Published in final edited form as:

J Anxiety Disord. 2014 October ; 28(7): 696–703. doi:10.1016/j.janxdis.2014.07.006.

Identification of Anxiety Sensitivity Classes and Clinical Cut-Scores in a Sample of Adult Smokers: Results from a Factor Mixture Model

Nicholas P. Allan^a, Amanda M. Raines^a, Daniel W. Capron^a, Aaron M. Norr^a, Michael J. Zvolensky^b, and Norman B. Schmidt^a

^aDepartment of Psychology, Florida State University, Tallahassee, FL 32306-4301, USA

^bDepartment of Psychology, University of Houston, Houston, TX 77004, USA

Abstract

Anxiety sensitivity (AS), a multidimensional construct, has been implicated in the development and maintenance of anxiety and related disorders. Recent evidence suggests that AS is a dimensional-categorical construct within individuals. Factor mixture modeling was conducted in a sample of 579 adult smokers (M age = 36.87 years, SD = 13.47) to examine the underlying structure. Participants completed the Anxiety Sensitivity Index-3 and were also given a Structured Clinical Interview for DSM-IV-TR. Three classes of individuals emerged, a high AS (5.2% of the sample), a moderate AS (19.0%), and a normative AS class (75.8%). A cut-score of 23 to identify high AS individuals, and a cut-score of 17 to identify moderate-to-high AS individuals were supported in this study. In addition, the odds of having a concurrent anxiety disorder (controlling for other Axis I disorders) were the highest in the high AS class and the lowest in the normative AS class.

Keywords

anxiety sensitivity; factor mixture modeling; anxiety disorders; clinical cut-score

1. Introduction

Anxiety sensitivity (AS) refers to an individual's fear of anxiety and anxiety-related sensations, arising from the belief that these sensations will have adverse cognitive, physical, and/or social consequences (Reiss & McNally, 1985). Research examining the latent structure of AS has converged on a higher-order solution with AS at the apex and three lower-order dimensions, cognitive concerns, physical concerns, and social concerns

© 2014 Elsevier Ltd. All rights reserved.

*Address correspondence to Nicholas P. Allan, allan@psy.fsu.edu or Norman B. Schmidt, schmidt@psy.fsu.edu, Department of Psychology, Florida State University, Tallahassee, FL 32306-4301.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

subsumed under AS (e.g., Taylor et al., 2007; Zinbarg et al., 1997). The Anxiety Sensitivity Index-3 (ASI-3; Taylor et al., 2007) appears to be the best measure of AS in adults for capturing this underlying multidimensionality across clinical and community samples (e.g., Allan, Capron, Raines, & Schmidt, 2014; Olthuis, Watt, & Stewart, 2014; Taylor et al., 2007; Wheaton, Deacon, McGrath, Berman, & Abramowitz, 2012). Therefore, a consensus has emerged that AS is a higher-order construct, comprising three lower-order dimensions, and this structure is best-captured by the ASI-3.

A second approach to exploring the relation between the measured structure of AS and the underlying construct involves between-individual variability. Specifically, research is needed to investigate whether AS is best-represented as continuously or categorically distributed within individuals. Taxometric methods (e.g., Meehl, 1999) were some of the first methods to examine the presence or absence of classes of individuals based on their AS levels (e.g., Asmundson, Weeks, Carelton, Thibodeau, & Fetzner, 2011; Bernstein, Zvolensky, Stewart, Comeau, & Leen-Feldner, 2006; Schmidt, Kotov, Lerew, Joiner, & Ialongo, 2005). Several of these studies found support for the presence of a small high-AS class comprising approximately 10–20% of individuals and a larger normative-AS class comprising 80–90% of individuals (Bernstein, Zvolensky, Kotov et al., 2006; Bernstein et al., 2007; Bernstein, Zvolensky, Weems, Stickle, & Leen-Feldner, 2005; Schmidt et al., 2005). However, other studies have not found support for the presence of multiple classes of individuals based on their AS levels (Asmundson et al., 2011; Broman-Fulks et al., 2010). This might reflect an issue with taxometric methods rather than with AS, as the lack of a consensus regarding dimensionality of psychopathology constructs is “the rule rather than the exception in CCK taxometric literature” (Bernstein, Stickle, & Schmidt, 2013, p. 2).

Factor mixture modeling (FMM; Bauer & Curran, 2004; Muthén, 2008) is well-suited to address the dimensional/categorical debate regarding AS. FMM can be used to categorize individuals into classes based on their AS levels across lower-order AS dimensions. In addition, unlike other methods, such as taxometrics (see Lubke & Tueller, 2010 for a comparison), FMM can model between-individual variability on lower-order AS dimensions within class as well as factor covariance differences between classes, across models with two or more classes allowed (Bauer & Curran, 2004; Lubke & Muthén, 2005; Ruscio, Haslam, & Ruscio, 2006).

There are relatively few studies that have examined the structure of AS using FMM (e.g., Allan, Korte, Capron, Raines, & Schmidt, 2013; Allan, MacPherson, Young, Lejuez, & Schmidt, in press; Bernstein et al., 2010; Bernstein et al., 2013). Studies by Allan et al. (2013) and Bernstein et al. (2010) were both conducted using the ASI-3 in adult samples. Bernstein et al. (2010) examined the structure of AS in a sample of 634 undergraduate students. They reported that a two-class three-factor model in which factor loadings, intercepts, and factor covariances were allowed to vary across classes was the best-fitting model. Classes consisted of a small class of individuals with elevated AS scores (high AS class) comprising 12% of the sample and a large class of individuals with normative levels of AS (normative AS class) comprising 88% of the sample. They further reported that the AS cognitive concerns and physical concerns dimensions, but not the AS social concerns dimension discriminated between the classes. Allan et al. (2013) examined the structure of

AS in a sample of 1157 undergraduate students. In contrast to Bernstein et al. (2010), they argued that a three-class three-factor model in which intercepts and factor covariances were allowed to vary was the best-fitting model. In addition to a high AS class, comprising 6% of the sample, and a normative AS class, comprising 83% of the sample, they also reported a moderate AS class, comprising 11% of the sample. Allan et al. (2013) further reported that AS social concerns was important for class enumeration as there were significant differences in mean levels of this dimension across classes. Other FMM studies, conducted in an adolescent sample using the Childhood Anxiety Sensitivity Index (CASI; Silverman, Fleisig, Rabian, & Peterson, 1991) and in adult treatment-seeking individuals using the Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky, & McNally, 1986) report the presence of at least two classes of individuals, high AS and normative AS classes (e.g., Allan et al., in press; Bernstein et al., 2013). Whereas there is now ample support that AS is categorical between individuals, it is less clear whether there are two or three classes of individuals.

