PSYCHOLOGICAL PREDICTORS OF PAIN RESPONSIVITY: EXPLAINING RACE AND SEX DIFFERENCES

by

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A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Arts in
the Department of Psychology
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2012

ABSTRACT

There are many factors used to predict pain responsivity. Both psychological and biological factors have been explored at length. The current study seeks to evaluate the unique and combined predictive power of psychological and biological factors on pain responsivity. The primary aims of this study were to 1) explore the unique contributions of primary appraisals (threat/harm and challenge), pain catastrophizing, and emotional vulnerability alongside race and sex to the pain responsivity, and 2) explore the relations between race and sex with pain responsivity, and determine if an interaction exists. Participants included 199 undergraduate students who completed a cold pressor task (CPT) and a battery of questionnaires. Regression analyses indicated that while primary appraisals, catastrophizing, and emotional vulnerability are unique constructs, pain catastrophizing continues to be the strongest, and often only, predictor of pain responsivity. This remained consistent even with the addition of race and sex to the model. MANOVA showed main effects for both race and sex on pain tolerance but no race by sex interaction emerged. Mediation analyses yielded information about the unique relations between the predictors that is worthy of continued exploration. Findings indicate that catastrophizing is not redundant when related to primary appraisal or personality variables and is a unique and important cognitive construct worthy of specific targeting in treatment.

LIST OF ABBREVIATIONS AND SYMBOLS

α	In statistical hypothesis testing, the probability of making a Type I error; Cronbach's index of internal consistency
β	Population values of regression coefficients
F	Fisher's *F* ratio: A ratio of two variances
M	Mean: the sum of a set of measurements divided by the number of measurements in the set
N	Statistical notation for total sample size
p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value.
ns	Non significant
r	Estimate of the Pearson product-moment correlation coefficient
R^2	Multiple correlation squared; measure of strength of association
SD	Standard deviation
Δ	Increment of change
<	Less than
=	Equal to

ACKNOWLEDGEMENTS

I would like to express my sincerest gratitude to a number of people who helped me in the journey towards the completion of this project. I would first like to thank my advisor and committee chair, Dr. Beverly Thorn, for providing support and guidance throughout the entire process and helping me manage the frustrations that come along with the logistics of any research study. I would also like to thank Dr. Phillip Gable for his patience while guiding my statistical exploration of this data and Dr. Norma Cuellar for her contributions to the organization and integration of theory into the write-up. I am particularly grateful to the undergraduate students who were involved in this study in various ways. I was very fortunate to have a team of reliable and enthusiastic undergraduate research assistants without whom this project would have taken an indefinite amount of time. I am particularly thankful for Liz Laughlin and Jason Snider who showed commitment to both the research lab and this project over the course of several semesters. I am also thankful to all of the subject pool participants who endured a painful (albeit harmless) experience to further our understanding of the pain experience. They will likely never understand their own unique contribution to the world of science. I would like to thank my friends and colleagues who not only supported me throughout this entire process but provided levity and perspective in a way I could not have managed on my own. Finally, I would like to thank my father; words cannot describe how important your role in this process has been.

LIST OF TABLES

Introduction

The transactional model of stress outlines how cognitive appraisal of an environmental event influences coping and can be used as a framework for how cognitive factors may be associated with one's ability to cope with pain (see Appendix A for pain related definitions) (Lazarus & Folkman, 1984). There are two types of cognitive appraisals: primary and secondary. "Primary appraisal" refers to the way in which one initially interprets a stressful event. Three types of cognitive appraisals have been identified: threat, harm/loss (frequently measured together as "threat/harm"), and challenge. When a person evaluates a stressful situation as posing danger, it is classified as a "threat" appraisal. In the context of pain, threat appraisals have been found to be associated with lower pain tolerance times, increased pain severity, and in clinical samples, increased interference in daily functioning (Pence, Thorn, Day, & Shelby, 2011; Unruh & Ritchie, 1998). "Harm/loss" appraisals indicate a perception that harm has already been caused and are associated with negative emotionality (i.e. sadness, grief, etc.) (Regan, Lorig, & Thorsen, 1988). Alternately, when a person evaluates a stressful situation and concludes that his or her coping ability is greater than the perceived danger anticipated, it is classified as a "challenge" appraisal. While threat and harm/loss appraisals are considered inhibitors of effective coping, challenge appraisals are believed to facilitate coping. Challenge appraisals have been found to be associated with increased pain tolerance (Jackson et al., 2005; Pence et al., 2011; Sanford, Kersh, Thorn, Rich, & Ward, 2002; Unruh & Ritchie, 1998).

A secondary appraisal is the method in which one evaluates the feasibility and effectiveness of various coping options (Lazarus & Folkman, 1984). Catastrophic thinking, a form of secondary appraisal, refers to the degree to which an individual engages in negative pessimistic evaluations of the situation, and has also been firmly established as a predictor of

pain responsivity (France et al., 2004; Keefe et al., 2000; Keefe, Rumble, Scipio, Giordano, & Perri, 2004; Sullivan & D'Eon, 1990; Sullivan, Bishop, & Pivik, 1995; Sullivan, Stanish, Waite, Sullivan, & Tripp, 1998; Sullivan & Neish, 1999; Sullivan, Tripp, & Santor, 2000; Sullivan, Tripp, Rodgers, & Stanish, 2000). Catastrophizing has been shown to consistently have a negative effect on pain responsivity in both experimental and clinical pain studies on several dimensions: increased severity, greater functional impairment, and lower threshold and tolerance of pain (France et al., 2004; Keefe et al., 2004; Sullivan & D'Eon, 1990; Sullivan et al., 1998; Sullivan & Neish, 1999; Sullivan, Tripp, & Santor et al., 2000; Sullivan, Tripp, Rodgers et al., 2000). Catastrophizing has been linked to both race and sex; women and racial minorities are more likely to engage in catastrophic thinking (Dixon, Thorn, & Ward, 2004; Osman et al., 2000; Pence et al., 2011; Sullivan, Tripp, & Santor et al., 2000; Thorn et al., 2004). Additionally, in the case of sex, pain catastrophizing has been shown to account for the differential experience of pain and pain related behavior (Dixon et al., 2004).

