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Pain Severity as a Predictor of Negative Affect following a Self-Guided Quit Attempt: An Ecological Momentary Assessment Study

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Abstract

Background: Past work has documented bi-directional associations between pain and cigarette smoking behaviors such that those who smoke evidence greater pain, and those in pain tend to smoke more. However, such work has not focused on the role of pain in relation to negative affect, which plays an important role during cessation attempts.

Objective: The current study evaluated pain as a predictor of negative affect as well as level of interference associated with negative affect among individuals undergoing a self-guided quit attempt.

Methods: Study variables were assessed via ecological momentary assessment (EMA) during the two weeks following a self-guided quit attempt. Participants included 54 daily smokers (33.3% female; M_{age} = 34.7, SD = 13.9).

Results: There were statistically significant within-person associations of pain ratings with negative affect and interference due to negative affect, such that greater pain was associated with higher levels of each dependent variable. Additionally, there was a within-person effect of smoking status (i.e., smoking vs. abstinence, measured via EMA) on negative affect, but not ratings of interference; smoking was associated with greater negative affect.

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Conflicts of Interest

The authors report no conflicts of interest.

Conclusion: These findings highlight the importance of bodily pain in relation to negative mood following a quit attempt. Clinically, the results suggest a greater focus on the experience of pain during quit attempts may be warranted.

Keywords

Pain; Negative Affect; Smoking; Ecological Momentary Assessment

Pain and smoking are highly prevalent and interplay in a bidirectional manner (Ditre & Brandon, 2008; Ditre, Brandon, Zale, & Meagher, 2011; Parkerson, Zvolensky, & Asmundson, 2013). Research suggests smoking increases the risk for chronic pain (Shiri, Karppinen, Leino-Arjas, Solovieva, & Viikari-Juntura, 2010), and individuals who live with painful medical problems evince greater cigarette dependence (Fertig, Pomerleau, & Sanders, 1986). Ditre and colleagues (2011) integrative reciprocal model of pain and smoking predicts a positive cycle wherein pain and smoking contribute to a worsening of both. Studies have found positive associations between pain intensity and smoking among persons in the general population (Hahn, Rayens, Kirsh, & Passik, 2006) and among those with chronically painful conditions (Andersson, Ejlertsson, & Leden, 1998; Deyo & Bass, 1989; Kaila-Kangas, Leino-Arjas, Riihimäki, Luukkonen, & Kirjonen, 2003; Melis et al., 2010; Oleske et al., 2004; Riley, Tomar, & Gilbert, 2004; Saag et al., 1997; Scott, Goldberg, Mayo, Stock, & Poîtras, 1999; Yunus, Arslan, & Aldag, 2002).

Although promising, previous research has been limited in three key ways. First, past studies of pain intensity and smoking have not evaluated the predictive validity of pain experience on negative affect during a quit attempt, although indirect work has found pain intensity to be associated with negative affect (Gaskin, Greene, Robinson, & Geisser, 1992; Geisser, Roth, Theisen, Robinson, & Riley, 2000). This information is important because elucidating the extent to which pain experience is associated with negative mood may directly inform whether smoking cessation interventions should target pain to offset the relative risk associated with negative affect during quit attempts. Indeed, research has found for over three decades that negative affect is consistently and generally robustly associated with poorer cessation outcome (e.g., Wills & Shiffman, 1985)

Second, from a methodological perspective, extant work focused on pain and smoking has rarely employed cutting-edge technologies in the assessment of theoretically-relevant pain and smoking processes. For example, research has yet to incorporate methodological advances in ambulatory Ecological Momentary Assessment (EMA) of pain and negative affect states and nicotine withdrawal in “real time” within the study of pain-smoking linkages (Shiffman, 2000). Using EMA, randomly timed assessments are combined with event-contingent assessments. Research suggests EMA data are more reliable when used via handheld computers than paper/pencil diaries (Vahabzadeh, Epstein, Mezghanni, Lin, & Preston, 2004). EMA tactics provide investigators with the capability to complete fine-grained monitoring of theoretically-relevant processes (e.g., nicotine withdrawal symptoms, mood states) and in real-world environments with personally-relevant cues and triggers (Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996). Thus, there is a need to bring state-of-the art scientific methodology to the study of pain and smoking-related processes that may play

key explanatory roles in smoking cessation outcome among persons with varying levels of pain. Indeed, doing so may help to advance knowledge regarding the affective and drug-state mechanisms linking pain experience to cessation outcomes, which may be mapped using EMA over the course of a quit attempt. For example, although past work using EMA showed that pain triggers episodes of cigarette smoking (Dhingra et al., 2014), such work has not examined how pain relates to negative affect.

