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The Roles of Sex, Anxious Reactivity to Bodily Arousal, and Anxiety Sensitivity in Coping Motives for Cigarette Smoking among Adolescents

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Abstract

Evidence suggests that smoking to cope among adolescents is associated with a number of problematic outcomes (e.g., greater smoking frequency, higher rates of dependence). It is thus imperative to better understand factors that may increase the likelihood of smoking to cope among adolescents. Research suggests anxiety sensitivity (AS) is associated with smoking to cope among adults, although the link between AS and coping motives for cigarette use among youth is less clear. Sex differences have also been noted in AS. The current study investigates this association using a biological challenge paradigm. Specifically, the indirect effects of anxious reactivity to bodily arousal on the relation between the physical and mental AS factors and coping motives for cigarette smoking were examined within a sample of 108 adolescent cigarette smokers. Sex was examined as a moderator. Results suggested significant indirect effects of self-reported anxiety in response to bodily arousal on the relation between physical AS and coping motives for cigarette smoking. This indirect effect was moderated by sex, such that it was significant for females but not males. Models examining AS mental concerns and psychophysiological responding to the challenge were not significant. These results suggest that, relative to their low-AS counterparts, female adolescents high in physical concerns respond with elevated anxiety in response to interoceptive arousal and, in turn, endorse elevated coping-related smoking motives. Findings are discussed in terms of implications for understanding the nature and origins of coping-related smoking motives and how such information can be utilized to inform intervention efforts.

Keywords

Adolescents; Coping motives; Cigarettes; Anxiety Sensitivity; Anxious Arousal

Cigarette Smoking among Adolescents Cigarette smoking remains the leading preventable cause of death in the United States (Centers for Disease Control and Prevention, 2012). One important avenue for enhancing our understanding of smoking among adolescents is refining

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our knowledge of the reasons adolescents report for smoking (i.e., smoking motives). Motives are considered proximal determinants of substance use that may play a role in the relation between distal risk factors, such as psychopathology (e.g., social anxiety; Buckner, Farris, Schmidt, & Zvolensky, 2014) or emotional processes (e.g., dysregulated anger; Mischel et al., 2014), and substance use (Cooper, 1994). Researchers have identified several motives for adolescent cigarette smoking (e.g., coping, conformity, social, enhancement; Comeau et al., 2001). For example, many adolescents endorse smoking for social reasons (Spijkerman, van den Eijnden, & Engels, 2005) and to alleviate boredom (Piko, Wills, & Walker, 2007). Notably, adolescents seem to be particularly likely to smoke to cope with stress, especially familial and interpersonal stress (Scales, Monahan, Rhodes, Roskos-Ewoldsen, & Johnson-Turbes, 2008). Indeed, available evidence clearly supports the idea that adolescents use cigarettes to cope with stress (Guthrie, Young, Boyd, & Kintner, 2001), to reduce negative affect (Stevens, Colwell, Smith, Robinson, & McMillan, 2005), and smoke more when anxious (Henker et al., 2002). Notably, among early stage smokers, daily smokers endorse more negative reinforcement motives for smoking (e.g., to reduce distress and alleviate withdrawal) than occasional smokers (Mathew et al., 2014). Further, prospective studies indicate negative affect reduction motives relate positively to adolescent smoking frequency, quantity, and symptoms of dependence at baseline and predict increases in cigarette use and dependence across 15 months (Weinstein & Mermelstein, 2013). Collectively, the data indicate smoking to cope with negative affect is a common and particularly problematic motive for tobacco use among adolescents, making it important to better understand factors that may increase the likelihood of smoking to cope among adolescents.

Although adult research suggests coping motives relate positively to anxiety symptoms (Tate et al., 1994) and are tied to smoking cessation difficulties among adults with anxiety problems (Morissette, Tull, Gulliver, Kamholz, & Zimering, 2007), linkages between anxiety-related processes and smoking to cope have not been well studied among adolescents. This relative degree of neglect is unfortunate given anxiety is a common negative affective state during adolescence (Tully, Zajac, & Venning, 2009) that some youth may learn to manage by smoking (e.g., Whalen, Jamner, Henker, & Delfino, 2001). From a theoretical perspective, smokers who believe anxiety-related states are dangerous may be particularly likely to smoke to escape anxiety-related aversive states (e.g., Parrot, 1999; Zvolensky et al., 2003). A research question that follows from such accounts is whether such beliefs, known as anxiety sensitivity (AS; Reiss & McNally, 1985), may be linked to smoking to cope among adolescents.