Emotional vulnerability, an aspect of personality which influences affect, could help explain subjective pain differences (Thorn et al., 2004; Ward, Thorn, Clements, Dixon, & Sanford, 2006). "Emotional vulnerability" has been used to identify personality traits which predispose one towards unstable affect (Spence & Helmreich, 1978; Ward et al., 2006). This term emerged from the use of a psychological measure of personality, the Personal Attributes Questionnaire (PAQ) which consists of five factors which evaluate emotionality, dependency, and interpersonal sensitivity (Spence & Helmreich, 1978). Emotional vulnerability has been identified as a mediator of sex differences in experimental pain tasks (Thorn et al., 2004; Ward et al., 2006).

Research indicates the presence of race and sex difference in pain. These differences exist in both clinical and experimental pain studies. Racial minorities consistently endorse higher prevalence of acute and chronic pain conditions and experience those conditions with greater severity, duration, and disability (Chibnall, Tait, Andresen, & Hadler, 2005; Creamer, Lethbridge, & Hochberg, 1999; C. L. Edwards, Fillingim, & Keefe, 2001; R. R. Edwards, Doleys, Fillingim, & Lowery, 2001; Fillingim, 2003; Payne, Meding, & Hampton, 2003; Stewart, Lipton, & Liberman, 1996). In experimental pain studies minorities report lower pain tolerance as well as greater unpleasantness (C. L. Edwards & Fillingim, 1999; Klatzkin, Mechlin, Bunevicius, & Girdler, 2007; Pence et al., 2011). However, pain intensity, the pain responsivity variable ostensibly least associated with psychological mechanisms, has not been shown to vary across race in experimental pain studies (C. L. Edwards & Fillingim, 1999; R. R. Edwards, Moric, Husfeldt, Buvanendran, & Ivankovich, 2005; J. L. Riley et al., 2002). Like minorities, women are at a greater risk for experiencing acute and chronic pain conditions and to report greater duration and interference in daily functioning from pain than men (Keefe et al., 2000; Lander, Foewler-Kerry, & Hill, 1990; Taenzer, Clark, & Curry, 2000; Unruh, 1996). Women also have lower tolerance times and rate pain as more unpleasant than men (Dixon et al., 2004; J. L. Riley, Robinson, Wise, Myers, & Fillingim, 1998). However, unlike minorities, experimental pain studies have shown a sex-difference for pain intensity (J. L. Riley et al., 1998; Sanford et al., 2002).

Current Study

The proposed study sought to build on previous research evaluating the role of both biological predictors of pain (e.g. race and sex) and psychological predictors of pain (e.g.

primary appraisals, catastrophizing, and emotional vulnerability). Specifically, this study extended the methodology of Pence, et al (2011), in an effort to determine whether a race by sex interaction on pain responsivity is present. Further, while other studies have explored the relationship between psychological variables like primary appraisals and catastrophizing (e.g., Pence et al., 2011), no study to date has explored the role of these factors combined with the personality factor emotional vulnerability. This study evaluated the role of all of these predictors (primary appraisals, catastrophizing, and emotional vulnerability) together to determine which predictors are most influential in the pain experience, thus extending the inquiry begun by Pence et al., (2011).

The first study hypothesis was that catastrophizing, primary appraisals, and emotional vulnerability would each be correlated with the pain responsivity variables (intensity, unpleasantness, and tolerance). Second, it was hypothesized that together these predictors (catastrophizing, primary appraisals, and emotional vulnerability) would explain a significant portion of the observed race and sex differences in pain responsivity. Further, the unique contribution of each of these variables on pain responsivity was explored.

Third, it was hypothesized that different racial groups (African-Americans and Caucasians in this study) would show different pain responsiveness on two dependent variables: tolerance (duration in seconds in the cold pressor task; CPT) and unpleasantness ratings on the Visual Analog Scale (VAS). Fourth, it was hypothesized that different sex groups (male and female) would report different pain responsivity on three dependent variables: tolerance (duration in seconds in the CPT), unpleasantness ratings on the VAS, and intensity ratings on the

VAS. Fifth, it was hypothesized that there would be an interaction effect when sex and race were used as independent variables to predict pain responsivity.

Method

Setting and Participants

This study was approved by the Institutional Review Board of The University of Alabama where the study was conducted (see Appendix B for approval letter). Participants were 199 undergraduate students currently enrolled in an introductory psychology course. All participants provided written informed consent. Students were recruited via the online subject pool website and received one credit towards their research participation requirement in Psychology 101. Exclusionary criteria for this study included: previous participation in a CPT, pregnancy, cardiovascular disease, hypertension, fainting spells, high blood pressure, diabetes, Reynaud's disease, Sickle Cell disease, seizure disorder, chronic pain, current use of pain medication, currently under psychiatric care, skin allergy or excessive bruising, and having not eaten yet that day.

Apparatus

This CPT used Thermo Scientific's Neslab RTE Series refrigerated bath. It consists of a basin that contains chilled water which is constantly circulated allowing it to maintain its temperature at 2º C without freezing and a ledge that allows a participant to submerge his/her hand and forearm into the chilled water while resting the remaining part of his/her arm on the outside of the apparatus.

Measures

Pain Catastrophizing Scale. The Pain Catastrophizing Scale (PCS) is a 13-item measure used to determine the degree of catastrophic thinking participants engage in as a

response to pain (Osman et al., 2000; Sullivan et al., 1995). Participants rate each item on a five point scale ranging from not at all (0) to all the time (4). Items are summed to obtain total PCS scores ranging from 0 to 52 and subscale scores: rumination, magnification of negative experience, and helplessness. People who score above 24 are considered "catastrophizers" (Sullivan et al., 1995). The questionnaire was given twice in an effort to assess catastrophizing in two ways. The first PCS (PCS1; Appendix C) instructed participants to "indicate the degree to which you have these thoughts and feelings when you experience pain." This standard administration of the PCS1 is intended to assess one's proclivity for catastrophic thinking in the presence of pain thus facilitating the trait-based evaluation of cognitions associated with pain experiences in general. The second PCS (PCS2; Appendix D) was administered following the second CPT immersion and instructed participants to "answer these questions as they relate to the pain you just experienced when your arm was submerged in the ice water." The PCS2 allows for a state-based evaluation of cognitions associated with a specific pain experience, which has been shown to be more predictive of experimental pain responsivity than the traditional (trait-based) method of administration (Dixon et al., 2004). For the purposes of this study, pain catastrophizing (CAT) was measured by PCS2 scores. The PCS has been shown to have good internal consistency (Cronbach's $\alpha = .91$) among chronic pain patients in the Netherlands as well as good test-retest reliability ($r = .78$) across a six-week period in a student population (Sullivan et al., 1995; Van Damme, Crombez, Bijttebier, Goubert, & Van Houdenhove, 2002). In the current study, the Cronbach alpha coefficient for the PCS1 was .90 and .93 for the PCS2.

