PROFILES OF REACTIVE TRANSDIAGNOSTIC VULNERABILITIES AMONG CIGARETTE SMOKERS

By

MARK V. VERSELLA JR.

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Teresa M. Leyro

And approved by

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ABSTRACT OF THE THESIS

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by MARK V. VERSELLA JR.

Thesis Director:

Teresa M. Leyro, Ph.D.

Among cigarette smokers, elevations in maladaptive transdiagnostic vulnerabilities, including distress intolerance (DI), anxiety sensitivity (AS), and experiential avoidance (EA) are associated with poorer outcomes across the course of use. A common mechanism underlying these outcomes is thought to be an increase in the frequency and intensity of negative affect elicited during nicotine use brought about by these elevations. Despite commonalities, to date no investigation has examined whether smokers can be characterized by latent subgroups of shared vulnerability profiles. To examine potential subgroups, a latent profile analysis (LPA) was conducted among a sample of treatment-seeking daily smokers (N = 435), with measures of DI, AS, and EA serving as indicators of class members, and demographic variables, smoking heaviness, motives, and expectancies serving as covariates. The initial model solution revealed that specific covariates exerted a direct effect on profile structure, necessitating a re-examination of the latent profile solution, including covariates that exhibited a significant pairwise association in the previous best-fitting model. The final model revealed a three-profile solution, wherein smokers were characterized primarily by Low EA (35.7% of the sample), Elevated EA (53.3%), or Elevated AS (11%). Individuals who endorsed smoking because of its addictive qualities were more likely to be members of the Elevated AS or Elevated EA profiles, relative to the Low EA profile. In addition, individuals of lower educational achievement were more likely to be members of the Elevated AS profile than the Elevated or Low EA profiles. Results provide preliminary evidence that treatment-seeking smokers exhibit discriminable transdiagnostic profiles, and that profiles are differentially related to demographics and smoking-specific outcomes.

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Smoking remains the leading preventable cause of death in the United States and increases risk for heart disease, pulmonary disease, and cancer (US Department of Health and Human Services, 2014). Despite a 57% decrease in daily smokers since 1965, the decline in smoking prevalence over the past decade has slowed (Jamal et al., 2015). Smoking rates have remained particularly elevated among individuals with psychiatric comorbidity (McClave, McKnight-Eily, Davis, & Dube, 2010). These individuals are subject to chronic and persistent stressors and may smoke to reduce negative affect (NA) brought about by these stressors (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Kassel, Stroud, & Paronis, 2003). A greater understanding of cognitive and affective vulnerabilities that promote or maintain cigarette use among this vulnerable population may further efforts to develop individualized, efficacious interventions for this subset of smokers.

Recent work suggests that focusing on behavioral traits that capture maladaptive responding to internal emotional states may prove fruitful in understanding smoking behavior, dependence, and motives (Leventhal & Zvolensky, 2015). Termed reactive transdiagnostic vulnerabilities, these constructs capture distinct aspects of how an individual reacts to emotional stimuli and states, such as fear of anxiety-related sensations (i.e., anxiety sensitivity; McNally, 2002; Reiss & McNally, 1985), intolerance of aversive physical or emotional states (i.e., distress intolerance; Leyro, Zvolensky, & Bernstein, 2010; Zvolensky, Vujanovic, Bernstein, & Leyro, 2010), and avoidance of emotionally distressing stimuli (i.e., experiential avoidance; Chawla & Ostafin, 2007; Hayes, Wilson, Gifford, Follette, & Strosahl, 1996). Maladaptive presentations of these vulnerabilities are thought to contribute to a broad array of psychopathology (Dozois, Seed, & Collins, 2009), in that they make maladaptive behaviors consistent with pathology more rewarding. For example, an individual with an anxiety disorder who exhibits greater fear of anxiety will find anxiety avoidance strategies more negatively reinforcing than an individual who is less fearful of anxiety, as the avoidance will remove a more subjectively aversive stimulus.

For cigarette smokers, elevations in reactive transdiagnostic vulnerabilities may increase nicotine dependence by both enhancing the perceived, acute affect-modifying effects of cigarettes and increasing the aversive qualities of cigarette abstinence (e.g., elevations in negative affect, physiological discomfort, greater nicotine cravings) (Leventhal & Zvolensky, 2015). Elevations in these vulnerabilities are associated

with an increase in both the frequency and intensity of negative affect (NA) experienced during nicotine withdrawal (Perkins, Karelitz, Giedgowd, Conklin, & Sayette, 2010; Farris, Zvolensky, & Schmidt, 2015; Zvolensky et al., 2004). This pathway creates more opportunities to learn that smoking can reduce aversive affective experiences and increases motivation to smoke in order to escape and avoid NA. Among smokers, there is evidence that targeting transdiagnostic vulnerabilities in cessation treatment improves cessation outcomes, including lowering subjective withdrawal distress (Brown et al., 2013) and improving the likelihood of success when making a cessation attempt (Zvolensky et al., 2003). Much of the current work examining transdiagnostic vulnerabilities and smoking has examined how each vulnerability relates individually to smoking behaviors, motives, and outcomes. While there is clear utility to explicating these relationships, examining potentially related constructs in isolation may obfuscate key interactions, fail to account for possible overlap among constructs, and exaggerate the explanatory power of single vulnerabilities.

Distress Intolerance

As noted earlier, distress intolerance (DI) is conceptualized as an individual's perceived or behavioral incapacity to withstand and tolerate aversive emotional or physical states (Leyro et al., 2010; Zvolensky et al., 2010), and has historically been conceptualized as a risk and maintenance factor for psychological disorders (Lynch & Bronner, 2006; Mennin, Heimberg, Turk, & Fresco, 2002). An individual's DI may predict how he or she responds to a distressing situation. Whereas individuals high in DI are motivated to engage in escape or avoidance behavior to remove themselves from distressing emotional states, those with low DI are able to engage in adaptive coping strategies in the face of distress (Leyro et al., 2010; Leventhal & Zvolensky, 2015). DI is typically measured by either self-report or behavioral instruments; whereas self-report measures assess an individual's perceived capacity to tolerate aversive events, behavioral measures index an individual's behavior in withstanding an aversive event (Leyro et al., 2010).