Third, previous research has not examined important clinically relevant dimensions of negative affect. For instance, individuals' perception of interference related to their negative moods should be considered in addition to the mood symptoms themselves (e.g., Brown, Di Nardo, Lehman, & Campbell, 2001). Such dimensions typically are employed to characterize the symptoms being considered "clinically significant" (American Psychiatric Association, 2013). Indeed, negative affect syndromes (i.e., psychological disorders such as anxiety and depressive disorders characterized by high levels of negative affect; Barlow, Allen, & Choate, 2004; Norton & Paulus, 2016) must have a component of perceived interference/impairment or distress in order for a diagnosis to be given per the DSM-5 (American Psychiatric Association, 2013).

Drawing from theoretical models and extant empirical studies of pain and smoking (Ditre et al., 2008), smokers higher in pain may be more affectively reactive to aversive internal cues (e.g., nicotine withdrawal, stress of quitting) during a planned period of smoking deprivation. For example, smokers with elevated pain symptoms may be more apt to engage in catastrophic thinking toward these aversive internal cues (e.g., "I cannot handle this") and experience greater change in the intensity of negative affect (e.g., greater symptoms). As a result, higher levels of pain may drive the affective drug-state experiences (negative affect) that this subgroup of smokers struggle to cope with effectively (Ditre et al., 2008). Specifically, pain severity may be related to greater propensity for negative affect and more interference.

The current study sought to test whether pain severity is a predictor of negative affect during a self-guided quit attempt using EMA. Daily smokers interested in quitting on their own were studied to provide knowledge about self-quitters, a large percentage of the overall smoking population (Levy & Friend, 2002). It was hypothesized that greater pain would be associated with heightened negative affect as well as state ratings of interference associated with negative affect during the two-week period following a quit attempt.

Methods

Participants

An initial 83 participants met eligibility criteria for study enrollment and were scheduled to engage in an unaided quit attempt. Study inclusion criteria included: (1) being between 18 and 65 years of age; (2) being a regular daily smoker for at least one year; (3) smoking an average of at least 8 cigarettes per day (verified via expired carbon monoxide [CO] breath analysis; ≥ 8ppm); (4) reporting motivation to quit smoking of at least 5 on a 0–10-point scale; (5) being interested in making a serious unaided quit attempt; and (6) not having decreased the number of daily cigarettes smoked by more than half in the past six months.

Participants were excluded from the study based on evidence of: (1) limited mental competency (not oriented to person, place, and/or time) and the inability to give informed, voluntary, written consent to participate; (2) pregnancy or the possibility of being pregnant (by self-report); (3) current use of nicotine replacement therapy and/or smoking cessation counseling; (4) current or past history of psychotic-spectrum symptoms or disorders; (5) current substance dependence (excluding cigarette dependence); (6) active suicidality; and, (7) any current use of psychotropic medication, taken as needed.

Of the 84 eligible persons, 25 did not attend their scheduled quit-day appointment and were excluded from the present analyses. An additional five participants were excluded from the analyses due to equipment malfunction and/or participants' failure to return the PDA device. Thus, the final sample was comprised of 54 participants (33.3% female; M_{age} = 34.7, SD = 13.9). The racial composition was 87% White, 7.4% Black or African American, 3.7% "mixed," and 1.9% Asian. In terms of smoking characteristics, participants reported smoking their first cigarette at 14.6 (SD = 2.7) years of age and being a daily smoker for 15.4 years (SD = 13.1). Participants reported smoking an average of 16.0 (SD = 9.9) cigarettes per day upon study entry, and endorsed an average of 3.1 (SD = 1.8) on the Fagerstrom Test for Cigarette Dependence (Fagerström, 2012), indicating low-moderate levels of dependence. Regarding prior cessation behavior, participants endorsed an average of 3.2 past "serious" quit attempts (SD = 2.5).