Emotional Vulnerability. Emotional vulnerability (EMV) was evaluated with the revised Personal Attributes Questionnaire (PAQ; Appendix E) is a 24-item measure used to

evaluate a number of personality factors including "emotional vulnerability" (Ward et al., 2006). Emotional vulnerability can be characterized by emotional instability and dependency. This questionnaire seeks to evaluate personality on a trait-based scale, i.e., how participants view themselves in general. Participants were asked to "choose a letter, which describes where YOU fall on the scale." For the purposes of this study, only the Emotional Vulnerability scale of the PAQ was evaluated (items 5, 13, 14, 18, and 23). This scale has been shown to have adequate internal consistency (Cronbach's α = .73) (Ward et al., 2006). In the current study, the Cronbach alpha was .66.

Pain Intensity and Pain Unpleasantness. The Visual Analog Scale (VAS; Appendix F) consists of two 10 centimeter lines on which participants rate their pain intensity and pain unpleasantness ratings between two anchors: "no pain" and "Pain as bad as it can be" for intensity and "not at all unpleasant" and "extremely unpleasant" for unpleasantness (Price, McGrath, Rafii, & Buckingham, 1983). The VAS has been shown to be a valid and reliable measure of pain intensity and unpleasantness in both experimental and clinical pain studies (Price et al., 1983). This measure was administered following each CPT and will be referred to as VAS1 and VAS2.

Pain Tolerance. Pain tolerance levels were measured by the amount of time (in seconds) between the submersion of the participant's hand in the cold pressor basin and the participant's removal of his or her hand from the water. Tolerance times for the first and second CPT trials will be referred to as TOL1 and TOL2.

Pain Appraisal Inventory. The Pain Appraisal Inventory (PAI; Appendix G) is a 16-item measure used to identify primary appraisals of pain as either threat/harm or challenge. Each

of the 16 items is rated on a 6-point Likert scale ranging from *strongly disagree* (1) to *strongly agree* (6) (Unruh & Ritchie, 1998). Examples of threat/harm and challenge statement on the PAI are, "I am concerned that the pain might become more than I can manage," and "I think the pain makes me a stronger person." Threat appraisals and harm/loss appraisals are frequently measured together (Jackson et al., 2005; Sanford et al., 2002; Unruh & Ritchie, 1998). The PAI has been shown to have adequate reliability for both the threat/harm (α = .80) and challenge (α = .86) subscales as well as having concurrent criterion validity with other pain measures (Pence et al., 2011). In the current study, the Cronbach alpha coefficient for the threat/harm subscale was .81 and .92 for the challenge subscale.

Procedure

Participants were first given a brief explanation of the purpose of the study, omitting any information about examination of race and sex differences, and asked to read and sign a consent form. They were then asked to complete an eligibility questionnaire to ensure minimized health risk associated with participation. If no exclusionary criteria were endorsed, participants were then asked to complete a demographics questionnaire (i.e. race and sex). Participants then completed the PCS1 to establish a baseline for CAT and the PAQ. Participants then completed an initial 30-second CPT trial (CPT1) in which they submerged their non-dominant hand in chilled water and were instructed to attempt to withstand the pain for 30 seconds. Participants who failed to reach a TOL1 time of 30 seconds on CPT1 completed the VAS 1, and were then administered the PCS2 and PAI, but they were not continued on to the second CPT trial (CPT2). Their TOL1 was recorded.

Those participants who yielded a TOL1 time of 30 seconds for the CPT1 also then completed the VAS1. Immediately thereafter they completed CPT2, removing their hands only when they could no longer tolerate the pain. TOL2 times were recorded. If the participant reached the unannounced five-minute maximum TOL2 time, he or she was told to remove his or her hand. The five-minute ceiling for CPT2 is common because after five minutes, the hand is numb and the cold water no longer serves as a nociceptive stimulus. After removal of the hand, the participant then completed the VAS2, the PAI, and the PCS2 based on his or her thoughts during the CPT2. The order distribution of these three questionnaires following the second tolerance measure was randomized among participants to protect against potential order effects.

Statistical Analyses

For the purposes of this study, participants who did not achieve a TOL1 of 30 seconds on CPT1 were not included in analyses except where expressly stated. Analyses used TOL2 times and intensity and unpleasantness ratings from the VAS2 except where expressly state. To determine if there was significant construct overlap between predictors, Pearson product-moment correlations were calculated. Pearson product-moment correlations were also calculated to determine the relationships between predictors, pain responsivity variables (tolerance, intensity, and unpleasantness), and race and sex.

Next, three separate regression analyses were conducted for the dependent pain responsivity variables (intensity, unpleasantness, and tolerance) using the independent predictors (EMV, race, sex, threat/harm appraisal, challenge appraisal, and CAT). For each model, race and sex were entered in Model 1, EMV was entered in Model 2, primary appraisals (threat/harm and challenge) were entered in Model 3, and secondary appraisal (CAT) was entered in Model 4.

Race and sex were entered first as the biological factors. EMV was entered second because it is classified as a personality characteristic. Threat/harm and challenge appraisals were entered third because they are considered to be primary appraisals (occurring prior to secondary cognitive appraisals) and CAT was entered last as it is considered to be a secondary appraisal.

A Multivariate Analysis of Variance (MANOVA) was run with race and sex as independent variables and the three dependent pain responsivity variables; multivariate T-tests were used to follow-up on significant MANOVAs . To further explore the relations between race, sex, and pain responsivity, exploratory Chi Square tests of independence were conducted on participants who did not achieve a TOL1 of 30 seconds on CPT1 as well as participants who achieved a TOL1 of 30 seconds on CPT1 but were unable to achieve a TOL2 of 30 seconds on CPT2.

Exploratory mediation analyses were conducted based on the observed relationships found in the omnibus MANOVA and regression analyses. Each mediation model was examined using the bootstrapping technique (n=5000 bootstrap re-samples) (Preacher & Hayes, 2008).