1.2 Factor Mixture Model Classes as a Basis for Deriving Clinical Cut-Scores

An important applied use for understanding latent classes is determining clinical cut-scores. Given the statistical rationale for selecting classes, and the opportunity for replication, FMM may be a good approach for deriving clinical cut-scores (Lubke & Spies, 2008). In this method, cut-scores can be computed by examining the sensitivity (i.e., categorizing individuals to a group who truly are part of that group) and specificity (i.e., not categorizing individuals in a group who are not part of that group) of FMM-derived latent class membership. Bernstein et al. (2010) developed the first such clinical cut-scores for the ASI-3, based on the two-class model of AS. They found that a score of 13 or higher on the combined score of the AS physical concerns and AS cognitive concerns subscales had the greatest balance of sensitivity and specificity for classifying individuals into the high-AS class. Allan et al. (2013) developed clinical cut-scores based on the total of all three lower-order ASI-3 dimensions (Allan et al., 2013). Their score was based on the presence of three AS classes (i.e., high AS, moderate AS, and normative AS). For classifying individuals into the high AS class, a cut-score of 23 was selected. For classifying individuals into the moderate-to-high AS classes, a cut-score of 17 was selected. Replication of one of these cut-scores depends on whether a two- or three-class model were to be found, and whether, in this model, the AS social concerns factor is an important predictor of class status.

1.3 Relations between Factor Mixture Model Anxiety Sensitivity Classes and Psychopathology

Identifying AS classes, and replicable cut-scores associated with these classes has important implications for anxiety disorders. Results of a recent meta-analysis indicated that AS was significantly elevated in individuals diagnosed with an anxiety disorder, including panic disorder (PD), social anxiety disorder (SAD), post-traumatic stress disorder (PTSD), and generalized anxiety disorder (GAD) as compared to AS rates in nonclinical control groups (Olatunji & Wolitzky-Taylor, 2009). AS was also elevated in individuals with major depressive disorder (MDD) as compared to AS rates in nonclinical control groups; however, this effect was smaller than the effects for anxiety disorder groups. Further, AS was significantly more elevated in individuals with PD and any anxiety disorder as compared to AS rates in individuals with MDD (Olatunji & Wolitzky-Taylor, 2009). Prior FMM studies

have uncovered these important relations between AS and anxiety disorders. For example, Bernstein et al. (2012) found that individuals in the high AS class were more likely to meet criteria for PD, SAD, GAD, obsessive-compulsive disorder (OCD), PTSD, and specific phobia diagnoses than were individuals in the normative AS class. They also found evidence of specificity, as there were no differences for mood or substance disorders diagnoses in individuals without a comorbid anxiety disorder diagnosis. Zvielli, Bernstein, and Berenz (2012), using cut-scores derived from Bernstein et al. (2010), also found more anxiety disorder diagnoses in individuals classified in the high AS class than in individuals classified in the normative AS class. They found more MDD diagnoses in the high AS class than in the normative AS class, but only when comorbid panic attacks were not controlled for. In the only study to date examining differences in psychopathology using the three-class solution, Allan et al. (2013) reported significant differences in continuous levels of anxiety and depression symptoms across all classes. Specifically, individuals in the high AS class had the highest symptom levels and individuals in the normative AS class had the lowest symptom levels.

1.4 The Current Study

The purpose of the current study was to provide clarity regarding the underlying class structure of AS (as measured by the ASI-3) in an at-risk sample. Two- and three-class models have been reported in past studies using the ASI-3 (e.g., Allan et al., 2013; Bernstein et al., 2010). We tentatively hypothesized that a three-class three-factor partially invariant (i.e., intercepts and factor covariances free to vary) would provide the best fit to the data as Allan et al. (2013) found a three-class solution when comparing similar two- and three-class solutions. An additional aim of this study was to verify clinical cut-scores for the ASI-3. Given our hypothesis in favor of the three-class model, we hypothesized a cut-score of 17 to classify individuals in the moderate-to-high AS class and a cut-score of 23 to classify individuals in the high AS class (e.g., Allan et al., 2013). Finally, only one study has directly evaluated the clinical relevance of FMM-derived classes, derived from the ASI (e.g., Bernstein et al., 2013). Therefore, we aimed to examine group differences in identifying individuals with an anxiety disorder, with MDD, and with any other Axis I disorder (each controlling for the other Axis I disorders). Based on past studies (e.g., Allan et al., 2013; Bernstein et al., 2013; Bernstein et al., 2011; Zvielli et al., 2012), we hypothesized that the high AS class would have the most anxiety disorders, followed by the moderate AS class. We hypothesized no differences in diagnostic rates for MDD or other Axis I disorders.

2. Methods

2.1 Participants

The current sample consisted of 579 adult smokers recruited from the community through various media outlets (i.e., newspaper ads, billboards) to participate in a study evaluating the effects of an anxiety-based smoking cessation treatment program. Participants who expressed severe current suicidal ideation, plans, or preparations were excluded. Additionally, psychotic individuals, those using another smoking cessation program or tobacco product, and those with a significant medical condition were excluded. Participants were divided evenly on gender (51.6% male) with ages ranging from 18 to 68 ($M = 36.87$,

SD = 13.47). The racial/ethnic composition of the sample was distributed as such: 82.9% were Caucasian, 9.8% Black/Non-Hispanic, .9% Black/Hispanic, 2.6% Hispanic, 1% Asian, and 2.8% other (e.g., bi-racial).

2.2 Procedure

Individuals who met initial requirements during a telephone screen and structured clinical interview were scheduled to come in for a baseline appointment to complete various demographic, anxiety, substance use, and smoking assessments. The current study utilizes data collected from the baseline appointment which took place prior to randomization and smoking cessation treatment. The study was approved by the university's IRB, and informed consent was obtained from all participants.

