Original investigation

Anxiety Sensitivity and Distress Tolerance in Smokers: Relations With Tobacco Dependence, Withdrawal, and Quitting Success[†]

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Abstract

Introduction: This study examined relations of two affective vulnerabilities, high anxiety sensitivity (AS) and low distress tolerance (DT), with tobacco dependence, withdrawal, smoking cessation, and pharmacotherapy response.

Methods: Smokers interested in quitting ($N = 1067$; 52.2% female, 28.1% African American) were randomized to 12 weeks of nicotine patch, nicotine patch plus nicotine lozenge, or varenicline. Baseline questionnaires assessed AS, DT, negative affect, anxiety, and dependence. Withdrawal was assessed the first-week post-quit via ecological momentary assessment.

Results: DT, but not AS, predicted biochemically confirmed point-prevalence abstinence at multiple endpoints: weeks 4, 12, 26, and 52 post-quit ($ps < .05$); relations remained after controlling for pharmacotherapy treatment, AS, baseline negative affect, anxiety, and anxiety disorder history ($ps < .05$). Additional exploratory analyses examining week 4 abstinence showed DT predicted abstinence ($p = .004$) even after controlling for baseline dependence, post-quit withdrawal (craving and negative affect), and treatment. DT moderated treatment effects on abstinence in exploratory analyses (interaction $p = .025$); those with high DT were especially likely to be abstinent at week 4 with patch plus lozenge versus patch alone.

Conclusions: DT, but not AS, predicted abstinence over 1 year post-quit (higher DT was associated with higher quit rates), with little overlap with other affective measures. DT also predicted early abstinence independent of dependence and withdrawal symptoms. Results suggest low DT may play a meaningful role in motivation to use tobacco and constitute an additional affective risk factor for tobacco cessation failure beyond negative affect or clinical affective disorders.

Implications: People in a stop-smoking study who reported a greater ability to tolerate distress were more likely to quit smoking and remain smoke-free 1 year later. Smokers with high DT were more likely to be smoke-free 4 weeks after their target quit day if they received nicotine patch plus nicotine lozenge rather than nicotine patch alone.

Trial Registration: NCT01553084.

[†] The primary smoking cessation outcomes from this randomized clinical trial were reported in Baker et al. (2016). A talk with a preliminary version of some of the findings in this paper was presented at the Society for Research on Nicotine and Tobacco annual convention in 2018.

Introduction

There is copious evidence that smokers' affective distress is associated with their tobacco dependence severity.¹⁻³ Such relations are important on both clinical and theoretical grounds. Clinically, measures of smokers' affective distress and related constructs (eg, relevant psychiatric diagnoses) can help predict relapse likelihood³ and perhaps guide treatment development and selection. In terms of theory, strong relations between affective distress and relapse support models positing that affective distress is associated with initiating and persisting in tobacco use.^{1,4} However, our understanding of affective distress' role in motivation to use tobacco is largely based on trait or phasic measures of affect per se.^{1,3} This restricted measurement of affective processing may have obscured the full impact of affect on tobacco motivation and use. A more comprehensive approach to assessing affective processing and vulnerabilities may enhance the prediction of treatment outcomes and offer new targets for treatment development.⁴

Two affective processing constructs appear particularly promising for additional study: anxiety sensitivity (AS) and distress tolerance (DT; see Leventhal and Zvolensky⁴). AS refers to a fear of anxious feelings and a belief that anxious feelings portend significant harmful consequences (eg, physical harm and loss of control).⁵ AS, typically measured via self-report, has been shown to relate to the severity of numerous affective disorders⁶, which are themselves associated with tobacco use and smoking cessation failure.⁷ Further, AS tends to be meaningfully related to indices of tobacco motivation and dependence. For instance, AS (or pre-quit change in AS) has been found to predict post-quit withdrawal,⁸ greater reductions in stress-induced negative affect following smoking,⁹ and lapse or relapse early in a quit attempt.¹⁰⁻¹² Also, a recent study offers some evidence that AS may be altered by "AS reduction treatment"¹³; however, there was no evidence of a direct effect of AS reduction treatment on cessation success. Overall, knowledge of the role of AS in tobacco motivation and cessation remains limited. It is unclear, for instance, that AS's prediction of smoking outcomes is robust and independent, that is, it predicts long-term abstinence independently of other affective dimensions such as DT.

