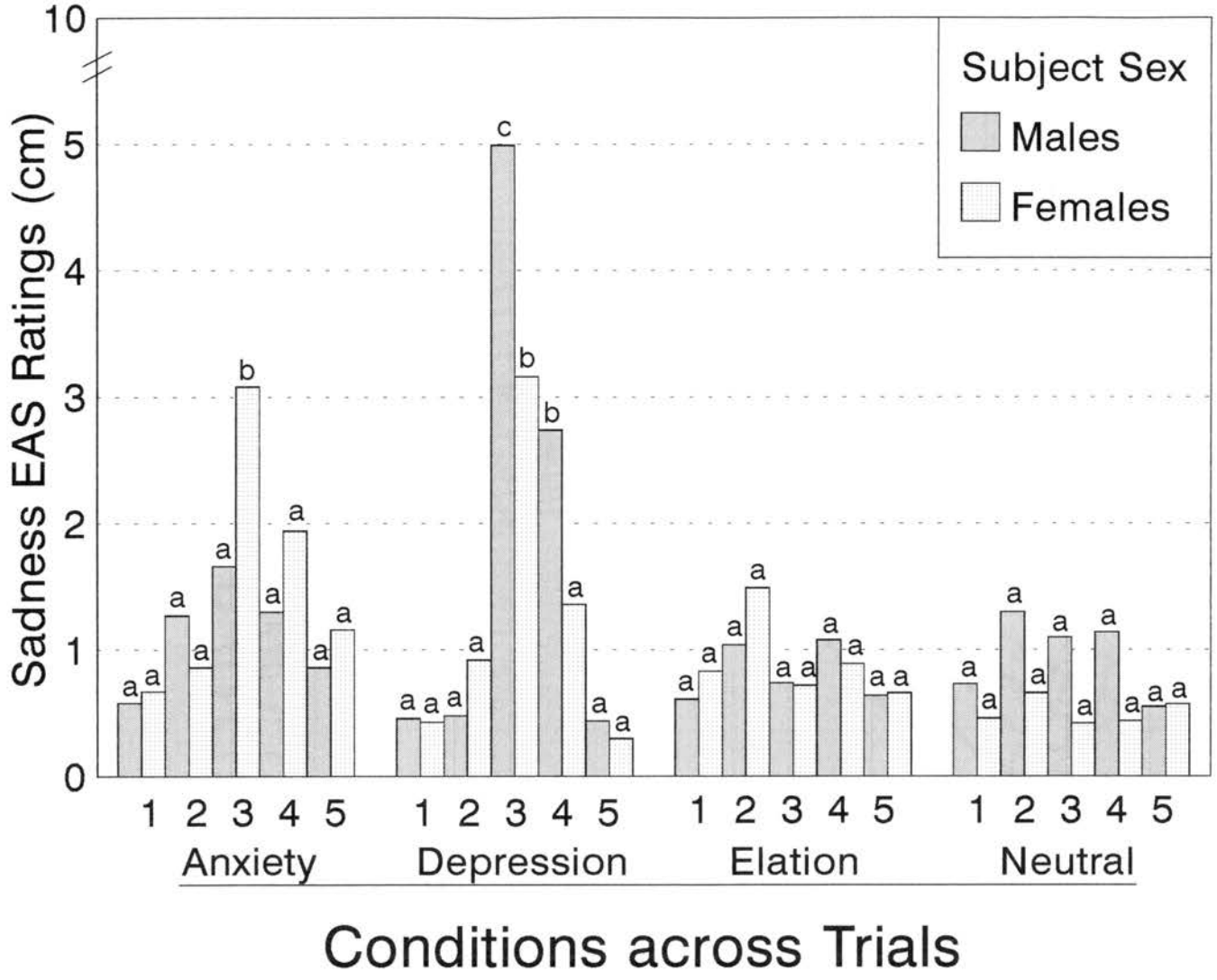

Fear EAS Ratings (cm)
10
3.5
3
2.5
2
1.5
1
0.5
0
Subject Sex
Males
Females
1 2 3 4 5
Anxiety
Depression
Elation
Neutral
Conditions across Trials