2.3 Measures

2.3.1 Clinician administered

2.3.1.1 Structured Clinical Interview for DSM-IV-TR (SCID): The SCID is a widely administered and well validated semi-structured interview designed to assess the presence of lifetime and current Axis I conditions (First, Spitzer, Gibbon, & Williams, 1996). All SCID's were administered by highly trained doctoral students in clinical psychology. Training included reviewing SCID training tapes, observing live SCID administrations, and conducting SCID interviews with other trained individuals. All trainees received feedback throughout the process until they demonstrated a high level of reliability. Additionally, all SCID's were reviewed by a licensed clinical psychologist at a weekly supervision meeting to ensure accurate diagnoses. Rates of agreement between clinical interviewers examined for a subset of individuals (12.5% of the sample) were 98%.

2.3.2 Self-report

2.3.2.1 Anxiety Sensitivity Index-3 (ASI-3): The ASI-3 is an 18-item self-report questionnaire containing items designed to measure the lower-order cognitive concerns, physical concerns, and social concerns AS dimensions. The physical concerns subscale contains six items relating to fear of arousal (e.g., "It scares me when my heart beats rapidly"). The cognitive concerns subscale contains six items relating to fear of the cognitive component of anxiety (e.g., "When my thoughts seem to speed up, I worry that I might be going crazy"). Finally, the social concerns subscale contains six items relating to the potential social consequences associated with anxiety (e.g., "I worry that other people will notice my anxiety"). Respondents were asked to indicate the degree to which they agree with each item on a 5-point Likert-type scale ranging from 0 (very little) to 4 (very much). The ASI-3 has been found to be a psychometrically sound and valid measure of anxiety sensitivity (Taylor et al., 2007). Within the current investigation the cognitive, physical, and social concerns subscales demonstrated good internal consistency (α 's = .91, .88 and .83, respectively).

3. Results

3.1 Factor Mixture Modeling

A three-factor (i.e., Cognitive Concerns, Physical Concerns, Social Concerns) model of the ASI-3 was examined using FMM in Mplus version 7 (Muthén & Muthén, 1998–2012). Full information maximum likelihood (FIML) with the Yuan-Bentler scaled chi-square (Y-B χ^2) to adjust for nonnormality was used to examine item-level ASI-3 data, treated as continuous. It was hypothesized that a three-factor model allowing for free covariances and intercepts across groups would be the best-fitting model of the ASI-3. Determination of the number of classes was guided by past findings as well as comparison of fit indices across models. Prior research suggests that between two and three classes of individuals should emerge (e.g., Allan et al., 2013; Bernstein et al., 2010; 2012). To be thorough, the upper limit of classes explored was four. Models were compared across classes using the Bayesian Information Criterion (BIC; Schwartz, 1978), the sample-size adjusted BIC (aBIC; Sclove, 1987), the Lo-Mendell-Rubin likelihood ratio test (LMR-LRT; Lo, Mendell, & Rubin, 2001), and the bootstrap likelihood ratio test (BLRT). Comparing across models, lower BIC and aBIC values indicate better model fit, and significant LMR-LRT and BLRT values indicate that the model currently assessed provides significantly better fit than a model with one less class. Of note, LMR-LRT and BLRT values are should only be compared across class classes with similar invariance structures (Clark et al., 2013). The BIC and BLRT have demonstrated the greatest accuracy in simulation studies (e.g., Nylund, Asparouhov, & Muthén, 2007; Yang, 2006), and therefore, were given the most weight in model selection. Entropy is also provided. Although it is not an index of model fit, it provides a useful assessment of the utility of the extracted classes (Ramaswamy, Desarbo, Reibstein, & Robinson, 1993). Entropy values range from 0 to 1, with higher values indicating greater class separation (Lubke & Muthén, 2007; Petras & Masyn, 2010).

FMM results can vary as a function of restrictions imposed across classes (Bauer & Curran, 2004; Lubke & Neale, 2008). Selecting which parameters to free requires a balance between finding models that converge adequately, theoretical arguments, and prior modeling attempts (Lubke, 2010). Because variance has primarily been detected in the covariances and intercepts across classes in prior FMMs of the ASI-3 (e.g., Allan et al., 2013; Bernstein et al., 2013), models were fit to test whether those parameters should be freed or restricted. Prior studies have also included tests of factor loading invariance, but these models tend not to converge on improper solutions (e.g., Allan et al., 2013; Bernstein et al., 2013), suggesting that freeing factor loadings across classes does not aid in selecting the best-fitting model. Therefore, factor loadings were held to equality across all models.

Fit indices for one-through four-class models with varying levels of model invariance (i.e., fully invariant, covariances free, covariances and intercepts free) are provided in Table 1. None of the four-class models provided interpretable solutions, either because the $-2\log$ likelihood did not replicate, or the model produced classes with factor correlations well above 1.0. Therefore, only the two- and three-class models were compared. The best fitting two- and three-class models allowed for free factor covariances and intercepts. Comparing these models, the three-class model had lower BIC and aBIC values than did the

two-class model. Whereas the LMR-LRT was not significant in the three-class model, it was approaching significance ($p = .06$), and the BLRT was significant, indicating that the three-class model was preferred to the two-class model. Finally, the entropy value of 1.00 suggested that this model correctly classified individuals. Given that the preponderance of evidence supported the three-class three-factor model allowing for free factor covariances and intercepts, this model was selected as the best-fitting model of the ASI-3 subscales.

The three classes that emerged were labeled High AS, Moderate AS, and Normative AS. There were 30 individuals (5.2 %; 40.0% male) in the High AS class with a posterior probability of 1.00. There were 110 individuals (19.0%; 46.4% male) in the Moderate AS class with a posterior probability of 1.00. There were 439 individuals (75.8%; 53.8% male) in the Normative AS class with a posterior probability of 1.00. There were no gender differences as a function of class status ($\chi^2 = 3.65$, $df = 2$, $p > .05$). Table 2 contains factor loadings, intercorrelations, and intercept values for the three-class three-factor solution with free factor covariances and intercepts. All items loaded significantly on their respective factor.

