Associations Between Past-Month Pain and Distress Intolerance Among Daily Cigarette Smokers

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ABSTRACT. Objective: A growing body of research indicates that pain is associated with the maintenance of tobacco smoking. Distress intolerance (DI) may play an important role in the link between pain and smoking. The goal of this study was to examine the association between past-month pain status and DI among a sample of daily cigarette smokers. It was hypothesized that smokers who reported past-month pain (vs. those reporting no past-month pain) would have higher perceived DI (i.e., lower scores on the Distress Tolerance Scale [DTS]) and higher physical DI (i.e., shorter persistence during the Breath-Holding Duration Task), and would report greater subjective distress and physical sensations during the breath-holding task. **Method:** Participants (N = 126) were daily smokers (56.3% male) who attended a baseline session for a larger experimental study on smoking behavior. Participants self-reported the presence and severity of past-month pain and completed two breath-holding duration trials approximately 15 minutes after smoking. Data were cross-sectional in nature. **Results:** Smokers with past-month pain had lower scores on the DTS relative to smokers without pain. No differences in breath-holding duration were observed. In addition, smokers with past-month pain, relative to those without, reported greater subjective distress and physical sensations during the initial, but not second, breath-holding trial. **Conclusions:** This is the first study to show that smokers with co-occurring pain may harbor beliefs about their inability to tolerate aversive psychological states, and are more emotionally reactive to physiological provocation (breath-holding task), than smokers without co-occurring pain. DI among smokers with pain may represent one mechanism by which pain contributes to the maintenance of smoking behavior. (*J. Stud. Alcohol Drugs, 79,* 781–789, 2018)

CIGARETTE SMOKING REMAINS the leading cause of preventable death worldwide (U.S. Department of Health & Human Services, 2014). Despite known health risks and an annual economic burden in excess of $300 billion in the United States alone, approximately 15.1% of American adults continue to smoke tobacco cigarettes (Jamal et al., 2016). Rates of smoking are higher among persons with co-occurring pain (30%–42%; e.g., Zvolensky et al., 2009), and there has been increasing empirical and clinical interest in the role of pain-related factors in the maintenance of tobacco dependence (e.g., Ditre et al., 2010, 2015). An evolving reciprocal model suggests 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, cigarette smoking has been identified as a risk factor in the onset and progression of painful conditions (e.g., Shiri et al., 2010). Indeed, among chronic pain patients, those who smoke to cope with pain report greater pain severity and interference relative to smokers who do not smoke for pain coping and to nonsmokers (e.g., Patterson et al., 2012). In addition, laboratory-induced physical pain produces increased smoking urges and shorter latency to smoking initiation (e.g., Ditre & Brandon, 2008).

Pain is a significant source of emotional distress (e.g., Gatchel et al., 2007), and it has been suggested that the construct of distress intolerance (DI) may help to explain complex pain–smoking interrelations (e.g., Zvolensky et al., 2010). DI refers to the perceived inability to tolerate negative emotional and/or other aversive states, as well as the behavioral act of being unable to withstand distressing states (Leyro et al., 2010). Accordingly, perceived DI is typically assessed using self-report questionnaires (e.g., Distress Tolerance Scale [DTS]; Simons & Gaher, 2005), whereas behavioral DI is typically measured as the duration of time that one can tolerate a physically or emotionally distressing task (e.g., breath-holding, mirror-tracing, thermal stress exposure; Leyro et al., 2010).

Accumulating evidence suggests that, similar to co-occurring pain, higher DI is associated with the maintenance

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of cigarette dependence. For example, DI has been positively associated with tobacco dependence (Leyro et al., 2011; Trujillo et al., 2017), cigarette craving (Trujillo et al., 2017), and negative reinforcement derived from smoking (Kauffman et al., 2017; Perkins et al., 2010; Trujillo et al., 2017). Prospective data have further shown that DI consistently predicts poorer smoking cessation outcomes (e.g., Brandon et al., 2003; Brown et al., 2009; Cameron et al., 2013; Hajek et al., 1987). Indeed, it has been hypothesized that DI may motivate smoking behavior and relapse via expectancies that smoking will ameliorate negative affect (e.g., Leventhal & Zvolensky, 2015). Moreover, treatment research suggests that DI may represent one mechanism of therapeutic change in smoking cessation outcomes (Farris et al., 2016). As a result, cessation treatments have been developed, in part, to modify DI to enhance clinical outcomes with varying degrees of success (Brown et al., 2013).

