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BRIEF REPORT

Evaluation of the Anxiety Sensitivity Index-3 Among Treatment-Seeking Smokers

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The Anxiety Sensitivity Index–3 (ASI-3; Taylor et al., 2007) is a self-report assessment of anxiety sensitivity, reflecting an individual's tendency to misinterpret the meaning of anxiety-relevant sensations. Despite this construct being related to a wide array of clinically significant smoking maintenance and relapse processes, the psychometric properties of scores on the ASI-3 have not yet been investigated for use among smokers. Therefore, the current study aimed to test the psychometric properties of the scores on the ASI-3 in a sample of cigarette smokers. Participants were treatment-seeking daily smokers who completed the ASI-3 at a precessation visit (Time 1, $N = 464$) and 3 months postcessation attempt (Time 2, $n = 137$). Confirmatory factor analyses results of the scores on ASI-3 at Time 1 and Time 2 revealed the hypothesized 3-factor model, including physical, social, and cognitive concerns. In addition, the ASI-3 factor scores evidenced factor stability, test–retest reliability, internal consistency, and convergent, and discriminant, and predictive validity. The present study provides evidence in support of the validity and reliability of scores on the ASI-3 as a measure of anxiety sensitivity among treatment-seeking cigarette smokers.

Keywords: anxiety sensitivity, ASI-3, confirmatory factor analysis, cigarette smoking

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The expectancy model of fear posits that, in the context of personal threat, anxiety sensitivity marks the extent to which one attends to, and perceives, anxiety-relevant sensations as harmful, dangerous, and indicative of catastrophic consequences across domains (physical, social, and cognitive concerns; Reiss & McNally, 1985). Anxiety sensitivity is a risk factor for the acquisition and maintenance of psychopathology, primarily anxiety and mood disorders (Olatunji & Wolitzky-Taylor, 2009).

Research over the past decade has convincingly indicated that anxiety sensitivity may serve as a central explanatory mechanism in substance use disorders; perhaps, best illustrated in the case of cigarette smoking (Leventhal & Zvolensky, 2015). Anxiety sensitivity may be particularly relevant to smokers, given that health consequences of smoking (e.g., Goodwin et al., 2012) may potentiate the salience of negative interoceptive experiences. Anxiety sensitivity is associated with affect-regulatory smoking expectancies and motives for use (e.g., Farris, Leventhal, Schmidt, & Zvolensky, in press) and various aspects of psychological inflexibility (e.g., Zvolensky, Farris, Schmidt, & Smits, 2014). Anxiety sensitivity also appears to be related to increases in positive affect

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after cigarette use (Wong et al., 2013) and reductions in subjective anxiety after stressful experiences (Perkins, Karelitz, Giedgowd, Conklin, & Sayette, 2010). Moreover, anxiety sensitivity impacts the process of quitting, including the experience of more severe nicotine withdrawal (e.g., Johnson, Stewart, Rosenfield, Steeves, & Zvolensky, 2012) and risk for cessation failure (Assayag, Bernstein, Zvolensky, Steeves, & Stewart, 2012).

The most recent published measure, the 18-item Anxiety Sensitivity Index–3 (ASI-3; Taylor et al., 2007), was designed, in part, based on previous measures of anxiety sensitivity (Reiss, Peterson, Gursky, & McNally, 1986; Taylor & Cox, 1998). Psychometric tests of the ASI-3 have consistently yielded a three-factor model of anxiety sensitivity, including physical, cognitive, and social concerns (Bernstein et al., 2010; Ebesutani, McLeish, Luberto, Young, & Maack, 2014; Stellman et al., 2008; Taylor et al., 2007). Although the ASI-3 has been validated among clinical (anxiety disordered) and nonclinical samples (Escocard, Fioravanti-Bastos, & Landeira-Fernandez, 2009; Kemper, Lutz, Bähr, Rüddel, & Hock, 2012; Osman et al., 2010; Wheaton, Deacon, McGrath, Berman, & Abramowitz, 2012), none of these past studies assessed for, or screened on the basis of, smoking behavior. Thus, the psychometric properties of scores on the ASI-3 have not yet been investigated for use among smokers. To address this matter, the current study examined the factor structure, factor-structure stability, reliability, and validity of scores on the ASI-3 measure among treatment-seeking adult daily cigarette smokers.