3.2 Comparison of ASI-3 Subscale Score by Class Membership using Analysis of Variance

Comparisons of mean scores for the Cognitive Concerns, Physical Concerns, and Social Concerns subscales by class membership are provided in Table 3. There were significant Bonferroni-corrected differences across classes such that individuals in the High AS class had the highest levels of ASI-3 subscale scores and individuals in the Normative AS class had the lowest levels of ASI-3 subscale scores.

3.3 Receiver Operating Characteristic Curve Follow-up Analysis of ASI-3 Classification

Following selection of the optimal number of classes, classes were exported from Mplus to conduct further analyses. Receiver operating characteristic (ROC) curves were used to determine whether the values from prior studies would replicate as optimal cut-score solutions. The primary purpose of the ROC curve analysis was to determine if the cut-score values from Allan et al. (2013) would generalize to this study, thus providing useful cut-scores that could be used outside of FMM studies to classify individuals based on their ASI-3 scores. Sensitivity and specificity around .80 or higher when examining past ASI-3 cut-scores in the current study would be seen as evidence of cut-score replication. Allan et al. (2013) determined that a cut-score of 23 was optimal for classifying individuals in the High AS class, with a sensitivity of .81 and a specificity of .88. In the current study, a cut-score of 23 classified individuals with a sensitivity of .90 and a specificity of .78, although a cut-score of 24 performed slightly better, with a sensitivity of .90 and a specificity of .80. Given how close specificity was when a cut-score of 23 was selected, compared to a cut-score of 24 in the current study, it was determined that because a cut-score of 23 could be supported across multiple studies, this was the optimal cut-score for classifying individuals in the High AS class. Allan et al. (2013) also examined the optimal cut-score for classifying individuals into the Moderate-to-High AS classes correctly. They determined that a cut-score of 17 was sufficient to classify individuals into the Moderate-to-High AS classes with a sensitivity of .80 and a specificity of .82. In the current study, a cut-score of 17 provided

the best balance between sensitivity and specificity with a sensitivity of .76 and a specificity of .71.

3.4 Examining ASI-3 Class Status as a Risk Factor for Anxiety Disorders and Other Psychopathology

A detailed listing of prevalence rates of Axis I disorders is provided in Table 4. Logistic regressions were conducted to examine class differences for a concurrent anxiety disorder diagnosis. Class was entered as a predictor for the presence of at least one anxiety disorder, which included PD, social phobia, OCD, PTSD, GAD, specific phobia, and anxiety disorder-not otherwise specified. Diagnostic status for MDD and other axis I disorders (i.e., the presence of at least one other Axis I disorder) were included as covariates. For all models, overall model fit and odds ratios, using 95% confidence intervals to assess significance were examined. There were two individuals in the High AS class and five in the Normative AS class who did not have diagnostic status available. Therefore, logistic regressions were based on 28 individuals in the High AS class, 110 individuals in the Moderate AS class, and 434 individuals in the Normative AS class (see Table 5). Controlling for MDD and other Axis I disorders, the odds of presenting with at least one current anxiety disorder were significantly elevated in the High AS class (71.4% had at least one anxiety disorder) and in the Moderate AS class (43.6%) as compared to the odds of presenting with an anxiety disorder in the Normative AS class (29.0%). The odds of presenting with an anxiety disorder in the High AS class were also significantly higher the odds of presenting with an anxiety disorder in the Moderate AS class.

To examine the specificity of AS to anxiety disorder diagnoses, logistic regression models were also examined for MDD and for any other Axis I disorder. Controlling for the presence of any anxiety disorder and other Axis I disorders, the odds of meeting diagnostic criteria for MDD were higher in the High AS class (25.0%) than in the Normative AS class (5.8%). There was not a significant difference between the High AS class and the Moderate AS class or between the Moderate AS class and the Normative AS class. This analysis was also conducted aggregating across all depressive disorder (i.e., MDD, MDD-seasonal, depressive disorder-not otherwise specified, and dysthymia). The results were similar, although the difference between the High AS class and the Normative AS class was only marginally significant. Controlling for any anxiety disorder and MDD, there were no significant differences in the odds of meeting diagnostic criteria for any other Axis I disorder.

4. Discussion

The current study provided support for a three-class three-factor model with intercepts and factor covariances free as representative of the between-individual structure of AS (as represented by the ASI-3) in an at-risk sample (due to their status as cigarette smokers). Classes consisted of a high AS class (5.2% of the sample), a moderate AS class (19.0%), and a normative AS class (75.8%). The number of classes, the constraints loosened, the presence of mean differences in all AS dimensions, and the size of the classes were consistent with the findings of Allan et al. (2013). The finding of three classes also appears to generalize across multiple populations as this study was conducted in a sample of older

individuals seeking smoking cessation treatment and the study conducted by Allan et al. (2013) was in a university sample. The other FMM study that used the ASI-3 to classify individuals only reported the presence of two classes (Bernstein et al., 2010). However, this study did not test a model comparable to the best-fitting model in the current study or the study conducted by Allan et al. (2013). This study provides support that a three-class, three-factor underlying structure of the ASI-3 is optimal. The presence of a three-class, rather than a two-class model implies important etiological implications. There have been two predominant theoretical models of the etiology of AS, the predisposition model (e.g., Reiss & Haverkamp, 1996) and the learning model (e.g., Schmidt, Lerew, & Joiner, 2000). The predisposition model posits AS is a heritable and stable trait (Reiss & Haverkamp, 1996; Stein, Jang, & Livesley, 1999). The learning model posits that AS either increases or decreases in response to “learning” about the consequences of anxiety (Reiss & McNally, 1985; Schmidt et al., 2000). Such a hybrid model suggests that there are individuals who inherit elevated AS, individuals who acquire elevated AS through learning, and individuals who inherit low levels of AS and never acquire elevated AS. In this study high, moderate, and normative AS classes, respectively, could be representative of such individuals at one point in time. By themselves, these results cannot fully support this proposed hybrid model. Specifically, a key tenet to such a theory is that individuals who inherit elevated AS remain stable in the high AS group, whereas those who acquire elevated AS through learning show an increase in AS over time. One study examined the development of AS in a large ($n = 2,356$) sample of adolescents using a longitudinal design (Weems, Hayward, Killen, & Taylor, 2002). Cluster analysis revealed three clusters with distinct trajectories that were consistently found in subsamples of the data: a stable high AS group (6% of the sample), an increasing AS group (14%), and a stable normative AS group (54%). Whereas more studies exploring the longitudinal stability of the AS classes found in the current study are needed, the results of the current study, coupled with the results from Weems et al. (2002), provide support for a hybrid predisposition/learning model of AS rather than an orthodox predisposition or learning model.