There is also reason to believe that smokers with co-occurring pain may have higher DI than smokers with no pain. Although associations between DI and pain have received scant empirical attention, there is a well-developed literature documenting differences in experimental pain tolerance (i.e., the maximum level of pain that a person is able or willing to withstand) as a function of current pain status (e.g., Zvolensky et al., 2011). For example, lower pain tolerance has been associated with the presence of several chronically painful conditions, including fibromyalgia (Reyes del Paso et al., 2011), whiplash-associated disorders (Kasch et al., 2005; Myrtveit et al., 2016), peripheral nerve injury (Taylor et al., 2010), rheumatoid arthritis (Vladimirova et al., 2015), and irritable bowel syndrome (Zhou et al., 2010). Together, these findings suggest that associations between DI and pain warrant further investigation. Such associations may be particularly important among tobacco smokers, as DI may represent one mechanism by which pain contributes to the maintenance of tobacco dependence. Escape and avoidance of aversive internal states has been conceptualized as a potent motivator of smoking (e.g., Baker et al., 2004), and it is possible that such motives are particularly salient among smokers with co-occurring pain. However, no research to date has examined associations between pain status and DI among tobacco smokers.

The primary goal of this study was to test the hypotheses that daily cigarette smokers with past-month pain (vs. no pain) would (a) endorse greater perceived DI, (b) demonstrate greater behavioral DI in the context of a breath-holding challenge, and (c) endorse greater subjective distress and physical sensations during the breath-holding challenge. These group differences were expected after adjusting for theoretically and empirically relevant demographic and smoking characteristics. A secondary goal of this study was to test the hypothesis that greater severity of past-month pain would be associated with (a) higher perceived DI, (b) higher behavioral DI, and (c) greater severity of subjective distress and physical sensations during the breath-holding challenge.

Method

Participants

Adult daily cigarette smokers were recruited from the local community for an experimental study on smoking behavior (Farris & Zvolensky, 2016). Respondents were screened by telephone for the following initial inclusion criteria: (a) between 18 and 65 years of age, (b) smoking 10 or more cigarettes per day for at least 1 year, and (c) smoked within the first 30 minutes of waking in the morning. Respondents were excluded if they endorsed current (a) frequent drinking (≥9 standard drinks/week), (b) illicit drug use (≥3 days/week), (c) or current psychotic symptoms. Potentially eligible respondents were invited for an in-person baseline assessment that included an eligibility assessment for the larger experimental study (described in Farris & Zvolensky, 2016), in addition to a behavior DI task regardless of eligibility for the larger study. The current analyses were conducted using data exclusively collected during the baseline assessment (N = 126).

Measures

Tobacco use and dependence. The Smoking History Questionnaire (Brown et al., 2002) was used to assess historical and current tobacco use (e.g., age at smoking initiation, smoking rate). Tobacco dependence was assessed using the Fagerström Test for Cigarette Dependence (FTCD; e.g., Fagerström, 2012). The FTCD is a six-item self-report measure that assesses level of tobacco dependence. Higher scores reflect greater tobacco dependence. The FTCD has positive relations with key smoking variables (e.g., saliva cotinine) and high test–retest reliability (Heatherton et al., 1991; Pomerleau et al., 1994). Internal consistency in the current sample was α = .39, which is likely a result of the low item count.

Biochemical verification of smoking status. Expired carbon monoxide (CO) was measured using the Vitalograph Breath Co carbon monoxide monitor. Expired CO is measured in parts per million (ppm), and provides an indirect, non-invasive measure of blood carboxyhemoglobin (Bittoun, 2008).