Method

Participants and Procedure

Adult daily smokers ($N = 464$; 48.2% female; $M_{age} = 37.4$, $SD = 13.40$) were recruited from the community to participate in a larger randomized control trial examining the efficacy of two smoking cessation interventions (clinicaltrials.gov No. NCT01753141). Participants eligible for inclusion in the current study were 18–65-year-olds who reported smoking ≥8 cigarettes per day, with motivation to quit rated as at least 5 or higher on a 10-point scale. 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–TR *Axis I Disorders* (SCID-I/NP; First, Spitzer, Gibbon, & Williams, 2007) and completed a computerized battery of baseline (pretreatment) self-report questionnaires. Eligible participants were then randomly assigned to one of two 4-session smoking-cessation treatment programs (described elsewhere; Farris, Zvolensky, DiBello, & Schmidt, 2015). Follow-up data were collected at various time points postquit attempt. 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. For the current psychometric investigation, data from two time points (baseline/Time 1; 3 months postcessation attempt/Time 2) were used.

At baseline, 464 cases were retained for analyses at Time 1 (i.e., those who provided complete baseline data for variables in the current study, regardless of parent-study eligibility). Of the 464 cases, 398 were deemed eligible and were randomized to treatment (i.e., the Panic-Smoking Prevention Program, $n = 223$, 56.0%, and the Smoking-Cessation Program, $n = 175$, 44.0%). Of those randomized, 137 provided complete data at Time 2.[1] At Time 1, the average daily smoking rate of this sample was 17.8 ($SD = 9.60$), with participants reporting regular daily smoking for 19.1 years ($SD = 13.29$); smoking heaviness index averaged 3.0 ($SD = 1.41$; possible range = 0–6 on the Fagerström Test for Nicotine Dependence; FTND). Tobacco-related medical problems were self-reported among 29.9% of the sample. Regarding Axis I psychopathology, 42.5% of the sample met criteria for a past-year (current) diagnosis. At Time 2, the self-reported rate of smoking was 4.4 cigarettes per day ($SD = 7.26$; range = 0–40), with a mean smoking heaviness index of 2.1 ($SD = 1.22$).

Measures

The ASI-3 (Taylor et al., 2007) is an 18-item self-report used to assess concern associated with possible negative consequences of anxiety-related symptoms (e.g., "It scares me when my heart beats rapidly"). The scale includes some items from the original ASI (Reiss et al., 1986). Responses are rated on a 5-point Likert scale ranging from 0 (*very little*) to 4 (*very much*).

Descriptive measures. The SCID-I/NP (First et al., 2007) is a clinician-administered structured diagnostic assessment of past-year Axis I psychopathology. Assessments were administered by trained research assistants or doctoral level staff. The Smoking History Questionnaire (Brown, Kahler, Zvolensky, Lejuez, & Ramsey, 2001) 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.

Convergent and discriminant validity. The ASI (Reiss et al., 1986) is the original 16-item measure of anxiety sensitivity, with five items that overlap with the ASI-3 (Taylor et al., 2007). The total score sum was used as a test of convergent validity (internal consistency of items was $\alpha = .93$). The Body Vigilance Scale (BVS; Schmidt, Lerew, & Trakowski, 1997) is a four-item self-report measure of the extent to which one focuses on internal bodily sensations. Items are summed to derive a total score. This measure has strong psychometric properties (Schmidt et al., 1997); internal consistency of items was $\alpha = .81$. The Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007) is a 64-item self-report measure of symptoms of major depression and related anxiety symptoms, with strong psychometric properties (Watson et al., 2007). The Panic subscale (eight items) was used for a test of convergent validity, as this subscale taps anxious arousal, the tendency to experience physiological arousal associ-

