

## **Pain-related Rumination, but not Magnification or Helplessness, Mediates Race and Sex Differences in Experimental Pain**

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## **Abstract**

Compared to White individuals and men, Black individuals and women demonstrate a lower tolerance for experimental pain stimuli. Previous studies suggest that pain catastrophizing is important in this context, but little is known about which components of catastrophizing contribute to these race and sex differences. The purpose of the current study was to examine the individual components of catastrophizing (rumination, magnification, and helplessness) as candidate mediators of race and sex differences in experimental pain tolerance. Healthy undergraduates (N=172, 74% female, 43.2% Black) participated in a cold pressor task and completed a situation-specific version of the Pain Catastrophizing Scale. Black and female participants demonstrated a lower pain tolerance than White ( $p<0.01$ ;  $d=0.70$ ) and male ( $p<0.01$ ;  $d=0.55$ ) participants, respectively. Multiple mediation analyses indicated that these race and sex differences were mediated by the rumination component of catastrophizing (indirect effect = -7.13 [95% CI: -16.20, -1.96] and 5.75 [95% CI: 0.81, 15.57], respectively) but not by the magnification (95% CI: -2.91, 3.65 and -1.54, 1.85, respectively) or helplessness (95% CI: -5.53, 3.31 and -0.72, 5.38, respectively) components. This study provides new information about race and sex differences in pain and suggests that treatments targeting the rumination component of catastrophizing may help mitigate pain-related disparities.

Perspective: This study suggests that differences in pain-related rumination, but not magnification or helplessness, are important contributors to race and sex differences in the pain experience. Interventions that target this maladaptive cognitive style may help reduce disparities in pain.

Keywords: Pain; catastrophizing; sex; race; rumination

## Introduction

Chronic pain affects approximately 100 million Americans<sup>33</sup>. Despite being widespread, the pain experience differs across races and sexes. Compared to White individuals, Black individuals report higher levels of pain for a number of clinical conditions and demonstrate greater sensitivity to experimental pain stimuli<sup>6,12,18,25,60</sup>. Likewise, compared to men, women report a greater number of pain episodes in more bodily areas and with greater frequency<sup>1,41,80</sup>. Further, women demonstrate a lower pain tolerance and higher pain ratings for experimental pain stimuli than do men<sup>23,24,62,77</sup>.

A number of biological and psychosocial factors have been hypothesized to contribute to these race and sex differences in pain. In the psychosocial domain, pain catastrophizing has received particular attention. Pain catastrophizing is an emotional and cognitive response to pain and is comprised of rumination (e.g., “I keep thinking about how much it hurts”), magnification (e.g., “I become afraid that the pain will get worse”), and helplessness (e.g. “There is nothing I can do to reduce the intensity of the pain”) cognitions. Pain catastrophizing is related to several important outcomes, including pain intensity, disability, and affective distress<sup>21,35,43,64,72</sup>. Furthermore, research has found that Black individuals and women more frequently catastrophize about pain than do White individuals and men, respectively<sup>25,36,46,72</sup>.

Given the relationship between catastrophizing and pain, along with evidence of race and sex differences in pain and catastrophizing, catastrophizing may contribute to race and sex differences in the pain experience. Indeed, studies have found that catastrophizing mediates race differences in pain intensity, pain tolerance, and affective responses to pain<sup>22,25,46</sup>.

Similarly, catastrophizing has been found to mediate sex differences in pain intensity and pain

behavior<sup>25,41,77</sup>. To our knowledge, the relevant literature has treated catastrophizing as a unitary construct. However, as noted above, catastrophizing is comprised of three distinct components – rumination, magnification, and helplessness. These three components may differentially contribute to race and sex differences in pain. Increased understanding of how the specific components of catastrophizing contribute uniquely and collectively to race and sex differences in pain may lead to better-targeted interventions that improve pain outcomes and reduce pain-related disparities.

The goal of the current study was to test the individual components of pain catastrophizing as candidate mediators of race and sex differences in experimental pain tolerance. We hypothesized that (1) compared to White individuals and men, Black individuals and women would engage in pain catastrophizing more frequently during an experimental pain task, and (2) these differences in pain catastrophizing would mediate race and sex differences in pain tolerance.

