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# Associations between pain intensity and urge to smoke: Testing the role of negative affect and pain catastrophizing

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ABSTRACT

*Background:* Cigarette smokers are more likely to experience pain than nonsmokers, and experimental research indicates that pain is a potent motivator of smoking. Urge to smoke is a predictor of early relapse, yet associations between pain and urge to smoke have yet to be tested among daily smokers. This study aimed to conduct the first crosssectional test of associations between current pain intensity and urge to smoke, and to test the role of negative affect and pain catastrophizing in relations between pain intensity and urge to smoke.
*Methods:* Participants (N = 229, 42.4% Female, 38.9% black/African American, Mcpd = 21.9) were recruited for a laboratory study of pain and smoking, and these data were collected at the baseline session. Data were analyzed using a series of regressions and conditional process models.
*Results:* Current pain intensity was positively associated with urge to smoke, and urge to smoke for the relief of negative affect. There was an indirect association via state negative affect, such that pain intensity was positively associated with negative affect, which in turn was associated with greater urge to smoke. Further, positive associations between pain intensity and urge to smoke were only evident among smokers who endorsed low (vs high) levels of catastrophizing.
*Conclusions:* These findings contribute to an emerging literature indicating that pain and related constructs are relevant to the maintenance of tobacco smoking. Future research should examine how painrelevant cognitive-affective factors may influence associations between the experience of pain and motivation to smoke tobacco.

## 1. Introduction

Cigarette smoking remains the leading cause of preventable death worldwide (WHO, 2008). In the United States, an estimated 42.1 million adults (~18%) are classified as current tobacco smokers (CDC, 2011; USDHHS, 2014). Although the majority of smokers report a desire to stop smoking, the most common result of a quit attempt is relapse (CDC, 2011; Hughes et al., 2004; Piasecki, 2006). Relapse is more likely to occur among individuals reporting higher (compared to lower) pre-quit urge to smoke (Allen et al., 2008; Nakamura et al., 2014). Urge to smoke has been defined as the acute desire for the negatively reinforcing effects and rewarding properties of tobacco and is positively associated with nicotine dependence (Cox et al., 2001). Given the importance of urge to smoke in the maintenance of tobacco dependence, researchers have recently turned their attention to pain as a motivator of tobacco smoking and proximal determinant of relapse (Ditre et al., 2017).

Pain and tobacco smoking has been linked to the clinical and empirical literature for decades (e.g., Nesbitt, 1973; Zale et al., 2016). Epidemiological and clinical data indicate that the prevalence of smoking among persons in pain may be greater than twice the rate observed in the general population (Zvolensky et al., 2009), and an evolving reciprocal model posits that pain and smoking interact in the manner of a positive feedback loop, resulting in greater pain and the maintenance of tobacco dependence (Ditre et al., 2011; Zale et al., 2016). Consistent with this perspective, there is evidence of covariation between pain and tobacco smoking. The frequency of pain has been positively correlated with cigarette consumption (Pisinger et al., 2011), and smokers who endorse past-week pain have been shown to smoke more cigarettes per day than smokers with no pain (Hahn et al., 2006). Furthermore, current pain intensity has been positively associated with current smoking status (Volkman et al., 2015) and daily cigarette consumption (Andersson et al., 1998; Bakhshaie et al., 2016; Pirouzi et al., 2011).

There is also evidence that pain can be a potent motivator for smoking urge and behavior. For example, smokers in pain readily

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endorse the use of tobacco to cope with pain (Hooten et al., 2011b), painful episodes have been shown to precede bouts of smoking (Dhingra et al., 2013), and smokers have reported a perceived need to smoke in the context of clinical pain (Jamison et al., 1991). The results of two laboratory studies indicate a causal effect of pain on the urge to smoke. Ditre and Brandon (2008) showed that cold-pressor pain induction (vs. no pain induction) increased the urge and decreased latency to smoking among a sample of daily tobacco smokers who were recruited from the local community. A recent follow-up study further demonstrated that thermal heat pain (vs. no pain) increased urge to smoke among tobacco users recruited from the local community (Parkerson and Asmundson, 2016). Given that pain is comprised of sensory-physiological (e.g., pain intensity), motivational-affective (e.g., state negative affect), and cognitive-evaluative (e.g., pain catastrophizing) components (IASP, 2008; Melzack and Wall, 1965; Turk and Melzack, 2001), additional research is needed to examine the role of these factors in relations between pain and urge to smoke tobacco.

Negative affect refers to a general form of subjective distress that encompasses a variety of unpleasant emotions (Kassel et al., 2003; Watson et al., 1988). Negative affect has been conceptualized in terms of both trait and state experiences (Watson and Clark, 1984), and measures of state negative affect have been more closely linked to current pain intensity than trait measures (Gaskin et al., 1992). Although negative affect is empirically-distinguishable from pain intensity (Dworkin et al., 2005), it frequently co-occurs with pain (Jensen and Karoly, 2011; Melzack, 1975), and has been positively associated with both pain intensity and tolerance (Janssen, 2002; Lacourt et al., 2015). Importantly, Ditre and Brandon (2008) found that state negative affect accounted for approximately 30% of the variance in the effects of experimental pain induction on self-reported urge to smoke. This observation is broadly consistent with the negative reinforcement model of tobacco dependence, which posits that escape from negative affect is a primary catalyst for smoking urge and behavior (Baker et al., 2004b).