Smokers exhibit greater behavioral DI than non-smokers (Quinn et al., 1996). In part, this may be due to individuals with high DI seeking out a low effort, immediately reinforcing means of alleviating or escaping distress (Leventhal & Zvolensky, 2015). However, continued cigarette use may also exacerbate maladaptive DI levels in smokers, as alleviation of aversive states via cigarette smoking may reinforce an

existing tendency to escape and avoid distress. Elevations in DI are related to negative smoking-related indices and outcomes across the course of use. Among daily smokers, high self-reported DI predicts greater motivation to smoke for relief of NA, above and beyond the effects of depressive and anxious symptoms (Trujillo et al., 2012). Self-reported DI is also positively associated with greater nicotine dependence (Leyro, Bernstein, Vujanovic, McLeish, & Zvolensky, 2011). In addition, high DI impedes cessation efforts, which may be due to lower subjective tolerance of withdrawal-related symptoms (Brown, Lejuez, Kahler, Strong, & Zvolensky, 2005). High behavioral DI is associated with a greater likelihood of lapse during a quit attempt (Abrantes et al., 2008; Brown et al., 2009), an inability to resist cigarette smoking among nicotine-deprived smokers (Kahler, McHugh, Metrik, Spillane, & Rohsenow, 2013), and a shorter lifetime abstinence duration (Brown, Lejuez, Kahler, & Strong 2002). In addition, cessation interventions targeting DI (e.g., Brown et al., 2008; Brown et al., 2013) appear to improve maintenance of abstinence following initial cessation, as compared to treatment as usual. Moreover, DI levels mediate the effect of a cessation treatment targeting anxiety-relevant processes, with lower levels of DI associated with greater abstinence likelihood (Farris et al., 2016). In sum, DI, measured both behaviorally and via self-report, appears to have relevance to smoking maintenance and cessation success.

Experiential Avoidance

Experiential avoidance (EA) is an unwillingness to remain in contact with, and the behavioral tendency to remove oneself from, stimuli that elicit aversive physical and emotional internal experiences (Chawla & Ostafin, 2007; Hayes et al., 1996). The construct of EA arose primarily from a clinical tradition, as EA is a frequent clinical target of interventions ranging from early Freudian psychoanalysis (Freud, 1924) to client-centered interventions (Raskin & Rogers, 1989), as well as modern behaviorally based interventions such as acceptance and commitment therapy (Hayes & Wilson, 1994) and dialectical behavior therapy (Linehan, 1993), all of which address avoidance (Hayes et al., 1996). When an individual with elevated EA encounters, or believes that they will encounter, an aversive experience, he or she tends to react by engaging in behaviors to alter the form and/or frequency of the unwanted event (Hayes et al., 1996). While EA-elicited strategies can be successful in immediately alleviating emotional discomfort, long term avoidance often increases unwanted thoughts and emotions (Feldner, Zvolensky, Eifert, & Spira,

2003; Kashdan, Barrios, Forsyth, & Steger, 2006) and may result in negative psychological outcomes (Penley, Tomaka, & Wiebe, 2002).

The limited research on smoking and EA to date has found a relation between elevated smoking-specific EA – the tendency to smoke to avoid or reduce distress associated with nicotine withdrawal and craving – and smoking outcomes. Elevated smoking-specific EA is associated with greater NA and withdrawal in the context of a cessation attempt (Farris et al., 2015). This suggests that elevated EA may intensify affective disturbances in the context of withdrawal, which in turn may enhance the reinforcing properties of cigarettes. In addition, smokers with elevated smoking-specific EA experience greater NA and depressive symptoms three months post-quit (Minami, Bloom, Hayes, Reed, & Brown, 2015) and are more likely to relapse after a cessation attempt (Gifford et al., 2004; Gifford et al., 2011).

Anxiety Sensitivity

Anxiety sensitivity (AS) is a malleable, trait-like vulnerability that indexes an individual's fear of anxiety-related sensations and belief that these sensations can cause personal harm (McNally, 2002; Reiss & McNally, 1995), and has been investigated primarily as an etiological precipitant of anxiety and somatoform disorders (e.g., post-traumatic stress disorder (PTSD): Federoff, Taylor, Asmundson, & Koch, 2000; social anxiety disorder (SAD): Scott, Heimberg, & Jack, 2000; hypochondriasis, panic disorder (PD): Otto, Pollack, Sachs, & Rosenbaum, 1992). Individuals with elevated AS are more fearful of their own anxiety (Olatunji & Wolitsky-Taylor, 2009), more vigilant for interoceptive anxiety cues (Brown et al., 2005; Schmidt, Lerew, & Trakowski, 1997) and typically engage in behavioral avoidance of situations that elicit anxiety (Leventhal & Zvolensky, 2015).

Elevated AS is conceptualized as a maintenance factor for cigarette smoking. Individuals with elevated AS report more concomitant anxiety and distress in the context of withdrawal (Zvolensky et al., 2004) and interpret withdrawal-related symptoms (e.g., anxiety, bodily discomfort) as more subjectively dangerous and frightening (Zvolensky & Schmidt, 2003). Thus, cigarette smoking may become a low-cost, highly reinforcing means of removing feared anxiety sensations among smokers, especially in the context of nicotine withdrawal; this repeated pairing of cigarette smoking with reduction of an intense, feared stimulus (anxiety) can increase nicotine dependence. In support of this, AS is associated with a greater rate of smoking (Brown, Kahler, Zvolensky, Lejuez, & Ramsay, 2001) and greater motivation to smoke due to

cigarettes' NA reduction and addictive properties (Gonzalez, Zvolensky, Vujanovic, Leyro, & Marshall, 2008; Leyro, Zvolensky, Vujanovic, & Bernstein, 2008). While smokers with elevations in AS typically report greater expectations that smoking will result in negative personal consequences (Leyro et al., 2008) and greater motivation to quit (Zvolensky et al., 2004), they also believe that quitting smoking will be problematic and personally challenging (Gonzalez et al., 2008), likely due to cigarettes serving as a primary means of alleviating anxiety. Furthermore, elevated AS is also associated with poorer cessation outcomes, predicting greater overall likelihood of lapse and greater odds of lapsing within the first week of a cessation attempt (Brown et al., 2001).

Overlap Among Constructs

While DI, EA, and AS theoretically capture distinct ways of responding to emotionally salient stimuli, the constructs exhibit substantial conceptual overlap. Each of these constructs broadly captures how one reacts to an anticipated or actual aversive stimulus. Furthermore, maladaptive levels of each are associated with greater symptom severity and worse treatment outcomes across a variety of disorders (e.g., PTSD: Marshall-Berenz, Vujanovic, Bonn-Miller, Bernstein, & Zvolensky, 2010; major depressive disorder: Williams, Thompson, & Andrews, 2013; generalized anxiety disorder: Roemer, Salters, Raffa, & Orsillo, 2005; panic disorder: Schmidt, Zvolensky, & Maner, 2006; SAD: Scott, Heimberg, & Jack, 2000). In fact, current research is mixed on whether these constructs are indeed distinct or whether they instead capture facets of a broader affective reactivity construct (Leyro, Zvolensky, & Bernstein, 2010; Leventhal & Zvolensky, 2015).

