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Distress intolerance during smoking cessation treatment

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ABSTRACT

Distress intolerance is a key vulnerability factor implicated in the maintenance and relapse of cigarette smoking. Yet, past work has not examined changes in these processes during smoking cessation treatment or their relation to smoking cessation outcomes. The aim of the present study was to examine the effect of two smoking cessation interventions on changes in self-report and behavioral distress intolerance indices during treatment, and whether these changes are associated with smoking cessation outcomes. Treatment-seeking smokers ($N = 384$) were randomly assigned to one of two 4-session smoking cessation treatment programs: Standard Cessation Program (SCP) or Smoking Treatment and Anxiety Management Program (STAMP). Quit dates were scheduled to coincide with the final treatment session. Physical domains of distress intolerance were assessed at baseline and at each weekly session, via the *Discomfort Intolerance Scale* (DIS; higher scores indicate more intolerance for discomfort) and *Breath Holding Duration Task* (shorter durations indicate more intolerance for respiratory distress). The STAMP condition produced a greater rate of reduction in DIS scores than did the SCP condition. Changes in DIS scores during treatment mediated the effect of STAMP treatment on 7-day point prevalence abstinence at Month 3 post-quit attempt. There were no treatment conditions differences in changes in Breath-Holding duration. Data suggest self-reported distress intolerance is malleable in the context of stress sensitivity reduction treatment, but not standard smoking cessation treatment, and such reductions may result in promotion of smoking abstinence.

Distress intolerance is defined as one's perceived or objective inability to withstand aversive psychological or physiological states (Leyro, Zvolensky, & Bernstein, 2010). Distress intolerance has frequently been conceptualized as a trait-like factor that is stable across situations (Trafton & Gifford, 2008), although an individual's inability to remain in contact with distress may be situationally-discriminant (specific to stimuli or provocation; McHugh et al., 2011). Distress intolerance has been conceptualized as hierarchical in nature, comprising of a global, domain-general 'experiential distress intolerance' factor (Bernstein, Zvolensky, Vujanovic, & Moos, 2009; Schmidt, Mitchell, Keough, & Riccardi, 2011), with several lower-order dimensions that include specific aversive emotional or physical states (e.g., intolerance of ambiguity, uncertainty, discomfort, frustration, exc.). Accordingly, several measures of distress intolerance have been developed (Zvolensky, Leyro, Bernstein, & Vujanovic, 2011) and evaluated (McHugh et al., 2011), including *self-report indices* that tap individuals' perception of their inability to tolerate distress states and *behavioral tasks* that objectively measure individuals' inability to persist during a difficult task in which aversive mental or physical distress states are induced.

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Growing evidence indicates that the inability to tolerate emotional or physiological distress is robustly linked to problematic substance use (Leyro et al., 2010). Here, individuals higher in distress intolerance appear more inclined to engage in avoidance or escape related behaviors in response to distressing stimuli. In particular, distress intolerance is posited as a key vulnerability factor associated with the maintenance of cigarette smoking (Leventhal & Zvolensky, 2015). Smokers relative to non-smokers have been characterized as having higher levels of distress intolerance, as indexed by the tendency to disengage in emotionally distressing tasks (e.g., mirror-tracing task; Quinn, Brandon, & Copeland, 1996). Smokers with higher perceived intolerance for emotional distress have been found to have longer histories of smoking and higher levels of nicotine dependence (Leyro, Bernstein, Vujanovic, McLeish, & Zvolensky, 2011), although the latter finding has not always been consistent (e.g., Brown et al., 2009). Additionally, perceived intolerance of emotional distress may maintain smoking behavior via stronger expectancies (beliefs) that smoking will reduce negative affective states and motivation to smoke to manage affective states (Leyro, Zvolensky, Vujanovic, & Bernstein, 2008; Trujillo et al., 2015), thereby increasing the reinforcing value of smoking (Perkins, Karelitz, Giedgowd, Conklin, & Sayette, 2010). Regarding physical distress intolerance, smokers relative to non-smokers demonstrate shorter persistence during physically uncomfortable tasks (e.g., pain via a cold pressor task; Pulvers, Hood, Limas, & Thomas, 2012). Additionally, intolerance of physical distress (shorter breath-holding duration and persistence in a cold pressor task) is associated with treatment dropout among smokers (MacPherson, Stipelman, Duplinsky, Brown, & Lejuez, 2008), and smokers with greater intolerance of physical distress states are more likely to lapse during a self-guided quit attempt or laboratory-based relapse analogue tasks (Abrantes et al., 2008; Brandon et al., 2003; Brown et al., 2009; Kahler, McHugh, Metrik, Spillane, & Rohsenow, 2013).

Although measures of distress intolerance suggest that it is relatively stable (Kiselica, Webber, & Bornovalova, 2014), data also indicate that distress intolerance scores may be malleable (i.e., Bernstein, Trafton, Ilgen, & Zvolensky, 2008; Szuhany & Otto, 2015) and may be an important treatment target. Distress tolerance treatment programs have been developed for substance users to specifically cultivate distress tolerance skills and control behaviors in the context of emotional distress (Bornovalova, Gratz, Daughters, Hunt, & Lejuez, 2012; Brown et al., 2008), which are largely informed by Dialectical Behavioral Therapy (DBT; Linehan, 1993; Linehan et al., 1999) and Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999). Specific to cigarette smoking, Brown et al. (2008) developed an intensive distress tolerance-focused smoking cessation intervention (combination of individual, group, and pharmacotherapy treatment) that targets distress intolerance by increasing acceptance and willingness to experience distress. In an open (uncontrolled) trial, this treatment produced favorable outcomes including decreased likelihood of smoking relapse and increased attempts to re-initiate a cessation attempt after lapsing (Brown et al., 2008). A follow-up pilot trial with a control comparison found that relative to standard smoking cessation treatment, the distress tolerance treatment increased likelihood of smoking abstinence at the end of behavioral treatment (four weeks post-quit day) but not abstinence likelihood at eight weeks post-quit day or longer term abstinence outcomes, although the distress tolerance treatment increased likelihood of 'recovery' following a smoking lapse (Brown et al., 2013). In addition, the active condition evidenced within-treatment reductions in smoking-specific experiential avoidance (the tendency to avoid or be unwilling to remain in contact with smoking-related distress) and craving and withdrawal symptoms following the quit attempt (Brown et al., 2013). Together, while distress tolerance appears to be an important target for smoking cessation treatment, it is unknown whether (a) a brief tailored smoking cessation treatment is associated with decreases in distress intolerance, (b) treatment effects on distress intolerance are unique to measurement method, and (c) reductions in distress intolerance are associated with more favorable smoking cessation outcomes.