[1] Given the difference in sample size between Time 1 and Time 2 (partly due to noneligible participants being excluded and partly due to study attrition), group differences were examined in terms of baseline factors. First, a series of t tests indicated that those who were randomized and provided Time 2 data ($n = 137$) versus those who did not ($n = 261$), did not significantly differ in terms of prior number of lifetime quit attempts, or baseline levels of nicotine dependence, expired carbon monoxide, negative or positive affectivity, panic or depressive symptoms (all $ps > .05$). In addition, those who provided Time 2 data versus those who did not were not significantly different in terms of Time 1 ASI-3 (Taylor et al., 2007) factor scores (all $ps > .05$). A χ^2 test also indicated that there were no sex differences in those who provided Time 2 data, $\chi^2(1) = 1.240$, $p = .265$, and the presence of anxiety or depressive psychopathology at Time 1 did not statistically differ between those participants who provided Time 2 data ($n = 41$, 29.9% with psychopathology) versus those who did not ($n = 91$, 34.9%); $\chi^2(1) = 989$, $p = .320$.

ated with anxiety (Watson et al., 2007). The IDAS Well-Being subscale (eight items indexing positive affective states) was used to assess discriminant validity. Internal consistency was α = .88 for the IDAS Panic subscale items and α = .91 for the IDAS Well-Being subscale items. The Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) is a 20-item self-report measure of broad negative and positive affect. The PANAS has strong documented psychometric properties (Watson et al., 1988). The negative and positive affect scales were used to assess convergent and discriminant validity, respectively. Internal consistency for the subscale items were α = .90 (*positive affect*) and α = .91 (*negative affect*).

Predictive validity. The FTND (Heatherton, Kozlowski, Frecker, & Fagerström, 1991) is a six-item scale that assesses gradations in tobacco dependence. The FTND items have adequate psychometric properties (Heatherton et al., 1991). A smoking heaviness index was derived from two items: "How many minutes after you wake do you smoke your first cigarette?" and "How many cigarettes a day do you smoke?" (Etter, Duc, & Perneger, 1999), which was assessed at Time 1 and Time 2 for predictive validity.

Data Analytic Plan

The factor structure at Time 1 was examined using structural equation modeling (confirmatory factor analysis; CFA). Single-factor and three-factor models were analyzed. Analyses were conducted using Mplus Version 7.1 (Muthén & Muthén, 1998–2012). A second CFA was conducted using data collected at Time 2 to confirm the factor structure. Factor stability was assessed, according to Meredith (1993), by first assessing measurement invariance and examining whether factor loadings (i.e., weak invariance), and then factor intercepts (i.e., strong invariance) held. Following this, within-factor paths were examined across Time 1 and Time 2 using the best fitting model. Cronbach's α was used to document internal consistency of factor items. Intercorrelations were computed to assess test–retest reliability of factor scores. Zero-order correlations were computed between the ASI-3 (Taylor et al., 2007) factor scores at Time 1 in relation to the relevant measures at Time 1. Path modeling in Mplus was used to assess the predictive validity of the ASI-3 factor scores at Time 1 and Time 2 in terms of smoking characteristics.

Robust maximum likelihood (MLR) was employed as the estimation method; indicators loaded on their underlying factors and interfactor correlations were allowed. Their corresponding measurement errors were estimated as well. Based on the original measure validation (Taylor et al., 2007), each item was constrained to load onto one factor. With respect to model fit, several tests were used to evaluate the models. First, the overall-model, Yuan–Bentler-adjusted χ^2 (e.g., Bollen, 1989) was used. Generally, a nonsignificant χ^2 test, leading to nonrejection of the model, would suggest a relatively good approximation of the data. Second, the model fit was evaluated using the root mean square error of approximation (RMSEA), with values of .00–.05 indicating excellent fit, values of .06–.08 indicating reasonable fit, and values about .10 suggesting poor fit (Browne & Cudeck, 1993). The Comparative Fit Index (CFI; Bentler, 1990) and the Tucker–Lewis Index (TLI) were also used, with values greater than .90 as indicative of good fit (Hu & Bentler, 1999). Finally, because the CFA models and the models of measurement invariance were nested models, we evaluated comparative model fit using the χ^2 difference test and the Akaike information criterion (AIC), with a nonsignificant χ^2 indicating better fit for the more parsimonious model and smaller AIC values indicating better fit (Kline, 2011).