Results

A total of 199 participants completed the study. Of these, there were 56 white males, 79 white females, 22, black males, and 29 black females. Thirteen participants endorsed a race other than white or black and were not included in the analysis as the purpose of this study was to examine the differences between white and black participants. Twelve participants obtained a TOL1 of less than 30 seconds on CPT1 and were not included in primary analyses. Participants' average age was 19.45 years. Summary information (means and standard deviations) for pain responsivity variables, for the 174 white and black participants included in the primary analyses is presented in Table 1.

Table 1.

Pain responsivity means and standard deviations

	Race	Sex	Mean	SD	N
Intensity	**White**	**Male**	6.77	2.56	55
		Female	7.70	1.94	74
		Total	7.30	2.27	129
	Black	**Male**	8.14	1.75	16
		Female	7.68	1.79	24
		Total	7.86	1.77	40
	Total	**Male**	7.08	2.46	71
		Female	7.69	1.90	98
		Total	7.43	2.17	169
Unpleasantness	**White**	**Male**	7.49	2.55	55
		Female	7.97	2.43	74
		Total	7.77	2.48	129
	Black	**Male**	8.56	1.73	16
		Female	8.08	2.22	24
		Total	8.28	2.03	40
	Total	**Male**	7.73	2.42	71
		Female	8.00	2.37	98
		Total	7.89	2.39	169
Tolerance	**White**	**Male**	125.99	98.55	55
		Female	75.00	74.17	74
		Total	96.74	88.75	129
	Black	**Male**	69.31	81.86	16
		Female	39.41	28.66	24
		Total	51.37	57.29	40
	Total	**Male**	113.22	97.46	71
		Female	66.28	67.62	98
		Total	86.00	84.48	169

Pearson product-moment correlations yielded statistically significant, low to moderate correlations between three of the pain responsivity predictors. CAT was positively related to EMV and threat appraisals. EMV was positively related to threat appraisals and challenge appraisal was positively correlated with threat appraisal. The size of the correlations did not

suggest construct overlap among any of the measures. A summary of these results is presented in Table 2.

Table 2.

Correlations among predictors of pain responsivity

	1	**2**	**3**	**4**
1. CAT	-			
2. EMV	.29*	-		
3. Threat Appraisal	.54*	.30*	-	
4. Challenge Appraisal	-.04	-.10	.16*	-

* $p < .05$

Pearson product-moment correlations among the four predictors (CAT, EMV, threat/harm appraisal, and challenge appraisal) and the three pain responsivity variables (intensity, unpleasantness, and tolerance) indicate that CAT was positively related to intensity and unpleasantness and negatively related to tolerance. EMV was negatively related to tolerance. Threat appraisal was positively related to intensity and negatively related to tolerance and challenge appraisal was positively related to tolerance. A summary of these results is presented in Table 3.

Table 3.

Correlations between predictors and pain responsivity variables

	Intensity	**Unpleasantness**	**Tolerance**
CAT	.55*	.39*	-.55*
EMV	.10	.08	-.18*
Threat Appraisal	.20*	.14	-.22*
Challenge Appraisal	-.10	-.10	.22*

* $p < .05$

Pearson product-moment correlations among the four predictors and race and sex indicate that race was related to EMV and CAT and sex was shown to be related to threat/harm appraisals, challenge appraisals, CAT , and EMV . Pearson product-moment correlations among race, sex, and pain responsivity variables indicate that race was related to TOL2 and sex was related to intensity and TOL2 . In general, black participants rated lower on EMV, higher on CAT, and had lower TOL2 times while women rated higher on threat/harm appraisals, lower on challenge appraisals, higher on EMV, higher on CAT, had higher pain intensity ratings, and lower TOL2 times. A summary of these results is presented in Table 4.

Table 4.

Correlations of race and sex with predictors of pain responsivity

	CAT	Threat/harm Appraisals	Challenge Appraisals	EMV	Intensity	Unpleasantness	Tolerance
Race	.16*	-.09	.15	-.17*	.08	.07	-.23*
Sex	.21*	.18*	-.16*	.44*	.15*	.06	-.28*

*$p < .05$

As stated previously, race and sex were entered in Model 1, EMV in Model 2, threat/harm and challenge appraisals in Model 3, and CAT in Model 4. In the regression analyses for the dependent variable pain intensity, Models 1 and 2 were not significant. The addition of primary appraisals in Model 3 explained a significant portion of variance. Threat/harm appraisals emerged from Model 3 as the only significant predictor of pain intensity. With the addition of CAT in Model 4, threat/harm appraisals dropped out of significance and CAT emerged as the sole significant predictor of pain intensity. A summary of these results is presented in Table 5.

Table 5.

Regression analyses of pain intensity on predictors

Model	**Predictor**	***β***
1		
	Race	.10
	Sex	.13
Notes: R^2 = .03, *p < .05, F(2,158) = 2.17, *ns*		
2		
	Race	.12
	Sex	.09
	EMV	.08
Notes: R^2 = .03, *p < .05, F(3, 157) = 1.72, *ns*		
3		
	Race	.14
	Sex	.06
	EMV	.03
	Threat/Harm Appraisal	.20*
	Challenge Appraisal	-.11
Notes: R^2 = .27, *p < .05, F(5,155) = 2.40, p = .04		
4		
	Race	-.02
	Sex	.06
	EMV	-.08
	Threat/Harm Appraisal	-.13
	Challenge Appraisal	-.03
	CAT	.64*
Notes: R^2 = .32, *p < .05, F(6, 154) = 12.31, p <.001		

In the regression analyses for the dependent variable pain unpleasantness, Models 1, 2, and 3 were not significant predictors. The addition of CAT in Model 4 explained a significant portion of variance. In Model 4, CAT emerged as the sole significant predictor of pain unpleasantness. A summary of these results is presented in Table 6.

Table 6.

Regression analyses of pain unpleasantness on predictors

Model	**Predictor**	***β***
1		
	Race	.09
	Sex	.04
Notes: R^2 = .01, *p < .05, F(2,158) = .80, *ns*		
2		
	Race	.11
	Sex	-.01
	EMV	.11
Notes: R^2 = .02, *p < .05, F(3, 157) = 1.01, *ns*		
3		
	Race	.13
	Sex	-.03
	EMV	.07
	Threat/Harm Appraisal	.14
	Challenge Appraisal	-.14
Notes: R^2 = .05, *p < .05, F(5,155) = 1.59, *ns*		
4		
	Race	.02
	Sex	-.04
	EMV	-.003
	Threat/Harm Appraisal	-.09
	Challenge Appraisal	-.08
	CAT	.44*
Notes: R^2 = .17, *p < .05, F(6, 154) = 5.26, p < .001		

In the regression analyses for the dependent variable TOL2, Model 1 explained a significant portion of the variance with race and sex each explaining a significant portion of the variance. With the addition of EMV in Model 2, the entire model remained significant. Race consistently explained a significant portion of the variance but sex dropped from significance and EMV explained a significant portion of the variance. The addition of primary appraisals in Model 3 explained a significant portion of variance. In Model 3, race, threat/harm appraisals, and challenge appraisals each explained a significant and unique portion of explained variance.