DT is defined as the ability to tolerate or endure distress and can be measured behaviorally or via self-report. Behavioral measures of DT reflect actual persistence in an aversive task, whereas self-reported DT is intended to assess people's *appraisal* of their ability to withstand distress.¹⁴ Behavioral measures of DT tend not to be highly correlated with self-report measures.^{15,16} Evidence suggests that DT predicts the latency or likelihood of lapse or relapse, with most, but not all, evidence coming from behavioral persistence tasks such as mirror tracing or breath holding.¹⁷⁻²¹ However, these tasks vary in their ability to predict cessation outcomes.¹⁷ The ability to draw conclusions about the relations between DT and cessation success is limited in some studies because some of the studies predicting smoking outcomes have used small samples¹⁸ and have been cross-sectional or retrospective rather than prospective.²² Conversely, a recent randomized controlled trial²³ found that DT treatment in unselected smokers did not improve cessation rates relative to standard treatment, suggesting that perhaps DT is not causally related to cessation (or that the intervention did not increase DT enough to affect outcomes in a general population of smokers).

The use of behavioral measures of DT can present interpretive challenges. For instance, in Brandon et al.,¹⁷ it is unclear why one behavioral persistence measure (mirror tracing) predicted lapse latency whereas another did not (an anagram task). Progress may be fostered

by using a DT questionnaire that has undergone psychometric analysis and construct validation with regard to tobacco dependence²⁴; that is, where the content can be examined and refined to better characterize the construct. In research with smokers,²⁴ the commonly used 15-item Distress Tolerance Scale (DTS)²⁵ has good internal consistency and is significantly negatively correlated with dependence (as measured by the Fagerstrom Test for Nicotine Dependence; FTND²⁶), negative affect,²⁷ and expectations that smoking will decrease negative affect.²⁸ However, to date, the DTS has not been used to prospectively predict smoking cessation outcomes.

It is also unclear how AS and DT may work together to influence dependence-related outcomes such as withdrawal and relapse. The relative and joint effects of AS and DT have rarely been explored^{29,30} and never in prospective studies of smoking cessation. Because both AS and DT invoke mechanisms designed to account for increased affective reactivity (and because some argue that both load onto a higher-order factor³¹), it is important to determine the extent of their orthogonality. It is also important to determine whether these measures exhibit unique predictive validity relative to other central affective and tobacco dependence constructs (see Leventhal and Zvolensky⁴). For instance, to the extent that AS and DT robustly affect withdrawal symptoms,⁸ they may also predict response to cessation medications that suppress withdrawal.³² Answering such questions may enhance our understanding of important influences on relapse and suggest strategies for treatment development and assignment.

This study uses data from a large smoking cessation randomized controlled trial³³ to explore the relations of AS and DT with measures of tobacco dependence, withdrawal, cessation outcome, and pharmacotherapy response and the degree to which these effects are distinct from negative affect and psychopathology. Because DT was found to have particularly robust relations with smoking cessation outcome, we further examined the nature of DT's joint relations with dependence and withdrawal in an attempt to characterize DT's nomological network.³⁴

Methods

Participants

Participants were drawn from a sample of 1086 smokers recruited via advertisements and earned media ($n = 917$) as well as from relapsed smokers who previously participated in the Wisconsin Smokers' Health Study ($n = 169$).³⁵ Participants who completed either the AS baseline questionnaire only ($n = 4$), the DT baseline questionnaire only ($n = 4$), or both ($n = 1059$) were included in the analyses; the final analysis sample was 1067 (98% of the 1086 randomized participants³³).