Pain catastrophizing is a cognitive-affective construct that reflects the tendency to interpret actual or anticipated pain in an exaggerated manner (Sullivan et al., 1995). Pain catastrophizing exhibits a wide distribution and is positively associated with physical and emotional distress in response to acute pain, among non-chronic pain samples (Sullivan et al., 1995; Kristiansen et al., 2014). Furthermore, catastrophizing has been positively associated with current pain ratings among non-chronic pain samples (Bialosky et al., 2008; Spanos et al., 1981; Sullivan et al., 1995), and individuals who score higher on measures of catastrophizing tend to report greater fear and worry about their pain (Edwards et al., 2011; Quartana et al., 2009). Interestingly, smokers have been shown to endorse greater pain catastrophizing than nonsmokers (Hooten et al., 2009), and cigarette smoking has been conceptualized as a behavioral coping strategy that is used to manage aversive internal experiences (Baker et al., 2004b; Lazarus and Folkman, 1984). Thus, smokers who are prone to greater pain catastrophizing may experience greater urge to smoke in the context of pain.

Previous studies that directly tested associations between pain and urge to smoke tobacco relied almost exclusively on experimental pain paradigms that are subject to limitations in terms of experimenter demand and generalizability (Ditre and Brandon, 2008; Ditre et al., 2015; Zale et al., 2016). Furthermore, most of the published cross-sectional studies investigating the relationship between pain and tobacco use have been conducted among smokers with chronic pain. Evidence that such associations extend to individuals without chronic pain would have clinical implications for many tobacco smokers (Nahin, 2015; Zvolensky et al., 2009). Thus, the current study was conceptualized as a cross-sectional extension of this formative laboratory work, with the goal of examining the association between current pain intensity (i.e., pain that is not experienced in the context of clinical pain or experimental pain induction) and self-reported urge to smoke, among a sample of daily cigarette smokers who did not report chronic pain. Given contemporary negative reinforcement models of addiction motivation (Baker et al., 2004a) and empirical work implicating negative affect in bidirectional relations between pain and smoking (Ditre et al., 2011; Zale et al., 2016), we were especially interested in the association between current pain intensity and self-reported urge to smoke for the purpose of relieving negative affect.

We hypothesized that current pain intensity would be positively associated with scores on self-report measures of overall urge to smoke and urge to smoke for the relief of negative affect. We also hypothesized an indirect association via state negative affect, such that greater pain would be associated with the greater state negative affect, which in turn would be associated with greater urge. Finally, we hypothesized that pain catastrophizing would moderate the association between pain intensity and urge to smoke, such that the relationship between pain intensity and urge scores would be greater among smokers who endorse high levels of catastrophizing.

## 2. Method

### 2.1. Participants

Participants ($N = 229$) were recruited from the greater Syracuse, New York area via local newspapers and internet advertisements (i.e., online versions of local newspapers, Craigslist advertisements) for a larger experimental study requiring two visits. Current analyses were conducted using data obtained from the baseline survey at the first visit. Potential participants were screened by phone for the following inclusion criteria: (1) current age between 18 and 65; (2) ability to speak and read English; and (3) currently smoking a mean of $\geq 15$ cigarette per day. Participants were excluded if they endorsed: (1) current chronic pain, (2) current use of prescription pain medications, (3) pepper allergy (contraindicated for the larger experimental study), or (4) actively engaging a current attempt to reduce or quit smoking. Eligible participants were scheduled for a baseline visit, at which time they provided informed consent and completed a baseline assessment that included measures of current pain, state negative affect, state urge to smoke, and trait catastrophizing. Both negative affect and urge to smoke have been shown to fluctuate over short periods of time (Morgan et al., 1999) and state negative affect has been positively associated the with urge to smoke in laboratory settings (Ditre and Brandon, 2008). Thus, we selected measures that reflect current experience. Smoking status was biochemically-verified via expired breath carbon monoxide ($CO \geq 8$ ppm; Benowitz et al., 2002). Exclusion based on smoking status was based solely on biochemical verification, regardless of self-reported smoking status.

### 2.2. Measures

#### 2.2.1. Pain intensity

Current pain intensity was rated on a Numerical Rating Scale (NRS; McCaffery and Beebe, 1989) that ranged from 0 (no pain) to 10 (pain as bad as you can imagine). The instructions asked participants to rate their pain at the time of assessment (i.e., "Please rate your pain by selecting the one number that tells how much pain you have right now."). The NRS has been used extensively to index pain in both research and clinical settings and has demonstrated excellent construct and discriminant validity (Hjermstad et al., 2011; Williamson and Hoggart, 2005).