However, with the addition of CAT in Model 4 threat/harm appraisals dropped from significance and race, challenge appraisals, and CAT explained a significant portion of variance. A summary of these results is presented in Table 7.

Table 7.

Regression analyses of pain tolerance on predictors

Model	**Predictor**	***β***
1		
	Race	-.26*
	Sex	-.23*
Notes: R^2 = .13, *p < .05, F(2,156) = 11.41, p < .001		
2		
	Race	-.29*
	Sex	-.16
	EMV	-.17*
Notes: R^2 = .17, *p < .05, F(3, 165) = 9.09, p < .001		
3		
	Race	-.33*
	Sex	-.12
	EMV	-.11
	Threat/Harm Appraisal	-.22*
	Challenge Appraisal	.23*
Notes: R^2 = .23, *p < .05, F(5,163) = 8.82, p < .001		
4		
	Race	-.20*
	Sex	-.11
	EMV	-.03
	Threat/Harm Appraisal	.04
	Challenge Appraisal	.16*
	CAT	-.49*
Notes: R^2 = .36, *p < .05, F(6, 162) = 15.26, p < .001		

The results of the regression analyses indicate that for each dependent variable, CAT was the most substantively significant and usually the only significant predictor among the six.

MANOVA omnibus tests on the three pain responsivity variables revealed a main effect for race, Wilks' Lambda = .94, F(3, 163) = 3.29, p = .022. Univariate follow-up testing

identified TOL2 as the only responsivity variable to vary by race with white participants yielding higher TOL2 times than black participants, $F(1, 165) = 9.89$, $p = .002$ (See Table 1 for means and standard deviations). MANOVA also revealed a main effect for sex, Wilks' Lambda = .95, $F(3, 163) = 2.90$, $p = .037$, on the pain responsivity variables. Univariate follow-up testing identified TOL2 as the only responsivity variable to vary by sex with female participants having significantly lower pain tolerance times than male participants, $F(1, 165) = 7.60$, $p = .006$. MANOVA did not yield a significant interaction effect between the independent variables race and sex on the three dependent pain responsivity variables. Exploratory analyses were conducted in an attempt to further examine the potential race and sex differences.

There seemed to be a trend in the types of participants who failed to achieve a TOL1 of 30 seconds on CPT1. Chi Square test of independence analysis of participants' TOL1 times (i.e. reached 30 seconds or not on CPT1) and their cell classification (i.e. white/male, black/male, white/female, black/female) indicated a significant association between the percentage of participants with a TOL1 time of less than 30 seconds and cell classification, $X^2 (3, n = 183) = 20.62$, $p < .001$, Cramer's V = .34. Further analyses showed a significant association between race and success in achieving a TOL1 of 30 seconds on CPT1 ($X^2 (1, n=183) = 19.65$, $p < .001$, Phi = -.33) but not for sex, such that black participants more frequently failed to achieve a TOL1 time of 30 seconds on CPT1 than whites and thus being eliminated from the analyses. See Table 8 for descriptive information.

Table 8.

Descriptive information of participants with TOL1 times < 30 seconds

Cell	N	# with TOL1 < 30 sec	% within cell
White Male	55	0	0
Black Male	22	5	22.7
White Female	77	2	2.6
Black Female	29	5	17.2

After evaluating participants who failed to achieve a TOL1 time of 30 seconds in CPT1, another interesting trend appeared. Some participants were more likely than others to achieve a TOL1 time of 30 seconds on CPT1 but subsequently fail to achieve a TOL2 time of 30 seconds on CPT2. Exploratory analyses sought to describe the participants who yielded a TOL1 of 30 seconds but a TOL2 of less than 30 seconds. Chi Square test of independence analysis of these participants and cell classification indicated a significant difference between cells, X^2 (3, n=169) = 18.17, $p < .001$, Cramer's V = .328. Additional Chi Square analyses showed no significant relation between sex and achieving a TOL2 of less than 30 seconds in CPT2. However, there was a significant relation between race and achieving a TOL2 of less than 30 seconds in CPT2, such that black participants more frequently achieved TOL2 times of less than 30 seconds on CPT2 than whites, X^2(1, n=169) = 16.36, $p < .001$, Phi = -.31. See Table 9 for descriptive information.

Table 9.

Descriptive information of participants with TOL2 times < 30 seconds

Cell	N	# with TOL2 < 30 sec	% within cell
White Male	55	5	9.1
Black Male	16	7	43.8
White Female	74	14	18.9
Black Female	24	11	45.83

Nine relations were identified that met the qualifications for exploratory mediation analyses (Baron & Kenny, 1986). The first mediation model examined CAT as a mediator for the relationship between sex and pain tolerance (time in seconds). Consistent with previous research, CAT was shown to completely mediate the relationship between sex and pain tolerance.

The second mediation model examined CAT as a mediator for the relationship between EMV and sex. CAT was shown to completely mediate the relationship between sex and EMV. The third mediation model examined EMV as a mediator for the relation between sex and CAT. EMV was shown to partially mediate the relationship between sex and CAT.

The fourth mediation model examined CAT as a mediator for the relation between race and pain tolerance. After controlling for CAT, the effect of race on tolerance was reduced to non significance; therefore, CAT is shown to completely mediate the relation between race and pain tolerance.

The fifth mediation model examined CAT as a mediator for the relation between race and EMV. After controlling for CAT, the relation between race and EMV was reduced to non significance; therefore, CAT is shown to completely mediate the relation between race and EMV. The sixth mediation model examined EMV as a mediator for the relation between race and CAT. After controlling for EMV, the relation between race and CAT was reduced to non significance; therefore, EMV is shown to completely mediate the relation between race and CAT. These results indicate a bidirectional relation between EMV and CAT.