Eligible participants reported smoking at least 5 cigarettes/day, being motivated to quit, being willing to use study medications and not use electronic cigarettes, no moderately severe or severe depression as assessed by the Patient Health Questionnaire,³⁶ no current suicidal ideation or attempts in the past 5 years, and no contraindications to study medications (see Baker et al.³³ for details). Participants provided written informed consent. The University of Wisconsin Health Sciences Institutional Review Board approved this study.

Study Design

Participants were randomized to receive varenicline, combination nicotine replacement therapy (NRT; nicotine patch + nicotine lozenge), or the nicotine patch. Participants were asked to use the patch

or combination NRT for 12 weeks, starting on their target quit day (TQD), or to use varenicline for 1-week pre-TQD followed by 11 weeks post-TQD. All participants were offered cessation counseling (~90 minutes over five visits and a telephone call).

Assessments

At baseline, participants completed questionnaires that assessed demographics, smoking history, and current smoking. Tobacco dependence was assessed with the FTND²⁶ and the brief Wisconsin Inventory of Smoking Dependence Motives (WISDM).³⁷ The brief WISDM includes two subscales associated with different motivations for smoking: primary dependence motives (PDM) related to automatized dimensions of tobacco dependence that arise with especially prolonged and heavy smoking, and secondary dependence motives (SDM) related to smoking for instrumental reasons such as to manage negative affect.³⁸ Psychiatric history was assessed by asking whether participants had ever been diagnosed with or treated for each of the following: depression, bipolar disorder, schizophrenia, an anxiety disorder, panic disorder, post-traumatic stress disorder, attention deficit disorder, or none of the above. Baseline negative affect was assessed using three items (distressed, irritable, and upset) from the Positive and Negative Affect Schedule (PANAS²⁷); baseline anxiety was assessed using three items (tense or anxious, impatient, and worrying about problems) from the anxiety subscale of the Wisconsin Smoking Withdrawal Scale³⁹.

At baseline, participants also completed the 18-item Anxiety Sensitivity Index-3⁴⁰ (Cronbach's alpha in this sample = .91) and the 15-item DTS²⁵ (Cronbach's alpha in this sample = .88). Both measures are commonly used, have acceptable psychometric properties,^{25,40} and are brief enough that they have potential for translation into clinical practice. On the Anxiety Sensitivity Index-3, response options range from 0 (*very little*) to 4 (*very much*), and the total score is the sum of the 18 items with higher scores indicating more severe AS. On the 15-item DTS, response options range from 1 (*strongly agree*) to 5 (*strongly disagree*), and the total score was determined by taking the mean of the four DTS subscales (tolerance, appraisal, absorption, and regulation; higher scores indicate greater DT).

Seven-day biochemically confirmed (via expired carbon monoxide [CO] $\leq$ 5 ppm) point-prevalence abstinence was assessed at weeks 4, 12, 26, and 52 post-TQD. Participants completed ecological momentary assessments of withdrawal symptoms via interactive voice response calls three times a day for 1 week pre-TQD through 4 weeks post-TQD. Participants rated their "negative mood" (ie, ecological momentary assessment-assessed negative affect) and "wanting to smoke" (ie, craving) in the last 15 minutes on a scale from 1 (*not at all*) to 7 (*extremely*). Mean scores were calculated from the three daily calls for the 7 days pre-TQD and separately for the TQD plus the subsequent 6 days.

Analytic Plan

We used *t*-tests to examine whether participants' self-reported AS or DT differed based on their gender, race (white vs. member of a racial minority), income (<\$35 000 vs. $\geq$ \$35 000), or self-reported history of one or more psychiatric disorders (yes vs. no). Correlations were computed to identify the relations between AS and DT and markers of dependence (eg, FTND score, WISDM total and subscale scores) and withdrawal elements (craving and negative affect accessed via ecological momentary assessment; 1 week post-TQD mean and standard deviation of craving and of negative affect, and mean

change from 1 week pre-TQD to 1 week post-TQD). As in prior research,^{38,41} we used partialled scores in analyses of the two WISDM subscales; thus in results reported for the PDM and SDM, the PDM score reflects variance remaining after partialling out the SDM score (and vice versa).