Roles of Anxiety Sensitivity and Anxious Arousal to Bodily Sensations

Anxiety sensitivity is defined as fear of the consequences of anxiety and arousal sensations (Reiss & McNally, 1985). AS and anxious arousal in response to bodily sensations are conceptually distinct concepts; the former refers to an outcome expectancy regarding the consequences of anxiety, while the latter reflects “real-time” emotional responsiveness to interoceptive sensations (Taylor, 1999). Factor analyses suggest the global AS factor is comprised of three lower-order factors reflecting domain-specific concerns about the consequences of anxiety-related sensations (i.e., physical, mental, and social concerns;

Brown et al., 2012; Walsh, Stewart, McLaughlin, & Comeau, 2004; Wright et al., 2010). Notably, there may be sex differences in how adolescents experience AS (e.g., Walsh et al., 2004). Indeed, recent work suggests female adolescents may experience more physical concerns and fear in the presence of unusual bodily sensations as compared to males (Wright et al., 2010). This is consistent with adult research suggesting that men and women may experience AS differently (Norr, Albanese, Allan, & Schmidt, 2015). Little work has examined how sex differences in AS may affect adolescent cigarette smoking.

Adult research suggests AS is associated with anxiety-relevant negative affect reduction smoking motives (e.g., “cigarettes help me deal with anxiety or worry;” Zvolensky et al., 2006). Indeed, research with daily smokers indicates AS is uniquely related to negative affect reduction motives to smoke, even after controlling for a number of theoretically-relevant covariates (e.g., psychopathology, negative affectivity, number of cigarettes smoked per day; Gonzalez, Zvolensky, Vujanovic, Leyro, & Marshall, 2009; Leyro, Zvolensky, Vujanovic, & Bernstein, 2008). Notably, AS is related to both motives for cigarette smoking and beliefs about cessation related difficulties, above and beyond panic attacks (Johnson, Farris, Schmidt, Smits, & Zvolensky, 2013), and AS mediates the relation between more distal smoking vulnerability processes (i.e., worry) and smoking rate, heaviness of smoking, and nicotine dependence among treatment seeking adult smokers (Olvera et al., 2015). Further, among adult smokers, anxiety focused on physical sensations (i.e., heart focused anxiety) is associated with coping motives for cigarette smoking above and beyond theoretically relevant covariates (Leyro, Zvolensky, Vujanovic, Johnson, & Gregor, 2010). Scant research has examined sex differences in the relation between AS and smoking motives.

To date, very little work has examined the relation between AS and smoking to cope among adolescents. This is a critical gap in the literature, given the unique biopsychosocial aspects of adolescence. Adolescents are more sensitive to drugs (Cicchetti & Rogosch, 2002; Monti et al., 2005; Winters, & McLellan, 2004), including nicotine (Strong, Schonbrun, Schaffran, Griesler, & Kandel, 2012). Additionally, adolescents typically are more temporally proximal to smoking initiation than adults (i.e., shorter “window” of use; Johnston, O’Malley, & Terry-McElrath, 2004). Interestingly, in the only study examining these factors among adolescents, Comeau and colleagues (2001) found, among 192 adolescents (grades 7–12; $M_{\text{age}} = 15.1$ years) who reported past-year cigarette use, that AS was not related to coping motives for cigarette smoking (or other substances). Instead, it moderated the relation between trait anxiety and coping motives, such that high AS trait anxious teens were at greater risk of smoking to cope than low AS trait anxious teens. Notably, the authors did not examine AS lower order factors, and although sex was examined as a covariate, no significant effect of sex was found.

Theoretical models suggest that, compared to their low-AS counterparts, high-AS individuals would be expected to experience stronger subjective anxious reactivity to bodily sensations (Bouton, Mineka, & Barlow, 2001). Empirical work with adolescents is consistent with this perspective. For example, both global AS and AS-physical concerns relate to subjective distress elicited by biological challenge procedures (Leen-Feldner, Feldner, Bernstein, McCormick, & Zvolensky, 2005; Rabian, Embry, & MacIntyre, 1999),

These data comport with adult work (e.g., Zvolensky & Eifert, 2001), and indicate AS potentiates anxious responding to interoceptive arousal. Moreover, they fit with theoretical accounts of smoking suggesting that high-AS individuals believe anxiety-related sensations are dangerous. These beliefs are thought to cause high AS individuals to respond to bodily arousal with elevated anxiety, which makes them particularly likely to smoke to reduce affective distress associated with such states (Stewart & Kushner, 2001; Zvolensky et al., 2003; Zvolensky & Bernstein, 2005).