Past-month pain severity. The Short Form Health Survey-12 (SFHS; Ware et al., 1996) is a widely used 12-item self-report measure of mental and physical health. A single item was used to assess the presence of past-month bodily pain (i.e., "How much bodily pain have you had during the past four weeks?") (Ware et al., 1996). Response options ranged from 1 (*none*) to 5 (*severe*). For the current analyses, responses were dichotomized to reflect the presence or absence of past-month pain. Past-month pain is a commonly

used index of recent, recurring pain (e.g., Ditre et al., 2015; LaRowe et al., 2017; Zale et al., 2014). For the secondary study aim, pain responses were examined continuously to test whether severity of pain was associated with key outcome variables.

Substance use disorders. The Structured Clinical Interview for DSM-IV Disorders-Non-Patient Version (SCID-I/NP; First et al., 2007) was used to assess the presence of past-year substance use disorders based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (DSM-IV-TR; American Psychiatric Association, 2000), diagnostic guidelines. The SCID-I/NP is a clinician-administered semi-structured diagnostic assessment. All diagnostic assessments were audio recorded and 100% of cases were supervised for diagnostic accuracy. A random 20% of recordings were subjected to blinded inter-rater reliability review by a doctoral-level clinical psychology graduate student. No cases of diagnostic disagreement were noted.

Perceived distress tolerance. Perceived DI was assessed using the DTS (Simons & Gaher, 2005). The DTS assesses an individual's perceived ability to tolerate negative emotional states (e.g., "I can't handle feeling distressed or upset"). Items are rated on a 5-point Likert-type scale ranging from 1 (*strongly agree*) to 5 (*strongly disagree*), and a total score is computed by calculating the mean response (range: 1–5). Higher DTS scores reflect higher tolerance for distress, and thus, lower DI. The 14-item version of the DTS was used, which has been validated among cigarette smokers (Leyro et al., 2011). Internal consistency in the current sample was excellent ($\alpha = .93$).

Breath-holding task. The Breath-Holding Duration Task is a behavioral index of DI (Asmundson & Stein, 1994). During the task, a standardized script is read to prompt participants to inhale as deeply as possible and then exhale once a full breath is achieved. At the completion of the exhalation, participants are prompted to inhale as deeply as possible and then hold their breath for as long as they can (Asmundson & Stein, 1994). No incentive or encouragement is given by the experimenter to promote duration. The length of time the participants can hold their breath is recorded via a stopwatch. This task has been frequently used as a measure of physical distress tolerance among smokers (e.g., Hogan et al., 2015), with shorter durations of breath-holding indicating greater intolerance of physical distress.

Following the breath-holding trial, participants were immediately asked to rate how distressing the experience was using the Subjective Units of Distress Scale (SUDS; Wolpe, 1958). Response options ranged from 0 (*not distressing at all*) to 10 (*extremely distressing*). Participants were also asked to rate the level of physical sensations that they noticed while holding their breath using a scale ranging from 0 (*no sensations*) to 10 (*an extreme amount of sensations;* Rapee et al., 1992). This entire process was repeated twice. Thus, each of two breath-holding trials consisted of the following data: (a) breath-holding duration, (b) SUDS rating, and (c) physical sensations rating.

The intercorrelation between Trials 1 and 2 persistence (in seconds) was $r = .87$, $p < .001$, indicating high consistency across trials. Thus, the average duration of the two trials was used. In contrast, the intercorrelations between Trials 1 and 2 SUDS ratings ($r = .40$, $p < .001$) and sensations ($r = .39$, $p < .001$) were small to moderate in size, indicating that each trial reflects unique information. Therefore, averaging scores was not indicated given that it would obfuscate potentially important trial differences. Thus, to increase specificity in the tests, the effects of past-month pain on SUDS and physical sensations were examined separately for each trial.