Based on the physical discomfort and distress associated with nicotine withdrawal and the relevance to smoking cessation, the current study specifically examined changes in one's perception and behavioral capacity to tolerate physical discomfort indexed by a self-report measure (Discomfort Intolerance Scale [DIS]; Schmidt, Richey, & Fitzpatrick, 2006) and a persistence task (Breath-Holding duration task; Asmundson & Stein, 1994). The present study aimed to address three specific questions: (1) Does distress intolerance change via a smoking cessation intervention designed to address anxiety, relative to standard smoking cessation treatment? (2) Do the effects of treatment on distress intolerance differ across self-report and bio-behavioral measurements? and (3) Do changes in distress intolerance mediate the effect of the anxiety-focused intervention on smoking outcomes (nicotine withdrawal severity, cigarette craving severity, and smoking abstinence)? To address these questions, data were drawn from a randomized controlled trial. This trial examined the efficacy of smoking cessation interventions on preventing the development of panic disorder (Schmidt, Raines, Allan, & Zvolensky, 2016). Specifically, this trial compared a brief (4-session) standard cognitive-behavioral Smoking Cessation Program (SCP; based on Fiore et al., 2008) to an anxiety-reduction smoking cessation intervention called Smoking Termination and Anxiety Management Program (STAMP; based on Zvolensky, Yartz, Gregor, Gonzalez, & Bernstein, 2008). The latter treatment specifically targeted anxiety-relevant emotional processes (sensitivity to interoceptive sensations; i.e., anxiety sensitivity). The parent study found that panic disorder symptoms were significantly lower among smokers who received STAMP, relative to SCP, on quit day and at one year post-quit day (Schmidt et al., 2016). Additionally, reductions in panic disorder symptoms were observed to occur through reductions in anxiety sensitivity during treatment (Schmidt et al., 2016).

In effort to extend findings from the primary outcome study, the present investigation examined whether decreased intolerance to somatic discomfort and distress, which theoretically is promoted by reductions in anxiety sensitivity, changes as a result of smoking cessation treatment and whether these changes relate to smoking cessation outcomes; a finding not previously reported. We hypothesized that STAMP, relative to SCP, would result in significantly greater decreases in distress intolerance (per self-report and bio-behavioral measurement) during treatment (sessions 1–4). It was also hypothesized that the effect of STAMP on smoking cessation outcomes would be mediated (explained) by reductions in distress intolerance. Lastly, it was hypothesized that the patterning of effects would be consistent for both perceived (self-report) and objective (bio-behavioral) distress intolerance.

1. Method

1.1. Participants

Adult daily smokers were recruited from the community (via flyers, newspaper ads, radio announcements) to participate in a large randomized controlled panic disorder prevention study that examined two smoking cessation treatments. A total of 724 cases were initially screened for the study; 529 were enrolled in the study (see Fig. 1 for CONSORT diagram). Participants were eligible if they were between 18 years of age or older, daily cigarette users,