Both AS and DI capture aspects of how one responds to aversive emotional states, and both lead individuals to engage in escape or avoidance coping when encountering said aversive states. One possibility is that AS captures cognitions related to the expectation of anxiety and the distal negative consequences that may arise from it, while DI captures an individual's ability to withstand more proximal aversive experiences (Leyro, Zvolensky, & Bernstein, 2010). However, it is unclear whether there is sufficient evidence to suggest that individuals' anticipatory and proximal responses to aversive stimuli are impacted by separate processes. In an effort to empirically examine this overlap, investigations have employed exploratory and confirmatory factor analysis to examine the distinctiveness and similarity of the two constructs (Bernstein, Zvolensky, Vujanovic, & Moos, 2009; McHugh et al., 2011). In one such

investigation in smokers, Bernstein and colleagues (2009) found that DI and AS were related--but distinct--lower order factors that were subsumed under a higher order affect sensitivity construct.

Less work has examined the relationship between EA and the other vulnerabilities of interest, although a limited body of literature exists. EA is conceptually similar to DI in that they are both measures of how one responds to distress. Similar to the distinction between AS and DI, the distinguishing factor between the two constructs may be temporal relevance. EA impacts behavior both before *and* after the onset of an aversive stimulus (Hayes et al., 1996), whereas DI is an index of one's willingness to tolerate, withstand, and persist once the experience has begun (Leyro et al., 2010). However, in a sample of individuals diagnosed with borderline personality disorder, indices of self-reported EA did not correlate with behavioral DI measures, exhibiting shared variance between 1-5% (Iverson, Follette, Pistorello, & Fruzzetti, 2012). While this is contrary to what one would expect considering the conceptual overlap between DI and EA, it is unclear whether the aforementioned results are due to the constructs being distinct, or simply differences in the manner in which they were measured (behavioral versus self-report). With regard to the relationship between EA and AS, the two constructs are also conceptually related; EA captures an individual's unwillingness to stay in contact with an unwanted experience, whereas AS is an index of one's beliefs and fears about the consequences of experiencing a specific type of aversive experience, anxiety. Measures of EA and AS exhibit shared variance of approximately 9% - 18% (Bardeen et al. 2013; Forsyth, Parker, & Finlay, 2003), suggesting that these measures may capture distinct aspects of psychological functioning. Importantly, no work to date has examined DI, AS, EA concurrently among daily smokers.

Within smokers, maladaptive levels of each of these transdiagnostic vulnerabilities are individually theorized to influence smoking behavior through the same pathway, by increasing both the frequency and intensity of NA experienced during nicotine withdrawal (Farris, Zvolensky, & Schmidt, 2015; Zvolensky et al., 2004). These subsequent elevations in NA may strengthen specific smoking motives and outcome expectancies aimed at the management and alleviation of negative emotions (Leyro et al., 2008; Brown, Kahler, Zvolensky, Lejuez, & Ramsey, 2001). While each of these reactive vulnerabilities acts within the negative reinforcement framework, it is unclear whether they act on identical

mechanisms, whether these constructs are distinguishable in this population, and if these vulnerabilities interact to impact smoking-relevant outcomes.

Current Study

Considering the substantial conceptual overlap among transdiagnostic vulnerabilities and evidence that they each exert similar influence on smoking behavior, it begs the question as to whether there are latent, unobservable subgroups of daily smokers characterized by common vulnerability presentations. The presence of subgroups characterized by elevations in multiple vulnerabilities would highlight smokers that may be particularly sensitive to the acute, negatively reinforcing aspects of nicotine use, who would likely exhibit greater nicotine dependence and greater difficulty quitting. Identifying subgroups of smokers with multiple elevations can also inform more personalized, targeted interventions; if there are groups characterized by multiple vulnerabilities, it would suggest the necessity for cessation efforts to both identify these subgroups and concurrently target these vulnerabilities in treatment.

Moreover, the presence of latent subgroups of broad emotional vulnerabilities may explain heterogeneity in smoking specific processes. For example, smoking-relevant cognitions, specifically those related to withdrawal and negative smoking relevant consequences, may manifest differently among these latent subgroups, as their broader tolerance of aversive stimuli may impact how a smoker understands their ability to tolerate the absence of nicotine. Indeed, much like broader transdiagnostic vulnerabilities, specific smoking motives (negative affect reduction, addictiveness, habitual use) and expectancies (negative reinforcement, negative consequences) are related to negative smoking-relevant indices, including nicotine dependence and likelihood of cessation failure (Piper et al., 2004; Wetter et al., 1994; Cohen, McCarthy, Brown, & Myers, 2002). These similar relations to smoking-relevant indices suggest that subgroups who exhibit elevations in multiple transdiagnostic emotional vulnerabilities may also report greater motivation to smoke to alleviate withdrawal and avoid negative abstinence-related consequences.

The current study utilized latent profile analysis (LPA) to identify latent profiles of daily smokers based on patterns of DI, EA, and AS, and to determine if specific profiles are associated with elevations in indices of smoking severity (e.g., heaviness of smoking, prior quit attempt success), cognitive-based smoking processes, and demographic differences. We expected to find multiple patterns of responding across these measures, including a profile characterized by elevations in all vulnerabilities, a profile low in

all vulnerabilities, and classes characterized by elevations in one distinct vulnerability. Furthermore, we expected that greater nicotine dependence, less prior cessation success, stronger endorsement of affect-related motives, and greater negative smoking-relevant expectancies would be associated with membership in profiles with elevations in one or more transdiagnostic vulnerabilities.

Method

Participants

Participants in the current study were recruited for a smoking treatment and anxiety management training (clinicaltrials.gov, #NCT01753141) clinical trial. Data for the current investigation were obtained from a sample of 724 individuals who met the following study inclusion criteria: (1) 18-65 years of age, (2) smoking ≥ 5 cigarettes per day for at least the past year, (3) moderately motivated to quit, and (4) were able to provide written informed consent. Of the 724 individuals evaluated for the trial, 574 completed an initial baseline assessment, and of these, 435 provided data on the variables necessary for the current investigation resulting in our final sample (51% male; M_{age} = 36.87, SD = 13.3).

Measures

Indicators of latent profile membership

Anxiety Sensitivity

Anxiety Sensitivity Index – 3 (ASI-3). Anxiety sensitivity was measured using the ASI-3 (Taylor et al., 2007), an 18-item self-report measure that uses a 5-point Likert type scale ranging from 0 (*very little*) to 4 (*very much*). The ASI-3 is a taxonic assessment (Taylor et al., 2007) of fear of anxiety across three domains (physical, cognitive, and social concerns) and yields a total score assessing general fear of anxiety; higher scores reflect greater anxiety sensitivity in the assessed domain. The measure displays improved psychometric properties over the original unidimensional ASI, and has demonstrated good reliability and validity (Taylor et al., 2007). In the current study, the total score was utilized to measure global anxiety sensitivity. Internal consistency of the ASI-3 in this sample was excellent (α = .93).