To examine the effects of AS and DT on the binary cessation outcome (0 = smoking; 1 = abstinent), we computed logistic regression models to identify predictors of CO-confirmed 7-day point-prevalence abstinence at 4, 12, 26, and 52 weeks post-TQD; we assumed that participants with missing cessation outcome data were likely smoking and, as such, set missing data to reflect smoking. In the first logistic regression model (Model 1), we used only the continuous AS or DT score as a predictor. In Model 2, we added treatment condition to Model 1 using dummy-coded variables for nicotine patch, varenicline, and combination NRT with the nicotine patch as the reference group (this coding was used in all analyses involving treatment). For timepoints where either AS or DT significantly predicted cessation in Model 2, we computed Model 3, which included four additional covariates selected a priori: (1) AS or DT (whichever was not already in the model), (2) baseline PANAS negative affect, (3) baseline Wisconsin Smoking Withdrawal Scale anxiety, and (4) self-reported lifetime history of diagnosis or treatment for an anxiety disorder. In exploratory analyses, we also examined whether AS or DT moderated treatment effects on abstinence. For all models involving interactions, continuous variables were grand mean centered.⁴²

Regression analyses indicated that DT had considerably stronger relations with outcomes than AS. Thus, we conducted additional exploratory DT analyses to characterize better relations among dependence, withdrawal, cessation, treatment, and DT. For these analyses, we report results for only week 4 endpoint, which should more sensitively reflect withdrawal and treatment effects than do later timepoints.⁴³ Relations of DT and 4-week abstinence were examined with individual and joint entry of the following covariates selected for their strong relations with DT (vs. a priori): ecological momentary assessment-assessed craving and negative affect and WISDM SDM. Treatment condition was also used as a covariate. Moreover, we elected not to control variance in DT that was related to AS because such variance could be an important component of the DT construct and we had already demonstrated DT orthogonality relative to AS in the previous Model 3 analysis.

Results

The analysis sample ($N = 1067$) was 52.2% female, 67.4% white, 28.1% African American, and 2.4% Hispanic; 54.1% had an annual income of less than \$35 000. Participants were a mean age of 48.06 years ($SD = 11.62$) and smoked a mean of 16.95 cigarettes per day ($SD = 8.24$; median = 17.00).

Anxiety Sensitivity

Individual Differences

Mean baseline AS was 14.76 ($SD = 12.21$; range 0–70.00; higher scores indicate more severe AS), which is similar to scores from another smoking cessation trial¹³ and lower than scores in people with an anxiety disorder.⁴⁰ The following groups reported higher AS than their comparison group (Supplementary Table): racial minority versus white participants, participants with annual incomes of less than \$35 000 versus at least \$35 000, and participants who reported

a history of one or more psychiatric disorders versus those who did not report such a history (all p s < .001).

Dependence and Withdrawal

The correlations of AS with dependence, withdrawal symptoms, and abstinence are presented in Table 1. AS was positively correlated with baseline FTND, WISDM total, and WISDM SDM. AS was positively correlated with post-quit craving and negative affect means and variability but was not associated with *change* in craving or negative affect from pre- to post-TQD.

Cessation

Participants higher in AS were significantly less likely to be abstinent at week 4 (Model 1; Table 2) but not at weeks 12, 26, or 52. The relation at week 4 remained significant after controlling for treatment (Model 2; odds ratio [OR] = 0.99, p = .02, 95% CI = [0.98 to 0.998]) but was not significant after controlling for treatment and the four other markers of affective vulnerability (baseline DT, PANAS negative affect, Wisconsin Smoking Withdrawal Scale anxiety, and self-reported history of an anxiety disorder; Model 3). AS did not moderate treatment effects at any timepoint.

Distress Tolerance

Individual Differences

Mean baseline DT was 3.76 (SD = 0.81; range 1.08–5.00; higher scores indicate greater DT), which appears similar or somewhat higher than scores from another study of daily smokers not seeking treatment²⁴ and higher than patients starting residential drug treatment.¹⁵ The following demographic groups reported lower DT than their comparison group (Supplementary Table): racial minority

versus white participants, participants with annual incomes of less than \$35 000 versus at least \$35 000, and participants with a history of one or more psychiatric disorders versus those who did not report such a history (all p s < .001).