## **Methods**

### *Participants*

Participants were 172 healthy Black and White undergraduates from a Midwestern university. Potential participants (n = 39) were excluded if they endorsed any of the following: chronic pain, circulatory problems, hypertension, diabetes, heart or vascular disease, history of fainting spells, seizure disorder, Raynaud's disease, sickle cell anemia, recently sprained or fractured wrist or hand, pregnancy, or previous participation in a cold pressor task (CPT).

### *Procedures*

All procedures were approved by the university institutional review board. Individuals who expressed interest in participating in the study were contacted via telephone to determine eligibility. Eligible participants scheduled a time to complete the study individually in a university laboratory.

Upon arrival, participants provided informed consent. Then, they completed a questionnaire concerning their use of analgesic medications, alcohol, and caffeine. Those who used analgesic medication within the previous 24 hours, and those who had consumed alcohol or caffeine within the previous 2 hours were rescheduled. Participants completed a computerized demographic questionnaire prior to completing the CPT. During the CPT, participants submerged their non-dominant hand up to their wrist in a circulating bath of 2 degree Celsius water (Thermo Scientific Arctic Series Refrigerated Bath Circulator; Thermo Scientific, Waltham, MA). Participants were instructed to leave their hand in the water until they were no longer able to tolerate the sensation. Upon reaching pain tolerance, participants were asked to say “pain limit” and remove their hand from the water. Participants who reached the 3 minute maximum time limit were asked to withdraw their hand from the water. After completing the CPT, participants completed a modified “in-vivo” version of the Pain Catastrophizing Scale <sup>72</sup>. They were then debriefed and compensated with either class credit or a \$10 gift card.

#### *Cold Pain Tolerance*

Pain tolerance was measured by the total number of seconds that participants kept their hand in the water. Cold pain tolerance has strong reliability and validity and demonstrated relevance to clinical pain <sup>9,17,27,61,81</sup>.

### *Pain Catastrophizing Scale*

The Pain Catastrophizing Scale (PCS) is a 13 item self-report measure of pain catastrophizing<sup>72</sup>. The PCS has been shown to tap into a singular construct, which is characterized by three dimensions: rumination, magnification, and helplessness<sup>55</sup>. Consistent with previous studies, we used a modified version of the PCS measuring situation-specific (i.e., in-vivo) pain catastrophizing<sup>15,29,32</sup>. Immediately following the cold presser task, participants rated how frequently they experienced catastrophic cognitions (e.g., “I can’t stop thinking about the pain,”) during the pain task using a 5-point scale ranging from 0 (*not at all*) to 4 (*all the time*)<sup>72</sup>. Past research has shown the PCS to have strong criterion-related, concurrent, and discriminant validity<sup>13,55,56</sup>, with situation-specific versions of the PCS being more strongly related to pain outcomes than the standard trait version of the PCS<sup>5,15</sup>. There was good overall ( $\alpha=0.94$ ) and subscale (range of  $\alpha =0.70-0.93$ ) reliability within this sample.

### *Data Analysis*

Independent samples *t*-tests were used to examine race and sex differences in pain tolerance and catastrophizing (total and subscales). Pearson’s correlations were used to evaluate the bivariate associations among catastrophizing (total and subscales) and pain tolerance.

A series of multiple mediation analyses were employed to test our hypotheses that catastrophizing would mediate the relationships between race and pain tolerance and between sex and pain tolerance. In a multiple mediation model, the overall mediation effect for all mediators can be tested, which indicates the total indirect effect. Additionally, the effects of each mediator can be estimated independently (i.e., specific indirect effects) and are