Procedure

Participants were screened for eligibility by telephone, scheduled for an in-person appointment, and instructed to bring their usual brand of cigarettes to the laboratory. Upon arrival, participants provided a carbon monoxide (CO) analysis of expired breath to verify smoking status, and completed a series of diagnostic and self-report assessments. Next, all participants completed an ad libitum smoking trial at a standardized point during the baseline assessment (approximately 90 minutes after arrival to the laboratory). After completion of the smoking trial, participants completed approximately 75 minutes of self-report and behavioral tasks. The DTS and breath-holding duration task were completed approximately 15 minutes after smoking. All participants were compensated $25 for the baseline assessment. The study was approved by the Institutional Review Board at the University of Houston, and informed consent was completed before initiation of study procedures.

Data analysis

Differences in demographic and smoking characteristics as a function of past-month pain status (0 = *no past-month pain,* 1 = *past-month pain*) were tested. Education status (0 = *high school education or less,* 1 = *at least part college*) differed as a function of past-month pain and was retained as a covariate in subsequent analyses. Participant sex (0 = *male,* 1 = *female*) and cigarette dependence were also retained as covariates because of known associations with pain (e.g., Von Korff et al., 1990; Weingarten et al., 2008) and DI (e.g., Simons & Gaher, 2005; Trujillo et al., 2017). To address the first study aim, analysis of covariance (ANCOVA) was used to test the effects of past-month pain status on perceived DI (i.e., DTS scores) and behavioral DI (i.e., Trial 1 and Trial 2 breath-holding duration), and subjective distress and physical sensations during separate breath-holding trials. Two sets of ANCOVAs were conducted for subjective distress and physical sensations in order to explicate potential unique differences across the trials. First, models were constructed

to test the effects of past-month pain status on task outcomes in Trial 1. Second, models were constructed to test the effects of past-month pain status on task outcomes in Trial 2, after adjusting for Trial 1 effects. To address the second study aim, hierarchical linear regression models were conducted to test associations between past-month pain severity and perceived DI, behavioral DI, and subjective distress and physical sensations following each breath-holding trial. Covariates were entered at the first step of the model, and past-month pain severity (continuous score) was entered in the second step. Change in R-squared (ΔR^2) at the second step of the model was used to index the relative incremental contribution of past-month pain severity to each outcome after accounting for covariate effects.

Results

Participant characteristics

Participants included 126 current daily tobacco smokers (56.3% male; M_{age} = 44.11, *SD* = 9.72), who reported smoking approximately 15 cigarettes per day (*M* = 15.09, *SD* = 6.91) for an average of nearly 24 years (*M* = 23.57, *SD* = 10.91). Mean expired CO was 22.56 (*SD* = 11.43), and the mean FTCD score was 4.67 (*SD* = 1.49), indicating a moderate level of tobacco dependence. Most of the sample identified as Black or African American (64%), and more than half (58%) reported education beyond high school. Approximately 60% of the sample endorsed past-month pain (*n* = 81), with greater than 17% of those reporting moderate to severe pain. Participants with past-month pain also reported lower educational attainment than participants without pain (*p* = .007). The prevalence of any substance-related disorder was 7.1% (*n* = 9), which included alcohol use disorder (5.6%, *n* = 7), cannabis use disorder (4.0%, *n* = 5), opioid use disorder (3.2%, *n* = 4), cocaine use disorder (2.3%, *n* = 3), and sedative use disorder (1.6%, *n* = 2). Additional sociodemographic and clinical data are presented in Table 1.

Perceived and behavioral distress intolerance

Perceived distress intolerance. Analyses revealed a main effect of past-month pain status on perceived DI, $F(1, 121) = 5.934$, $p = .016$, $\eta_p^2 = .047$ (Figure 1). Specifically, smokers with past-month pain had significantly lower scores on the DTS (*M* = 3.135, *SE* = 0.113) than smokers without past-month pain (*M* = 3.606, *SE* = 0.153). In addition, the model with severity of past-month pain predicting perceived DI was significant, $F(4, 121) = 3.54$, $p = .009$, $R^2 = .11$. After we adjusted for the nonsignificant covariates in Step 1, severity of past-month pain was significantly and incrementally associated with lower DTS scores ($b = -0.28$, $t = -3.15$, $p = .002$; $\Delta R^2 = .074$).