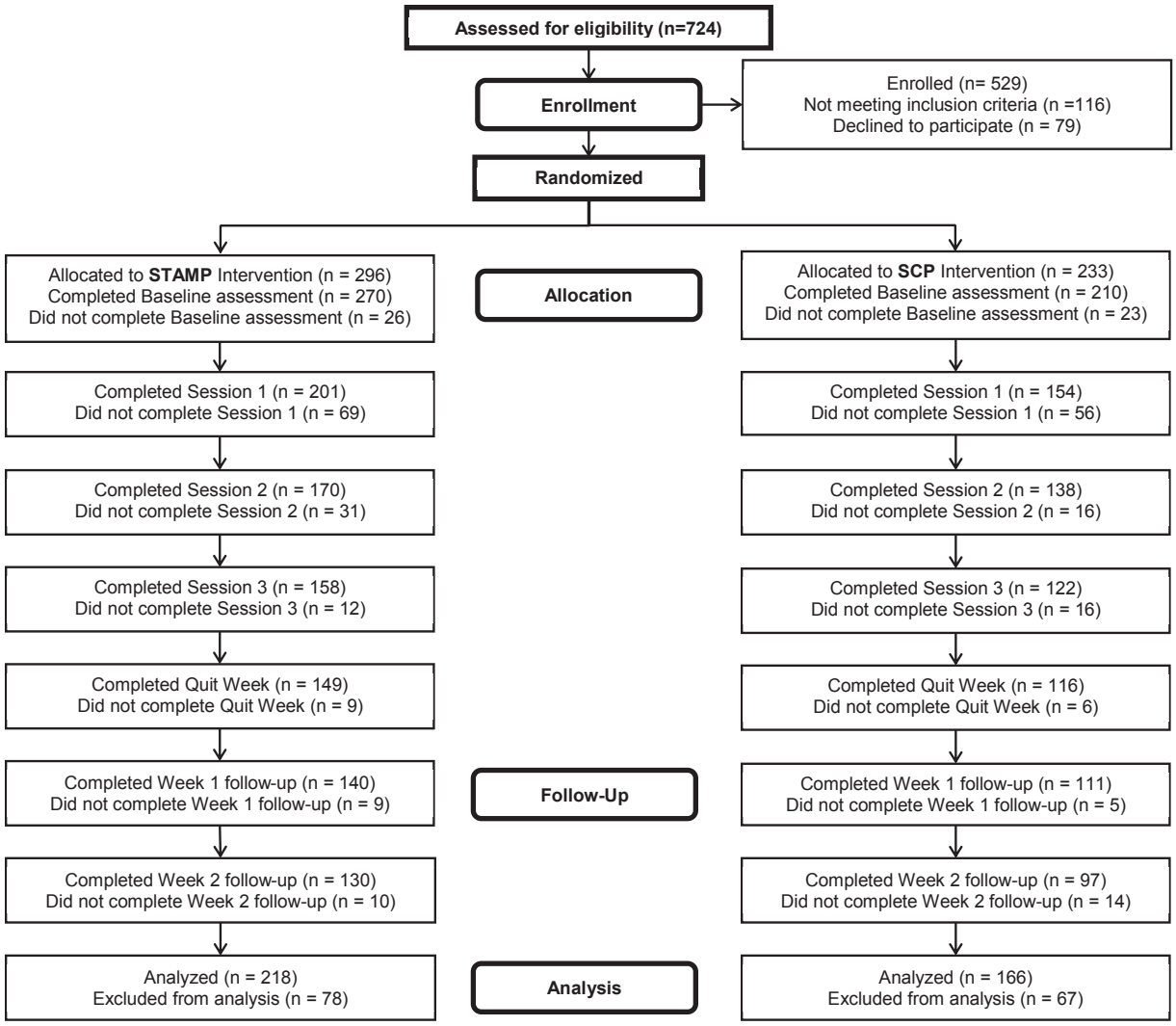

Fig. 1. CONSORT chart of participants detailing patient flow, assignment, and dropout.

averaged ≥8 cigarettes per day for at least 1 year, and reported a motivation to quit smoking within the next six months or sooner (e.g., at least 5 on a 10-point scale). Participants were excluded on the basis of inability to provide informed consent, current use of smoking cessation treatment, reduction of cigarettes per day by more than half in the past six months, past-month suicidality, history of psychotic-spectrum disorders, currently pregnant or nursing, or having a history of panic disorder (current or past).

Of the 529 individuals randomized to intervention, 384 attended at least one treatment session and were therefore included in the final sample to be analyzed. There were no significant differences in baseline demographics or study measures between cases included in analyses versus those cases that were excluded. Participants (M_{age} = 38.7, SD = 13.7; 50.0% female) were primarily white (83.1%) and completed at least part of college (73.2%). At baseline, participants reported smoking an average of 16.6 (SD = 9.02) cigarettes per day and expired carbon monoxide (CO) breath samples values averaged 20.3 (SD = 11.83). On average, participants reported being a daily smoker for 20.3 (SD = 13.62) years and reported moderate levels of nicotine dependence on the Fagerström Test for Cigarette Dependence (FTCD; M = 5.2, SD = 2.22). Regarding presence of psychopathology, 43.5% of the sample met criteria for a current psychological disorder, which included social phobia (13.3%), specific phobia (9.9%), generalized anxiety disorder (9.1%), alcohol use disorder (7.8%), major depressive disorder (7.3%), substance use disorder (5.8%), posttraumatic stress disorder (4.4%), dysthymic disorder (4.2%), obsessive-compulsive disorder (2.3%), anxiety disorder NOS (1.3%), depressive disorder NOS (0.8%), Bipolar disorder I/II (0.8%), or other disorder (2.6%). Full sample characteristics are presented in Schmidt et al. (2016).

1.2. Procedure

Individuals responding to study advertisements were scheduled for an in-person, baseline assessment. After providing written informed consent, participants were interviewed using the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I/NP; First, Spitzer, Gibbon, & Williams, 2007) and completed a computerized battery of baseline assessments, behavioral measures of distress intolerance (Breath-Holding Duration Task), and provided an expired CO breath sample to verify smoking status. Eligible participants were randomly assigned to one of two smoking cessation treatment programs and scheduled for treatment initiation approximately 1–2 weeks following the baseline assessment.

Participants were randomized to one of two smoking cessation treatments: (1) Smoking Cessation Program (SCP; n = 166), which consisted of standard cognitive-behavioral strategies (recommended by Fiore et al., 2008) including self-monitoring of cigarette consumption, psychoeducation about smoking and health, review of high-risk situations and management of smoking cues, smoking reduction, planning for quit day (e.g., enlisting social support, having a lapse plan, provision of self-help materials, etc.), and relapse prevention; or (2) Smoking Termination and Anxiety Management Program (STAMP; n = 218; Zvolensky et al., 2008), which consisted of several modifications to the cognitive-behavioral, self-monitoring, and relapse prevention strategies in order to additionally target anxiety, as well as psychoeducation about the link between anxiety and smoking, planned deprivation periods in addition to cutting back, and interoceptive exposure exercises to address maladaptive cognitions related to anxiety and the ability to quit smoking. Participants were randomized at a roughly 1.25:1 ratio, STAMP to SCP to increase power to detect treatment effects for STAMP and to reduce costs (Dumville, Hahn, Miles, & Torgerson, 2006). Both treatment protocols are fully described in Schmidt et al. (2016; pp. 140–141).

Both treatment groups were provided with nicotine replacement therapy via the transdermal nicotine patch, which was initiated at treatment session four, which coincided with the targeted quit day. Treatment consisted of four 60-min weekly sessions conducted by trained doctoral-level graduate students. Distress intolerance was assessed at each session. All treatment was supervised by study authors (fifth and sixth authors) and treatment fidelity checks were conducted by independent reviewers. All participants provided written informed consent prior to participation and the study protocol was approved by the Institutional Review Boards at the University of Vermont and Florida State University, where the study was conducted.