Current Study

The current study is designed to provide a test of this perspective, that adolescent smokers who are high in AS will evidence elevated anxious reactivity in the context of interoceptive arousal and, in turn, be more likely to report smoking to cope, and further that these processes would differ as a function of sex. Specifically, drawing from prior work with adults (e.g., Battista et al., 2008; Zvolensky et al., 2006) the study was designed to address the hypothesis that, among adolescent cigarette smokers, there would be significant indirect effects of self-reported anxiety (SR-A) following a voluntary hyperventilation procedure (VH) on the relation between the mental and physical factors of AS and coping motives for cigarette smoking. Given a lack of evidence for a relation between AS social concerns and VH responding (e.g., Leen-Feldner et al., 2005), this association was not expected to be significant. In line with prior work (e.g., Wright et al., 2010), it was further hypothesized that adolescent sex would moderate the expected indirect effects. Specifically, it was expected that AS physical and mental concerns would be more strongly related to self reported anxiety following the VH in females than males. This study addresses several notable gaps in the literature; no study in this domain has addressed this question among adolescents, used a biological challenge procedure to elicit real-time anxious responding, examined the role of sex in these relations, or evaluated the lower-order AS factors. Examining these relations among adolescent cigarette smokers thus represents a valuable extension to the literature that may help to inform etiologic models of smoking behavior among adolescents.

Consistent with Rutter's (1994) suggestion to conduct tests of non-replication in which predictions are made regarding the absence of effects in order to isolate hypothesized mechanisms and inform subsequent work, specificity was also examined. Previous work has not supported a link between AS and psychophysiological response to the VH among youth (e.g., skin conductance; Leen-Feldner et al., 2005, 2006). Given evidence AS may be associated with smoking motives as a result of cognitive processes (e.g., outcome expectancies about the consequences of psychophysiological arousal) rather than actual psychophysiological reactivity elicited by the challenge (Zvolensky et al., 2004), no significant indirect effects of galvanic skin response elicited by the challenge were expected.

Method

Participants

One hundred and eight adolescents (59 males) between the ages of 12 and 17 years ($M_{\text{age}} = 15.69$) were recruited from the local community to take part in a larger study examining the

effects of cigarette smoking on adolescent psychological functioning. Adolescents were selected from the larger sample ($n = 180$) based on (a) endorsing a positive history of cigarette smoking ($n = 130$) and (b) completion of all measures employed in data analysis for the current study. Adolescents were recruited in equal numbers across four stages of smoking uptake (e.g., Mayhew, Flay, & Mott, 2000); Triers ($n = 33$; $M_{\text{cig/day}} = 0.04$, $SD = 0.20$), Experimenters ($n = 24$; $M_{\text{cig/day}} = 0.3$, $SD = 0.64$), Regular Smokers ($n = 17$; $M_{\text{cig/day}} = 2.56$, $SD = 1.80$), and Daily Smokers ($n = 34$; $M_{\text{cig/day}} = 10.53$, $SD = 7.36$). All participants had at least tried smoking cigarettes, and reported smoking an average of 4 cigarettes per day. Smoking status was also examined using CO analysis, 23 youth had a score of 10ppm or above (Cocores, 1993) indicating they had smoked within the last 24 hours.

Individuals who did not complete all questionnaires relevant to the current study (e.g., TSMQ, CASI) were not included in the current analyses. Psychophysiological data was missing for 18 participants due to equipment malfunction, participant movement, and measurement error. These participants were included in the self-report analyses and excluded from analyses employing psychophysiological data. Chi-square tests were conducted to evaluate differences between individuals who completed all measures and those who did not. No significant differences were observed between completers and non-completers in terms of sex, $\chi^2(1) = .06$, $p = .807$ or ethnicity, $\chi^2(1) = .353$, $p = .553$. On average, completers were older than non-completers, $\chi^2(5) = 28.85$, $p < .001$. Several substances were used by a relatively large percentage of the sample on a consistent basis; see Table 1 for rates of substance use, age of smoking onset, and additional demographic information.