Dependence and Withdrawal

DT was negatively correlated with the FTND, the WISDM total, and the WISDM SDM, but was not correlated with the WISDM PDM or baseline cigarettes per day (Table 1). Although DT was associated with both lower post-TQD craving and negative affect, its relation with negative affect was stronger than that with craving (z value = -2.66 ; p < .008). Similar to the findings for AS, DT was not associated with *change* in mean craving or negative affect from pre- to post-TQD.

To better understand these relations and to assist with interpretation of the treatment response finding described later in this paper, we categorized DT as a trichotomy with low DT (≤ 26.2 percentile), medium DT (26.3–74th percentile), and high DT (≥ 75 th percentile) and graphed post-TQD craving and negative affect. Post-TQD negative affect scores were 22% lower in those high versus low in DT, whereas craving scores were only 9% lower (Supplementary Figure).

Cessation

DT significantly predicted CO-confirmed abstinence at weeks 4, 12, 26, and 52 (Model 1; Table 2), even after controlling for treatment (Model 2), plus the four markers of affective vulnerability (Model 3).

Treatment Response

There was a significant DT $\times$ Treatment interaction at week 4 (Wald = 7.41, p = .025), driven primarily by the combination NRT

Table 1. Correlations of Anxiety Sensitivity and Distress Tolerance with Measures of Dependence, Smoking, Affect, Withdrawal, and Cessation

Measure	Mean (SD)	Range	Anxiety sensitivity	Distress tolerance	Week 4 abstinence ^c	Week 26 abstinence ^c
Anxiety sensitivity	14.76 (12.21)	0.00–70.00	—	–0.51***	–0.07*	–0.02
Distress tolerance	3.76 (0.81)	1.08–5.00	–0.51***	—	0.14***	0.07*
Age started smoking daily	17.55 (4.62)	6–52	–0.02	0.07*	0.04	–0.02
Cigarettes per day	16.95 (8.24)	1–75	0.01	–0.03	–0.05	–0.07*
Baseline carbon monoxide level (ppm)	15.09 (8.39)	4–67	–0.09**	0.05	–0.02	–0.09**
FTND	4.80 (2.11)	0–10	0.16***	–0.14***	–0.10**	–0.11**
WISDM total	43.84 (12.75)	11.00–75.50	0.28***	–0.22***	–0.12***	–0.11***
WISDM Primary Dependence Motives ^a	4.64 (1.31)	1.00–7.00	0.04	–0.001	0.03	–0.05
WISDM Secondary Dependence Motives ^b	3.61 (1.22)	1.00–7.00	0.18***	–0.17***	–0.12***	–0.04
Baseline negative affect	5.00 (2.58)	3.00–15.00	0.33***	–0.27***	–0.11***	–0.07*
Baseline anxiety	2.60 (1.55)	1.00–7.00	0.36***	–0.30***	–0.11**	–0.07*
Mean craving 1 week post-quit day	3.23 (1.63)	1.00–7.00	0.11***	–0.11***	–0.14***	–0.09**
SD of craving 1 week post-quit day	0.96 (0.64)	0.00–4.24	0.07*	–0.11***	–0.11**	–0.13***
Change in craving (1 week post-quit day minus 1 week pre-quit day)	–0.29 (1.35)	–6.00 to 4.25	–0.06	–0.01	–0.08*	–0.02
Mean negative affect 1 week post-quit day	1.92 (1.06)	1.00–7.00	0.22***	–0.23***	–0.10**	–0.04
SD of negative affect 1 week post-quit day	0.71 (0.63)	0.00–3.89	0.16***	–0.16***	–0.11**	–0.08*
Change in negative affect (1 week post-quit day minus 1 week pre-quit day)	–0.04 (0.89)	–5.25 to 4.40	–0.003	–0.04	–0.01	0.02

FTND = Fagerstrom Test for Nicotine Dependence; WISDM = Wisconsin Inventory of Smoking Dependence Motives; SD = standard deviation. *ns* vary from 967 to 1067.