Procedure

Detailed protocol information is presented elsewhere (Langdon, Farris, Øverup, & Zvolensky, 2016). Briefly, individuals who responded to advertisements (via craigslist and fliers) for a research study on "quitting smoking" were scheduled for an in-person session to determine eligibility and collect baseline data. Upon arrival at the laboratory, participants provided informed consent, completed a structured interview, provided a breath sample of CO, and completed a packet of self-report questionnaires. All participants were compensated $20 for participating in the baseline session.

Eligible participants were invited to participate in the intervention study. Specifically, these participants were instructed to select a quit day on which they would quit smoking on their own, without any assistance (i.e., absent of pharmacological or psychosocial treatment). On their selected quit day, participants returned to the laboratory to biochemically verify smoking abstinence via breath sample of CO and receive the handheld palm pilot. Participants were asked to carry the palm pilot device with them at all times between the hours of 10AM and 7PM for two weeks to ensure consistency of responding.

Participants completed in-person follow-up assessments at 3, 7, and 14 days post-quit to verify abstinence. On days 3 and 7 post-quit abstinence was verified via CO analysis of breath samples; on day 14 post-quit abstinence was verified by both CO analysis of breath samples as well as collection of saliva cotinine. Smoking was verified by CO during in person sessions only. Participants were compensated an additional $10 for completion of each of the follow-up assessments regardless of abstinence status.

Ecological Momentary Assessment (EMA).—Participants completed daily assessments (approximately 5 minutes) away from the laboratory, in their regular daily environments, for the first 14-days of their cessation attempt using a pocket PC mini-computer (palm-sized device) utilized in past smoking research. Each palm pilot handheld was pre-programmed to administer the selected self-report measures, over the course of the first 14-days of the cessation attempt, at 3 random-intervals during the day, each day (between 10AM and 7PM). Participants had to respond to the prompt when it was given. A total of 42 repeated EMA assessments were administered across the initial 14 days of the quit attempt.

Measures

Smoking History Questionnaire (SHQ).—The SHQ is a self-report measure used to collect descriptive information regarding smoking history (e.g., onset of regular smoking), pattern (e.g., number of cigarettes consumed per day), past quit attempts (e.g., how many times in your life have you made a serious quit attempt), and problematic symptoms experienced during quitting (e.g., weight gain, nausea, irritability, and anxiety).

Fagerström Test for Cigarette Dependence (FTCD).—The FTCD is a 6-item scale that assesses gradations in tobacco dependence (e.g, how soon after you wake up do you smoke your first cigarette; Fagerström, 2012; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). Scores range from 0–10, with higher scores reflecting high levels of physiological dependence on cigarettes. The FTCD has adequate internal consistency, positive relations with key smoking variables (e.g., saliva cotinine), and high test-retest reliability (Heatherton et al., 1991; Pomerleau, Carton, Lutzke, Flessland, & Pomerleau, 1994). In the current study, the FTCD total score was used to characterize cigarette dependence (α = .62).

Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988).—The PANAS is a self-report measure used to assess the degree to which respondents generally experience 20 different emotions and feelings (e.g., excited, distressed). Each emotion was rated using a five-point Likert scale (1 = very slightly or not at all to 5 = extremely). The measure yields two factors, positive affect (PANAS-PA) and negative affect (PANAS-NA), which have demonstrated strong psychometric properties (Watson et al., 1988). In the present study, negative mood was assessed with the PANAS-NA at baseline as well as during the cessation attempt via EMA procedures (3× per day for 14 days). During the EMA portion, the time-referent of the PANAS was changed from generally to currently in order to capture state-level, as opposed to trait-level, negative affect. Internal consistency of the PANAS-NA items in the current sample at baseline was good (α = .84).