Distress Intolerance

Discomfort Intolerance Scale (DIS). Perceived intolerance of physical distress and discomfort was measured using the DIS (Schmidt, Richey, & Fitzpatrick, 2006), a 5-item self-report measure that uses a 7-point Likert type scale ranging from 0 (*Not at all like me*) to 6 (*Extremely like me*). Higher scores reflect greater perceived intolerance of physically distressing events. The DIS has demonstrated good test-retest reliability, convergent validity, and high levels of internal consistency (Schmidt et al., 2006). In the current study, the total score was utilized to measure global distress intolerance. Internal consistency of the DIS in this sample was fair (α = .70).

Breath-Holding Task (BH). Behavioral distress tolerance was assessed using BH (Asmundson & Stein, 1994). Participants' breath holding duration was measured over two trials, with the mean latency to termination of the two attempts utilized as an index of behavioral DI (Zvolensky, Feldner, Eifert, & Brown, 2001). The task has frequently been used as an index of physical distress intolerance, with shorter breath-holding durations indicating greater physical distress intolerance, so below average breath holding is a marker of vulnerability (Brown et al., 2009; Hajek, Belcher, & Stapleton, 1987). The BH task has exhibited high test-retest reliability (Sütterlin et al., 2013) and good convergent validity (McHugh & Otto, 2011). Test-retest reliability in the current sample was also high (r = .83).

Experiential Avoidance

Avoidance and Inflexibility Scale (AIS). Smoking-specific experiential avoidance was measured using the AIS (Gifford et al., 2004), a 13-item self-report measure that uses a 5-point Likert type scale ranging from 1 (*Not at all*) to 5 (*Very much*). Higher scores reflect greater inflexibility and avoidance when encountering smoking related feelings, thoughts, and sensations. The AIS has demonstrated high internal consistency, good test-retest reliability, and high convergent, discriminant, and incremental predictive validity (Farris, Zvolensky, DiBello, & Schmidt, 2015). Internal consistency of the AIS in this sample was excellent (α = .93).

Covariates

Demographic Variables. Participant demographic variables were collected via self-report. Participant age was entered as a continuous variable; gender, education level, and race were entered as categorical variables (see Table 1 for variable categories). Demographic variables were chosen as covariates due to their prior association with negative smoking-related outcomes such as nicotine dependence (Breslau, Johnson, Hiripi, & Kessler, 2001) and likelihood of cessation success (Piper et al., 2010; CDC, 2009; Hymowitz et al., 1997).

Heaviness of Smoking Index (HSI). Nicotine dependence was measured using the HSI (Heatherton, Kozlowski, Frecker, Rickert & Robinson, 1989), a self-report measure containing one item each assessing time to first cigarette of the day and average number of cigarettes smoked per day (CPD). Responses are transformed into 4-point Likert-type scales (CPD: 0= 1–10; 1= 11–20; 2= 21–30; and 3= 31+; time to first cigarette: 0 = 61+ min; 1 =31–60 min; 2= 6–30 min; and 3= ≤5 min). The two items are then summed to

yield a final dependence score ranging from 0 – 6. The HSI has displayed both good test-retest reliability (Borland, Yong, O'Connor, Hyland, & Thompson, 2010) and predictive validity (Borland et al., 2010; Chaiton, Cohen, McDonald, & Bondy, 2007). Split-half reliability of the HSI in the current sample was adequate (p' = .62).

Smoking History Questionnaire (SHQ). Self-reported smoking history was assessed using the SHQ (Brown et al., 2002), a 30-item measure that includes items assessing smoking rate, years of consumption, quit attempt history, and family smoking history. In the current analysis, items assessing years as a daily smoker and number of quit attempts lasting longer than 24 hours were utilized as covariates.

Reasons for Smoking Questionnaire (RFS). Self-reported smoking motives were measured using the RFS (Ikard, Green, & Horn, 1969), a 23-item self-report questionnaire that uses a 5-point Likert type scale ranging from 1 (*Never*) to 5 (*Always*). The RFS has displayed high internal consistency and good test-retest reliability (Shiffman, 1993). In the current study, the following RFS subscales were used owing to their theoretical relevance to the indicators of profile membership: Negative Affect Reduction (RFS-NA), Habitual (RFS-HA), and Addictive (RFS-AD). Internal consistency of the subscales used in this study ranged from adequate (RFS-HA α=.71) to good (RFS-NA α = .88).

Smoking Consequences Questionnaire (SCQ). Expectations about cigarette smoking were assessed using the SCQ (Brandon & Baker, 1991), a 50-item self-report questionnaire that uses a 10-point scale ranging from 0 (*Completely Unlikely*) to 9 (*Completely Likely*). The SCQ yields four subscale scores (positive reinforcement, appetite control, negative reinforcement/negative affect reduction, and negative consequences); in the current study, the negative reinforcement/negative affect reduction (SCQ-NR) and negative consequences (SCQ-NC) subscales were used owing to their theoretical relevance to the indicators of profile membership. The SCQ has displayed adequate internal consistency and test-retest reliability (Buckley et al., 2005). Internal consistency for the subscales used in this investigation ranged from good (SCQ-NR α = .83) to excellent (SCQ-NC α = .91).

Data Analysis

Descriptive analyses were conducted using SPSS Version 23 (IBM, 2015). All models were run using MPlus Version 7.4 (Muthén & Muthén, 1998-2015) using maximum likelihood estimation with 1000 random starts. Latent profile analysis (LPA) was used to identify profiles of reactive emotional

vulnerabilities among treatment-seeking daily smokers. LPA considers item endorsement rates among persons to classify them into homogeneous "profiles" based on their self-reported and behaviorally indicated levels of transdiagnostic emotional vulnerabilities (Muthén & Muthén, 2000). LPA does not require a-priori assumptions of profile structure (Beauchaine, 2003). In the current LPA, total scores from the DIS, BH duration, AIS, and ASI were entered as indicators of profile membership; each was treated as a continuous variable. All participants were included in all analyses, as MPlus utilizes Full Information Maximum Likelihood estimation to account for missing data.

First, we examined a one-profile, unconditional model, after which the number of profiles was increased until model fit no longer evidenced substantial improvement (Nylund, Asparouhov, et al., 2007; Nylund, Bellmore, et al., 2007). First, Akaike Information Criteria (AIC; Akaike, 1987), Bayesian Information Criteria (BIC; Schwartz, 1978), and sample-size adjusted BIC (ABIC; Sclove, 1987) were examined, with the model producing the smallest absolute value on these indices considered the best fit. Next, the Bootstrap Likelihood Ratio Test (BLRT) and Vuong-Lo-Mendell-Rubin test (VLMRLRT) were examined to determine if a model with k profiles significantly improved model fit over a model with $k - 1$ profiles (Nylund, Asparouhov, et al., 2007; Nylund, Bellmore, et al., 2007; Henson, Reise, & Kim, 2007). Next, entropy was examined to determine accuracy of individual classification in latent profiles. Lastly, models were examined to determine if they were theoretically and clinically meaningful. Following the identification of the best-fitting latent profile model, demographic variables that are purported to differentially relate to smoking outcomes (age, gender, minority status, and education level), heaviness of use, smoking use characteristics (number of quit attempts lasting longer than 24 hours, years as a smoker), indices of smoking motivation, and outcome expectancies, and, as measured by the HSI, SHQ, RFS, and SCQ, were entered as covariates of latent profile membership in conditional models.