interpreted as the indirect (i.e., mediation) effect of the independent variables (race and sex) on a dependent variable (pain tolerance), through a mediator (rumination, magnification and helplessness), while controlling for all other mediators in the model. We conducted the analyses using a bias-corrected bootstrapped multiple mediation analysis with 10,000 bootstrapped resamples. Bootstrapping is a nonparametric procedure that does not assume that the indirect effects (path  $a \times b$ ) of an independent variable on the dependent variable are normally distributed. The total effect (path  $c$ ) of race or sex (examined in two separate models) on pain tolerance is the sum of the direct effect of race or sex on pain tolerance (path  $c'$ ) and the indirect effect of race or sex through the candidate mediators of rumination, magnification and helplessness. The effect of race or sex on the subscales of catastrophizing defines paths  $a_{1-3}$ , whereas paths  $b_{1-3}$  are the effects of the mediators on pain tolerance. 95% confidence intervals (CIs) were produced from the 10,000 bootstrapped samples to test the significance of both the total and indirect effects produced from each mediator. Mediation models are significant if zero is not contained within the 95% CIs.

## **Results**

### *Participant Characteristics*

The sample consisted of 172 participants (74% female, 43.2% Black). The distribution of sex did not differ significantly between races ( $\chi^2 = 0.02, p = 0.89$ ). The mean age for Black (23.15 years, [7.64]) and White (21.81 years, [6.11]) participants did not significantly differ ( $t(188) = -0.14, p = 0.89$ ). Male participants (25 years, [9.64]) were slightly older than female participants (22 years, [5.24];  $t(59.64) = 2.42, p = 0.02$ ).

### *Race Differences in Pain Tolerance and Catastrophizing*

The results of independent samples t-tests (see Table 1) indicated that Black participants demonstrated a lower pain tolerance than White participants ( $t(187.99) = 4.85, p < 0.01; d = 0.70$ ). Compared to White participants, Black participants endorsed more frequent overall catastrophizing ( $t(186) = -3.59, p < 0.01; d = 0.53$ ), as well as more frequent rumination ( $t(186) = -3.23, p < 0.01; d = 0.48$ ), magnification ( $t(186) = -2.42, p = 0.02; d = 0.36$ ), and helplessness ( $t(186) = -3.56, p < 0.01; d = 0.52$ ).

#### *Sex Differences in Pain Tolerance and Catastrophizing*

The results of independent samples t-tests (see Table 2) indicated that female participants demonstrated a lower pain tolerance than male participants ( $t(66.72) = 3.10, p < 0.01; d = 0.55$ ). Compared to male participants, female participants endorsed more frequent rumination ( $t(186) = -2.60, p < 0.05; d = 0.43$ ). However, there were no significant sex differences in overall catastrophizing, or in the specific components of magnification and helplessness ( $p$ 's  $> 0.05$ ).

#### *Bivariate Associations between Pain Tolerance and Catastrophizing*

Pain tolerance was significantly negatively correlated with overall catastrophizing ( $r = -0.38, p < 0.01$ ) and with the specific components of rumination ( $r = -0.41, p < 0.01$ ), magnification ( $r = -0.26, p < 0.01$ ), and helplessness ( $r = -0.34, p < 0.01$ ).

#### *Mediation*

The mediating role of catastrophizing components (rumination, magnification, and helplessness) on race and sex differences in pain tolerance was examined using bias-corrected bootstrapped multiple mediation analyses (Figures 1 & 2). Results (Tables 3 & 4) indicated that overall catastrophizing (all 3 components combined) accounted for 23% of the variance in pain



tolerance for the race model and 21% of the variance in pain tolerance for the sex model. There was a significant relationship between race and catastrophizing as a whole (Table 3). Of the three components of catastrophizing, only rumination had a significant indirect effect on pain tolerance in the race model (Figure 1; indirect effect = -7.13; 95% CI = -16.20 to -1.96). Consistent with the mediation analysis for race, there was a significant relationship between sex and catastrophizing as a whole (Table 4), with rumination being the only component that had a significant indirect effect on pain tolerance (Figure 2; indirect effect = 5.75; 95% CI = 0.81 to 15.57). Collectively, these results indicated that race and sex were not only directly related to pain tolerance but also indirectly related to pain tolerance through the rumination component of catastrophizing, but not through the magnification or helplessness components. More specifically, the lower pain tolerance demonstrated by Black and female participants was partly accounted for by their more frequent pain-related rumination during the cold pressor task.