Measures

The 18-item *Childhood Anxiety Sensitivity Index* (CASI; Silverman, Fleisig, Rabian, & Peterson, 1991) was used to index anxiety sensitivity. The CASI has a hierarchical structure, with one global factor and three lower order factors (Silverman et al., 1991; Wright et al., 2010). The 12-item physical concerns factor (e.g., “it scares me when my heart beats fast”), the 3-item social concerns factor (e.g., “I don’t like to let my feelings show”), and the 3-item mental concerns factor (e.g., “when I cannot keep my mind on schoolwork, I worry that I might be going crazy”) were examined (Brown et al., 2012; Walsh, Stewart, McLaughlin, & Comeau, 2004). Internal consistency estimates for the physical, social, and mental concerns factors were similar to previously published work (alphas = 0.84, 0.57, and 0.68, respectively; Knapp, Blumenthal, Mischel, Badour, & Leen-Feldner, 2015; Walsh et al., 2004).

The *Teen Smoking Motives Questionnaire* (TSMQ; Comeau, Stewart, & Loba, 2000) is a 20-item questionnaire that measures 4 motives for cigarette use. Frequency of coping motives for cigarette smoking (e.g., “to forget about your problems”) was measured on a 5-item subscale using a Likert scale ranging from 1 (*almost never/never*) to 5 (*almost always/always*). The 20-item TSMQ evidences good psychometric properties, including criterion-related validity in predicting adolescent smoking behavior (Comeau et al., 2000). Internal consistency for the coping motives subscale in the current study was good ($\alpha = 0.86$).

Anxiety Ratings were used to measure self-reported state anxiety (SR-A) at baseline (i.e., prior to the experimental task) and in response to the VH. Ratings are made on a scale ranging from 0 (*no anxiety*) to 10 (*extreme anxiety*). Change in SR-A from baseline to post-challenge was used to assess anxious reactivity.

To evaluate changes in *skin conductance* elicited by the challenge, a J & J Engineering I-330-C2 system was used to digitally record skin conductance levels (SCL) throughout the procedure. SCL was monitored via SE-35 electrodes placed on the middle segment of the index finger and connected to an RV-5 skin resistance lead. SCL output was converted to microsiemens (μS), and average SCL was computed for the baseline and challenge periods.

Laboratory Challenge

Participants completed a well-established voluntary hyperventilation (VH) procedure (Hornsveld, Garssen, Dop, & Van Spiegel, 1990). The VH was selected because it reliably elicits symptoms of bodily arousal and has been safely used with youth (Blumenthal, Leen-Feldner, Knapp, Bunaciu, & Zamboanga, 2012; Hawks, Blumenthal, Feldner, Leen-Feldner, & Jones, 2011). The challenge involved a 3-min VH during which participants were asked to breathe at a rate of 30 respiratory cycles per minute, a rate which has been demonstrated to increase pCO₂ levels, elevate blood pH, and increase lactate levels (Fried & Grimaldi, 1993).

Procedure

The Institutional Review Board of a large university in the south-central U.S. approved all study procedures before participant contact. Eligible adolescents and their parents were invited for a laboratory visit, at which time study procedures were comprehensively reviewed. Thereafter, written, informed adolescent assent and parental consent (for self-participation in the larger study and child participation) were obtained. Adolescent participants next completed a battery of randomly ordered questionnaires. Participants were then escorted to the experimental room and seated at a small desk with a computer. Electrodes were attached to continuously monitor SCL throughout the procedure, and instructions for the challenge were reviewed. Upon completion of the study, participants were thanked, debriefed, and compensated \$45.

Analytic Approach

Following the computation of descriptive statistics and a manipulation check, the primary hypotheses for this study were conducted using the PROCESS custom dialog in SPSS 19 (Hayes, 2013). Analyses were undertaken to evaluate the conditional indirect effects of SR-A and SCL on the relation between three lower order AS factors (i.e., CASI physical concerns, mental concerns scores, and social concerns) and coping motives for cigarette use. SR-A and SCL were analyzed in separate models, and baseline levels of these factors were entered as covariates in their respective models in order to examine increases in self-reported anxiety and psychophysiological arousal (i.e., anxious reactivity to the VH). Smoking group status (i.e., trier, experimenter, regular smoker and daily smoker) was also entered as a covariate. Conditional indirect effects were identified using a bootstrapping approach, a technique recommended for use with smaller samples (MacKinnon, Lockwood, & Williams,

2004; Shrout & Bolger, 2002; Williams & MacKinnon, 2008). As recommended (Hayes, 2015), 5000 bootstrapping samples were used, and significance was assumed if an index of moderated mediation bias-corrected 95% confidence interval, generated based on the established sampling distribution, excluded zero. Conditional indirect effects were identified if the indirect effects estimated at each level of the moderator were significantly different from each other (Hayes, 2015). Moderated mediation is said to occur when path *a* (from AS to SRA) is moderated by sex. As suggested, the association between CASI scores and smoking motives (path *c'*) are not required for indirect effects (Haynes, 2009).