The seventh mediation model examined CAT as a mediator for the relationship between threat appraisals and pain intensity. After controlling for CAT, the effect of threat appraisal on pain intensity was reduced to non-significance. CAT completely mediated the relationship between threat appraisals and pain intensity. We were unable to evaluate threat/harm appraisal as a mediator for the relation between CAT and pain intensity as this relationship did not meet the criteria to justify mediation analyses.

The eighth mediation model examined challenge appraisals as a mediator between sex and pain tolerance. Challenge appraisals were shown to partially mediate the relationship between sex and pain tolerance. A ninth mediation model examined sex as a mediator between challenge appraisals and pain tolerance. Sex was shown to partially mediate the relation between challenge appraisals and pain tolerance indicating a bi-directional relation between sex and challenge appraisal. See Table 10 for summary mediation information.

Table 10.

Mediation results (5000 bootstrap samples)

Independent Variable (IV)	**Mediating Variable (M)**	**Dependent Variable (DV)**	**Effect of IV on M (a)**	**Effect of M on DV (b)**	**Total Effects (c)**	**Direct Effects (c´)**	**Indirect Effect (a x b)**	**Confidence Interval[b]**
Sex	CAT	Tolerance	2.77	-7.75	-3.60	-2.46	-2.61[a]	-34.47 to -5.83
Sex	CAT	EMV	2.58	2.88	6.16	5.59	1.93	.01 to .13
Sex	EMV	CAT	6.16	2.88	2.58	1.11	2.63[a]	.64 to 4.88
Race	CAT	Tolerance	2.21	-7.94	-2.96	-2.07	-2.14[a]	-37.83 to -1.74
Race	CAT	EMV	2.09	4.27	-2.17	-2.95	1.88	.004 to .21
Race	EMV	CAT	-2.17	4.27	2.09	2.89	-1.94	-3.51 to -.21
Threat/Harm Appraisal	CAT	Intensity	8.14	7.9	2.63	-1.64	5.69[a]	.07 to .13
Sex	Challenge Appraisal	Tolerance	-2.14	2.53	-3.56	-3.15	-1.64	-12.52 to -.82
Challenge Appraisal	Sex	Tolerance	-2.07	-3.23	2.93	2.46	1.75	.05 to .90

[a] Significant point-estimate ($p < .05$)

Discussion

Emotional vulnerability has never been examined contiguously with other psychological predictors of pain responsivity (catastrophizing, threat/harm appraisals, and challenge appraisals) as well as with biological predictors like race and sex. Emotional vulnerability has been linked to catastrophizing as a partial mediator of pain tolerance in the literature (Thorn et al., 2004; Ward et al., 2006). It was our goal to determine the unique contribution of this personality trait-based factor in the pain experience. Results indicate that while emotional vulnerability is a unique construct, catastrophizing is the most significant and often only predictor of pain responsvity. This study also sought to replicate and possibly extend previous results suggesting a possible race by sex interaction on pain responsivity. One study discovered a trend toward this race by sex interaction on pain tolerance in women (Pence et al., 2011). In another study, black and white men (but not women) were shown to vary on pain tolerance in one study (Woodrow, Freidman, & Siegel, 1972). Results from the present data indicate there is no presence of a race by sex interaction.

Initial correlational analyses of the four hypothesized predictors of pain responsivity indicated that catastrophizing was related to all other predictors (emotional vulnerability, threat appraisals, and challenge appraisals). Emotional vulnerability was also related to threat appraisal. However, the degree of the relationship was not enough to indicate construct overlap. Based on these analyses, the predictors seem to be unique constructs measuring different aspects of the pain experience.

Based on literature, it was predicted that all four predictors would be related to pain responsivity. Results indicated that catastrophizing was associated with increased pain intensity

and unpleasantness and decreased pain tolerance. Emotional vulnerability was associated with decreased pain tolerance. Threat appraisals were associated with increased pain intensity and decreased pain tolerance and challenge appraisals were associated with increased pain tolerance. These results are consistent with literature which indicates that catastrophizing is a strong predictor of pain responsivity; however, questions have been raised about the unique role of threat/harm appraisal in predicting pain responsivity (France et al., 2004; Keefe et al., 2004; Pence et al., 2011; Sullivan & D'Eon, 1990; Sullivan et al., 1998; Sullivan & Neish, 1999; Sullivan, Tripp, & Santor et al., 2000; Sullivan, Tripp, Rodgers et al., 2000). Catastrophizing has never before been evaluated contiguously with primary appraisals (threat/harm and challenge appraisals), and emotional vulnerability, looking specifically at possible race by sex interactions. This study sought to evaluate the unique contribution of explained variance of each of these predictors. Results show that for both pain intensity and pain unpleasantness, when all other predictors are accounted for, catastrophizing remained the only significant predictor. However, for pain tolerance, when all other predictors are accounted for, race, challenge appraisals, and catastrophizing were all significant predictors. Nonetheless, catastrophizing remains the strongest predictor even in this case. This is particularly interesting considering previous data which suggested threat/harm appraisals might provide a unique contribution to the explained variance in pain tolerance (Pence et al., 2011). The present results did not confirm a unique contribution of threat/harm appraisals to pain tolerance.

Relations between race, sex, and pain responsivity have been well documented. Minorities and women both have lower pain tolerance and report higher pain unpleasantness ratings (Dixon et al., 2004; Loggia & Mogil, 2008; J. L. Riley et al., 1998; J. L. Riley et al.,

2002). Additionally, women report greater pain intensity than men (J. L. Riley et al., 1998; Sanford et al., 2002). It was predicted that main effects for both race and sex would exist for pain responsivity. More specifically, based on previous literature it was predicted that there would be a main effect of race on pain tolerance and unpleasantness and a main effect for sex on pain tolerance, unpleasantness, and intensity. In the current study, results indicated that the main effects of race and sex on pain responsivity were carried only by main effects of race and sex on pain tolerance. Black and white participants as well as male and female participants were not shown to vary significantly on pain unpleasantness or pain intensity ratings.

In addition to main effects for race and sex, a small body of research indicated further review of the possibility of a race by sex interaction on pain responsivity (Pence et al., 2011). This study sought to extend a previous study to determine the presence of such an interaction. It was predicted that a race by sex interaction would emerge. However, results indicate that there exists no interaction between race and sex on pain responsivity.