Interference from Negative Mood.—State-level interference of negative mood was assessed with the question: How interfering is the negative mood state that you are currently feeling? Participants reported their degree of interference of negative mood on a scale from 0 (not at all [*interfering*]) to 100 (extremely [*interfering*]). This item was assessed during the cessation attempt via EMA procedures (3× per day for 14 days).

Pain Assessment.—State-level pain was assessed with a single item: Indicate to what extent you are currently feeling bodily pain?". Participants rated their state-level pain using a five-point Likert scale (0 = none to 4 = severe). The single item was assessed during the cessation attempt via EMA procedures (3× per day for 14 days).

Daily Smoking Behavior Status.—Self-reports of smoking status were collected from participants via EMA procedures (3× per day for 14 days). Specifically, at each prompt, participants were asked "Have you smoked any cigarettes since the last time you completed questions on the handheld?" Participants were instructed to indicate "yes" even if it was just a puff. Reports of abstinence were verified by expired CO breath sample (8ppm cutoff) at in-person follow-up assessment points (quit day, 3, 7, 14). A cutoff of 8ppm was used, consistent with recommended guidelines at the time of this study (Irving, Clark, Crombie, & Smith, 1988). Expired air CO levels were assessed with a Vitalograph Breathco CO monitor. Detected values above the stated cutoff scores were considered indicative of smoking. Smoking was coded as 1 for smoked and 0 for abstinence.

Apparatus.—Throughout the initial 14-days of the quit attempt, participants were instructed to carry with them the Palm Z22 Handheld PDA. Each palm pilot was programmed with the Experience Sampling Program, Version 4.0 (ESP). ESP is an open-source software package designed to administer questionnaires, surveys, or experiments via a palm pilot or compatible handheld computer. ESP allows the researcher to create a pre-determined schedule of assessment, prompting participants to answer and record their responses using the palm pilot device. Participants' responses were recorded and stored on the palm pilot device throughout the duration of the study (e.g., initial 14-days of cessation), and were later accessible to download onto a computer for analysis.

Data Analytic Strategy

The nested structure of the data was evaluated for primary variables of interest. Based on intraclass correlation coefficients (ICCs) it was determined that a two-level model (Level-1: assessment and Level-2: individual) appropriately captured variance in models of interest.[1] Additionally, two-level models are appropriate in EMA research (Nezlek, 2012; Schwartz & Stone, 2007). Level-1 predictors included EMA pain ratings and EMA smoking status. Level-2 predictors included person-average pain rating, baseline negative affect, and baseline smoking rate. The person-average score of EMA pain ratings was included as Level-2 predictors. The Level-1 continuous predictor (EMA pain ratings) was centered within-person, such that the score at a given time point reflected the deviation from the participant's overall average. Grand mean centering was conducted for Level-2 predictors to improve interpretability of coefficients. Standardized estimates are reported. Considering that an aggregate of a Level-1 predictor was included as a Level-2 predictor, contextual effects were examined by evaluating the difference in the aggregated effect on the outcome at Level-2 and the interindividual effect at Level-1 (Lüdtke et al., 2008). Contextual effects

[1]ICC values at Level-1 (assessment), Level-2 (day) and Level-3 (person) were evaluated for EMA pain, EMA negative affect, and EMA interference from negative affect. Findings suggested that the majority of variance was at Level-1 and Level-3 (Level-1 ICC: 0.33, 0.27, 0.27, respectively; Level-2: 0.10, 0.08, 0.11, respectively; Level-3: 0.57, 0.64, 0.62, respectively). Thus, models were evaluated in a 2-level nested structure.

provide information on the relative effect of the aggregated Level-2 predictor on the outcome above what is accounted for by the Level-1 effect of the predictor. A significant contextual effect suggest that the studied relation at the aggregated level is stronger than the relation at the individual level.

To test the primary study aims, a multi-level model (MLM) analytic approach was used. All analyses were performed using Mplus version 8.0. Two models were run for the two independent outcomes: EMA negative affect and EMA interference from negative affect. Primary hypotheses focused on the lagged effect of pain ratings measured via EMA on the two outcomes. The lagged models were developed such that pain at the previous EMA assessment served as a predictor of the outcome of interest at the next EMA assessment. Thus, models inherently considered the time component of assessment. Bayesian estimation was employed to estimate models and accommodate missing data.