Results

Confirmatory Factor Analysis

First, a single-factor model was fit to the data. The model was statistically significant, $\chi^2(135, n = 464) = 799.40, p < .01$. Overall, the results indicated poor model fit (RMSEA = .10, 90% confidence interval [CI] [.10, .11]; CFI = .80; TLI = .78). Based on its poor fit, the single-factor model was rejected. Next, the three-factor model was fit to the data (Taylor et al., 2007). The model and results are shown in Figure 1. The model was statistically significant, $\chi^2(132, n = 464) = 335.29, p < .01$. Furthermore, this model evidenced adequate fit (RMSEA = .06, 90% CI [.05, .07]; CFI = .94; TLI = .93). Using the nested χ^2 difference test, results indicated that the three-factor model improved the model significantly, relative to the single-factor model, $\chi^2(3) = 219.56, p < .001$. In addition, the three-factor model produced a lower AIC value than the single-factor solution (AICs = 18,928, 19,624, respectively). Next, ASI-3 data from Time 2 were used to examine the three-factor model. Consistent with Time 1, the model was significant, $\chi^2(132, n = 137) = 171.04, p < .05$. The model

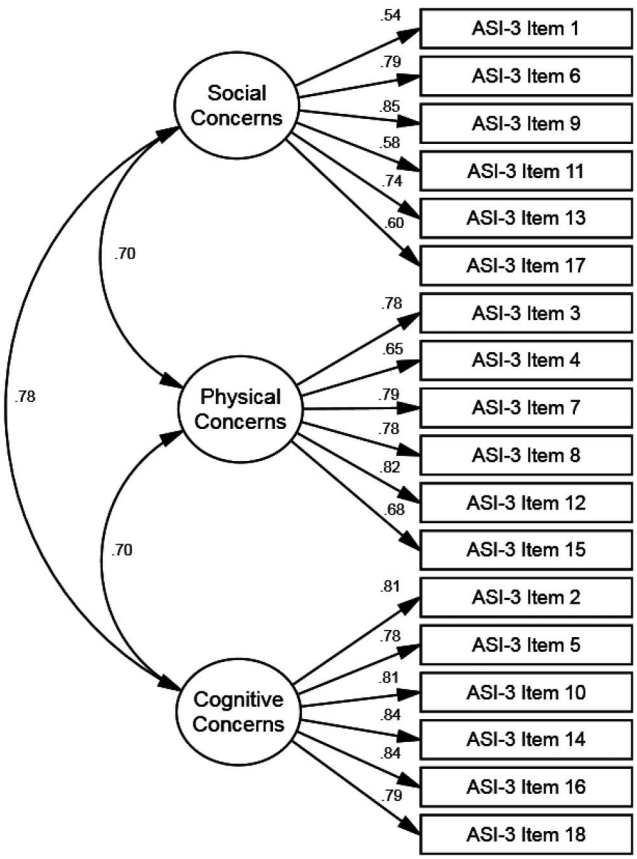

Figure 1. Three-factor model for Time 1. Path estimates are standardized regression weights. All path estimates are significant at $p < .001$.

Table 1
Psychometric Statistics for the ASI-3 Constructs

Variable	Mean (*SD*)	ASI-3 Physical	ASI-3 Cognitive	ASI-3 Social
Reliability				
Internal consistency (α)	—	.881	.920	.842
Test–retest[a] (*r*)	—	.702*	.600*	.815*
Convergent validity (*r*)				
Anxiety Sensitivity Index[b]	18.0 (11.26)	.80*	.74*	.72*
Anxious arousal[c]	11.1 (4.24)	.54*	.50*	.49*
Body vigilance[d]	12.1 (7.70)	.44*	.29*	.31*
Negative affect[e]	19.1 (7.31)	.50*	.62*	.60*
Discriminant validity (*r*)				
Positive affect[f]	32.2 (7.36)	−.20*	−.31*	−.28*
Well-being[g]	22.6 (6.70)	−.21*	−.29*	−.29*