The present findings corroborate the ASI-3 cut-scores for the moderate-to-high AS and high AS classes from Allan et al. (2013). This replication is impressive given that we supported the exact cut scores from Allan et al. (2013; i.e. 23 for the high AS class; 17 for the moderate-to-high AS class). Previous AS interventions have selected participants with non-empirically informed cut-scores, typically based on standard deviations above the mean (e.g., Feldner, Zvolensky, Schmidt, & Smith, 2008; Keough & Schmidt, 2012). Unfortunately, because only the ASI has been used for cut-scores in the extant literature we can't compare these cut-offs to the empirically derived cut-scores in the present study. Given that the ASI-3 takes only minutes to administer, these cut scores are an efficient method to provide clinicians with a wealth of knowledge about a client's potential anxiety risk in a minimal amount of time.

There are several potential advantages of identifying moderate-to-high and high AS cut-scores versus a single cut-score. First, it creates a middle “buffer” which should lend more confidence in classifying/treating normative versus high AS individuals. For example, a client below the moderate AS class cut-off (normative AS group) is very likely not a good

candidate for AS intervention, whereas clients above this cut-off are likely very strong candidates. An additional advantage has to do with amenability to treatment. Individuals above the moderate AS cutoff but below the high AS cutoff (moderate AS class) may be more amenable to treatment whereas individuals above the high AS cutoff may require more intensive treatment. The elevated rate of individuals presenting with an anxiety disorder in the high AS class compared to individuals in the moderate AS class support this supposition. However, research examining whether there are differences in treatment effects for individuals in the moderate versus high AS class is needed to support the claims that individuals in the moderate AS class might be more amenable to treatment.

We found that AS class status differentially predicted the presence of an anxiety disorder even after controlling for MDD and other Axis I diagnoses. Specifically, results revealed that the odds of presenting with at least one current anxiety disorder were significantly elevated in the high AS class compared to the moderate AS class and the normative AS class. These findings are consistent with previous FMM research in both adolescents and adults demonstrating elevated levels of anxiety symptoms and diagnoses among individuals classified in the high AS class compared to individuals not classified in the high AS class (e.g., Allan, et al., in press; Bernstein et al., 2013; Zvielli et al., 2012). These findings are also consistent with the one prior study identifying three classes in that there were differences in anxiety such that the high AS class was the most at-risk for an anxiety disorder, followed by the moderate AS class (e.g., Allan et al., 2013). In addition, with the exception of MDD diagnoses in the high AS class versus the normative AS class, results indicated that AS class did not predict the presence of other Axis I disorders. Given the high rates of comorbidity among depression and anxiety symptoms (see Mineka, Watson, & Clark, 1998 for review), it is possible that elevated levels of AS not only serve as a risk factor for various anxiety-related conditions, but also, to a lesser degree, as a risk factor for depressive disorders. This finding lends further support for the importance of identifying three classes of individuals based on their AS scores.

There were several limitations to consider. Conducting this study in adult daily smokers was both a strength and a weakness. The present study demonstrated that a multi-class structure of AS generalizes to adult daily smokers. This was not unexpected, given that whereas AS has been implicated in motivation for smoking (i.e., reduction of anxious arousal), but not cigarette consumption, even in daily smokers (e.g., Gonzalez, Zvolensky, Vujanovic, Leyro, & Marshall, 2008; Novak, Burgess, Clark, Zvolensky, & Brown, 2003). However, replication is needed in additional samples with diverse population characteristics to determine generalizability of these findings. The current study used the ASI-3 to measure AS. Whereas this measure appears to best capture the lower-order dimensions of AS, differences between the ASI-3 and other measures that have been used in prior FMMs (i.e., CASI, ASI), especially in items measuring AS cognitive and social concerns limit comparisons between this study and these studies (Allan et al., in press; Bernstein et al., 2013) regarding the class structure of AS. Replication is also needed longitudinally to examine the stability of the AS classes over time. We did not include moderator variables such as gender or race in this study. These potential moderator variables might impact class enumeration. However, there is debate about the meaning of moderator variables for class enumeration, so researchers should proceed with care when including moderators and

compare results with and without moderator variables (Lubke & Muthén, 2007). Because we were interested in replicating prior studies that did not include moderators, we also chose not to include them. Finally, although the criteria we used for model selection has been supported in the literature, there are other approaches that have also been used. To alleviate concerns about the solution we identified, our solution was to be as clear as possible about model selection criteria so that researchers can compare our model selection strategies to others.

This study replicated a previous finding of three classes of individuals based on lower-order AS dimensions as well as the clinical cut-scores for classifying individuals into moderate-to-high and high AS classes (e.g., Allan et al., 2013). Further, the Class status was invariant across gender. Support for these classes was provided by the tiered nature of the associations between AS class status and the likelihood of an anxiety disorder, such that individuals were the most at-risk for an anxiety disorder when classified in the high AS class and least at-risk for an anxiety disorder when classified in the moderate AS class. Longitudinal work should be used to explore susceptibility to anxiety disorders over time and the stability of AS class status.

Acknowledgments

Funding source: This research was funded by NIH grant R01-MH076629. NIMH did not have influence over the study design, collection, analysis, and interpretation of data, in the writing of the report or the decision to submit this article for publication.