## **Discussion**

There are well-documented race and sex differences in experimental pain, with Black individuals and women having a lower pain tolerance and reporting greater pain intensity than White individuals and men, respectively<sup>6,19,23–25,62,77</sup>. Studies have also found that Black individuals and women engage in more frequent pain-related catastrophizing<sup>10,22,25,29,36,46,47,72</sup>, which partially accounts for the race and sex differences in pain tolerance<sup>22,25,41,46,77</sup>. However, it was unclear which specific components of catastrophizing were driving these mediation effects.

We examined the three distinct components of catastrophizing – rumination, magnification, and helplessness – as candidate mediators of race and sex differences in

experimental pain tolerance. The results indicated that catastrophizing mediated the race and sex differences in experimental pain tolerance, and that this effect was driven by differences in rumination but not magnification or helplessness. Specifically, Black individuals and women engaged in pain-related rumination more frequently, and these differences were associated with a lower pain tolerance compared to their demographic counterparts.

The finding that Black individuals catastrophized more frequently to experimental pain was consistent with our hypothesis and with previous experimental studies<sup>22,25,46</sup>. Our results also align with those from clinical studies. For example, Chibnall and Tait<sup>10</sup> found that, among a large sample of Workers' Compensation claimants with low back injuries, African-Americans reported more frequent rumination, magnification, and helplessness compared to Caucasians. Black individuals' more frequent catastrophizing may be related to discrimination in the clinical setting. Race-related pain treatment disparities are well-documented in the literature<sup>30</sup> and have garnered considerable media attention<sup>26,49</sup>. Because of previous experiences with suboptimal pain care – experienced personally and/or by close others – Black individuals may be more prone to think about current and future painful events in a catastrophic manner (i.e., “No matter what I do, my pain will persist and will be poorly managed”).

Previous studies have found sex differences in overall pain catastrophizing, as well as in the rumination and helplessness components<sup>41,56,72,77</sup>, whereas we found significant sex differences only for the rumination component. Women more frequently engage in ruminative coping in response to a wide array of potential stressors, including role burden, parenting strains, negative interpersonal experiences, achievement events (e.g., failure on an exam), and body image<sup>48,53,69</sup>. Thus, it is not surprising that similar sex differences in pain-related

rumination were observed in the current study and are frequently reported in the broader pain literature. It is not clear why we failed to replicate previous findings wherein women scored significantly higher on measures of overall catastrophizing and on the helplessness component. Despite our non-significant results, the pattern was consistent with previous reports such that women in the current sample reported more frequent catastrophizing (overall and helplessness) during the CPT than did men. The most parsimonious conclusion is that, given the unbalanced sample of men and women, we were underpowered to detect these meaningful but less pronounced sex differences in the current study.

This study provides important new information about the specific components of pain catastrophizing that perpetuate race and sex differences in experimental pain outcomes. Our results suggest that pain-related rumination, but not magnification or helplessness, is the critical component of catastrophizing in this context. Of the three components of pain catastrophizing, rumination has been shown to be most strongly related to clinical pain intensity<sup>74,76</sup>. Such rumination may arise from beliefs about the uncontrollability of pain. Indeed, studies have found that compared to White individuals and men, Black individuals and women report lower perceived control over pain, respectively<sup>71,78</sup>. Research has also found that uncontrollability appraisals are related to increased rumination among healthy, community-dwelling adults<sup>52</sup>. Taken together, these findings suggest that controllability appraisals may influence both the race and sex differences in pain rumination. Future studies should examine the role of such appraisals in the relationship between gender, race, and pain rumination.