#### 2.2.2. Nicotine dependence

The Heaviness of Smoking Index (HSI; Heatherton et al., 1989) is comprised of two items: cigarettes smoked per day, and time to the first cigarette after waking. The HSI has demonstrated excellent sensitivity and specificity (Huang et al., 2008), and good reliability over time (Borland et al., 2010). The HSI is highly correlated with the widely used Fagerstrom Test for Cigarette Dependence (FTCD) and avoids potential

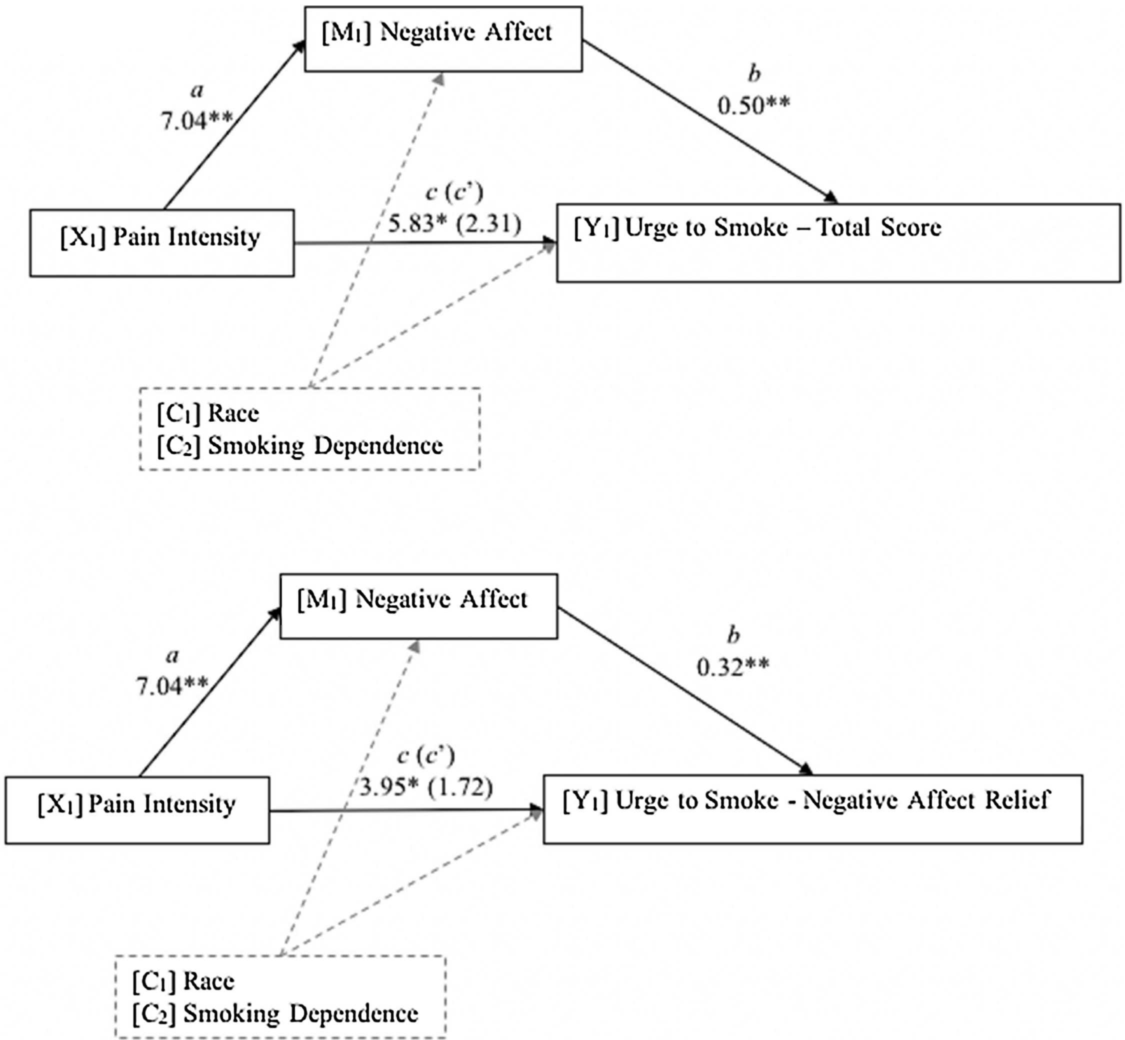


**Fig. 1.** Conceptual models depicting negative affect as a mediator of the association between pain intensity and urge to smoke for pleasure/reward and urge to smoke for negative affect relief. *p < .05, **p < .01.

confounds associated with the additional items included in the FTCD (Chabrol et al., 2005; Etter et al., 1999; Fagerstrom et al., 2012).

#### 2.2.3. *State negative affect*

The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) is a measure of positive and negative emotions, that asks participants to rate the extent to which they are experiencing each emotion at the time of the assessment (i.e., "right now").The negative affect subscale (PANAS-NA), which consists of 10 adjectives that describe a range of current negative emotions (e.g., "distressed", "nervous", and "irritable"). Each adjective is rated on a 5-point Likert-type scale ranging from 1 (very slightly or not at all) to 5 (extremely). Items are summed to generate a total score (range = 10–50), with higher scores indicating greater state negative affect. The PANAS-NA has demonstrated good internal reliability and validity (Watson et al., 1988), and exhibited good internal consistency in the current sample (α = 0.89).

#### 2.2.4. *Pain catastrophizing*

The Pain Catastrophizing Scale (PCS; Sullivan et al., 1995) measures the tendency to interpret pain in an exaggerated or threatening manner and yields a total score that reflects a sense of helplessness in managing pain, exaggeration of the threat value of pain, and heightened attention toward pain (Chaves and Brown, 1987; Rosenstiel and Keefe, 1983; Spanos et al., 1981). Each of the 13 items is rated on a 5-point Likert-type scale ranging from 0 (not at all) to 4 (all the time). Items are summed to yield a total score that ranges from 0 to 52, with higher scores indicating more threatening interpretations of pain. High levels of pain catastrophizing can be indexed by scores of 30 or more on the PCS (Sullivan et al., 1995). The PCS has exhibited good reliability and internal consistency among community samples without chronic pain (Osman et al., 2000; Sullivan et al., 1995). Participants were asked to report on the degree to which they have each thought or feeling when experiencing pain. The PCS demonstrated excellent internal consistency in the current sample (α = 0.95).