Behavioral distress intolerance. Results indicated a nonsignificant association between past-month pain status and average breath-holding duration, $F(1, 121) = 0.08$, $p = .778$. In addition, the regression model with severity of past-month pain predicting average breath-holding duration was significant, $F(4, 121) = 3.89$, $p = .005$, $R^2 = .11$; however, the results were driven by the significant effect of female sex on shorter trial duration ($b = -113.15$, $t = -3.56$, $p = .001$). The effect of pain severity in Step 2 of the model was nonsignificant.

Subjective distress and physical sensations

Breath-holding Trial 1. Smokers with past-month pain reported significantly higher levels of subjective distress (*M* = 3.385, *SE* = 0.276) compared to smokers with no past-month pain (*M* = 2.417, *SE* = 0.374) during breath-holding Trial 1, $F(1, 121) = 4.227$, $p = .042$, $\eta_p^2 = .034$. Smokers with past-month pain also reported more severe physical sensations (*M* = 3.580, *SE* = 0.283) compared to smokers without pain (*M* = 2.489, *SE* = 0.384) during breath-holding Trial 1, $F(1, 121) = 5.082$, $p = .026$, $\eta_p^2 = .040$. All presented means are adjusted for covarying factors. Results of ANCOVAs are depicted in Figure 2. The overall regression model with severity of past-month pain predicting SUDS during breath-holding Trial 1 was nonsignificant, $F(4, 121) = 1.69$, $p = .156$, $R^2 = .053$. In addition, the overall regression model with severity of past-month pain predicting physical sensations during breath-holding Trial 1 was nonsignificant, $F(4, 121) = 1.85$, $p = .123$, $R^2 = .058$.

Breath-holding Trial 2. After we adjusted for Trial 1, no differences were observed between smokers with and without any past-month pain on SUDS, $F(1, 120) = 0.82$, $p = .367$, or physical sensations, $F(1, 120) = 0.97$, $p = .327$, during Trial 2 (Figure 2). The regression model with severity of past-month pain predicting Trial 2 SUDS rating was significant, $F(5, 120) = 25.477$, $p < .001$, $R^2 = .515$. However, the effect of pain severity in Step 2 of the model did not reach statistical significance ($p = .055$). Similarly, the regression model with severity of past-month pain predicting Trial 2 physical sensation ratings was significant, $F(5, 120) = 41.498$, $p < .001$, $R^2 = .634$. However, the effect of pain severity in Step 2 of the model was nonsignificant ($p = .212$).

Discussion

The current study presented a novel test of associations between pain and DI among daily cigarette smokers. First, smokers with past-month pain (relative to those without) reported significantly higher perceived DI, and greater severity of pain was incrementally associated with perceived DI. However, contrary to hypothesis, smokers with and without past-month pain did not demonstrate differences in their behavioral capacity to withstand distress during the breath-