^aCorrelations are based on the primary dependence motive score partialled for shared variance with the secondary dependence motive score.

^bCorrelations are based on the secondary dependence motive score partialled for shared variance with the primary dependence motive score.

^cBiochemically confirmed 7-day point-prevalence abstinence coded 0 = smoking and 1 = abstinent.

* p < .05. ** p < .01. *** p < .001.

Table 2. Separate Logistic Regression Analyses Examining Relations of Anxiety Sensitivity or Distress Tolerance with Biochemically Confirmed 7-Day Point-Prevalence Abstinence at Four Timepoints

Timepoint	Percent abstinent	Anxiety Sensitivity Inventory-3			Distress Tolerance Scale		
		Wald χ^2	<i>p</i> Value	OR [95% CI]	Wald χ^2	<i>p</i> Value	OR [95% CI]
Week 4	34.6	5.10	.02	0.99 [0.98 to 0.998]	18.92	<.0001	1.44 [1.22 to 1.70]
Week 12	29.3	2.95	.09	0.99 [0.98 to 1.00]	13.78	<.001	1.39 [1.17 to 1.65]
Week 26	24.7	0.31	.58	1.00 [0.99 to 1.01]	5.49	.02	1.24 [1.04 to 1.48]
Week 52	20.1	0.85	.36	0.99 [0.98 to 1.01]	8.46	.004	1.34 [1.10 to 1.63]

0 = smoking; 1 = abstinent. Anxiety sensitivity and distress tolerance were tested in separate models. *n* = 1063 in each analysis.

Figure 1. Point-prevalence abstinence rates at week 4 by pharmacotherapy treatment and distress tolerance group (created by categorizing distress tolerance as a trichotomy). The sample sizes were as follows. Among those receiving nicotine patch, 56 participants reported low distress tolerance (DT), 121 reported moderate DT, and 57 reported high DT. Among those receiving varenicline, 117 reported low DT, 190 reported moderate DT, and 110 reported high DT. Among those receiving nicotine patch + nicotine lozenge, 105 reported low DT, 198 reported moderate DT, and 109 reported high DT.

versus patch-only effect (Wald = 7.24; *p* = .007 with DT entered as a continuous variable). The varenicline versus patch-only contrast was not statistically significant (Wald = 1.50; *p* = .22). We unpacked the significant interaction by computing ORs at three different values of DT: -1 SD below the grand mean, at the grand mean, and +1 SD above the grand mean. The only OR that was significant was at +1 SD above the grand mean (OR = 1.76, 95% CI [1.10 to 2.82]), indicating that the significant DT × Treatment interaction reflected a significant difference in combination NRT versus patch at high levels of DT.

To graph the DT × Treatment interaction, we used the categorization of DT as a trichotomy as described earlier. Week 4 abstinence rates were almost 20 percentage points higher among high DT participants who received combination NRT versus nicotine patch alone (Figure 1). The interaction between treatment and DT as a

continuous variable was only statistically significant at week 4, but the pattern of effects was similar across the other three follow-up timepoints. Week 4 abstinence rates were almost 10 percentage points higher among high DT participants who received varenicline versus patch, although, as described earlier, the varenicline versus patch-only contrast was not statistically significant.

Unique Impact of DT on Early Cessation

We examined the independent association of DT with early cessation outcome (ie, week 4), relative to dependence and withdrawal symptoms. Treatment did not independently predict abstinence, consistent with previous findings.³³ However, DT remained a significant predictor when post-TQD craving, post-TQD negative affect, and SDM were entered into the regression model individually or jointly (Table 3).