1.3. Measures

1.3.1. Distress intolerance indices

The **Discomfort Intolerance Scale** (DIS; Schmidt et al., 2006) is a 5-item self-report measure that assesses the degree to which a respondent agrees with statements related to their perceived intolerance of physical distress or discomfort (e.g., "I take extreme measures to avoid feeling physically uncomfortable") on a 7-point Likert-type scale (0 = not at all like me to 6 = extremely like me). Possible scores range from 0 to 30, with higher scores reflecting greater intolerance for physical discomfort. The DIS has demonstrated good psychometric properties in past work (Mitchell, Riccardi, Keough, Timpano, & Schmidt, 2013; Schmidt et al., 2006). Internal consistencies ranged from $\alpha = 0.37–0.49$, which is consistent with previously reported psychometric properties (Luberto, Carle, & McLeish, 2013) and are likely lower due to low item count on the DIS.

The **Breath-Holding Duration Task** (Asmundson & Stein, 1994) is a behavioral assessment of distress intolerance. During the task, participants are read a standardized script that prompts participants to inhale as deeply as possible and then exhale once a full breath is achieved. At the completion of the exhalation, the participants, are asked to again breathe in as deeply as possible and, and this time, are prompted to hold their breath for as long as they can (Asmundson & Stein, 1994). The length of time the participants are able to hold their breath is recorded via a stopwatch. No additional incentive or encouragement is given by the experimenter to promote duration. The task is completed twice, with the longest of the two breath holding trials used as the final index. The intercorrelation between the two trials was high (*r*'s range = 0.83–0.91). This task has been frequently used as measure of physical distress intolerance (Hajek, Belcher, & Stapleton, 1987; Hogan, Farris, Brandt, Schmidt, & Zvolensky, 2015), with shorter durations of breath-holding indicating greater intolerance of physical distress.

1.3.2. Smoking outcome measures

Abstinence status was determined based on self-reported continuous abstinence for the 7 days prior to the Week 1, Week 2, Month 1, and Month 3 post-quit assessments. The **Timeline Follow-Back** (TLFB; Robinson, Sobell, Sobell, & Leo, 2014) was used to collect self-report smoking data, aided by a clinician who prompted participants to retrospectively recall smoking behavior for the specified time (Robinson et al., 2014). In addition, cases of self-reported abstinence were biochemical verified via **expired carbon monoxide (CO) breath samples** (using the CMD/CO Carbon Monoxide Monitor, Model 3110; Spirometrics, Inc.) Expired CO levels $\leq$ 4 ppm collected on the assessment day was used to indicate abstinence (Perkins, Karelitz, & Jao, 2013). Data were coded 0 = abstineint and 1 = smoking. Available data at each assessment point were as follows: Week 1 (n = 277; 42.6% abstinent, 57.4% non-abstinent), Week 2 (n = 273; 45.8% abstinent, 54.2% non-abstinent), Month 1 (n = 224; 42.9% abstinent, 57.1% non-abstinent), and Month 3 (n = 221; 35.6% abstinent, 64.4% non-abstinent).

The ***Minnesota Nicotine Withdrawal Scale*** *(MNWS; Hughes & Hatsukami, 1986)* is an 9-item measure of nicotine withdrawal symptom severity, with items rated on a 4-point Likert-type scale, ranging from 0 = *not present* to 3 = *severe* (e.g., insomnia, irritability/frustration, difficulty concentrating, restlessness); a total sum score is computed. Participants were asked to rate the extent to which they experienced each withdrawal symptom during the past week. Internal consistency of items was good at Week 1 and Week 2 post-quit attempt (α range = 0.88 - 0.89).

The ***Questionnaire of Smoking Urges*** *(QSU; Tiffany & Drobes, 1991)* is a 32-item self-report measure of smoking urges and craving severity in which respondents rate the extent to which they agree or disagree with each item based on a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree). Items are summed to create a total index of craving severity. Internal consistency of items was adequate at Week 1 and Week 2 post-quit attempt (α range = 0.61 - 0.63).

1.3.3. Descriptive measures

The **Structured Clinical Interview for DSM-IV Axis I Disorders - Non-Patient Version** (SCID-I/NP; First et al., 2007) is a diagnostic assessments of past year Axis I psychopathology. Assessments were administered by trained research assistants or doctoral level staff and supervised by independent doctoral-level professionals. Interviews were audio-recorded and the reliability of a random selection of 12.5% of interviews was checked for diagnostic accuracy; no disagreements were noted. The SCID-I/NP was used for descriptive purposes in the current study.

The **Smoking History Questionnaire** (SHQ; Brown, Lejuez, Kahler, & Strong, 2002) is a self-report questionnaire used to assess smoking history (e.g., onset of regular daily smoking), pattern (e.g., number of cigarettes consumed per day), and quit history. In the present study, the SHQ was employed to describe the sample on smoking history and patterns of use (e.g., smoking rate, years as a regular smoker), as in past work (Zvolensky et al., 2005).

1.3.4. Covariate measures

The **Fagerström Test for Cigarette Dependence** (FTCD; Heatherton, Kozlowski, Frecker, & Fagerström, 1991, Fagerström, 2012) is a 6-item scale that assesses gradations in tobacco dependence. Scores range from 0 to 10, with higher scores reflecting high

levels of physiological dependence on nicotine. 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). Internal consistency of the FTCD items was $\alpha = 0.65$ in the current sample.

The **Positive and Negative Affect Scale** (PANAS; Watson, Clark, & Tellegen, 1988) is a self-report measure that requires participants to rate the extent to which they experience each of 20 different feelings and emotions (e.g., nervous, interested) based on a Likert-scale that ranges from 1 ("Very slightly or not at all") to 5 ("Extremely") in the past month. The measure yields two factors, negative and positive affect, and has strong documented psychometric properties (Watson et al., 1988). Internal consistency of PANAS − Negative Affect subscale items was $\alpha = 0.90$.