Table 1. Sociodemographic, smoking, and pain characteristics

Variable	Past-month pain (n = 81) n (%)	No past-month pain (n = 45) n (%)	Total (N = 126) n (%)
Gender			
Male	44 (54.3%)	27 (60.0%)	71 (56.3%)
Female	37 (45.7%)	18 (40.0%)	55 (43.7%)
Race			
White	28 (34.6%)	9 (20.0%)	37 (29.4%)
Black or African American	47 (58.0%)	34 (75.6%)	81 (64.3%)
Other	6 (7.4%)	2 (4.4%)	8 (6.3%)
Ethnicity			
Hispanic or Latino	6 (7.4%)	0 (0.0%)	6 (4.8%)
Non-Hispanic	75 (92.6%)	45 (100.0%)	120 (95.2%)
Marital status			
Never married	37 (45.7%)	23 (51.1%)	60 (47.6%)
Married/living with someone	10 (12.3%)	7 (15.6%)	17 (13.5%)
Separated/divorced	30 (37.0%)	14 (31.1%)	44 (34.9%)
Widowed	4 (4.9%)	1 (2.2%)	5 (4.0%)
Education**			
High school or less	27 (33.3%)	26 (57.8%)	53 (42.1%)
At least part college	54 (66.7%)	19 (42.2%)	73 (57.9%)
Employment status			
Full time	19 (23.5%)	12 (26.7%)	31 (24.6%)
Part time	18 (22.2%)	9 (20.0%)	27 (21.4%)
Other	13 (16.0%)	8 (17.8%)	21 (16.7%)
Unemployed	31 (38.3%)	16 (35.6%)	47 (37.3%)
Past-4-week pain severity[a]**			
None	0 (0.0%)	45 (100.0%)	45 (35.7%)
Very mild	40 (49.4%)	0 (0.0%)	40 (31.7%)
Mild	27 (33.3%)	0 (0.0%)	27 (21.4%)
Moderate	13 (16.0%)	0 (0.0%)	13 (10.3%)
Severe	1 (1.2%)	0 (0.0%)	1 (0.8%)
	M (SD)	M (SD)	M (SD)
Age, years	43.47 (9.88)	45.27 (9.43)	44.11 (9.72)
Cigarettes per day	15.47 (7.45)	14.40 (5.84)	15.09 (6.91)
Years of smoking	23.68 (10.85)	23.38 (11.14)	23.57 (10.91)
Cigarette dependence[b]	4.59 (1.51)	4.80 (1.47)	4.67 (1.49)
Distress intolerance[c]*	3.14 (1.00)	3.60 (1.04)	3.30 (1.03)

[a]Short Form Health Survey–12; [b]Fagerström Test of Cigarette Dependence; [c]Distress Tolerance Scale.
*p < .05; **p < .01.

holding task. The combination of these findings indicates that although smokers with (versus without) co-occurring pain did not differ in their ability to withstand physical distress, they were more likely to harbor beliefs of having a limited capacity to tolerate distress. This divergence in outcomes is broadly consistent with evidence that self-report and behavioral measures of DI are often not highly correlated with one another, which may be because these measures tap different aspects of DI (e.g., perceived vs. demonstrated distress tolerance; e.g., McHugh et al., 2011). However, the current patterning of effects is consistent with previous observations that perceived but not behavioral DI is uniquely linked with substance use (e.g., Farris et al., 2015, 2016; Hasan et al., 2015) and is more malleable to treatment (Farris et al., 2016). Moreover, pain and high perceived DI have both been associated with greater tobacco dependence, stronger cigarette craving, and greater difficulty quitting smoking (e.g., Ditre & Brandon, 2008; Trujillo et al., 2017; Zale et al., 2014). Thus, higher perceived DI may represent one mechanism by which pain contributes to the maintenance of smoking.

In addition, smokers with co-occurring pain reported experiencing more distress in response to aversive physical states, relative to those without pain. Specifically, compared to smokers with no pain, those with past-month pain reported greater distress and physical sensations during the first breath-holding trial, but not the second trial. This novel pattern of findings may offer nuanced information about how smokers with pain respond to physical distress. For example, it is possible that these effects reflect greater habituation to respiratory distress from Trial 1 to 2 in smokers with past-month pain (e.g., Rankin et al., 2009), and greater sensitization to respiratory distress from Trial 1 to 2 among smokers without past-month pain (e.g., Barnes, 1988). The tendency

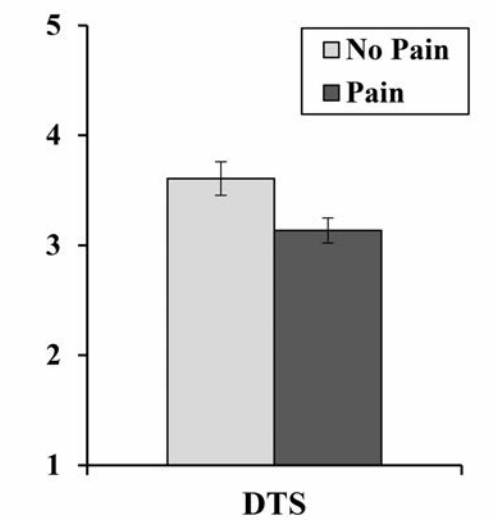

FIGURE 1. Distress Tolerance Scale (DTS) scores as a function of past-month pain (possible range: 1–5). Adjusted means are presented.