Table 3. Exploratory Logistic Regression Analyses Examining Relations of Distress Tolerance with Biochemically Confirmed Point-Prevalence Abstinence at Week 4, Controlling for Treatment, Withdrawal, and Dependence Measures

Predictors of week 4 abstinence	Wald χ^2	<i>p</i> Value	OR [95% CI]
Model with DT			
DT	18.97	<.0001	1.45 [1.23 to 1.71]
Model with DT + craving			
DT	13.57	.0002	1.39 [1.17 to 1.65]
Post-quit craving	16.89	<.0001	0.84 [0.77 to 0.91]
Model with DT + negative affect			
DT	13.29	.0003	1.38 [1.16 to 1.65]
Post-quit negative affect	4.72	.03	0.86 [0.75 to 0.99]
Model with DT + SDM			
DT	13.39	.0003	1.37 [1.16 to 1.63]
SDM	9.12	.0025	0.79 [0.68 to 0.92]
Model with DT + All			
DT	8.31	.004	1.30 [1.09 to 1.56]
Post-quit craving	13.02	.0003	0.84 [0.77 to 0.92]
Post-quit negative affect	0.26	.61	0.96 [0.83 to 1.12]
SDM	7.14	.008	0.81 [0.69 to 0.94]

Treatment condition (nicotine patch, nicotine patch + nicotine lozenge, and varenicline) was entered as a covariate in all models but was not statistically significant in any models. 0 = smoking; 1 = abstinent. DT = distress tolerance. SDM = the Secondary Dependence Motive scale of the Wisconsin Inventory of Smoking Dependence Motives partialled for shared variance with the Primary Dependence Motive score. *ns* vary from 974 to 1063.

Discussion

Using data from a smoking cessation randomized controlled trial, this study found two key affective vulnerabilities, high AS and low DT, were each associated with greater tobacco dependence and post-quit craving and negative affect. However, only DT was consistently related to abstinence at weeks 4, 12, 26, and 52, even after controlling for AS and other related affective constructs. These latter results suggest self-reported DT is a promising, independent index of affective vulnerability for cessation failure. That DT consistently enhances predictions of abstinence supports negative affect or negative reinforcement models of tobacco motivation.^{1,44} In fact, these results suggest the field may have underestimated the role of affective processing and distress in addiction motivation because of an impoverished assessment of affective vulnerabilities (eg, by assessing ratings of negative affect per se).

DT's consistent, strong relations with abstinence encouraged further characterization of its nomological network,³⁴ including its relations with key constructs indexing smoking motivation, dependence, and pharmacotherapy response. DT was negatively associated with post-quit craving and negative affect, withdrawal symptoms that generally show negative relations with tobacco abstinence.^{32,45} However, DT was more strongly negatively associated with post-quit negative affect than with craving, consistent with the notion that DT is an index of affective vulnerability. This affective vulnerability may be independent of smoking deprivation, as DT was not related to the change in craving or negative affect from pre- to post-quit, but only to the mean levels of each construct post-quit.

DT was associated with measures of tobacco dependence, but results with the multidimensional WISDM revealed DT was only related to WISDM SDM (eg, smoking for instrumental motives such as affect regulation), not PDM, which are typically more strongly related to heavy smoking and quitting success than SDM.^{38,41} Prior research²⁴ similarly found lower DT was associated with smoking for negative reinforcement. These findings encourage reconsideration of SDM's role in smoking behavior. The link between DT and SDM seems plausible, given that both target coping with negative affect. However, the relatively strong association between SDM and

abstinence at week 4 is unusual. One possibility is that PDM was somewhat truncated in this sample because smokers are smoking fewer cigarettes/day than in the past.⁴⁶ Participants in studies with strong relations between PDM and abstinence³⁸ smoked around 5–6 more cigarettes/day and their mean CO level was about twice the current sample's level (eg, 27 vs. 15 ppm).³³ Light and intermittent smoking is becoming commonplace among smokers.⁴⁷ This may result in increased instrumental tobacco use, making SDM an increasingly important influence on cessation success. It is also possible DT has a causal influence on SDM such that low DT leads smokers to use cigarettes instrumentally to cope with distress.^{4,48} Future research is needed to determine whether low DT leads to higher SDM (ie, instrumental use of cigarettes), which, in turn, could undermine cessation attempts.