1.4. Statistical analyses

Latent growth curve (LGC) modeling was used to examine the effects of treatment condition on changes in distress intolerance (i.e., DIS and Breath-Holding duration) across the intervention (i.e., session 1 through session 4). Full information maximum likelihood was used, incorporating data from all individuals with data available for at least one data point between baseline and session 4 (i.e., an intent-to-treat analysis). The intercept was centered on the final timepoint (time coded as session 1 [-3], session 2 [-2], session 3 [-1], and session 4/quit day [0]) to allow for the examination of differences following completion of the intervention and the intercept and slope were allowed to covary. All continuous baseline covariates were centered at their mean. Treatment condition (0 = SCP, 1 = STAMP) was included as a predictor of the intercept and slope values. Models were fit in Mplus version 7.4 (Muthen & Muthen, 1998–2008). Overall model fit was assessed using the χ^2 as well as additional χ^2-based model fit indices. A non-significant χ^2 value indicates that the model fit the data well. In addition, a comparative fit index (CFI) > 0.95 and a root mean square error of approximation (RMSEA) < 0.05 indicate adequate model fit. For the RMSEA, 90% confidence intervals (CIs) are provided, with a lower bound containing 0.05 suggesting adequate fit cannot be ruled out and an upper bound containing 0.10 suggesting poor fit cannot be ruled out (Browne & Cudeck, 1993; Hu & Bentler, 1999; MacCallum, Browne, & Sugawara, 1996).

Mediation models were then examined to determine if continuous 7-day point prevalence abstinence at Week 1, Week 2, Month 1, and Month 3 post-quit day were impacted by the intervention, and whether these effects occurred through reductions in DIS or increases in Breath-Holding duration (i.e., through extracted slope parameters). Nicotine withdrawal severity (MWNS) and smoking urges/craving (QSU) at Week 1 and Week 2 post-quit attempt were also examined as smoking treatment outcomes; these time points were selected based on the documented persistence withdrawal symptoms (Shiffman et al., 2006). The direct effects of treatment on these smoking outcomes were first examined. However, mediation models were still examined even if treatment did not directly impact smoking-related outcomes, as indirect effects, especially in longitudinal designs, can still emerge in spite of nonsignificant direct effects (Shrout & Bolger, 2002). The mediation models were conducted using bias-corrected bootstrapped CIs with 1,000 bootstrap samples to provide consistent and replicable results (Preacher & Hayes, 2008). This method is preferred to other approaches as asymmetric CIs optimally balance Type I and Type II error (Hayes & Scharkow, 2013; MacKinnon, Lockwood, & Williams, 2004).

2. Results

2.1. Descriptive overview and bivariate associations

Means, standard deviations of distress intolerance indices, and available data at each timepoint for the full sample and by treatment condition, are presented in Table 1. At baseline, no statistically significant differences between treatment conditions were observed, including age, gender, presence of psychological disorders, cigarettes per day, level of tobacco dependence, DIS scores or Breath-Holding duration. The average number of treatment sessions completed was 3.1 ($SD = 1.11$), with 54.7% of participants completing all four sessions. There were no significant differences in the number of sessions completed between treatment conditions (STAMP: $M = 3.1$, $SD = 1.15$ versus SCP: $M = 3.2$, $SD = 1.06$). In the STAMP condition, interoceptive exposures were conducted at sessions 2 and 3. Among participants in the STAMP condition, attendance at these sessions was 78.3% and 72.4%, respectively.

Table 2 presents the correlations between distress intolerance measures and smoking-relevant variables, along with means and standard deviations. At baseline, the DIS and Breath-Holding duration were significantly inter-related, although the correlation was small in strength ($r = -0.21$, $p = 0.001$). The DIS and Breath-Holding duration measures were not correlated with cigarettes per day, number of prior quit attempts or baseline levels of tobacco dependence, although the DIS was positively associated with negative affect per the PANAS ($r = 0.15$, $p = 0.003$); although the magnitude of the association was small. Baseline distress intolerance per the DIS was significantly positively correlated with nicotine withdrawal and urges/craving severity at W1 and W2 post-quit day (r's = 0.15-0.16, p's < 0.01).

2.2. Latent growth curve analysis of discomfort intolerance

An unconditional LGC analysis was first fit to the data, modeling a linear slope, with the intercept centered on the final timepoint. This model fit the data well ($\chi^2 = 0.80$, $df = 5$, $p = 0.98$, CFI = 1.00, RMSEA = 0.00, 90% CI [0.00, 0.00]). Intercept and slope variance for DIS were both significant, suggesting that covariates could be used to account for this significant variance. Inclusion of the quadratic term did not result in improved model fit ($\Delta\ \chi^2 = 0.44$, $df = 4$, $p > 0.05$). The conditional model for DIS, including treatment condition as well as the centered baseline covariates (DIS, PANAS,

Table 1
Data available, Means, and Standard Deviations at each time point.

	Discomfort Intolerance Scale				Breath-Holding duration			
	n	Full sample *M (SD)*	STAMP *M (SD)*	SCP *M (SD)*	*n*	Full sample *M (SD)*	STAMP *M (SD)*	SCP *M (SD)*
Baseline	381	12.1 (5.32)	12.3 (5.49)	11.8 (5.11)	282	53.4 (22.33)	52.7 (22.06)	54.3 (22.70)
Session 1	354	12.6 (5.46)	13.1 (5.42)	11.9 (5.47)	251	53.0 (23.95)	51.8 (24.02)	54.2 (23.91)
Session 2	308	12.5 (5.19)	12.9 (5.02)	12.1 (5.39)	219	53.6 (24.80)	53.3 (24.77)	53.9 (24.95)
Session 3	280	12.2 (5.05)	12.3 (4.95)	12.1 (5.20)	192	54.4 (23.14)	54.5 (22.54)	54.2 (23.85)
Session 4	263	12.3 (5.22)	12.3 (5.46)	12.3 (4.90)	204	57.9 (23.36)	56.5 (21.72)	59.5 (25.21)

Note: Quit day coincided with treatment session 4.

Table 2
Correlations among study variables, along with means and standard deviations by treatment condition.