for smokers with pain to respond to the initial onset of physical distress states is relevant to the experience of distress due to nicotine withdrawal. Smokers with co-occurring pain tend to experience more severe nicotine withdrawal symptoms when attempting to quit, relative to smokers without co-occurring pain (Ditre et al., 2016). Indeed, it is possible that smokers with co-occurring pain, particularly those with high perceived DI, attempt to escape/avoid distress and discomfort by smoking (e.g., Ditre et al., 2016). Of note, the effects of pain on distress and physical sensations were not amplified by severity of pain, suggesting that pain as a status may be more predictive of smokers' responses to aversive physical states than the intensity of pain.

Several limitations and directions for future research should be noted. First, although the inclusion of a behavioral measure of DI was a methodological strength, future work may benefit from including additional behavioral measures of DI (e.g., CO_2 challenge task, radiant heat stimulation en-

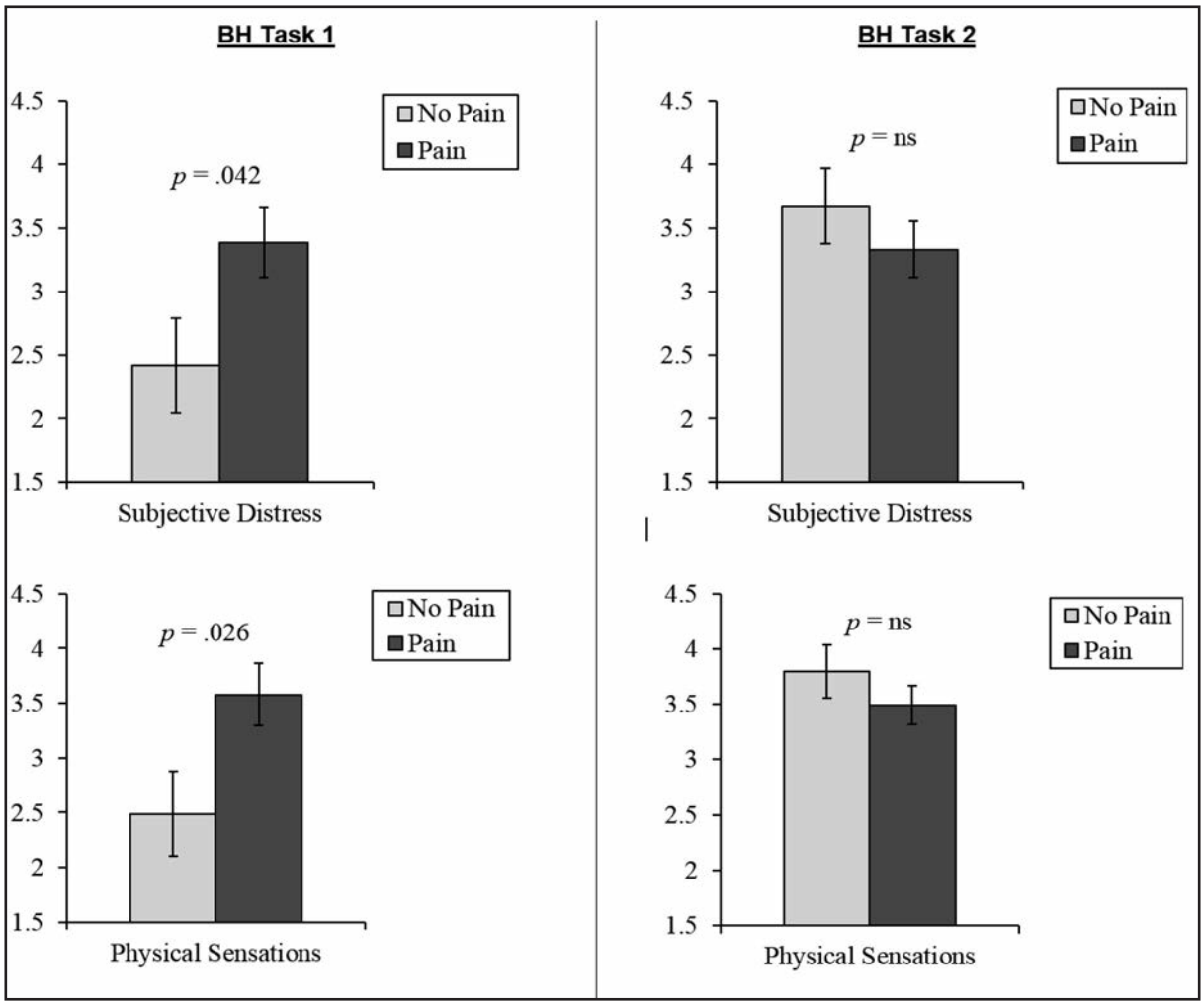

FIGURE 2. Breath-holding distress and sensations as a function of past-month pain. Note: Subjective distress measured with Subjective Units of Distress Scale (possible range: 0–10). Physical sensations measured by asking participants to "rate the level of sensations that you noticed while holding your breath" (possible range: 0–10). ns = not significant.

durance, mirror tracing task; Zvolensky et al., 2011). Second, participants completed measures of DI under nicotine-sated conditions (i.e., approximately 15 minutes after smoking). Given that acute substance intoxication (Farris & Metrik, 2016) and deprivation (Bernstein et al., 2008) may influence DI, future work should examine associations between pain and DI among deprived versus satiated tobacco smokers. Third, participants responded to a single item that assessed past-month pain. Although items that assess past-month pain are commonly used and likely capture a large portion of individuals who would also endorse chronic pain, future studies should test DI among smokers with and without co-occurring clinical pain. Future work should also examine the effects of other pain-related factors (e.g., pain duration, disability, and catastrophizing) on DI. Fourth, only 11% of