#### 2.2.5. *Urge to smoke*

The Questionnaire of Smoking Urges-Brief (QSU-B; Cox et al., 2001) includes 10 items (e.g., "I have an urge for a cigarette.") that are rated on a 7-point Likert type scale ranging from 1 (strongly disagree) to 7 (strongly agree). Items are summed to yield a total score (QSU-B total) and two subscale scores; urge to smoke for pleasure/reward (QSUB-PR) and urge to smoke for negative affect relief (QSU-B-NA). Higher scores indicate greater urge to smoke and the QSU-B total scores range from 10 to 70. The subscale scores range from 5 to 35. Participants were instructed to report on their urge to smoke "right now" for all items. The QSU-B has demonstrated good reliability and internal consistency (Cox et al., 2001; West and Ussher, 2010), and we observed evidence of good internal consistency in the current sample (QSU-B total score α = 0.93; QSU-B-NA α = 0.88).

### 2.3. Data analytic strategy

All analyses were conducted using SPSS Statistics 21 (IBM Corp, 2012). First, descriptive statistics were generated to characterize sample demographics and smoking history. The distributions of all continuous variables were examined for normality, and positive skewness was observed for current pain intensity scores (skew = 1.28). A log transformation was applied by adding one to all scores (given that the range of values included zero) and applying a logarithmic transformation ($\log_{10} + 1$) Tabachnick and Fidell, 2004), which resulted in a normalized distribution (skew = 0.24). Sociodemographic and smoking variables were selected as covariates based on observed relations with urge to smoke scores, as evidenced by a statistically significant *t*-test (for categorical variables) or correlation (for continuous variables).

Separate hierarchical regressions were conducted to test linear relations between the independent variable of pain intensity and the criterion variables of the urge to smoke (QSU-B total) and urge to smoke to relieve negative affect (QSU-B-NA) and urge to smoke for pleasure/reward (QSU-B-PR). Covariates were entered in the first step, and pain intensity was entered in the second step of each model. The relative contribution of pain intensity in explaining observed variance in each criterion variable was assessed by examining change in the *R*-squared statistic ($\Delta R^2$) at the second step of each model.

Indirect effects and moderation were tested using a series of conditional process models via the PROCESS macro for SPSS (Preacher and Hayes, 2008), which employs an ordinary least-squares-based approach. See Figs. 1 and 2 for a graphical depiction of these models. Individual paths (for indirect effects) or slope interactions (for moderation) are considered statistically significant if the upper and lower limits of the confidence intervals do not cross zero (Hayes, 2013). For indirect effects, recommended 95% confidence intervals and path coefficients were generated via bootstrapping set at 10,000 resamples with replacement (Hayes, 2013; Preacher and Hayes, 2008). A statistically significant indirect effect is observed when the 95% confidence intervals surrounding test of the indirect path do not overlap with zero. Bootstrapping is a non-parametric approach to path analysis, which reduces limitations associated with statistical power and Type 1 error inherent to stepwise regression (Preacher and Hayes, 2004). We also tested our theoretically-driven ordering of variables by re-running the indirect models in reverse by swapping the ordering of the predictor and indirect variables (Hayes, 2013).

Tests of moderation were considered significant if slopes are significantly different between two specified values of the moderator, which is tested by deriving an interaction term from the product of the independent variable and moderator variable. A statistically significant moderation effect is observed when the 95% confidence interval around this product does not overlap with zero. One question of theoretical and empirical interest is whether clinical levels of pain catastrophizing interact with pain intensity to predict smoking urge. Scores of 30 or more on the PCS are consistently observed among clinical pain samples across multiple countries (e.g., Hayashi et al., 2015; Hooten et al., 2011a), are predictive of pain-related unemployment and disability status following injury and correspond to the upper 75th percentile of the clinical pain validation sample (Sullivan et al., 1995). Thus, moderation was tested by dummy-coding values of the moderator using a clinical cutoff of greater than or equal to 30.

## 3. Results

### 3.1. Sample characteristics

Participants were 229 current daily tobacco smokers (42% female; $M_{age}$ = 41.60, *SD* = 12.41). More than a third of the sample (38.9%) identified as black or African American. The majority of the sample (58.9%) reported their highest level of education as a high school graduate or less, and nearly 40% reported incomes of less than $10,000.00 per year. Participants smoked an average of 22 cigarettes per day (*M* = 21.95; *SD* = 12.94) for approximately 25 years (*M* = 24.50; *SD* = 12.31). The mean HSI score was 3.78 (*SD* = 1.34), indicating a relatively high level of nicotine dependence (Chaiton et al., 2007). The mean QSU-B total score was 39.29 (SD = 16.25), which is similar to that observed among other samples of daily tobacco smokers (West and Ussher, 2010). The mean QSU-B-NA (urge to smoke to relieve negative affect) score was 16.23 (SD = 8.52). Nearly half of the sample (49.6%) endorsed current pain intensity greater than zero, with an average pain intensity score of approximately 3.5/10 among those reporting *any* current pain (*M* = 3.57; *SD* = 2.29). Approximately 20% of the sample (*n* = 44) scored in the clinical range of pain catastrophizing (Sullivan et al., 1995). Measures of pain catastrophizing, negative affect, and urge to smoke all exhibited good-to-excellent internal consistency in the current sample (α = 0.88–0.95). See Table 1 for full sample characteristics and Table 2 for bivariate associations.