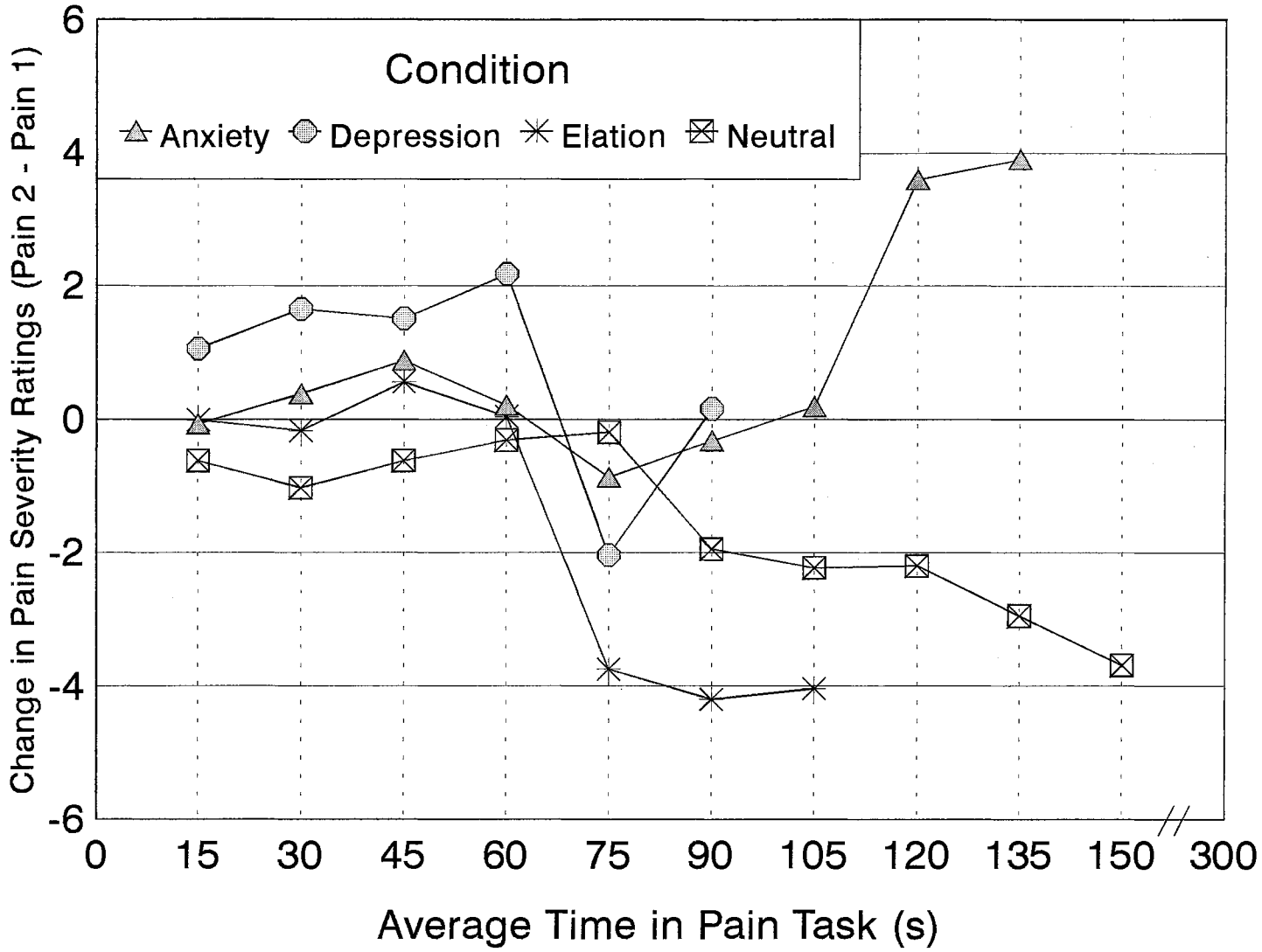

Subject Sex
Males
Females
Fear EAS Ratings (cm)
10
2.5
2
1.5
1
0.5
0
a
a
a,b
a,b
a
a,b
a
a
a
a
b
b
a
a
b
a
b
a
a
1
2
3
4
5
1
2
3
4
5
Males
Females
Experimenter across Trials