Predictive validity		Outcome β (*SE*)		
	Predictor	ASI-3 Physical	ASI-3 Cognitive	ASI-3 Social
	Gender[h]	−.01 (.39)	−.02 (.32)	−.07 (.40)
	Axis I psychopathology[i]	.12 (.42)*	.15 (.35)*	.15 (.43)*
	Medical problems[j]	.10 (.41)*	−.05 (.35)	−.05 (.43)
	Negative affect	.45 (.03)*	.58 (.02)*	.55 (.03)*
			Time 1 Smoking Heaviness Index[k]	
	Gender		−.07 (.05)	
	Medical problems		−.01 (.05)	
	Axis I psychopathology		.05 (.05)	
	Negative affect		−.10 (.06)	
	ASI-3 Physical		.17 (.07)*	
	ASI-3 Cognitive		.02 (.08)	
	ASI-3 Social		−.05 (.07)	
			Time 2 Smoking Heaviness Index	
	Smoking heaviness Time 1		.66 (.06)*	
	Treatment condition[l]		.04 (.11)	
	ASI-3 Physical		.25 (.09)*	
	ASI-3 Cognitive		.03 (.11)	
	ASI-3 Social		−.10 (.12)	

Note. Test of predictive validity was tested simultaneously in one predictive path model.
[a] Test–retest of Time 1–Time 2. [b] Anxiety Sensitivity Index-3 (ASI-3). [c] Inventory of Depression and Anxiety Scale (IDAS-Panic subscale). [d] Body Vigilance Scale (BVS). [e] Positive and Negative Affect Scale (PANAS Negative Affect subscale). [f] Positive and Negative Affect Scale (PANAS Positive Affect subscale). [g] Inventory of Depression and Anxiety Scale (IDAS Well-Being subscale). [h] Gender (coded 0 = male; 1 = female). [i] Axis I psychopathology (past year, per SCIDI/NP; coded 0 = no disorder, 1 = disorder). [j] Tobacco-related medical problems (coded 0 = no, 1 = yes). [k] Fagerström Test for Nicotine Dependence Heaviness Index (FTND Items 1 and 2). [l] Treatment condition (coded 0 = standard, 1 = anxiety-focused).
* $p < .05$.

evidenced good fit (RMSEA = .05, 90% CI [.02, .07]; CFI = .96; TLI = .95). This model is visually displayed in the article supplement (Figure 1s).

Test of Factor Structure Stability

Weak measurement invariance (i.e., equal factor loadings) was achieved, $\chi^2(15) = 9.71$, $p = .84$, as was strong invariance, i.e., equal intercepts; $\chi^2(15) = 37.48$, $p = .16$; see Figure 2s in the article supplement. Within-factor paths across Time 1 and Time 2 CFA models were tested (as in Berninger et al., 2010). Each of the ASI-3 factor items exhibited high levels of stability, as estimated by the values of the within-factor paths across Time 1 and Time 2 for the CFA. The path effects for each factor were as follows: ASI-3 Physical Concerns factor (β = .73), ASI-3 Social Concerns factor (β = .82), and ASI-3 Cognitive Concerns factor (β = .65); all *p*s < .001.

Reliability: Internal Consistency and Test–Retest

Reliability tests are presented in Table 1. Results revealed high internal consistency at Time 1 and Time 2 for the all ASI-3 factor items. For test–retest reliability, intercorrelations from Time 1 to Time 2 for all of the ASI-3 factor scores were statistically significant.[2]

[2] A paired-samples *t* test revealed a significant reduction in ASI-3 factor scores from Time 1 to Time 2: Physical Concerns, $M = 4.2$ ($SD = 4.54$) versus $M = 2.8$ ($SD = 3.57$), $t = 4.89$, $p < .0001$; Social Concerns, $M = 7.0$ ($SD = 4.90$) versus $M = 5.5$ ($SD = 5.00$), $t = 4.94$, $p < .0001$; and Cognitive Concerns, $M = 3.1$ ($SD = 4.19$) versus $M = 2.2$ ($SD = 3.59$), $t = 2.89$, $p = .005$.