		1.	2.	3.	4.	5.	6.	7.	8.	Sample Mean (*SD*)
1.	Mean DIS	–								12.7 (5.11)
2.	Mean Breath-Holding	−.257**	–							54.3 (22.45)
3.	BL DIS	.818**	−.234**	–						12.1 (5.32)
4.	BL Breath-Holding	−.246**	.840**	−.206**	–					53.4 (22.33)
5.	BL FTCD	.033	−.061	−.002	−.078	–				5.2 (2.22)
6.	BL PANAS	.169**	−.062	.153**	.033	.016	–			18.4 (6.74)
7.	Mean Craving	.214**	−.068	.155*	−.044	.100	.180**	–		79.0 (31.70)
8.	Mean Withdrawal	.213**	−.082	.152*	.005	.163**	.436**	.458**	–	15.2 (4.41)
	STAMP Mean (*SD*)	12.9 (5.09)	54.6 (22.63)	12.3 (5.49)	52.7 (22.06)	5.2 (2.14)	19.2 (7.04)	82.5 (34.25)	15.3 (4.29)	15.3 (4.29)
	SCP Mean (*SD*)	12.4 (5.13)	53.9 (22.41)	11.8 (5.11)	54.3 (22.71)	5.3 (2.33)	17.5 (6.22)	74.5 (27.67)	15.0 (4.58)	15.0 (4.58)

Note. Mean DIS (Discomfort Intolerance Scale) and Mean Breath-Holding duration refer to the average value across treatment timepoints (sessions 1–4). FTCD = Fagerström Test of Cigarette Dependence; PANAS = Negative affect per the Positive and Negative Affect Scale. BL = Baseline. Mean Craving = Scores on Questionnaire of Smoking Urges at W1 and W2 post-quit day. Mean Withdrawal = Scores on the Minnesota Nicotine Withdrawal Scale at W1 and W2 post-quit day.
$^{**}p < .01$; $^{*}p < .05$.

FTCD) as predictors of the intercept and slope parameters, provided excellent fit to the data ($\chi^2 = 17.29$, $df = 16$, $p = 0.37$, CFI = 1.00, RMSEA = 0.01, 90% CI [0.00, 0.05]; see Table 3 for model parameters). There was a significant intercept parameter ($\alpha_i = 12.98$, $p < 0.001$). Treatment condition marginally predicted the intercept ($B = -0.67$, $p < 0.10$) controlling for covariates, indicating a marginally significant difference between the STAMP condition and the SCP condition such that individuals in the SCP condition had elevated DIS levels at the final timepoint compared to DIS levels for individuals in the STAMP condition. Baseline DIS significantly predicted the intercept as well ($B = 0.74$, $p < 0.001$) indicating that initially high levels of DIS were associated with higher levels of DIS over the course of treatment. There was also a significant slope parameter ($\alpha_s = 0.23$, $p < 0.05$), indicating that at mean levels of the covariates, participants in SCP condition experienced a significant increase in DIS across time. There was a significant effect of condition on slope as well ($B = -0.43$, $p < 0.001$), indicating a significant difference in slope parameters such that a decline of −0.20 units per session was found for STAMP and an increase of 0.23 units per session was found for the SCP (see Fig. 2 for estimated intercepts and slopes by condition). Cohen's *d*, calculated using the formula proposed by Raudenbush and Liu (2001; d = Condition B^*sessions/*SD* session 1), was 0.17, indicating a small effect. There were no other significant predictors of the slope parameter. These models were re-analyzed including only participants with Breath-Holding duration data. There were no substantive differences in the findings.

Table 3
Unstandardized parameters for the conditional latent growth curve model of Discomfort Intolerance and Breath-Holding duration.

	Discomfort Intolerance		Breath-Holding duration	
	Parameters	SE	Parameters	SE
Intercept	12.98***	0.30	54.10***	1.52
Intercept variance	9.65***	1.01	165.09***	24.30
Slope	0.23*	0.10	0.32	0.51
Slope variance	0.35*	0.15	12.95	3.45
Covariance	1.13***	0.30	27.47***	7.52
Intercept Predictors				
Baseline DIS	0.74	0.04	–	–
Baseline BH	–	–	0.77***	0.05
Baseline PANAS	0.03	0.03	−0.47**	0.17
Baseline FTCD	0.01	0.09	0.31	0.47
Condition	−0.67	0.40	3.33	2.07
Slope Predictors				
Baseline DIS	−0.02	0.01	–	–
Baseline BH	–	–	−0.05**	0.02
Baseline PANAS	−0.004	0.01	−0.11*	0.06
Baseline FTCD	−0.03	0.03	0.08	0.16
Condition	−0.43***	0.13	1.10	0.71

Note. Parameters are all unstandardized. *SE* = Standard error. DIS = Discomfort Intolerance Scale. BH = Breath-Holding duration. PANAS = Negative Affect scale from the Positive and Negative Affect Scale. FTCD = Fagerström Test for Cigarette Dependence. Condition coded as 0 = SCP, 1 = STAMP. Intercept is centered on session 4 (quit day).
$^{***}p \leq 0.001$, $^{**}p \leq 0.01$, $^{*}p \leq 0.05$.