Results

See Table 1 for profile indicator and covariate data in the current sample and Table 2 for zero-order correlations between indicators and covariates. In addition, 41.3% of the sample (N = 175) met criteria for a current DSM-IV TR Axis 1 diagnosis, and 55.2% (N = 234) met criteria for a past diagnosis; 11 participants were missing data on diagnostic status. Incidence of current and lifetime mental illness in the current sample was commensurate with previous estimates of prevalence among daily cigarette smokers (Lasser et al., 2000; McClave et al., 2010). Five latent models were examined, with up to five profiles (see Table 3). Examination of fit indices supported retaining the 3-profile solution. Our ultimate selection of the 3-profile was informed by several observations. First, the AIC, BIC, and adjusted BIC improved from the 2- to 3-profile solution, and exhibited negligible improvement between the 3- and 4-profile, and 4- and 5-profile solutions. Furthermore, VLMRLRT did not reach significance for the 3, 4, and 5-profile solutions, indicating a lack of improvement with k+1 profiles for each solution. Additionally, the 4 and 5-profile solutions included profiles comprised of small *N's* (e.g., *N*=11, 2.5% of the sample). Furthermore, in the 4-profile solution the smallest profile exhibited significant overlap with another, larger profile, exhibiting near identical self-report and behavioral DI levels, and slight elevations in EA and AS. Due to the small size and conceptual overlap of this profile, the 4-profile solution did not add significant information to the model, and the 3-profile solution was retained.

The latent profiles that were retained as part of the 3-profile solution are characterized as follows (see Figure 1). The *Low Vulnerability* profile (68.2% of the sample) is characterized primarily by lower than average anxiety sensitivity, and average experiential avoidance and behavioral and self-reported distress intolerance scores. The *Moderate AS* profile (26.1%) is characterized by moderate levels of anxiety sensitivity scores, and average experiential avoidance and behavioral and self-reported DI scores. The smallest profile, the *High AS/Moderate DI* profile (5.7%) is characterized by an elevation in anxiety sensitivity, moderate elevations in behavioral and self-report distress intolerance, and average experiential avoidance scores.

Covariates were then each tested individually, in univariate models, to screen for association with profile membership, and to determine whether any covariates significantly altered profile structure from the unconditional model. Only covariates that were significantly associated with profile membership were

retained for further analysis, including: age, level of education, HSI, RFS-AD, RFS-NA, SCQ-NC, and SCQ-NR. Examination of these covariates in multivariate conditional models resulted in significantly different profile structure and prevalence. Specifically, the following covariates affected profile membership: RFS-AD, RFS-NA, SCQ-NC, and SCQ-NR. Covariates exerting a direct effect on profile structure suggested misspecification in the original unconditional model (Muthen, 2004). Because of this, the latent profile structure was re-examined starting with one latent class and examining the extent to which model fit changed with each additional class up to five latent classes, while including covariates that demonstrated a significant pairwise association in the previous best-fitting model (age, level of education, HSI, RFS-AD, RFS-NA, SCQ-NC, and SCQ-NR). As before, the 3-profile solution was retained (see Table 4). In comparison to the 2-profile solution, the VLMRLRT for the 3-profile model was a poorer fit. In addition, level of entropy was marginal in the 3-profile solution (0.76). However, the majority of the fit indices (e.g., BIC, AIC, adjusted BIC, and BLRT) suggested that a 3-profile solution was a better fit. Furthermore, the 2-profile solution produced profiles that were similar on all but one transdiagnostic vulnerability (EA), whereas the 3-profile solution included profiles with more theoretically and clinically meaningful variability. Although the sample-size adjusted BIC improved with a fourth class, this additional class was highly similar to another class.

The latent profiles that were retained in the conditional model are characterized as follows (see Figure 2) and were different from those obtained in the unconditional model. The *Low EA* profile (35.7% of the sample) is characterized by average anxiety sensitivity and distress intolerance scores, and below average experiential avoidance. The *Elevated EA* profile (53.3%) is also characterized by average anxiety sensitivity and distress intolerance scores, and above average experiential avoidance. The *Elevated AS* profile (11%) is characterized by an extreme elevation in anxiety sensitivity, moderate elevations behavioral and self-report distress intolerance, and average experiential avoidance scores.

Covariates were significantly related to profiles in the revised model (see Table 5). Specifically, greater educational achievement significantly increased the likelihood of membership in the *Low EA* and *Elevated EA* profiles, relative to the *Elevated AS* profile. Furthermore, a higher RFS-AD scale score was associated with a significantly increased likelihood of membership in the *Elevated EA* and *Elevated AS* profiles, relative to the *Low EA* profile. That is, individuals who reported greater motivation to smoke

because of cigarettes' addictive qualities were more likely to exhibit affective profiles characterized by elevated AS and DI, or elevated smoking specific EA, than low smoking specific EA. Lastly, a higher score on the SCQ-NC significantly increased the likelihood of membership in the *Elevated EA* profile, relative to the *Low EA* profile. That is, individuals who expected to experience negative consequences due to smoking (e.g., increased health risks, seeming less attractive) were more likely to exhibit an affective profile characterized by elevated smoking specific EA than low smoking specific EA. Importantly, differences in expectations related to negative affect reductions (SCQ-NA) or nicotine dependence were not associated with differential membership in latent profiles.

Discussion

The current study examined whether daily smokers are characterized by latent underlying profiles of transdiagnostic emotional vulnerabilities, and whether profiles characterized by elevations in one or more vulnerabilities are related to greater nicotine use and dependence, as well as endorsement of maladaptive smoking-related motives and outcome expectancies. Initial examination of profile membership found that daily treatment-seeking smokers fell into one of three profiles characterized primarily by differences in self-reported AS and DI. Upon adding specific smoking motives (addiction, negative affect reduction), use expectancies (negative reinforcement/negative affect reduction, negative personal consequences) into the model, profile membership was altered, suggesting they may play an important role in model specification. After re-examining the optimal model solution with covariates concurrently examined, the final model revealed three distinct profiles of daily smokers, primarily differentiated by variable levels in AS and EA, with similar class differences in DI as in the unconditional model. That is, EA only differentiated latent classes when covariates were considered; in their absence, latent classes did not differ in EA, but did differ markedly in AS, and to a lesser extent, DI.