These findings have important clinical implications. Among the psychosocial approaches to pain, cognitive-behavioral treatments have received the most attention in this literature and

have been found to effectively target catastrophizing<sup>51,70</sup>. Nevertheless, the outcome literature on cognitive-behavioral treatments for pain is inconsistent, and these treatments show only modest effect sizes for decreasing maladaptive coping strategies such as catastrophizing<sup>39,50,70</sup>. One possible reason for this inconsistency and modest effects is that many cognitive-behavioral treatments do not explicitly consider the separate components of catastrophizing, and how these components may require alternative therapeutic approaches. The effectiveness of cognitive-behavioral and other psychosocial treatments may be enhanced by targeting specific components of catastrophizing. Taken together with other findings, our results argue for a particular focus on reducing pain-related rumination, especially among Black individuals and women. Mindfulness-based therapies, such as mindfulness-based stress reduction<sup>37</sup>, mindfulness-based cognitive therapy<sup>67</sup>, and Acceptance and Commitment Therapy<sup>31</sup> may be especially potent strategies. Indeed, these treatments have been shown to improve pain outcomes such as pain intensity, functional limitations, and psychological distress<sup>57,65</sup>, and they have also been found to reduce ruminative thinking associated with depression, cancer, and school-related stress<sup>14,34,44</sup>. Unfortunately, although mindfulness-related treatment effects have been demonstrated in women<sup>8,38,63,68</sup>, only a few studies have examined their effectiveness in Black individuals and none were focused on pain<sup>16,66,82</sup>. The current results suggest that ongoing clinical and research efforts to better understand pain-related rumination and its responsiveness to different treatments might, among other things, mitigate long-standing race and sex disparities in pain.

In the course of such work, clinicians and researchers would do well to consider that although catastrophizing is associated with negative pain-related outcomes, the fact that

catastrophizing exists at all suggests that it may have some adaptive value. Unfortunately, little is known about the adaptive nature of catastrophizing, and even less is known about potential race and sex differences in this area. According to the communal model of coping, catastrophizing may be used to elicit support or assistance from others<sup>20,73</sup>. Indeed, pain catastrophizing has been associated with increased partner support and solicitousness<sup>7,28,79</sup>, although this is not always the case<sup>2,3,42</sup>. A related factor that might be relevant to understanding the adaptive nature of catastrophizing is emotional expression/suppression. Research suggests that emotional suppression, particularly anger suppression, is associated with worse pain<sup>4,58,59</sup>, whereas emotional disclosure, especially for high catastrophizers, is associated with positive pain-related outcomes<sup>45,54,75</sup>. Learning new ways to adaptively express their pain-related concerns (e.g., through structured written/emotional disclosure<sup>45</sup>) may help high ruminators disengage from unhelpful “cognitive churning” and direct their attention and behavior to more valued life activities. Moreover, there is reason to hypothesize that these disclosure strategies might be especially beneficial for high ruminating Black individuals and women. Many Black cultures are characterized by a more collectivistic (vs. individualistic) orientation<sup>11</sup>. Similarly, women’s self-construal is more relational than men’s<sup>40</sup>. These race and gender differences suggest that a communal model of catastrophizing may be especially applicable for Black and female pain patients. If so, rather than seeking to indiscriminately eliminate catastrophizing entirely, clinicians may be better served by helping these patients adopt strategies that are consistent with their general inclination (i.e., to secure social resources via cognitive, emotional, and behavioral expressions) but that are more

adaptive in nature. Such culturally-sensitive approaches might be an important component of the broader public health effort to reduce pain disparities.

Several limitations should be considered when interpreting these findings. First, we used a sample of healthy, college-aged adults participating in an experimental pain task. Thus, caution is in order when generalizing these findings from the laboratory to the more diverse population found in clinical settings. Second, socioeconomic status, which often contributes to race differences in the pain experience, was not considered in this study. Third, although we recruited similar numbers of Black and White participants, the sample included significantly more women than men, which may have reduced our power to identify sex differences. Fourth, due to limited power and concerns about Type I error inflation, we did not examine the interaction of race and sex. Future theoretical and empirical work is needed to elucidate how sociodemographic variables interact with one another to influence the experience and management of pain. Finally, this study used cross-sectional data, which prevents us from drawing strong causal conclusions about the relationships examined herein. Future studies could experimentally manipulate the specific types of catastrophizing cognitions employed by participants in order to better elucidate these relationships.

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## Figure Legend

Figure 1. The mediating effect of coping strategies in the association between race and pain tolerance.

Figure 2. The mediating effect of coping strategies in the association between sex and pain tolerance.