2.3. Latent growth curve analysis of breath-holding duration

The unconditional model for Breath-Holding duration, with linear growth (centered on the final timepoint), fit the data well ($\chi^2 = 8.90$, $df = 5$, $p = 0.11$, CFI = 1.00, RMSEA = 0.05, 90% CI [0.00, 0.11]). Intercept and slope variance for Breath-Holding duration were both significant. Inclusion of the quadratic term did not result in improved model fit ($\Delta\chi^2 = 8.70$, $df = 4$, $p > 0.05$). The conditional model, including treatment condition as well as the centered baseline covariates (Breath-holding duration, PANAS, FTCD) as predictors of the intercept and slope parameters for Breath-Holding duration, provided adequate fit to the data ($\chi^2 = 25.50$, $df = 16$,

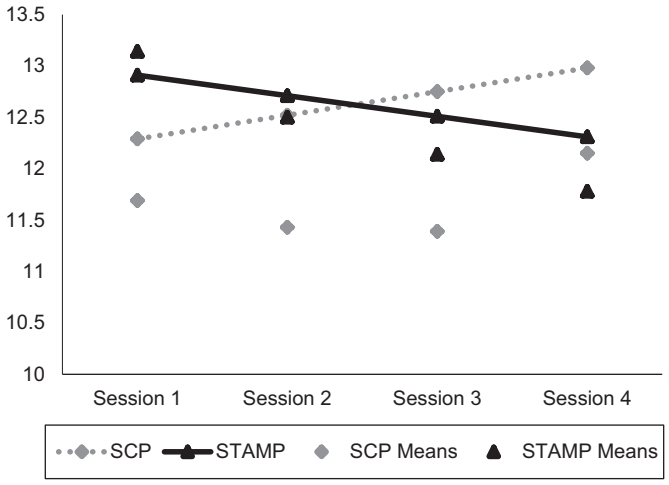

Fig. 2. Estimated Discomfort Intolerance means by condition, controlling for baseline covariates for SCP and STAMP conditions (lines). Unadjusted means by condition (points). *Note:* Quit day coincided with treatment session 4..

$p = 0.06$, CFI = 0.99, RMSEA = 0.05, 90% CI [0.00, 0.08]; see Table 3 for model parameters). There was a significant intercept parameter ($\alpha_i = 54.10$, $p < 0.001$). Both baseline Breath-Holding duration ($B = 0.77$, $p < 0.001$) and PANAS ($B = -0.47$, $p < 0.001$) significantly predicted the Breath-Holding duration intercept, indicating elevated Breath-Holding duration at the final timepoint for those with elevated Breath-Holding duration at baseline and decreased Breath-Holding duration for those with elevated PANAS at baseline. The slope parameter for Breath-Holding duration ($\alpha_s = 0.32$, $p > 0.05$) was not significant. Further, treatment condition did not influence the slope, indicating relatively stable rates of Breath-Holding duration across both the STAMP and SCP conditions. Both baseline Breath-Holding duration ($B = -0.11$, $p < 0.001$) and PANAS ($B = -0.05$, $p < 0.001$) were significant predictors of the slope parameter.

2.4. Examining the mediating role of discomfort intolerance on cigarette smoking outcomes

There were no direct effects or significant mediation effects when cigarette urges/craving or nicotine withdrawal severity (e.g., QSU or MWSC) were modeled as outcome variables. Therefore, results from these models were not included, although they are available from the first author upon request. Mediation models for the 7-day point prevalence abstinence variables (Week 1, Week 2, Month 1, Month 3) were examined for DIS growth only given there was neither significant growth nor a significant moderating impact of treatment condition on growth for Breath-Holding duration. Each abstinence outcome timepoint was modeled individually. Direct effects models of treatment condition on outcome variables were first examined, controlling for baseline variables (PANAS, FTCD, DIS). There were no direct effects of treatment condition on abstinence outcomes at any timepoint. Direct and indirect effects for the mediation models are provided in Table 4. Controlling for baseline DIS, PANAS, and FTCD, there were no significant indirect effects at Weeks 1 and 2 or at Month 1 post-quit attempt. A significant indirect path was found from treatment condition to continuous 7-day point prevalence abstinence through DIS slope for Month 3 post-quit attempt ($B = -0.65$, 95% CI [-1.33, -0.17]), with a corresponding odds ratio (OR) of 0.52 (95% CI [0.26, 0.85]) of smoking likelihood at Month 3 post-quit attempt if in STAMP versus SCP.

3. Discussion

Findings indicated that daily smokers randomized to participate in a brief four-session smoking cessation treatment specifically designed to additionally improve the management of anxiety-related symptoms, as compared to a standard cessation intervention, evidenced a significant decrease in self-reported distress intolerance over the course of treatment. Specifically, for smokers in the STAMP condition, scores on the DIS decreased from baseline to session 4, whereas scores increased for individuals in the SCP condition. Overall, the significant difference in the DIS slope by treatment condition suggests that smokers assigned to the anxiety-reduction intervention evidenced a greater rate of reduction in discomfort intolerance over the course of four treatment sessions, relative to the non-significant change for smokers assigned to standard smoking cessation treatment. Interestingly, a similar pattern of results was not found utilizing the bio-behavioral index of intolerance to respiratory distress states. Thus, the current findings suggest explanatory specificity of distress intolerance indices such that perceived, versus actual, physical distress intolerance, uniquely changes during smoking cessation treatment. Together, these findings provide initial evidence for within individual malleability of perceived distress intolerance to physical states in the context of a cognitive-behavioral smoking cessation treatment designed to include specific features purportedly relevant to distress intolerance (e.g., interoceptive exposure exercises prior to quit day).

Additionally, reductions in perceived distress intolerance to physical states emerged as a statistical mediator of the treatment effect of STAMP on increased likelihood of CO verified seven day point-prevalence smoking abstinence at 3 Months post-quit day, but not earlier (Week 1, Week 2, Month 1 post-quit day). No mediation effects were observed in predicting nicotine withdrawal and urges/craving severity. The current findings offer novel evidence that distress intolerance is malleable in the context of a brief targeted smoking intervention program and that it may serve as a prognostic indicator of certain smoking cessation outcomes. These data extend prior work that has found that a distress tolerance smoking cessation intervention produces reductions in the tendency to avoid internal distress states related to smoking (i.e., smoking-specific experiential avoidance; Brown et al., 2013). Interestingly, consistent with previous work (Kapson, Leddy, & Haaga, 2012), data indicate that standard smoking cessation treatment does not produce changes in perceived distress intolerance; this underscores the importance of tailored and targeted smoking cessation interventions (Ziedonis et al., 2008).