The differences in class structure and prevalence in the conditional and unconditional models suggest that the covariates are related to profile indicators in important ways, even if they are not significantly related to odds of membership in particular latent profile comparisons (see Table 5). Specifically, the changes in EA differentiation among latent profiles in the conditional versus unconditional model suggest that this particular vulnerability may be especially related to motive and expectancy covariates, which is supported by the AIS exhibiting significant correlations with each of the motives and expectancies subscales utilized in the current sample (see Table 2). This is also conceptually consistent, as the measure of EA used was specific to smoking, unlike the measures of AS and DI. Considering that profiles characterized by variability in smoking-specific EA only emerged in the conditional models, it is possible that the emergence of profiles primarily discriminated by EA is an artifact of the specific measures utilized. Because of this, interpretation of these profiles as broadly characteristic of daily smokers should be tempered, and future studies should attempt to replicate the current class structure with a global EA measure (i.e., the Multidimensional Experiential Avoidance Questionnaire; Gamez, Chmielewski, Kotov,

Ruggero, & Watson, 2011) while including a broader set of covariates (e.g., treatment response, behavioral approach and avoidance).

This final solution suggests that, when accounting for smoking-related cognitions, smoking-specific and global affective tolerance may be differentially predictive of smoking-related motives, expectancies, and use/dependence characteristics. Alternatively, differences in profile composition may be due to the constructs capturing related but distinct processes associated with broader approach/avoidance tendencies. Specifically, whereas EA captures the degree to which one is willing to engage with an aversive stimulus, DI and AS measure how much one is emotionally affected by aversive somatic and affective experiences. To better examine this, direct measures of behavioral approach and avoidance (e.g., the BIS/BAS scales, Carver & White, 1994) and covariates that have exhibited a relation to approach and avoidance, such as personality and psychopathology indices, (Elliot & Thrash, 2002; Johnson, Turner, & Iwata, 2003) should be included in future analyses.

In the final model, the first two profiles identified, the *Low EA* and *Elevated EA* profiles, diverged on EA scores but exhibited average AS and self-report and behavioral DI scores. This suggests two profiles of individuals that are similar in their general ability to tolerate physiological distress, as well as their sensitivity to anxiety and worry about potential negative consequences of anxiety. However, the profiles differ in their response to smoking-specific aversive experiences; whereas members of the *Low EA* profile may be better able to tolerate aversive thoughts and physiological sensations encountered during nicotine withdrawal, individuals in the *Elevated EA* profile may be more apt to avoid or escape aversive experiences that occur during smoking abstinence (Hayes et al., 1996; Farris et al., 2015). Importantly, individuals with greater addictiveness motives and expectancies of negative consequences were more likely to be members of the *Elevated EA* versus the *Low EA* profile, suggesting that individuals with negative beliefs regarding the short and long term consequences of smoking are less willing to engage with and tolerate more proximal nicotine-elicited discomfort.

The third and smallest profile, *Elevated AS* displayed relative elevations in AS, as well as behavioral and self-reported DI scores, with average EA. Indeed, across both conditional and unconditional models, AS discriminated latent profiles strongly, and in conjunction with smaller deviations in DI. High levels of AS accompanied by modest elevations in DI appear to distinguish a small, latent group of smokers

who are characterized by general elevations in affective distress, but who do not exhibit marked intolerance and avoidance of aversive thoughts, feelings, or sensations that encourage smoking (e.g., withdrawal symptoms). In the final model, the latent profile characterized by high levels of AS and moderate DI was associated with maladaptive levels in a number of covariates, including lower educational achievement than both the *High EA* and *Low EA* profiles, and greater addiction motives than the low vulnerability (*Low EA*) profile. In past studies, AS, DI, (Brown et al., 2001; Abrantes et al., 2008), and addictiveness-related motives (Piper et al., 2004) have been associated with poorer cessation-related outcomes. Furthermore, in the current sample lower educational achievement was significantly related to more cigarettes smoked per day in the past week and an earlier age of smoking initiation ($p < .05$), each of which are also independently associated with poorer cessation outcomes (Breslau & Johnson, 2000; Khuder, Dayal, & Mutgi, 1999; Chen, Stanton, Shankaran, & Li, 2006; Piper et al., 2010). This demonstrates a profile of individuals who are likely experiencing multiple dispositional barriers to successful abstinence. This suggests that individuals presenting with these vulnerabilities may be resistant to current evidence-based interventions, and that future work should attempt to identify and prospectively examine whether individuals who present with elevations in AS and DI are indeed particularly resistant to existing interventions. If so, it would suggest the need to develop targeted interventions aimed at concurrently addressing these treatment barriers.

Notably, a number of covariates were not associated with differential class membership, despite being retained from univariate models. Nicotine dependence was not associated with differential likelihood of class membership, despite evidence that suggests that elevations in individual vulnerabilities are associated with greater dependence (DI - Leyro et al., 2011), elevated withdrawal intensity (EA - Farris et al., 2015), and heavier use (AS - Brown et al., 2001). These findings suggest that elevated dependence among high-vulnerability smokers may be driven by a co-occurring third variable (i.e., psychiatric diagnosis), and not primarily by maladaptive levels of vulnerabilities. However, the current sample is composed of longer-duration smokers (years as a smoker = 18.47), a population that typically reports greater nicotine dependence (Pomerlau, Carton, Lutzke, Flessland, & Pomerlau, 1994). This suggests that these findings may be due to sample characteristics, and suggests examining these relationships in shorter duration smokers before concluding that dependence is not related to varied vulnerability profiles across

smokers. In addition, the degree of motivation to smoke in order to reduce NA was not associated with likelihood of class membership. This is surprising, as maladaptive levels of each of these vulnerabilities are theorized to primarily impact smoking behavior by increasing NA during withdrawal (Farris et al., 2015; Zvolensky et al., 2004). While similar nicotine dependence may account for some of this lack of heterogeneity, this finding also suggests that individuals with elevations in trasdiagnostic vulnerabilities are primarily motivated to smoke to reduce smoking-specific discomfort (greater addictiveness motives), and not to alleviate the experience of broader negative emotional experiences.

Limitations

The current study included a relatively small sample size for the analyses in question. This lack of power may have obscured relations between covariates and profile membership. The current sample may also not be representative of the broader smoking population. Participants were largely white and relatively well educated, while current estimates suggest that a substantial portion of current smokers are of lower socioeconomic status and identify as racial minorities (Garrett, Dube, Winder, & Caraballo, 2013). Understanding potential affective vulnerabilities in these individuals is particularly important, as minority and low SES smokers are among the least successful in making a cessation attempt (Barbeau, Krieger, & Soobader, 2004). Recruitment of a larger, more economically and racially diverse sample is necessary to determine whether the current profiles generalize to the broader smoking population. Furthermore, the current investigation did not comprehensively assess potential transdiagnostic vulnerabilities that may be important in understanding profile differences among smokers. This includes the domain-limited assessment of DI and EA in the current study, as well as the lack of inclusion of other important vulnerabilities as model indicators (e.g., anhedonia, Leventhal & Zvolensky, 2015), and indices of internalizing or externalizing symptomology as covariates (e.g., impulsivity, disinhibition). Future studies should more comprehensively assess these constructs to gain a broader and more complete understanding of emotional reactivity and pathology among smokers.