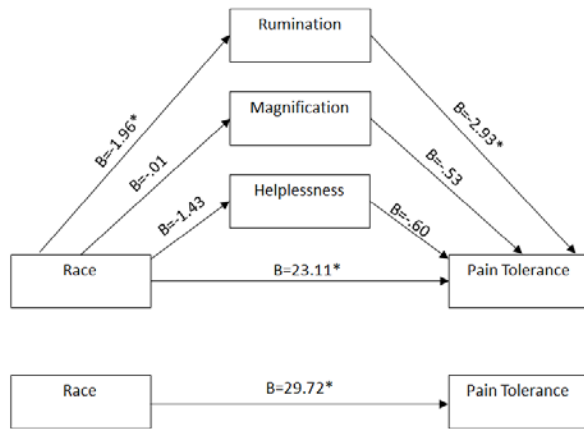


Figure 1. The mediating effect of coping strategies in the association between race and pain tolerance.  $*p < .05$

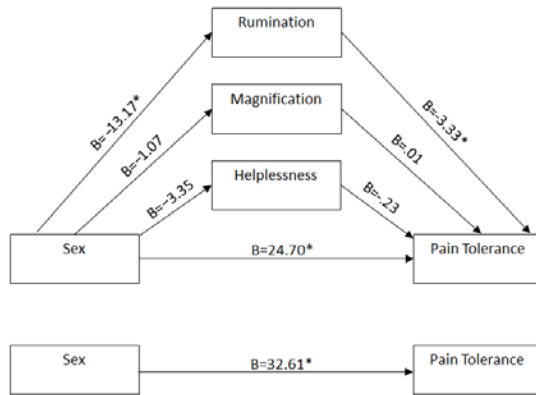


Figure 2. The mediating effect of coping strategies in the association between sex and pain tolerance.  $*p < .05$

**Table 1. Race Differences in Pain Tolerance and Catastrophizing**

Variable	Black (N=82)	White (N=108)	T Value	Cohen's D
Pain tolerance (in seconds)	48.99 ± 37.89	80.03 ± 50.36	4.85**	0.70
Catastrophizing	40.63±12.53	34.06±12.29	-3.59**	0.53
Rumination	15.31 ± 4.31	13.17 ± 4.63	-3.23**	0.48
Magnification	7.79 ± 3.19	6.71 ± 2.86	-2.42*	0.36
Helplessness	17.54 ± 6.78	14.19 ± 6.09	-3.56**	0.52

\* $p < .05$

\*\*  $p < .01$



**Table 2. Sex Differences in Pain Tolerance and Catastrophizing**

Variable	Female (N=140)	Male (N=50)	T Value	Cohen's D
Pain tolerance (in seconds)	59.27 ± 41.01	87.25 ± 58.91	3.10**	0.55
Catastrophizing	37.75±12.48	34.34±13.41	-1.61	0.26
Rumination	14.59 ± 4.51	12.63±4.64	-2.60*	0.43
Magnification	7.17 ± 2.99	7.16 ± 3.22	-0.02	0.00
Helplessness	15.99 ± 6.44	14.55 ± 6.94	-1.31	0.22

\* $p < .05$

\*\*  $p < .01$

**Table 3. Bootstrapped Multiple Mediation Analysis  
Testing Indirect Effects of Race on Pain Tolerance through  
Components of Catastrophizing**

Effects	Point Estimate	Bootstrapping BC 95% CI	
		Lower	Upper
Indirect effects			
Total	-32.61	-45.59	-19.62
Rumination	-7.13	-16.2	-1.96
Magnification	0.01	-2.91	3.65
Helplessness	-0.79	-5.53	3.31

**Table 4. Bootstrapped Multiple Mediation Analysis  
Testing Indirect Effects of Sex on Pain Tolerance  
through Components of Catastrophizing**

<b>Effects</b>	<b>Point Estimate</b>	<b>Bootstrapping BC 95% CI</b>	
		<b>Lower</b>	<b>Upper</b>
Indirect effects			
Total	29.722	14.77	44.68
Rumination	5.75	0.81	15.57
Magnification	0.01	-1.54	1.85
Helplessness	0.85	-0.72	5.38