Results

Descriptive Statistics

First, inter-correlations between aggregate study variables were examined. Correlations, as well as means and standard deviations, are reported in Table 1. Average pain within person ranged from 0 to 3.56. 74.1% reported average pain above 0. There was a significant and positive association between the person-average daily score in pain, negative affect, and interference, and between person-average daily score in both outcomes. No other significant associations were observed. Participants provided at least partial data on variables of interest for 1019 of the 2251 EMA assessments (average of 18.86 per participant [SD=8.51]). The average length between assessments was 8.0 (SD = 7.5) hours.

MLM Results

Results from EMA negative affect are presented in Table 2. The ICC for the model was 0.65, indicating that most of the variance in negative affect was at the between-person level. The model with all the predictors accounted for a significant proportion of the within-person (2.5%; $p < .001$) and between-person variance (46.3%; $p < .001$) for EMA negative affect. At the within-person level, smoking and pain were both positively related to EMA negative affect. Thus, smoking between assessments and greater pain at the previous assessment related to greater EMA negative affect at the next assessment. At the between-person level, baseline negative affect and mean pain rating were significantly related to average negative affect during the two weeks post-quit day. A significant contextual effect emerged for this model (estimate = 2.80, 95% Credible Intervals: 1.22, 4.38).

Results from EMA interference from negative affect are presented in Table 2. The ICC for the model was 0.63, indicating that most of the variance in interference was at the between-person level. The model with all the predictors accounted for significant variance at the within-person (0.9%; $p < .12$) and between-person levels (24.8%; $p < .001$). At the within-person level, pain at the previous assessment was marginally related to EMA interference from negative affect at the next assessment. At the between-person level, mean pain rating was significantly related to average negative affect interference during the two-weeks post-

quit day; baseline negative affect was marginally related to the outcome. A non-significant contextual effect emerged for this model (estimate = 8.95, 95% Credible Intervals: −0.32, 17.24).

Discussion

Generally consistent with prediction, the experience of pain was a significant predictor of negative affect, as well as level of perceived interference associated with negative affect. Specifically, when considering within-person ratings, greater pain was associated with greater negative affect and greater levels of interference resulting from the experience of negative affect. These findings indicate that pain has a lagged effect on negative affect and interference related to negative affect in the two-week period following a self-guided quit attempt. Smoking (relative to abstinence) in the EMA period was also associated with greater negative affect, but did not impact level of interference related to negative affect. Thus, when individuals smoked, they were more likely to experience greater negative mood symptoms, relative to when they were abstinent.

At the between-person level, baseline levels of negative affect were associated with EMA-rated negative affect but not level of interference, a dimension frequently used by clinicians to determine clinical significance of symptoms (e.g., Brown et al., 2001). These findings reinforce the notion that interference is a separable quality of the symptoms themselves (i.e., that interference is not simply a redundant measurement for severity of mood symptoms). Between-person mean pain levels were also associated with greater EMA ratings of negative affect and interference associated with negative affect, indicating that in addition to within-person effects, the average reports of pain were associated with all dependent measures.

Although not a primary study aim, between-person smoking rate (at baseline) was not associated with any dependent measure. Thus, the severity of smoking, indexed by cigarettes per day, did not impact negative affect or interference of negative affect. Future work could usefully explore whether other facets of tobacco use relate to negative affect states and dimensions of interference, including cognitive and affective processes (e.g., smoking outcome expectancies, motives for use, perceptions of stress associated with quitting). It may be that smoking-negative mood relations ‘work’ through these other process-based factors. Additionally, a significant contextual effect emerged for pain on negative affect, but not for perceived interference associated with negative affect. This dissimilar pattern not only provides additional evident for the uniqueness of each outcome, but also suggests that an aggregated pain score may be more relevant to understanding *experienced* mood related symptoms (i.e., negative affect) than *interpretation* of the impact of these symptoms.