It is worth noting that distress intolerance is a vulnerability process that is theoretically relevant ("activated") when considered in the context of physiological or psychological distress states (Leyro et al., 2010). For example, prior literature has found that distress intolerance may only be linked to nicotine withdrawal symptoms severity and risk for smoking lapse when considered in the context of negative affect (Abrantes et al., 2008; Farris, Zvolensky, Otto, & Leyro, 2015). We did not statistically model 'distress states' in relation to distress intolerance (e.g., an

Table 4
Effects of treatment condition and baseline covariates on point-prevalence abstinence post-quit Attempt.

	Smoking week 1			Smoking week 2			Smoking Month 1			Smoking Month 3		
	B	*SE*	*p*	*B*	*SE*	*p*	*B*	*SE*	*p*	*B*	*SE*	*p*
BL DIS	−0.001	0.03	0.97	0.03	0.03	0.33	0.12	0.08	0.11	0.06	0.04	0.10
BL PANAS	0.01	0.02	0.71	0.02	0.02	0.28	0.06	0.09	0.51	0.06	0.03	0.07
BL FTCD	0.05	0.06	0.39	−0.01	0.06	0.87	−0.11	0.08	0.14	−0.14	0.08	0.09
Condition	−0.35	0.33	0.28	−0.03	0.30	0.93	0.07	0.09	0.44	0.37	0.48	0.44
Slope	0.24	0.37	0.53	0.18	0.38	0.63	−0.01	0.09	0.91	1.46*	0.65	0.02
	B	**LL**	**UL**	***B***	**LL**	**UL**	***B***	**LL**	**UL**	***B***	**LL**	**UL**
Indirect	−0.11	−0.47	0.22	−0.08	−0.41	0.26	0.02	−0.39	0.39	−0.65	−1.33	−0.17

Note. Abstain coded as 0 = abstain, 1 = did not abstain. BL = Baseline. PANAS = Negative Affect scale from the Positive and Negative Affect Scales. FTCD = Fagerström Test of Cigarette Dependence. Condition coded as 0 = Standard Cessation Program, 1 = Smoking Treatment and Anxiety Management Program. SE = Standard error. LL = 95% confidence interval lower limit. UL = Upper limit. Smoking abstinence was coded as 0; Smoking was coded as 1.

interaction effect) in the current study; however, discomfort intolerance was examined during a smoking cessation attempt, which has been conceptualized as a critical 'window' for experiencing acute distress (Shiffman, West, & Gilbert, 2004). Nevertheless, this line of work could be meaningfully extended with ecological momentary assessment data, which would allow for tests of whether discomfort intolerance in the context of fluctuations in psychological or psychological affective or withdrawal relevant distress related to smoking lapse likelihood (e.g., Langdon, Farris, Øverup, & Zvolensky, 2016).

Despite the novelty of the current findings, they should be interpreted in the context of several important limitations. First, data were not systematically collected about smoking behavior during treatment, thus it is unknown how smokers may have changed their smoking prior to quit day, and whether this varied by treatment condition or as a function of distress intolerance. Changes in smoking behavior may influence distress intolerance. Therefore, it is possible that smoking reduction status during treatment may have modulated the interaction between treatment condition and time. Relatedly, while Breath-Holding duration did not significantly change during treatment, it is plausible that smoking abstinence during treatment may have confounded the measurement of Breath-Holding duration due to pulmonary changes (i.e., bronchodilation effect of abstinence). However, existing evidence indicate that acute abstinence is associated with *shorter* Breath-Holding durations (Bernstein et al., 2008) and this measurement is not confounded by medical conditions (Hogan et al., 2015), thus such a confound may be less likely. It is also possible that lack of personal salience or incentives for the Breath-Holding duration task could influence individuals' willingness to persist during the task. Second, the current study utilized measures of physical distress intolerance. It is unknown whether these same effects would be replicated with measures of intolerance of emotional distress states or other measures of physical distress (e.g., cold pressor task); this replication would be important given discordant findings have been documented as a function of measurement domain (e.g., Daughters et al., 2005; Farris et al., 2015). Third, despite the observed findings, the size of the observed effects was small ($d = 0.17$), perhaps related to the brevity of the smoking cessation treatment (4 sessions). Importantly, only 54.7% of the participants completed all 4 sessions. Thus, while brief treatment resulted in reductions in perceived distress intolerance to physical states, it is possible that more intensive treatment may have resulted in a larger effect. Lastly, the current sample was primarily white and highly educated. Participants were also treatment-seeking smokers with low levels of comorbid substance use disorders, perhaps based on their primary goal of smoking cessation. Collectively, these sample characteristics should be considered when interpreting the generalizability of the current findings.

These findings contribute to the literature on negative reinforcement-based smoking, which is a key motivational process that is thought to maintain problematic substance use (Leventhal & Zvolensky, 2015). This is the first investigation to our knowledge to suggest that a brief anxiety-focused treatment may result in measurable and significant reductions in distress intolerance of physical states, and such reductions are related to smoking abstinence likelihood at follow-up (3 Months post-quit attempt). The active and standard treatments in the present investigation were matched for time and both utilized cognitive-behavioral strategies; they differed in terms of inclusion of modified education about anxiety/smoking, practice quit attempts, and interoceptive exposures, as a means to help individuals learn to tolerate and withstand associated distress, as well as interpret it as less harmful or threatening. Theoretically, these targeted components may be driving observed differences. Given previous research has found that smokers assigned to an intervention designed to mitigate distress intolerance evidence more favorable smoking cessation outcomes (e.g., Brown et al., 2008, 2013), but did not report on changes in distress intolerance, this line of inquiry is imperative to advancing research in this domain. Moreover, the 'dosing' and nature of treatment required to produce changes in distress intolerance is important to carefully consider. Further understanding of barriers to treatment non-engagement and attrition is needed (Daughters et al., 2005), which may enhance the effect of brief treatments on smoking abstinence.

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Conflict of interest

The authors declare that there is no conflict of interest.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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