Results

Manipulation Check

Compared to baseline, bodily arousal increased during the VH. SCL increased pre- ($M = 11.12$, $SD = 5.37$) to post-challenge ($M = 15.15$, $SD = 6.48$; $t(80) = -10.50$, $p < .001$). Additionally, baseline self-reported anxiety ($M = 3.53$, $SD = 2.64$) was significantly higher at the post-challenge assessment ($M = 4.91$, $SD = 3.00$; $t(98) = -4.77$, $p < .001$).

Descriptive Analyses and Zero-Order Correlations

See Table 1 for descriptive data and zero-order correlations among predictor and outcome variables. Means and standard deviations for CASI physical, social, and mental concerns subscales (Knapp et al., 2015) as well as the TSMQ (Comeau et al., 2001), were similar to previously published findings among adolescents..

Primary Hypothesis Tests

Anxiety ratings—In terms of physical concerns, after co-varying for smoking group status, sex moderated the association between CASI physical concerns scores and post-challenge SR-A (path *a*: $\beta = .24$, $SE = .10$, $p = .019$). In addition, post-challenge SR-A was associated with coping motives (path *b*: $\beta = .10$, $SE = .03$, $p = .001$). The direct path was not significant; CASI physical concerns were unrelated to coping motives (path *c'*: $\beta = .02$, $SE = .02$, $p = .369$). The index of moderated mediation indicated that sex significantly moderated the indirect association of post challenge SR-A on the relation between CASI physical concerns scores and coping motives ($\beta = .02$, $SE = .01$, BC 95% CI [.01, .06]). Analysis of the moderated mediation indicated that the indirect association of post challenge SR-A on the relation between CASI physical scores and coping motives was significant for females ($\beta = .03$, $SE = .01$, BC 95% CI [.01, .06]) but not for males ($\beta = .00$, $SE = .01$, BC 95% CI [-.02, .02]). See Figure 1.

In terms of mental concerns, after co-varying for smoking group status, sex did not moderate the association between CASI mental concerns scores and post-challenge SR-A (path *a*: $\beta = .07$, $SE = .40$, $p = .853$). SR-A was associated with coping motives above and beyond CASI mental concerns (path *b*: $\beta = .10$, $SE = .03$, $p < .001$). The direct path from CASI mental concerns scores to coping motives was not significant (path *c'*: $\beta = .07$, $SE = .06$, $p = .217$). Contrary to hypotheses, the index of moderated mediation indicated that sex did not significantly moderate the indirect association of post challenge SRA on the relation

between CASI mental concerns scores and coping motives ($\beta = .01$, $SE = .04$, BC 95% CI [-.06, .11]).

In terms of social concerns, sex did not moderate the association between CASI social concerns scores and post-challenge SR-A (path a: $\beta = -.23$, $SE = .31$, $p = .452$). SR-A was associated with coping motives above and beyond CASI social concerns (path b: $\beta = .12$, $SE = .03$, $p < .001$). The direct path from CASI mental concerns scores to coping motives was not significant (path c': $\beta = -.03$, $SE = .05$, $p = .520$). Consistent with hypotheses, the index of moderated mediation indicated that sex did not significantly moderate the indirect association of post challenge SRA on the relation between CASI social concerns scores and coping motives ($\beta = -.03$, $SE = .04$, BC 95% CI [-.13, .05]).

Specificity Tests

Skin conductance levels—After co-varying for smoking group status, sex did not moderate the association between CASI physical concerns scores and SCL reactivity (path a: $\beta = .26$, $SE = .18$, $p = .145$). Additionally, post-challenge SCL was not associated with coping motives above and beyond CASI physical concerns (path b: $\beta = .00$, $SE = .02$, $p = .931$). The direct path between CASI physical and coping motives was significant (path c': $\beta = .04$, $SE = .02$, $p = .044$). As expected, the index of moderated mediation indicated that sex did not significantly moderate the indirect association of post challenge SCL on the relation between CASI physical concerns scores and coping motives ($\beta = .00$, $SE = .01$, BC 95% CI [-.01, .02]).