References

- Allan NP, Korte KJ, Capron DW, Raines AM, Schmidt NB. Factor mixture modeling of anxiety sensitivity: A three class structure. Manuscript submitted for publication. 2013
- Allan NP, MacPherson L, Young KC, Lejuez CW, Schmidt NB. Examining the latent structure of anxiety sensitivity in adolescents using factor mixture modeling. *Psychological Assessment*. (in press).
- Asmundson GJG, Weeks JW, Carleton RN, Thibodeau MA, Fetzner MG. Revisiting the latent structure of the anxiety sensitivity construct: More evidence of dimensionality. *Journal of Anxiety Disorders*. 2011; 25:138–147. [PubMed: 20888185]
- Bauer DJ, Curran PJ. The integration of continuous and discrete latent variable models: Potential problems and promising opportunities. *Psychological Methods*. 2004; 9:3–29. [PubMed: 15053717]
- Bernstein A, Stickle TR, Schmidt NB. Factor mixture model of anxiety sensitivity and anxiety psychopathology vulnerability. *Journal of Affective Disorders*. 2013; 149:406–417. [PubMed: 23261139]
- Bernstein A, Stickle TR, Zvolensky MJ, Taylor S, Abramowitz J, Stewart S. Dimensional, categorical, or dimensional-categories: Testing the latent structure of anxiety sensitivity among adults using factor-mixture modeling. *Behavior Therapy*. 2010; 41:515–529. [PubMed: 21035615]
- Bernstein A, Zvolensky MJ, Kotov R, Arrindell WA, Taylor S, Sandin B, Schmidt NB. Taxonicity of anxiety sensitivity: A multi-national analysis. *Journal of Anxiety Disorders*. 2006; 20:1–22. [PubMed: 16325111]
- Bernstein A, Zvolensky MJ, Norton PJ, Schmidt NB, Taylor S, Forsyth JP, Stewart SH. Taxometric and factor analytic models of anxiety sensitivity: Integrating approaches to latent structural research. *Psychological Assessment*. 2007; 19:74–87. [PubMed: 17371124]
- Bernstein A, Zvolensky MJ, Stewart SH, Comeau NM, Leen-Feldner EW. Anxiety sensitivity taxonicity across gender among youth. *Behaviour Research and Therapy*. 2006; 44:679–698. [PubMed: 16098477]

- Bernstein A, Zvolensky MJ, Weems C, Stickle T, Leen-Feldner EW. Taxonicity of anxiety sensitivity: An empirical test among youth. *Behaviour Research and Therapy*. 2005; 43:1131–1155. [PubMed: 16005702]
- Broman-Fulks JJ, Deacon BJ, Olatunji BO, Bondy CL, Abramowitz JS, Tolin DF. Categorical or dimensional: A reanalysis of the anxiety sensitivity construct. *Behavior Therapy*. 2010; 41:154–171. [PubMed: 20412882]
- Clark SL, Muthén BO, Kaprio J, D’Onofrio BM, Viken R, Rose RJ. Models and strategies for factor mixture analysis: An example concerning the structure underlying psychological disorders. *Structural Equation Modeling: A Multidisciplinary Journal*. 2013; 20:681–703.
- Feldner MT, Zvolensky MJ, Schmidt NB, Smith RC. A prospective test of anxiety sensitivity as a moderator of the relation between gender and posttraumatic symptom maintenance among high anxiety sensitive young adults. *Depression and Anxiety*. 2008; 25:190–199. [PubMed: 17340601]
- First MB, Spitzer RL, Gibbon M, Williams JBW. *Structured Clinical Interview for DSM-IV Axis I Disorders Research Version (SCID-I)*. New York, New York State Psychiatric Institute. Biometrics Research. 1996
- Gonzalez A, Zvolensky MJ, Vujanovic AA, Leyro TM, Marshall EC. An evaluation of anxiety sensitivity, emotional dysregulation, and negative affectivity among daily cigarette smokers: Relations to smoking motives and barriers to quitting. *Journal of Psychiatric Research*. 2008; 43:138–147. [PubMed: 18417153]
- Keough ME, Schmidt NB. Refinement of a brief anxiety sensitivity reduction intervention. *Journal of Consulting and Clinical Psychology*. 2012; 80:766–772. [PubMed: 22468909]
- Lo Y, Mendell NR, Rubin DB. Testing the number of components in a normal mixture. *Biometrika*. 2001; 88:767–778.
- Lubke, GH. Latent variable mixture modeling. In: Hancock, GR.; Mueller, RO., editors. *The Reviewers Guide to Quantitative Methods in the Social Sciences*. New York, NY: Routledge; 2010. p. 283-297.
- Lubke GH, Muthén B. Investigating population heterogeneity with factor mixture models. *Psychological Methods*. 2005; 10:21–39. [PubMed: 15810867]
- Lubke G, Muthén BO. Performance of factor mixture models as a function of model size, covariate effects, and class-specific parameters. *Structural Equation Modeling*. 2007; 14:26–47.
- Lubke G, Neale M. Distinguishing between latent classes and continuous factors with categorical outcomes: Class invariance of parameters of factor mixture models. *Multivariate Behavioral Research*. 2008; 43:592–620. [PubMed: 20165736]
- Lubke, GH.; Spies, JR. Choosing a “correct” factor mixture model: Power, limitations, and graphical data exploration. In: Hancock, GR.; Samuelsen, KM., editors. *Advances in latent variable mixture models*. Charlotte, NC: Information Age Publishing; 2008. p. 1-24.
- Lubke G, Tueller S. Latent class detection and class assignment: A comparison of the MAXEIG taxometric procedure and factor mixture modeling approaches. *Structural Equation Modeling*. 2010; 17:605–628. [PubMed: 24648712]
- Meehl PE. Clarifications about taxometric method. *Applied and Preventive Psychology*. 1999; 8:165–174.
- Mineka S, Watson D, Clark LA. Comorbidity of anxiety and unipolar mood disorders. *Annual Review of Psychology*. 1998; 49:377–412.
- Muthén, BO. Latent variable hybrids: Overview of old and new hybrids. In: Hancock, GR.; Samuelsen, KM., editors. *Advances in latent variable mixture models*. Charlotte, NC: Information Age Publishing; 2008. p. 1-24.
- Muthén, BO.; Muthén, LK. *Mplus User’s Guide*. Seventh Edition. Los Angeles, CA: Muthén & Muthén; 1998–2012.
- Novak A, Burgess ES, Clark M, Zvolensky MJ, Brown RA. Anxiety sensitivity, self-reported motives for alcohol and nicotine use, level of consumption. *Journal of Anxiety Disorders*. 2003; 17:165–180. [PubMed: 12614660]
- Nylund KL, Asparouhov T, Muthén BO. Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling*. 2007; 14:535–569.