Fear EAS Ratings (cm)
10
3
2.5
2
1.5
1
0.5
0
Experimenter Sex
Males
Females
1 2 3 4 5
Anxiety
Depression
Elation
Neutral
Condition across Trials


Happiness EAS Ratings (cm)
10
5
4
3
2
1
0
Trials
Baseline
Pain Task
Emotion Induction
a,c
b
b
b
b
c
b
b
b
a
a,c
b
c
b
a,b
a
b
b
b
a,b
1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
1 2 3 4 5
Anxiety
Depression
Elation
Neutral
Conditions across Trials


Happiness EAS Ratings (cm)
10
4
3
2
1
0
Trials
Baseline
Pain Task
Emotion Induction
a
b
b
b
c
c
b
b
b,c
b
1
2
3
4
5
1
2
3
4
5
Males
Females
Subject Sex across Trials


Subject Sex
Males
Females
Sadness EAS Ratings (cm)
10
5
4
3
2
1
0
1 2 3 4 5
Anxiety
Depression
Elation
Neutral
Conditions across Trials


Condition
Anxiety
Depression
Elation
Neutral
Change in Pain Severity Ratings (Pain 2 - Pain 1)
6
4
2
0
-2
-4
-6
0
15
30
45
60
75
90
105
120
135
150
300
Average Time in Pain Task (s)

VITA

Leslie E. Carter

Candidate for the Degree of

Doctor of Philosophy

Thesis: EFFECTS OF EMOTION ON PAIN REPORTS, TOLERANCE, AND PHYSIOLOGY

Major Field: Clinical Psychology

Biography:

Personal Data: Born in Portland, Oregon, November 4, 1961, the daughter of Beverly and William Eppick.

Education: Graduated from Newberg High School in May of 1979, Newberg, Oregon; received a Bachelor of Arts Degree in Psychology from Whitman College in May of 1984, Walla Walla, Washington; received a Master of Science Degree from Oklahoma State University in December of 1990; completed requirements for the Doctor of Philosophy Degree at Oklahoma State University in December, 1994.

Professional Experience: Clinical Psychology Intern, University of California at San Diego, July, 1993 - June, 1994; Research Associate, Anxiety and Psychophysiology Research Laboratory, Oklahoma State University, Department of Psychology, August, 1989 - June, 1993; Rehabilitation Counselor, Jim Thorpe Rehabilitation Center, Southwestern Medical Center, Oklahoma City, July, 1992 - June 1993; Psychological Associate, Psychological Services Center, Oklahoma State University, September, 1990 - December, 1992.

Student Memberships: American Psychological Association, Association for the Advancement of Behavior Therapy, Society for Psychophysiological Research.

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
FOR HUMAN SUBJECTS RESEARCH

Proposal Title: THE EFFECT OF EMOTION ON PAIN TOLERANCE AND PHYSIOLOGY

Principal Investigator: DR. DAN MCNEIL/LESLIE CARTER

Date: AUGUST 4, 1992 IRB #AS-93-004

This application has been reviewed by the IRB and

Processed as: Exempt [ ] Expedite [ ] Full Board Review [XX]

Renewal or Continuation [ ]

Approval Status Recommended by Reviewer(s):

Approved [XX] Deferred for Revision [ ]

Approved with Provision [ ] Disapproved [ ]

Approval status subject to review by full Institutional Review Board at next meeting, 2nd and 4th Thursday of each month.

Comments, Modifications/Conditions for Approval or Reason for Deferral or Disapproval:

Signature: Marcia K. Tilley Date: AUGUST 28, 1992

Chair of Institutional Review Board