Further exploratory analyses of pain responsivity in the contexts of race and sex yielded interesting insight into the possible mechanism driving race (and occasionally sex) differences. Of the participants, 13 failed to achieve a TOL1 of 30 seconds on CPT1. Black participants were far more likely to fail to achieve a TOL1 of 30 seconds on CPT1 than their white counterparts. These findings indicate that black participants, even when told of a concrete end point, are more likely to fail to tolerate pain to the same degree as white participants. Another group of participants, while yielding a TOL1 of 30 seconds on CPT1, then proceeded to yield TOL2 scores less than 30 seconds on CPT2. Again, black participants were more likely to yield TOL2 scores of less than 30 seconds than their white counterparts. Both findings indicate that black

participants are more likely than whites to fail to achieve a TOL1 and/or TOL2 time of at least 30 seconds on either CPT1 or CPT2. These results have not been previously reported and their meaning is unclear. The findings may suggest the presence of differential motivation between black and white participants. Motivation has not been previously examined in regards to pain responsivity. However, if it were only an issue of commitment to performance in the study, the main difference would have occurred in participants failing to reach 30 seconds on CPT1. The fact that some black participants tolerated for 30 seconds on CPT1 but not on CPT2 suggests that it is not merely an issue of motivation to succeed in the study. It is possible therefore, that the race differences observed in CPT2 may highlight a motivational construct similar to a learned helplessness phenomoneon; if true, this race difference may be generalizable to clinical pain situations and not simply represent an artifact of differential motivation to fully participate in an experimental pain trial. Future research would benefit from the exploration of motivational differences between groups undergoing experimental pain tasks as well as a deeper look at race differences in pain tolerance.

Further mediation analyses sought to describe the relationship between emotional vulnerability, catastrophizing, and sex. Correlation data indicates that emotional vulnerability has a stronger relationship with sex than catastrophizing, however, this relation had not yet been explored. Results of mediation analysis indicate that emotional vulnerability partially mediates the relation between catastrophizing and sex. When mediation analyses were run to explore the role of catastrophizing as a mediator for the relation between emotional vulnerability and sex, catastrophizing was shown to completely mediate the relation between emotional vulnerability and sex. A bi-directional relation between catastrophizing and emotional vulnerability seems to

exist. It seems that the personality trait could predispose one to catastrophic cognitions about pain, however, catastrophic cognitions about pain may also occur without a general predisposition toward emotional instability. Catastrophizing was also shown to completely mediate the relation between race and pain tolerance. Catastrophizing completely mediated the relation between race and emotional vulnerability and emotional vulnerability completely mediated the relation between race and catastrophizing. Just as with sex, there exists a bi-directional relation between catastrophizing and emotional vulnerability in the contexts of race.

Further mediation analyses sought to explore the relation between catastrophizing, threat/harm appraisals, and pain intensity. Results indicate that catastrophizing completely mediates the relation between threat/harm appraisals and pain intensity. Thus, the effect of threat/harm appraisals on pain intensity is indirect, while the effect of catastrophizing on pain intensity is direct. Challenge appraisals, on the other hand, were shown to partially mediate the relation between sex and pain tolerance. It seems that while negative primary appraisals of pain (i.e. threat/harm appraisals) do not add to our understanding of poor pain outcomes but positive primary appraisals of pain (i.e. challenge appraisals) can lead to better pain outcomes. A differential relation exists in which adaptive primary appraisals are more directly related to pain responsvity than maladaptive primary appraisals.

Limitations to this study include the small sample of black participants. The number of white participants far exceeded the number of black participants. The smaller sample of black participants decreases power to identify a race by sex interaction should one exist. Literature also suggests that experimental designs may not be conducive to the study of primary appraisals

(Lander et al., 1990). The ability to withdraw from the pain experience at any point could make assessment of primary pain appraisals less generalizable to a non experimental pain experience.

Overall, these data suggest that catastrophizing remains the strongest if not the sole predictor of the pain experience. While catastrophising and primary appraisals do seem to be unique constructs, the impact of catastrophizing on the pain experiences seems to supersede that of primary appraisals in most cases. Emotional vulnerability seems to be a mechanism that operates only in the context of sex differences and its role in the pain experience should continue to be explored. Further exploration of these predictors and their role in the pain experience could provide greater insight into the needs of pain patients in a clinical setting, particularly in the context of non-medical interventions. Race and sex differences in the pain experience exist and are shown to be related to catastrophising in similar ways. However, further exploration of the mechanisms which produce sex and race differences (e.g. motivation) in the pain experience could allow for more tailored pain interventions.

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APPENDIX A

Key Terms Not Defined in the Text

Pain responsvity: a term used to describe one's overall pain experience; a composite variable made up of pain intensity, unpleasantness, and tolerance.

Pain intensity: the sensory component of a pain experience; a self-reported evaluation of physical intensity as measured by the intensity scale on the Visual Analog Scale.

Pain unpleasantness: the affective component of a pain experience; a self-reported evaluation of the unpleasantness of pain experiences as measured by the unpleasantness scale on the Visual Analog Scale.

Pain tolerance: one's ability to tolerate pain; generally measured by the amount of time one is able to withstand a pain experience. In this study, pain tolerance is measured with the use of a cold pressor task (CPT).

APPENDIX B

Institutional Review Board Approval Letter

(Next Page)

IRB # 10-007-ME - R1

UNIVERSITY OF ALABAMA INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS
REQUEST FOR APPROVAL OF RESEARCH INVOLVING HUMAN SUBJECTS

I. Identifying information

	Principal Investigator	**Second Investigator**
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Title of Research Project: Race and Sex Differences in Pain Responsivity: An Exploration of Psychological Mechanisms

Date Printed: 3/20/2011 Funding Source: none

Type of Proposal: ___New | __X_Revision X_Renewal ___Completed | ___Exempt

Attach a renewal application

Attach a continuing review of studies form

Please enter the original IRB # at the top of the page

UA faculty or staff member signature: _____

II. NOTIFICATION OF IRB ACTION (to be completed by IRB):

Type of Review: ___✓___ Full board _____ Expedited

IRB Action:

___Rejected Date:_____

___Tabled Pending Revisions Date:_____

___Approved Pending Revisions Date:_____

___✓___Approved—this proposal complies with University and federal regulations for the protection of h subjects.

Approval is effective until the following date: 4-14-12

Items approved: ___ Research protocol (dated ____)
___ Informed consent (dated ____)
___ Recruitment materials (dated ____)
___ Other (dated ____)

Approval signature

Date 4-20-11

APPENDIX C

Pain Catastrophizing Scale (Trait Based)

Everyone experiences painful situations at some point in their lives. Such experiences may include headaches, toothaches, joint pain or muscle pain. People are often exposed to situations that may cause pain such as illness, injury, dental procedures or surgery.