- Olatunji BO, Wolitzky-Taylor KB. Anxiety sensitivity and the anxiety disorders: A meta-analytic review and synthesis. *Psychological Bulletin*. 2009; 135:974–999. [PubMed: 19883144]
- Petras, H.; Masyn, K. General growth mixture analysis with antecedents and consequences of change. In: Piquero, A.; Weisburd, D., editors. *Handbook of quantitative criminology*. New York, NY: Springer; 2010. p. 69-100.
- Ramaswamy V, DeSarbo WS, Reibstein DJ, Robinson WT. An empirical pooling approach for estimating marketing mix elasticities with PIMS data. *Marketing Science*. 1993; 12:103–124.
- Reiss S, Havercamp S. The sensitivity theory of motivation: Implications for psychopathology. *Behaviour Research and Therapy*. 1996; 34:621–632. [PubMed: 8870288]
- Reiss, S.; McNally, RJ. *Theoretical issues in behavior therapy*. New York, NY: Academic Press; 1985. Expectancy model of fear; p. 107-121.
- Reiss S, Peterson RA, Gursky DM, McNally RJ. Anxiety sensitivity, anxiety frequency and the prediction of fearfulness. *Behaviour Research and Therapy*. 1986; 24:1–8. [PubMed: 3947307]
- Ruscio, J.; Haslam, N.; Ruscio, AM. *Introduction to the taxometric method: A practical guide*. Lawrence Erlbaum Associates Publishers; 2006.
- Schwartz G. Estimating the dimension of a model. *The Annals of Statistics*. 1978; 6:461–464.
- Sclove L. Application of model-selection criteria to some problems in multivariate analysis. *Psychometrika*. 1987; 52:333–343.
- Silverman WK, Fleisig W, Rabian B, Peterson RA. Childhood Anxiety Sensitivity Index. *Journal of Clinical Child and Adolescent Psychology*. 1991; 20:162–168.
- Taylor S, Zvolensky MJ, Cox BJ, Deacon B, Heimberg RG, Ledley DR, Stewart SH. Robust dimensions of anxiety sensitivity: Development and initial validation of the Anxiety Sensitivity Index-3. *Psychological Assessment*. 2007; 19:176–188. [PubMed: 17563199]
- Weems CF, Hayward C, Killen J, Taylor CB. A longitudinal investigation of anxiety sensitivity in adolescence. *Journal of Abnormal Psychology*. 2002; 111:471–477. [PubMed: 12150423]
- Wheaton MG, Deacon BJ, McGrath PB, Berman NC, Abramowitz JS. Dimensions of anxiety sensitivity in the anxiety disorders: Evaluation of the ASI-3. *Journal of Anxiety disorders*. 2012; 26:401–408. [PubMed: 22306133]
- Zinbarg RE, Barlow DH, Brown TA. Hierarchical structure and general factor saturation of the Anxiety Sensitivity Index: Evidence and implications. *Psychological Assessment*. 1997; 9:277–284.
- Zvielli A, Bernstein A, Berenz EC. Exploration of a factor mixture-based taxonic-dimensional model of anxiety sensitivity and transdiagnostic psychopathology vulnerability among trauma-exposed adults. *Cognitive Behaviour Therapy*. 2012; 41:63–78. [PubMed: 22375733]

Highlights

- Anxiety sensitivity (AS) classes were examined in an at-risk sample.
- Three classes emerged, comprising high, moderate, and normative AS levels.
- The odds of having an anxiety disorder were highest in the high AS class.
- The odds of having an anxiety disorder were lowest in the normative AS class.
- Clinical cut-scores were established to distinguish between classes.

Factor Mixture Models of Cognitive Concerns, Physical Concerns, and Social Concerns Subscales of the ASI-3

Table 1

Model (Class Selection)	-2Loglikelihood	Free parameters	BIC	aBIC	LMR-LRT	BLRT	Entropy
1 Class Model	-12125.69	57	24614	24433	--	--	--
2 Class Models							
Fully Invariant	-11988.66	61	24365	24172	263.69*	274.06*	.95
Covariances Free	-11981.32	64	24370	24167	282.41*	288.75*	.94
Covariances and Intercepts Free	-11859.72	79	24221	23971	528.17*	531.95*	.99
3 Class Models							
Fully Invariant	-11934.68	65	24283	24076	103.88	107.97 ^a	.93
Covariances Free	-11879.80	71	24211	23986	243.14*	248.60 ^a	.80
Covariances and Intercepts Free	-11654.82	101	23952	23632	406.88	409.78*	1.00
4 Class Models							
Fully Invariant ^c	-11870.38	69	24180	23961	123.73	-- ^a	.95
Covariances Free ^c	-11827.24	78	24151	23903	102.82	-- ^a	.83
Covariances and Intercepts Free ^c	-11535.27	123	23853	23463	-- ^b	-- ^a	.91

Note. BIC = Bayesian Information Criterion. aBIC = Sample Size Adjusted BIC. LMR-LRT = Lo-Mendell-Rubin Likelihood Ratio Test. BLRT = Bootstrapped Likelihood Ratio Test.

^aReliable BLRT were not provided because of a failure to replicate the comparison $k - 1$ solution. For models that list BLRT values, the best value was not replicated. For models without BLRT values, no best value was produced.

^bA reliable LMR-LRT was not provided because of a failure to provide a value for the comparison $k - 1$ class.

^cReliable solutions for these models were not provided, either because of a failure to replicate or because unreliable parameters were provided for at least one class in the provided solution.

* $p < .05$.