### 3.2. Identification of covariates

No group differences by sex were observed for pain intensity ($t = 1.44$; $p = .15$) or urge to smoke scores (*ps* > 05). Smoking dependence scores were positively associated with QSUB total scores ($r = 0.34$; $p < .01$), QSUB-NA scores ($r = 0.30$; $p < .01$), and QSUB-P/R scores ($r = 0.33$; $p < .01$). Participants identifying as white reported significantly lower QSUB total scores (M = 35.11), relative to participants who identified as black or African American (M = 44.62; $t = -4.48$; $p < .001$; 95% CI = −13.68, −5.32). There were no group differences by race in terms of HSI scores or average cigarettes per day over the past week (*ps* < 0.05), suggesting that observed differences in QSUB scores cannot be explained by differences in nicotine dependence or current cigarette consumption. Thus, HSI scores and Race were selected as covariates for subsequent analyses. No other sociodemographic factors were associated with criterion variables, and both race and smoking dependence were included as covariates in subsequent models.[1]

### 3.3. Current pain intensity and urge to smoke

As hypothesized, hierarchical regression indicated that greater pain intensity was positively associated higher QSU-B total scores, $\Delta R^2 = 0.02$; β = 0.12; $t = 2.03$; $p < .04$; 95% CI [0.18, 11.49]. Also, as hypothesized, hierarchical regression indicated that pain intensity was positively associated with QSU-B-NA scores, $\Delta R^2 = 0.02$; β = 0.16; $t = 2.61$; $p = .01$; 95% CI [0.97, 6.93]. Thus, individuals who endorsed greater current pain intensity also endorsed greater current overall urge to smoke and greater urge to smoke for the relief of negative affect, after accounting for smoking dependence and race. No association between pain intensity and QSU-B-PR scores was observed $\Delta R^2 = 0.01$; β = 0.07; $t = 1.54$; $p = .25$; 95% CI [−1.35, 5.12], and this criterion variable was therefore not included in further analyses. See Table 3 for full data from regression analyses.

### 3.4. Indirect association between pain intensity and urge to smoke via state negative affect

As hypothesized, analysis of indirect associations revealed that state negative affect statistically mediated the positive association between pain intensity and QSU-B total scores, $b = 3.53$; $SE = 1.33$; 95% CI [1.35, 6.65], such that current pain intensity was positively associated

[1] Race did not moderate the relationship between pain intensity and overall urge to smoke, $F(1, 216) = 0.04$; $\Delta R^2 < 0.0001$; $p = .84$, or urge to smoke for the relief of negative affect, $F(1, 216) = 0.04$; $\Delta R^2 < 0.0001$; $p = .94$. HSI scores did not moderate the relationship between pain intensity and total urge to smoke, $F(1, 216) = 0.66$; $\Delta R^2 < 0.002$; $p = .42$, or urge to smoke for the relief of negative affect, $F(1, 216) = 2.97$; $\Delta R^2 < 0.001$; $p = .59$.