Conclusions

To our knowledge this is the first investigation that examines the presence of latent structural profiles of transdiagnostic emotional vulnerabilities among daily smokers. The current results suggest that within daily smokers there are discriminable latent profiles, characterized by variability primarily in their

sensitivity to anxiety and avoidance of aversive smoking-specific experiences. Importantly, model specification was dependent on allowing motives and expectancies related to the onset or removal of aversive experiences to directly influence profile membership, suggesting that global vulnerabilities may not sufficiently account for variability in this population. Both smoking motives (addictiveness) and expectancies (negative consequences), as well as demographic variables (education level) were significantly related to likelihood of profile membership.

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Table 1. Summary of indicators and covariates for current sample

Indicator/Covariate	*Mean*	*SD*
Breath Holding Duration	49.65	20.89
Anxiety Sensitivity: ASI	15.35	12.36
Distress Intolerance: DIS	11.85	5.4
Experiential Avoidance: AIS	44.4	10.81
Age (years)	36.87	13.31
Years as a Smoker	18.47	13.05
Number of Quit Attempts	3.45	2.53
Heaviness of Smoking Index	2.77	1.49
RFS – Habitual	2.32	0.71
RFS – Addictive	3.30	0.77
RFS – Negative Affect Reduction	3.45	0.79
SCQ – Negative Consequences	6.55	1.27
SCQ – Negative Reinforcement/Negative Affect Reduction	5.66	1.67

ASI = Anxiety Sensitivity Index; DIS = Discomfort Intolerance Scale; AIS = Avoidance and Inflexibility Scale; RFS = Reasons for Smoking Scale; SCQ = Smoking Consequences Questionnaire

Table 1, continued

Covariate	*N*	*%*
Race		
Caucasian	375	85.8
African-American	36	8.2
Hispanic	10	2.3
Asian	5	1.1
Other	11	2.5
Gender (female)	210	48.1
Highest Education Attained		
Part High School	26	5.9
High School Graduate or Equivalent	94	21.5
Part College	148	33.9
2-year College	43	9.8
4-year College	64	14.6
Part graduate/professional school	26	5.9
Completed graduate/professional degree	36	8.2

Table 2

Zero-Order Correlations between Class Indicators and Covariates

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. DIS	-													
2. Breath Holding Duration	-.17**	-												
3. AIS	.00	.04	-											
4. ASI	.23**	-.07	.05	-										
5. Age	.10*	-.21**	-.04	-.11*	-									
6. Gender (0 = male)	.04	-.33**	.03	.04	.06	-								
7. HSI	.10*	-.04	.17**	.06	.08	-.04	-							
8. Years as a daily smoker	.07	-.16**	.00	-.09	.92**	.09	.06	-						
9. Number of prior quit attempts	.00	.02	-.05	.01	.24**	.00	-.05	.21**	-					
10. RFS - Habitual	.00	.02	.22**	.02	.00	.01	.38**	.00	.01	-				
11. RFS - Addictive	.00	.08	.51**	.07	-.05	-.05	.36**	-.03	-.03	.50**	-			
12. RFS – Negative Affect Reduction	.00	.11*	.47**	.02	-.06	-.06	.25**	-.04	-.03	.42**	.67**	-		
13. SCQ – Negative Consequences	.00	-.04	.45**	.05	.01	.06	.07	.03	.01	.19**	.26**	.26**	-	
14. SCQ – Negative Reinforcement	.04	-.01	.46**	.02	-.05	-.04	.10*	.04	.00	.17**	.46**	.68**	.38**	-

ASI = Anxiety Sensitivity Index; DIS = Discomfort Intolerance Scale; AIS = Avoidance and Inflexibility Scale; HSI = Heaviness of Smoking Index; RFS = Reasons for Smoking Scale; SCQ = Smoking Consequences Questionnaire

$^{*}p < .05$, $^{**}p < .01$.

Table 3. Model fit indices for unconditional models.

Profiles	Parameters	Log Likelihood	AIC	ΔAIC	BIC	ΔBIC	SS adj BIC	ΔSS adj BIC	BLRT	VLMRLRT	Entropy
1	8	-6217.46	12450.91	-	12483.55	-	12458.17	-	-	-	-
2	13	-6162.31	12350.62	100.296	12403.66	79.896	12362.4	95.764	p<.001	0.003	0.857
3	18	-6136.91	12309.82	40.794	12383.26	20.395	12326.14	36.262	p<.001	0.1155	0.852
4	23	-6120.65	12287.3	22.526	12381.14	2.126	12308.15	17.994	p<.001	0.27	0.864
5	28	-6111.54	12279.09	8.211	12393.32	-12.188	12304.47	3.679	0.0128	0.5054	0.813

Note: BIC = Bayesian information criteria, with smaller values indicating better model fit. AIC = Akaike Information Criteria, with smaller values indicating better model fil. SS adj BIC = BIC adjusted for sample size, with smaller values indicating better model fit. BLRT = Bootstrap Likelihood Ratio Test, with significant *p* values indicating the current model is a better fit than a model with $k - 1$ profiles. VLMRLRT = Vuong-Lo-Mendell-Rubin test, with significant *p* values indicating the current model is a better fit than a model with $k - 1$ profiles. Entropy measures accuracy of participant classification, with greater values indicating better classified models.

Table 4. Model fit indices for conditional models.