Table 2
Standardized Factor Loadings and Intercept Values for the Final Three-Class Three-Factor FMM Solution

<i>Cognitive Concerns</i>	Loading	High AS Class		Moderate AS Class		Normative AS Class	
		Intercept	SE	Intercept	SE	Intercept	SE
Item 2	.74*	1.63	.25	.82	.09	.30	.03
Item 5	.71*	2.23	.21	1.29	.11	.58	.04
Item 10	.73*	1.63	.25	.78	.10	.26	.03
Item 14	.77*	1.67	.25	.93	.10	.24	.03
Item 16	.79*	2.30	.21	1.28	.11	.49	.04
Item 18	.69*	1.90	.20	1.20	.11	.35	.03
<i>Physical Concerns</i>							
Item 3	.75*	2.27	.19	1.86	.11	.88	.04
Item 4	.53*	1.57	.22	.66	.09	.24	.03
Item 7	.73*	2.87	.19	2.07	.11	.85	.05
Item 8	.73*	2.53	.25	1.70	.12	.64	.04
Item 12	.71*	2.37	.24	1.52	.11	.46	.04
Item 15	.27*	3.30	.08	1.28	.04	.00	.00
<i>Social Concerns</i>							
Item 1	.55*	2.40	.20	2.16	.09	1.66	.06
Item 6	.76*	2.63	.21	1.49	.11	.85	.05
Item 9	.83*	2.80	.22	1.85	.11	1.00	.05
Item 11	.54*	1.60	.24	.75	.10	.41	.04
Item 13	.67*	2.47	.23	1.66	.12	.77	.05
Item 17	.55*	2.83	.23	2.15	.13	1.46	.06
Factor Inter correlations							
Cognitive Concerns	High AS Class		Moderate AS Class		Normative AS Class		
	Physical	.43*	Social	.77*	Physical	.40*	Social
						.68*	.78*

<i>Cognitive Concerns</i>	High AS Class		Moderate AS Class		Normative AS Class	
	Loading	Intercept	Intercept	SE	Intercept	SE
Physical Concerns		1.00	1.00	.42 *	1.00	.62 *

Note. Loading values and factor correlations are standardized, intercept values are unstandardized.

* $p < .05$.

ANOVAS Comparing Mean ASI-3 Cognitive Concerns, Physical Concerns, and Social Concerns across Classes

Table 3

ASI-3 Subscales	High AS	SD	Moderate AS	SD	Normative AS	SD	F-test
Cognitive Concerns	11.37	5.91	6.30	5.14	2.22	3.26	115.71 ^{*1,2,3}
Physical Concerns	14.90	4.88	9.10	4.47	3.06	3.17	253.98 ^{*1,2,3}
Social Concerns	14.73	5.34	10.05	5.04	6.13	4.58	69.44 ^{*1,2,3}

Note.

¹ Significant difference between Normative AS and Moderate AS classes using Bonferroni correction.

² Significant difference between Normative AS and High AS.

³ Significant difference between Moderate AS and High AS.

* $p < .05$.

Table 4

Prevalence Rates of Current Axis I Disorders

	Overall	High AS	Moderate AS	Normative AS
Panic Disorder	20 (3.5%)	5 (17.9%)	5 (4.5%)	10 (2.3%)
Social Phobia	80 (14.0%)	10 (35.7%)	19 (17.3%)	51 (11.8%)
Obsessive Compulsive Disorder	15 (2.6%)	2 (7.1%)	5 (4.5%)	8 (1.8%)
Posttraumatic Stress Disorder	31 (5.4%)	6 (21.4%)	6 (5.5%)	19 (4.4%)
Generalized Anxiety Disorder	51 (8.9%)	5 (17.9%)	13 (11.8%)	33 (7.6%)
Specific Phobia	57 (10.0%)	4 (14.3%)	13 (11.8%)	40 (9.2%)
Anxiety Disorder-NOS	8 (1.4%)	1 (3.6%)	3 (2.7%)	4 (0.9%)
Major Depressive Disorder	45 (7.9%)	7 (25.0%)	13 (11.8%)	25 (5.8%)
Major Depressive Disorder-Seasonal	2 (0.3%)	0 (0.0%)	1 (0.9%)	1 (0.2%)
Dysthymic Disorder	23 (4.0%)	5 (17.9%)	4 (3.6%)	14 (3.2%)
Depressive Disorder-NOS	5 (0.9%)	0 (0.0%)	0 (0.0%)	5 (1.2%)
Bipolar I	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.2%)
Bipolar II	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.2%)
Alcohol Abuse	21 (3.7%)	2 (7.1%)	1 (0.9%)	18 (4.1%)
Alcohol Dependence	25 (4.4%)	0 (0.0%)	5 (4.5%)	20 (4.6%)
Substance Abuse	24 (4.2%)	4 (14.3%)	3 (2.7%)	16 (14.5%)
Substance Dependence	22 (3.8%)	1 (3.6%)	6 (5.5%)	15 (3.5%)
Body Dysmorphic Disorder	1 (0.2%)	0 (0.0%)	1 (0.9%)	1 (0.2%)
Anorexia Nervosa	1 (0.2%)	0 (0.0%)	1 (0.9%)	1 (0.2%)
Bulimia Nervosa	1 (0.2%)	1 (3.6%)	0 (0.0%)	0 (0.0%)
Any Anxiety Disorder	194 (33.9%)	20 (71.4%)	48 (43.6%)	126 (29.0%)
Non-Mood/Anxiety Axis I Disorders	80 (14.0%)	5 (17.9%)	12 (10.9%)	63 (14.5%)

Note. NOS = Not otherwise specified.

Table 5
Logistic Regression Predicting Anxiety Disorders, MDD, and Other Axis I Disorders by ASI-3 Class Membership and Covariates

Disorder	Odds Ratio	95% Confidence Interval		Model χ^2	R ^{2#}
		Lower Limit	Upper Limit		
Any anxiety disorder				78.00***	.13
MDD	7.36	4.02	13.47		
Axis I disorders (other)	1.38	.81	2.33		
(Normative AS reference class)					
High AS class	4.86	1.99	11.86		
Moderate AS class	1.82	1.15	2.86		
(Moderate AS reference class)					
High AS class	2.68	1.03	6.95		
MDD				41.08***	.07
Any anxiety disorder	6.06	2.95	12.47		
Axis I disorders (other)	1.21	.52	2.78		
(Normative AS reference class)					
High AS class	3.00	1.12	8.10		
Moderate AS class	1.75	.84	3.66		
(Moderate AS reference class)					
High AS class	1.71	.59	5.02		
Axis I disorders (Other)				4.65	.01
MDD	1.17	.50	2.71		
Any anxiety disorder	1.54	.93	2.57		
(Normative AS reference class)					
High AS class	1.03	.37	2.91		
Moderate AS class	.67	.34	1.30		
(Moderate AS reference class)					
High AS class	1.55	.49	4.91		

Note. R^{2#} = Cox and Snell quasi-R². MDD = Major depressive disorder.

p .001.