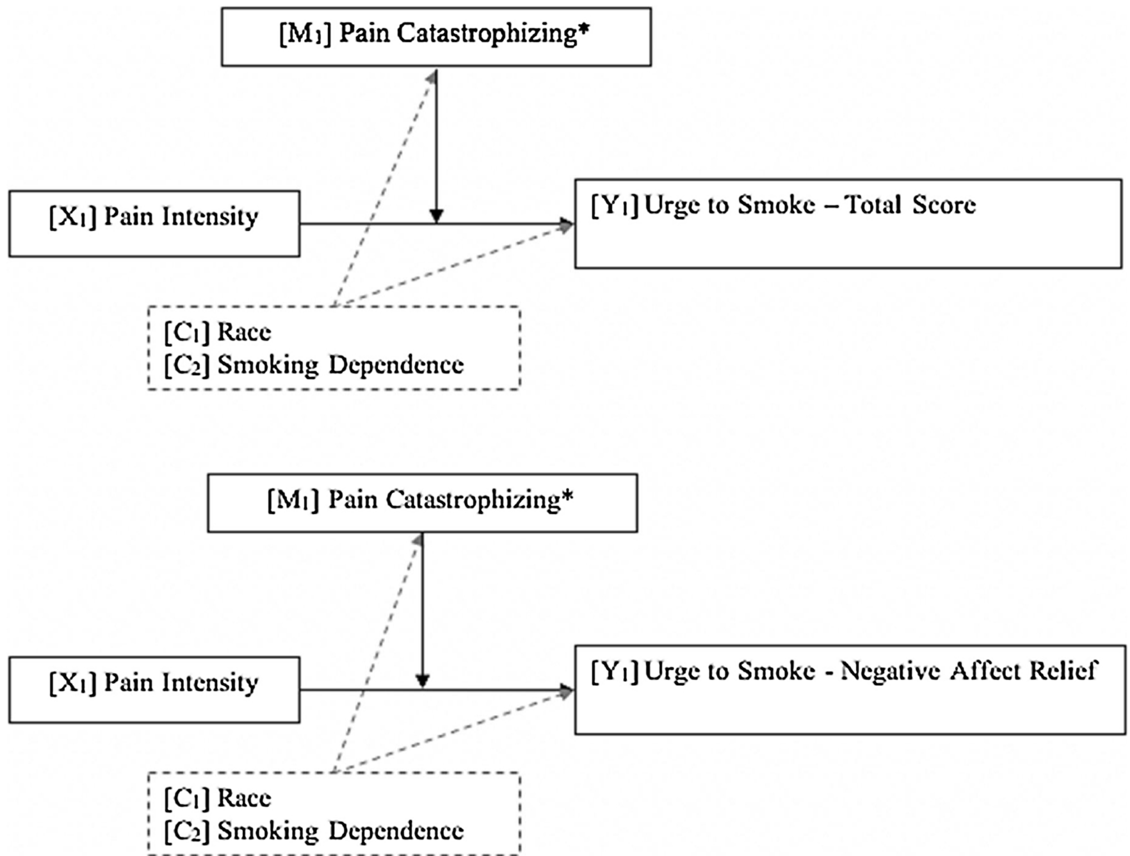


**Fig. 2.** Conceptual models depicting pain catastrophizing as a moderator of the association between pain intensity and urge to smoke scores. *$p < .05$.

with negative affect, which in turn was associated with greater overall urge to smoke. Examination of QSU-B-NA subscale score revealed a similar pattern of findings, such that state negative affect statistically mediated the positive association between pain intensity and QSU-B-*NA* scores $b = 2.23$; SE = 0.71; 95% CI [1.08, 3.89]. Models were no longer significant when ran in reverse (all 95% confidence intervals crossed zero), thus providing statistical support for our theoretically-driven ordering of the variables. See Table 4 for full data from the indirect models.

### *3.5. Catastrophizing as a moderator of the relation between pain intensity and urge to smoke*

Pain catastrophizing was found to partially moderate the association between current pain intensity and QSU-B total scores ($p = .01$), with a corresponding significant change in R-squared, $F(1, 222) = 7.72$; $\Delta R^2 = 0.03$. However, examination of the path coefficients and confidence intervals revealed that the direction of moderation was opposite of expectation, such that the association between pain intensity and QSU-B total scores was only observed among individuals who scored *below* the clinical cutoff on our measure of pain catastrophizing, $b = 9.22$, SE = 3.26, $t = 2.82$, $p < .01$, 95% CI [2.78, 15.65]. A similar moderating effect was observed for QSU-B-NA scores, $F(1, 222) = 6.58$; $\Delta R^2 = 0.02$; $p = .01$, such that the positive association between pain intensity and urge to smoke for the relief of negative affect was only evident among individuals who scored *below* the clinical cutoff on our measure of pain catastrophizing, $b = 5.56$, SE = 1.72, $t = 3.22$, $p < .01$, 95% CI [2.16, 8.96]. See Table 5 for full data from the indirect models.

## 4. Discussion

The goal of this study was to test cross-sectional relations between current pain intensity and self-reported urge to smoke, among a sample of daily tobacco users who did not endorse chronic pain. Consistent with prediction, current pain intensity was found to be positively associated with the total urge to smoke and the urge to smoke for the relief of negative affect. Thus, the observed cross-sectional relationship between pain intensity and overall urge to smoke was driven by the associations with urge to smoke for negative reinforcement. Also consistent with prediction, state negative affect was shown to statistically-mediate associations between current pain and urge, such that pain intensity was positively associated with negative affect, which in turn was associated with the greater urge, in general, as well as urge to smoke for the relief of negative affect, specifically. These findings are consistent with the negative reinforcement model of tobacco dependence (Baker et al., 2004b), which posits that tobacco smoking is maintained primarily by the motivation to alleviate aversive internal experiences. These findings are also consistent with previous experimental work demonstrating that pain can motivate smoking urge, partly via indirect effects of increased negative affect (Ditre and Brandon, 2008; Parkerson and Asmundson, 2016).

Although pain catastrophizing was found to moderate relations between pain intensity and urge to smoke, the direction of effects was in contrast to expectation. Specifically, the positive associations between pain intensity and urge to smoke were only evident among smokers who endorsed low (vs. high) levels of catastrophizing. This was unexpected given that evidence indicates that smoking has been shown to motivate smoking behavior (Ditre and Brandon, 2008), and that chronic pain patients endorse smoking to cope with pain (Hooten et al., 2011a). In examining the broader substance use literature, there is some evidence that lower or emerging levels of pain catastrophizing