The present findings uniquely extend previous work on pain and negative affect (Gaskin et al., 1992; Geisser et al., 2000) to a sample of smokers during a self-quit attempt. Clinically, the results suggest pain may play an important role in the quitting process via its relation to negative affect. Given voluminous work implicating the role of negative affect in lapse/relapse (e.g., Piper et al., 2004; Shiffman & Waters, 2004), future work may usefully explore ways to target the experience of pain during quit attempts. For those undergoing self-guided quit attempts, medical and mental health professionals may provide psychoeducation

regarding pain and negative affect and potentially offer skills that individuals can utilize during self-quit attempts such as mindfulness, which has been shown to positively impact both pain and symptoms of negative mood (e.g., Hilton et al., 2017).

The study has several limitations that must be noted. First, the sample was majority White and future work should extend the current work to more diverse samples, particularly considering documented health disparities for racial/ethnic minorities (Fagan, 2016; Jamal et al., 2014). Second, only one third of the sample was female, and future work should include samples with relatively balanced gender distributions. Third, although intensive data analyses methods were used (i.e., EMA), the sample was relatively small and future work should examine larger samples, examining potential moderators (e.g., race/ethnicity, gender) of these associations documented here. Fourth, due to the intensive data collection and repeated sampling, questionnaire batteries were limited and at times limited to one-item assessments (e.g., pain). For example, the experience of pain was limited to one item assessing pain. As such, future work should replicate the current findings with an emphasis on the source and type of pain (e.g., neuropathic, musculoskeletal) as potential moderators of associations between pain and negative affect in the context of smoking abstinence. Fifth, although the study focused on the clinically-important segment of smokers undergoing self-guided quit attempts, the study was limited by a lack of control group. Finally, although the findings indicate the lagged effect of pain and negative affect during a self-guided quit attempt, current methods cannot speak to the temporal precedence of these variables. For example, although participants indicated whether they had smoked since the previous assessment, it is not known when exactly that smoking occurred relative to ratings of pain and affect. Future work should examine whether changes in pain precede changes in negative moods during quit attempts, as well as whether changes in negative moods mediate the effects of pain on smoking outcomes, consistent with past work (e.g., Ditre & Brandon, 2008).

Taken together, the present study found that greater levels of pain are associated with greater negative affect as well as more severe interference resulting from negative affect following a self-guided quit attempt. These associations were evident after accounting for smoking status and smoking rate.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Means and correlations for all study variables

	Mean	SD	1	2	3	4	5
EMA Smoking	.46	0.36	--				
EMA Pain	.73	0.73	−.02	--			
Smoking Rate	15.91	9.82	.12	−.19	--		
Negative Affect (Baseline)	18.53	6.19	.09	.43**	−.17	--	
Negative Affect (EMA)	16.56	4.62	.13	.63**	.02	.50**	--
Interference from Negative Mood (EMA)	20.83	19.77	.17	.46**	−.08	.36*	.70***

Note.

*** p < .001.

** p ≤ .01.

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Table 2.

Effects Estimates

Negative Affect (EMA)			
Within-person	**Estimate**	**95% CI**	**Sig**
EMA Smoking	0.11	0.02, 0.20	.01
EMA Pain (lagged)	0.10	0.002, 0.194	.02
Between-person			
Intercept	2.88	2.19, 3.68	< .001
Smoking Rate	0.18	−0.04,0 .40	.052
Negative Affect	0.32	0.08, 0.54	.01
Mean Pain	0.54	0.29, 0.73	< .001
Interference from Negative Mood (EMA)			
Within-person	**Estimate**	**95% CI**	**Sig**
EMA Smoking	−0.02	−0.12, 0.08	.38
EMA Pain (lagged)	0.08	−0.02, 0.18	.059
Between-person			
Intercept	0.61	0.21, 1.11	.001
Smoking Rate	0.04	−0.24, 0.32	.38
Negative Affect	0.22	−0.09, 0.50	.08
Mean Pain	0.39	0.07, 0.63	.01

Note: CI = Credible Intervals.