the current sample endorsed moderate to severe past-month pain, and this may have limited our ability to detect an incremental effect of pain severity on indices of DI. Extension to this line of inquiry to smokers with clinically significant pain is warranted. Fifth, future work is needed to explicate the nuanced context in which smokers with pain are vulnerable to greater responding to physical distress states. For example, studies should examine how pain influences isolated and/or consecutive periods of physical provocation. Last, future research would benefit from examining associations between pain and DI among nonsmokers, testing the predictive utility of DI in the onset and progression of chronic pain, and investigating potential synergistic effects of pain and DI on smoking cessation outcomes.

Clinical research has implicated DI in the maintenance of tobacco dependence (e.g., Brown et al., 2002, 2013), and these data provide initial evidence that DI may also be elevated among smokers with co-occurring pain. Thus, DI may warrant consideration as a potential transdiagnostic factor in comorbid pain and tobacco dependence. It is possible that a lower threshold for tolerating distress among smokers with pain (vs. smokers without pain) may increase smoking behavior and serve as a barrier to quitting (e.g., Brown et al., 2005). The current findings underscore the importance of clinically assessing and addressing DI among cigarette smokers with co-occurring pain. Indeed, treatments informed by Dialectical Behavioral Therapy (Linehan, 1993; Linehan et al., 1999) and Acceptance and Commitment Therapy (Hayes et al., 1999) may be particularly beneficial for smokers with co-occurring pain. One such protocol was developed for individuals with substance use disorders and incorporated elements aimed at increasing skills needed to tolerate distress and control behaviors in the context of emotional distress (Bornovalova et al., 2012). Importantly, treatments should address both the behavioral capacity to withstand distress as well as perceptions and beliefs about one's inability to tolerate distress. Increasing individuals' willingness and confidence in their ability to tolerate discomfort may improve smoking cessation outcomes among smokers with co-occurring pain.

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