**Table 1**
Sample Characteristics.

| | N (%) |
|---|---|
| Gender | |
| Female | 97 (42.4) |
| Male | 132 (57.6) |
| Ethnicity | |
| Hispanic/Latino | 10 (4.4) |
| Race | |
| White | 132 (57.6) |
| Black/African American | 89 (38.9) |
| American Indian/Alaskan Native | 8 (3.5) |
| Education | |
| Did not graduate high school | 53 (23.1) |
| High school graduate | 82 (35.8) |
| Some college | 53 (23.1) |
| Technical school or Associates degree | 27 (11.8) |
| Four-year college degree | 7 (3.1) |
| Some school beyond 4-year college | 6 (2.6) |
| Professional degree | 1 (0.4) |
| Income | |
| < 10,000/year | 91 (39.7) |
| 10,000-19,999/year | 41 (17.9) |
| 20,000-29,999/year | 38 (16.6) |
| 30,000-39,999/year | 17 (7.4) |
| 40,000-49,999/year | 10 (4.4) |
| 50,000-59,999/year | 15 (6.6) |
| ≥60,000/year | 17 (7.4) |
| | *M (SD)* |
| Age | 41.60 (12.41) |
| Cigarettes per day | 21.95 (12.94) |
| Smoking Dependence Severity[a] | 3.78 (1.34) |
| Time Since Last Cigarette in Minutes | 23.90 (26.33) |
| Pain Intensity[b] | 1.77 (2.41) |
| Negative Affect[c] | 16.88 (7.37) |
| Pain Catastrophizing[d] | 17.90 (12.62) |
| Urge to Smoke Total Score[e] | 39.29 (16.25) |
| Negative Affect Relief Factor | 16.23 (8.52) |

*Note*. 0 = Female, 1 = Male.
[a] Heaviness of Smoking Index.
[b] Numerical Rating Scale.
[c] Positive and Negative Affect Schedule – Negative Affect subscale.
[d] Pain Catastrophizing Scale.
[e] Brief Questionnaire of Smoking Urges.

**Table 3**
Hierarchical Models: Urge to Smoke Regressed on Pain Intensity.

| Criterion Variables | $R^2$ | $\Delta R^2$ | β | t | p |
|---|---|---|---|---|---|
| QSU-B[a] – Total | 0.205 | 0.015 | 0.122 | 2.032 | 0.043* |
| QSU-B[a] – Negative Affect Relief | 0.196 | 0.024 | 0.158 | 2.608 | 0.010** |
| QSU-B[a] – Positive Reinforcement | 0.158 | 0.005 | 0.071 | 1.149 | 0.252 |

*Note: N* = 229. These data reflect step two of the respective hierarchical models of smoking urge scores regressed on pain intensity scores. All analyses presented adjusted for participant race and heaviness of smoking index (HSI) scores.
[a] Brief Questionnaire of Smoking Urges.
* $p < .05$.
** $p < .01$.

may be linked to greater use of addictive substances (i.e., a prescription pain medication; Sharifzadeh et al., 2017). A second possibility is that fear and concern about the pain among high catastrophizers may be associated with avoidance of activities perceived to increase the risk for pain, such as smoking (Zale et al., 2013). A third possible explanation for this finding is that rumination about the pain that is characteristic of high pain catastrophizing may shift attentional resources away from urges to smoke. Additional research is needed to clarify the role and clinical importance of catastrophizing in pain-smoking relations.

Several limitations should be noted. First, the use of cross-sectional data prohibits causal inferences and any conclusions regarding temporal precedence in the models tested. Future research would benefit from using prospective and naturalistic research methods, such as momentary ecological assessment (e.g., Dhingra et al., 2013), to examine temporal and potentially bidirectional relations between the experience of pain and smoking urge/behavior over time. Second, although these findings may not generalize to smokers who have chronic pain, individuals who live with persistent pain would likely encounter a greater number of occasions to experience pain as a proximal antecedent of smoking urge and behavior (Ditre et al., 2017; Zale et al., 2016). Third, although pain intensity and urge to smoke may vary as a function of pain etiology (e.g., musculoskeletal, migraine), the current data did not allow for such comparisons. Fourth, our sample was comprised of nicotine-dependent tobacco users who reported smoking greater than 20 cigarettes per day. Future research should examine

**Table 2**
Bivariate Associations.

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 Age | – | −0.04 | −0.07 | 0.02 | 0.07 | −0.03 | −0.03 | −0.13 | −0.03 |
| 1 Gender | | – | 0.05 | 0.06 | 0.11 | −0.01 | −0.16 | −0.14 | −0.09 |
| 1 HSI[a] | | | – | −0.18** | 0.13* | 0.10 | 0.05 | 0.34** | 0.30** |
| 1 TSLC[b] | | | | – | 0.06 | 0.08 | 0.04 | 0.09 | 0.07 |
| 1 NRS[c] | | | | | – | 0.34** | 0.28** | 0.19** | 0.22** |
| 1 PANAS-NA[d] | | | | | | – | 0.37** | 0.31** | 0.36** |
| 1 PCS[e] | | | | | | | – | 0.23** | 0.25** |
| 1 QSU-B – Total[f] | | | | | | | | – | 0.92** |
| 1 QSU-B – NA[g] | | | | | | | | | – |

*Note. N* = 229. Gender: 0 = Male, 1 = Female.
[a] Heaviness of Smoking Index.
[b] Time Since Last Cigarette in Minutes.
[c] Numerical Rating Scale Pain Intensity.
[d] Positive and Negative Affect Schedule – Negative Affect.
[e] Pain Catastrophizing Scale.
[f] Brief Questionnaire of Smoking Urges – total score; Brief Questionnaire of Smoking Urges – Negative Affect Relief Scale.
[g] Brief Questionnaire of Smoking Urges – Pleasure/Reward Scale.
* $p < .05$.
** $p < .01$.