Profiles	Parameters	Log Likelihood	AIC	ΔABIC	BIC	ΔBIC	SS adj BIC	ΔSS adj BIC	BLRT	VLMRLRT	Entropy
1	22	-13691.9	27427.82	-	27517.58	-	27447.76	-	-	-	-
2	20	-6098.83	12237.66	15190.16	12319.16	15198.41	12255.69	15192.07	<.0001	<.0001	1
3	32	-6058.01	12180.02	57.641	12310.43	8.737	12208.88	46.819	0.1488	<.0001	0.758
4	44	-6027.69	12143.39	36.628	12322.7	-12.276	12183.07	25.806	0.3576	<.0001	0.759
5	56	-6002.6	12117.21	26.18	12345.43	-22.725	12167.71	15.356	0.2758	<.0001	0.822

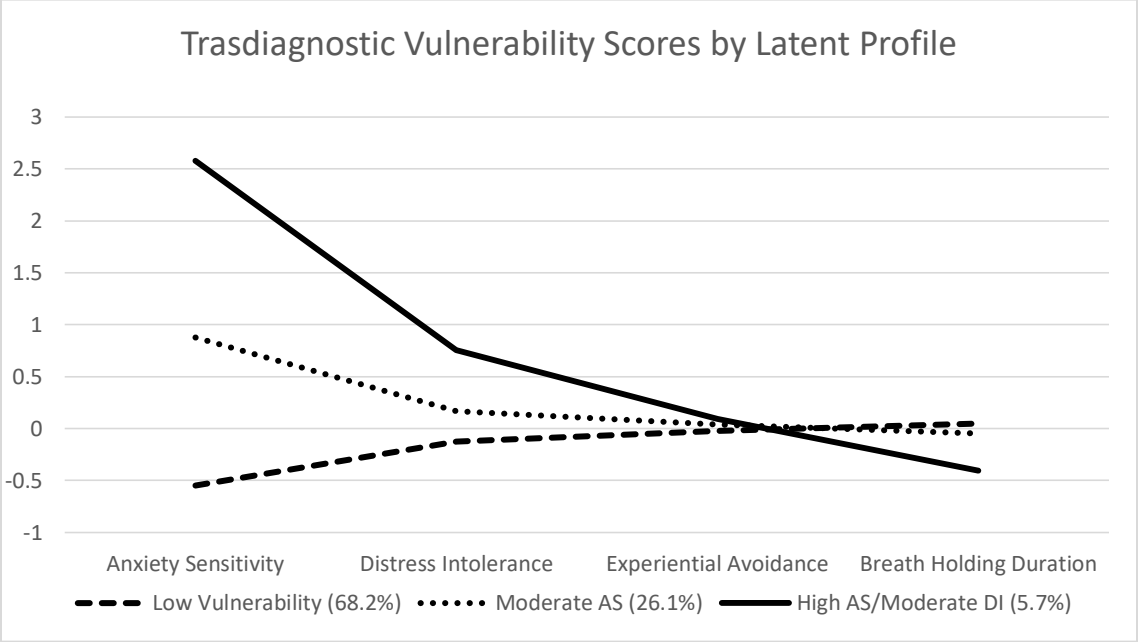
Note: BIC = Bayesian information criteria, with smaller values indicating better model fit. AIC = Akaike Information Criteria, with smaller values indicating better model fil. SS adj BIC = BIC adjusted for sample size, with smaller values indicating better model fit. BLRT = Bootstrap Likelihood Ratio Test, with significant *p* values indicating the current model is a better fit than a model with $k - 1$ profiles. VLMRLRT = Vuong-Lo-Mendell-Rubin test, with significant *p* values indicating the current model is a better fit than a model with $k - 1$ profiles. Entropy measures accuracy of participant classification, with greater values indicating better classified models.

Table 5. Covariate contrast odds ratios and 95% confidence intervals for conditional model

	Low EA (35.7%)	*Elevated EA (53.3%)*
Panel A: Reference Group: Elevated AS (11%)		
Age	1.00 (0.95 – 1.05)	1.00 (0.97 – 1.03)
Education Level	1.67* (1.06 – 2.65)	1.67* (1.10 – 2.52)
HSI	0.91 (0.61 – 1.35)	1.01 (0.83 – 1.23)
RFS-AD	0.18* (0.04 – 0.67)	1.57 (0.60 – 4.11)
RFS-NA	0.76 (0.26 – 2.23)	1.50 (0.57 – 3.97)
SCQ-NC	0.68 (0.42 – 1.10)	1.56 (0.91 – 2.67)
SCQ-NR	0.68 (0.37 – 1.29)	1.04 (0.76 – 1.44)
Panel B: Reference Group: Elevated EA (53.3%)		
Age	1.00 (0.94 – 1.06)	
Education Level	1.00 (0.65 – 1.55)	
HSI	0.90 (0.61 – 1.34)	
RFS-AD	0.12* (0.03 – 0.39)	
RFS-NA	0.51 (0.13 – 2.01)	
SCQ-NC	0.43* (0.23 – 0.84)	
SCQ-NR	0.65 (0.30 – 1.40)	

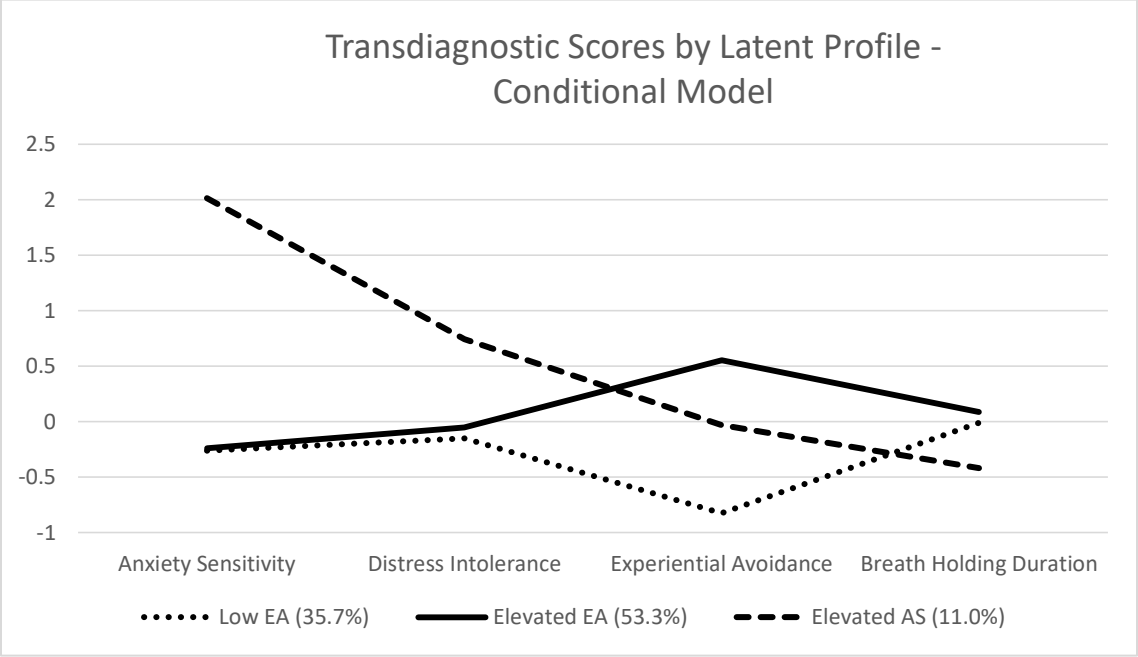
* $p < .05$

Figure 1



Note: Scale scores are presented as standardized for ease of interpretation. Y-axis represents standard deviations from the sample mean of the given variable.

Figure 2



Note: Scale scores are presented as standardized for ease of interpretation. Y-axis represents standard deviations from the sample mean of the given variable.