We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are thirteen statements describing different thoughts and feelings that may be associated with pain. Using the following scale, please reflect back on time in which you experienced pain and indicate the degree to which you had these thoughts and feelings when you experience pain.

0	1	2	3	4
not at all	to a slight degree	to a moderate degree	to a great degree	all the time

When I'm in pain ...

_____ 1. I worry all the time about whether the pain will end.

_____ 2. I feel I can't go on.

_____ 3. It's terrible and I think it's never going to get any better.

_____ 4. It's awful and I feel that it overwhelms me.

_____ 5. I feel I can't stand it anymore.

_____ 6. I become afraid that the pain will get worse.

_____ 7. I keep thinking of other painful events.

_____ 8. I anxiously want the pain to go away.

_____ 9. I can't seem to keep it out of my mind.

_____ 10. I keep thinking about how much it hurts.

_____ 11. I keep thinking about how badly I want the pain to stop.

_____ 12. There's nothing I can do to reduce the intensity of the pain.

_____ 13. I wonder whether something serious may happen.

APPENDIX D

Pain Catastrophizing Scale (State Based)

Please answer these questions as they relate to the pain you just experienced when your arm was submerged in the ice water. Using the following scale, please indicate the degree to which you had these thoughts and feelings when you were experiencing this pain.

0	1	2	3	4
not at all	to a slight degree	to a moderate degree	to a great degree	all the time

When I'm in pain ...

_____ 1. I worry all the time about whether the pain will end.

_____ 2. I feel I can't go on.

_____ 3. It's terrible and I think it's never going to get any better.

_____ 4. It's awful and I feel that it overwhelms me.

_____ 5. I feel I can't stand it anymore.

_____ 6. I become afraid that the pain will get worse.

_____ 7. I keep thinking of other painful events.

_____ 8. I anxiously want the pain to go away.

_____ 9. I can't seem to keep it out of my mind.

_____ 10. I keep thinking about how much it hurts.

_____ 11. I keep thinking about how badly I want the pain to stop.

_____ 12.There's nothing I can do to reduce the intensity of the pain.

_____ 13. I wonder whether something serious may happen.

APPENDIX E

Personal Attributes Questionnaire

Instructions:

The items below inquire about what kind of person you think you are. Each item consists of a PAIR of characteristics, with the letters A-E in between. For example,

Not at all artistic A.....B.....C.....D.....E Very artistic

Each pair describes contradictory characteristics - that is, you cannot be both at the same time, such as very artistic and not at all artistic.

The letters form a scale between the two extremes. You are to chose a letter, which describes where YOU fall on the scale. For example, if you think that you have no artistic ability, you would choose A. If you think that you are pretty good, you might choose D. If you are only medium, you might choose C, and so forth.

1. Not at all aggressive	A.....B.....C.....D.....E	Very aggressive
2. Not at all independent	A.....B.....C.....D.....E	Very independent
3. Not at all emotional	A.....B.....C.....D.....E	Very emotional
4. Very submissive	A.....B.....C.....D.....E	Very dominant
5. Not at all excitable in a major crisis	A.....B.....C.....D.....E	Very excitable in a major crisis
6. Very passive	A.....B.....C.....D.....E	Very active
7. Not at all able to devote self completely to others	A.....B.....C.....D.....E	Able to devote self completely to others
8. Very rough	A.....B.....C.....D.....E	Very gentle
9. Not at all helpful to others	A.....B.....C.....D.....E	Very helpful to others
10. Not at all competitive	A.....B.....C.....D.....E	Very competitive

11. Very home oriented	A.....B.....C.....D.....E	Very worldly
12. Not at all kind	A.....B.....C.....D.....E	Very kind
13. Indifferent to others= approval	A.....B.....C.....D.....E	Highly needful of others' approval
14. Feelings not easily hurt	A.....B.....C.....D.....E	Feelings easily hurt
15. Not at all aware of feelings of others	A.....B.....C.....D.....E	Very aware of feelings of others
16. Can make decisions easily	A.....B.....C.....D.....E	Has difficulty making decisions
17. Gives up very easily	A.....B.....C.....D.....E	Never gives up easily
18. Never cries	A.....B.....C.....D.....E	Cries very easily
19. Not at all self-confident	A.....B.....C.....D.....E	Very self-confident
20. Feels very inferior	A.....B.....C.....D.....E	Feels very superior
21. Not at all understanding of others	A.....B.....C.....D.....E	Very understanding of others
22. Very cold in relations with others	A.....B.....C.....D.....E	Very warm in relations with others
23. Very little need for security	A.....B.....C.....D.....E	Very strong need for security
24. Goes to pieces under pressure	A.....B.....C.....D.....E	Stands up well under pressure

APPENDIX F

Visual Analog Scale

Place a mark like this | at the point on the line below that best describes the intensity of pain that you are currently experiencing.

---

no pain — pain as bad as it can be

Place a mark like this | at the point on the line below that best describes any unpleasantness related to pain that you are currently experiencing.

---

not at all unpleasant — extremely unpleasant

APPENDIX G

Pain Appraisal Inventory

We are interested in how you have been thinking about your pain. Please read each of these sentences. Think about whether you agree or disagree with the sentence. Circle the number that fits with your answer.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6

1. I am concerned that the pain might mean something is wrong with me….1 2 3 4 5

2. I think the pain is a chance to prove myself……1 2 3 4 5

3. I am concerned that the pain might become more than I can manage……1 2 3 4 5

4. I think the pain is a test of my strength and ability……..1 2 3 4 5

5. I think something good might come out of having the pain……..1 2 3 4 5

6. I am worried about getting things done……..1 2 3 4 5

7. I think the pain makes me a stronger person……...1 2 3 4 5

8. I am concerned about how much more pain I can take……...1 2 3 4 5

9. I think the pain is a chance to learn more about myself……..1 2 3 4 5

10. The pain seems threatening……...1 2 3 4 5

11. I think without pain, there is no gain……1 2 3 4 5

12. I am worried about being depressed or discouraged because of the pain……1 2 3 4 5

13. I think of this pain as a challenge…….1 2 3 4 5

14. I feel controlled by the pain……...1 2 3 4 5

15. I think the pain tests how well I can manage…….…...1 2 3 4 5

16. I think of the pain as a threat……..……...1 2 3 4 5