**Table 4**
Pain Intensity and Urge to Smoke: Indirect Role of Negative Affect.

| Path | Path Description | *b* | SE | *t* | *p* | CI (l) | CI (u) |
|---|---|---|---|---|---|---|---|
| Model 1 ($Y_1$) Criterion Variable: Urge to Smoke Total Score | | | | | | | |
| *a* | NRS[a] → NA[b] | 7.045 | 1.360 | 5.182 | < 0.001 | 4.366 | 9.724 |
| *b* | NA → QSU-B[c] | 0.500 | 0.137 | 3.651 | < 0.001 | 0.230 | 0.770 |
| *c* | NRS → QSU-B | 5.833 | 2.871 | 2.032 | 0.043 | 0.176 | 11.490 |
| *c'* | NRS → QSU-B | 2.308 | 2.957 | 0.780 | 0.436 | −3.520 | 8.135 |
| Model 2 ($Y_2$) Criterion Variable: Urge to Smoke for the Relief of Negative Affect | | | | | | | |
| *a* | NRS → NA | 7.045 | 1.360 | 5.182 | < 0.001 | 4.366 | 9.724 |
| *b* | NA → QSU-B-NA[d] | 0.317 | 0.071 | 4.441 | < 0.001 | 0.176 | 0.457 |
| *c* | NRS → QSU-B-NA | 3.946 | 1.513 | 2.608 | 0.010 | 0.965 | 6.928 |
| *c'* | NRS → QSU-B-NA | 1.716 | 1.538 | 1.116 | 0.266 | −1.315 | 4.747 |

*Note.* $N = 229$.
In all models, path *a* represents the association between the independent variable and the mediator, path *b* represents the associations between the mediator and the dependent variable, controlling for the independent variable, path *c* represents the total effect of the model (direct effect + indirect effect), and path *c'* represents the direct effect of the independent variable on the dependent variable.
[a] Numerical Rating Scale- pain intensity.
[b] Positive and Negative Affect Schedule – Negative Affect.
[c] Questionnaire of Smoking Urges-Brief (QSU-B) – total score.
[d] QSU-B – Negative Affect Relief.

**Table 5**
Pain Intensity on Urge to Smoke: Moderating Role of Pain Catastrophizing.

| Path | | *Coeff.* | SE | *t* | *p* | CI (l) | CI (u) |
|---|---|---|---|---|---|---|---|
| *Pain Catastrophizing as a Moderator of Pain on Urge to Smoke Total Scores* | | | | | | | |
| Constant | *c* | 36.915 | 5.021 | 7.352 | < 0.001 | 27.019 | 46.810 |
| Pain Intensity (X) | $b_1$ | 9.22 | 3.26 | 2.82 | 0.005 | 2.78 | 15.65 |
| Pain Catastrophizing (M) | $b_2$ | 12.438 | 3.439 | 3.616 | < 0.001 | 5.659 | 19.216 |
| NRS × PCS-M (X*M) | $b_3$ | −17.944 | 6.456 | −2.779 | 0.006 | −30.668 | −5.221 |
| *Pain Catastrophizing as a Moderator of Pain on Urge to Smoke for Negative Reinforcement* | | | | | | | |
| Constant | *c* | 16.214 | 2.655 | 6.107 | < 0.001 | 10.982 | 21.446 |
| Pain Intensity (X) | $b_1$ | 5.558 | 1.725 | 3.221 | 0.001 | 2.158 | 8.959 |
| Pain Catastrophizing (M) | $b_2$ | 6.434 | 1.818 | 2.538 | < 0.001 | 2.850 | 10.018 |
| NRS × PCS-M (X*M) | $b_3$ | −8.757 | 3.413 | −2.565 | 0.011 | −15.484 | −2.030 |

*Notes.* $N = 229$. All models covaried for nicotine dependence (Heaviness of Smoking Index) scores and Race. Pain Intensity (NRS) scores were log transformed after adding 1 to the raw value. Pain catastrophizing was dichotomized at ± 30 and dummy coded at "0" and "1". NRS scores were entered as a continuous variable.

associations between pain intensity and motivation to smoke among lighter and intermittent smokers (e.g., Ditre et al., 2016b).

The current population of "recalcitrant" smokers may harbor characteristics that make tobacco cessation especially difficult (Hughes and Brandon, 2003; Irvin and Brandon, 2000), and current pain intensity may represent an important barrier to quitting (Zale et al., 2014). Consistent with this notion, the current findings contribute to an emerging literature indicating that pain and pain-related constructs may be relevant to nicotine/tobacco consumption among smokers with and without co-occurring chronic pain (Ditre and Brandon, 2008; Ditre et al., 2015; Zale et al., 2014; Zale et al., 2016). Indeed, urge to smoke is a reliable predictor of lapse and relapse following a cessation attempt (Allen et al., 2008; Nakamura et al., 2014), and these findings suggest that pain may constitute a high-risk situation for smokers who are attempting to quit. Future work is needed to determine whether smokers would benefit from tailored interventions that address the role of current pain in the context of smoking cessation. For example, given that nicotine has been shown to aid in the management of smoking urges (Hansson et al., 2012; Hartwell et al., 2013) and reduce pain in the short term (Ditre et al., 2016a), smokers who endorse current pain may benefit from high-dose or combination nicotine replacement therapy (Hatsukami et al., 2007; Mills et al., 2012).

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## Contributors

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## Conflicts of interest

No conflict declared.

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