DT in this study was related to SDM, post-quit craving, and negative affect, and all these variables were independently related to week 4 cessation success. However, DT remained a strong predictor of week 4 abstinence even when these variables were entered into regression models. This further supports the notion that, despite DT's strong relations with affect and dependence measures, DT accounts for unique vulnerability to cessation failure.

That low DT is related to more severe craving and negative affect suggests smokers low in DT might be especially aided by more intense pharmacotherapy (eg, combination NRT, which is more effective than nicotine patch in quelling withdrawal craving³²). However, a very different pattern was found. Combination NRT was especially beneficial relative to the patch among those *high* in DT. Any account of this unanticipated finding must be highly speculative at this point. One possibility is suggested by DT's stronger relations with negative affect versus craving; that is, participants high in DT tended to be especially low in *affective* risk for cessation failure. Thus, among participants high in DT, relapse risk may be primarily because of craving versus negative affect. Indeed, post-quit negative affect was almost 25% lower in those high versus low in DT, whereas craving scores were only slightly lower. Therefore, the craving suppression afforded by combination NRT³² may have been especially determinant of abstinence among those high in DT.

Future research is needed to explore the potential benefit of tailoring pharmacotherapy to smokers' DT levels.

This study assessed DT via questionnaire. Much research linking DT to cessation outcome has used behavioral measures of DT (eg, mirror tracing^{17,20} and breath holding¹⁸). At present, though, the extent to which the behavioral and questionnaire measures index the same construct is unknown¹⁵ and some behavioral measures, such as mirror tracing, also assess cognitive skills, which may influence cessation success.

AS, although related to dependence and withdrawal symptoms (perhaps reflecting its role when coping with early, affectively-based withdrawal), did not predict cessation at any timepoint except week 4, and this relation did not remain after adding other affective vulnerability constructs to the regression model (including DT). This finding is congruent with other studies suggesting AS does not robustly predict cessation outcome¹² (cf.¹¹). This may be because AS is focused on fear of a single type of affect (anxiety) and quitting does not solely involve tolerating anxiety. DT, by contrast, is a broader construct related to any type of distress and ability to withstand such distress. Although both AS and DT may be malleable,^{13,49} they index distinct constructs and represent different types of vulnerability with the broader construct of DT seemingly more relevant to successfully quitting.

Certain demographic groups reported more affective vulnerability on average (ie, higher AS and lower DT) than their comparison groups: participants with annual incomes of less than \$35 000, racial minorities, and participants who reported a psychiatric history. These groups tend to have lower than average quit rates.^{7,50} Research should explore the extent to which DT accounts for quitting likelihood among such smokers. Research should also continue to explore whether interventions designed to improve DT^{51,52} can improve quit rates (although cf.²³ where DT vs. standard treatment did not improve quit rates). "Just-in-time" adaptive interventions delivered via mobile phones might help smokers with low DT to cope without lapsing by reminding them of ways to tolerate distress in the moment they need the help.⁵³

This study's strengths include its large, diverse sample, biochemical verification of abstinence, comprehensive assessment of relevant affective and dependence constructs, and validated DT and AS measures. Limitations include (1) the absence of a placebo control group, (2) exclusion of people reporting moderately severe or severe depression or suicidal ideation (because of the use of varenicline), and (3) the absence of a behavioral measure of DT (eg, the Mirror Tracing Persistence Task, which has predicted cessation outcome^{17,20}).

In summary, this study found high AS and low DT were each associated with stronger tobacco dependence and withdrawal symptoms. However, only DT consistently predicted cessation outcome over time, independent of other markers of affective vulnerability. Further, DT was related to multiple important influences on cessation motivation and indices of tobacco dependence: post-quit negative affect, craving, and baseline SDM, which index using smoking for instrumental goals such as affect regulation. DT interacted with pharmacotherapy such that combination NRT was especially effective among those high in DT, suggesting medication-induced craving reduction was particularly beneficial among those at low affective risk. Additional research is needed to identify mechanisms that can account for the relations of high DT with cessation success.

Supplementary Material

Supplementary data are available at *Nicotine and Tobacco Research* online.

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Declaration of Interests

The authors have no conflicts of interest to declare.

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