Validity: Convergent, Discriminant, and Predictive

Tests of convergent, discriminant and predictive validity are presented in Table 1. All ASI-3 factor scores were positively associated with Time 1 scores on measures of anxiety sensitivity, anxious arousal, body vigilance, and negative affect. All ASI-3 factor scores were significantly and negatively correlated with positive affect, as indexed by two different measure scores. Regarding tests of predictive validity, a path model was constructed to examine the ASI-3 factor scores (allowed to correlate) in terms of predicting smoking heaviness at Time 1 and Time 2. Gender, presence of tobacco-related medical problems, presence of past-year psychopathology[3], and trait-negative affect were entered as covarying predictors of the ASI-3 factors and Time 1 smoking heaviness index. Time 1 smoking heaviness and treatment condition were entered as predictors of the Time 2 smoking heaviness index. Model fit was good, $\chi^2(14) = 28.46$, $p = .012$; RMSEA = .05, 90% CI [.02, .07]; CFI = .98; TLI = .96). Results indicated that only ASI-3 Physical Concerns scores were predictive of smoking heaviness at Time 1 ($\beta = .17$, $p = .014$) and at Time 2 ($\beta = .25$, $p = .005$).

Discussion

The test of the factor structure of the ASI-3 revealed a three-factor solution to be stronger in fit to the data than a one-factor model. This was true of data collected at two time points, approximately 4 months apart. Thus, at least among treatment-seeking smokers, it appears that the lower order constituent factor scores of the ASI-3 (Taylor et al., 2007) remain consistent over time. Moreover, follow-up reliability testing of the identified ASI-3 factor scores revealed high internal consistency for all factor scores at both time points. These results are consistent with findings in nonsmoking samples (Ebesutani et al., 2014; Taylor et al., 2007). In addition, the ASI-3 factor scores demonstrated adequate test–retest reliability. It is important to note that reductions in anxiety sensitivity were observed across all ASI-3 factor scores from Time 1 to Time 2. As such, these data documented the stability of the factor structure and measure reliability at both time points, regardless of intervention or status of acute smoking abstinence.

Findings also support the convergent validity of the ASI-3 factor scores in terms of other anxiety-sensitivity indices, anxious arousal, body vigilance and negative affectivity, and divergent validity evidenced by negative associations of ASI-3 factor scores and positive affectivity scores. Physical concerns about anxiety-relevant sensations emerged as a unique predictor of smoking heaviness at both time points, after adjusting for relevant covariates. In particular, (mis)interpreting the meaning of bodily sensations may specifically pose as a barrier for actual cessation, given that high anxiety-sensitive smokers tend to expect interoceptive/somatic threat during acute smoking abstinence (Farris, Langdon, DiBello, & Zvolensky, 2014).

A few limitations should be considered. First, study attrition should be considered when interpreting test–retest indices. In addition, given that the participants in the sample were undergoing a cessation attempt, and changes in anxiety sensitivity were observed[2], this test of reliability may not be the strongest test of measure stability, thus warranting replication to determine the generalizability of these findings. Second, the psychometric properties (e.g., factor structure) could not be tested at Time 2 by smoking abstinence status, given the small sample size at that time point. Last, reductions in ASI-3 scores were reported for primarily descriptive purposes[2]; however, the reasons for these reductions were not explicitly tested here; they were beyond the scope of this investigation.

There is overwhelming evidence that documents the role of anxiety sensitivity in terms of various aspects of cigarette smoking (Leventhal & Zvolensky, 2015). Findings here support the validity and reliability of scores on the ASI-3 as a measure of anxiety sensitivity among treatment-seeking cigarette smokers, and suggest that the multidimensional nature (i.e., constructs had differential predictive effects) of anxiety sensitivity is particularly important to consider among smokers.

[3] Table 1s in the article supplement includes means, standard deviations, and tests of group differences by ASI-3 subscales for gender, presence of past-year psychopathology vs. no disorder; anxiety psychopathology vs. no anxiety psychopathology, and presence of tobacco-related disease vs. no self-reported tobacco-related disease.

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