Also as expected, after co-varying for group status, sex did not moderate the association between CASI mental concerns scores and SCL reactivity (path a: $\beta = .87$, $SE = .62$, $p = .164$). Further, post-challenge SCL was not associated with coping motives above and beyond CASI mental concerns (path b: $\beta = .01$, $SE = .02$, $p = .683$). The direct path between CASI mental concerns and coping motives was not significant (path c': $\beta = .09$, $SE = .06$, $p = .152$). As expected, the index of moderated mediation indicated that sex did not significantly moderate the indirect association of post challenge SCL on the relation between CASI mental concerns scores and coping motives ($\beta = .01$, $SE = .02$, BC 95% CI [-.03, .09]).

Finally, after co-varying for group status, sex moderated the association between CASI social concerns scores and SCL reactivity (path a: $\beta = .96$, $SE = .47$, $p = .043$). However, post-challenge SCL was not associated with coping motives above and beyond CASI social concerns (path b: $\beta = .02$, $SE = .02$, $p = .490$). The direct path between CASI social concerns and coping motives was not significant (path c': $\beta = -.07$, $SE = .05$, $p = .188$). As expected, the index of moderated mediation indicated that sex did not significantly moderate the indirect association of post challenge SCL on the relation between CASI social concerns scores and coping motives ($\beta = .02$, $SE = .03$, BC 95% CI [-.02, .09]).

Discussion

Improving our understanding of factors that relate to cigarette smoking in adolescents is critical for efforts to reduce smoking and associated consequences. Empirical data suggest adolescents often smoke to cope with negative affect (Henker et al., 2002; Stevens et al.,

2005) and theoretical accounts suggest youth, particularly girls, who are distressed by anxious arousal (high in AS), may learn to smoke cigarettes to cope (Zvolensky & Bernstein, 2005). However, the roles of sex, AS, anxious arousal in response to bodily sensations, and coping-related smoking motives have not been evaluated among adolescents. The current study utilized a biological challenge procedure to begin to address this gap in the literature.

First, as hypothesized, sex moderated the significant indirect relations of self-reported anxiety elicited by the VH on the association between AS physical concerns and coping motives for cigarette smoking. The conditional indirect association indicated that this indirect relation was present for females, but not males. These results are consistent with previous findings which suggest that AS physical concerns are elevated among females, compared to males, and that females may experience the AS-physical concerns differently than males (e.g., Walsh et al., 2004; Wright et al., 2010). These findings demonstrate that among female adolescent cigarette smokers, anxious responding to bodily arousal is related to smoking motives for cigarette smoking, suggesting an indirect path wherein female adolescents who are high in AS physical concerns may learn to smoke to manage negative affect associated with bodily arousal. Given adolescence is a core-risk period for the onset of anxiety psychopathology (Beesdo, Knappe, & Pine, 2009), these findings point toward an important potential pathway to coping-related smoking among girls. These findings are also significant in light of evidence that although women smoke less than men (Dube, Asman, Malarcher, & Caraballo, 2009), they have more difficulty with cessation (Smith et al., 2015) and are more likely to use cigarettes for subjective (i.e., non-pharmacological) reasons (Perkins, Jacobs, Sanders, & Caggiula, 2002). Moreover, women endorse smoking for stress relief (Fidler & West, 2009) and negative affect reduction (Livson & Leino, 1988) at higher rates than men. These findings suggest one pathway by which these sex differences in smoking behavior may emerge. This is an important extension to the extant literature, which currently includes scant data regarding these processes among youth. Further, relative to an exclusive reliance on retrospective self-report measures, use of a VH procedure to elicit interoceptive arousal in the current study allowed for a more refined and methodologically sophisticated evaluation of the link between anxious arousal and coping-related smoking motives (e.g., reduced impact of memory bias; Nisbett & Ross, 1980).

Second, contrary to hypotheses, there was no significant indirect effect of self reported anxiety elicited by the VH on the relation between AS mental concerns and coping motives for cigarette smoking. Further, sex did not moderate this relation. There are a number of possible explanations for these results. First, developmental factors may be implicated. For instance, it is possible that adolescents have some limitations with regard to identifying cognitive processes (e.g., difficulty concentrating) and linking them to anxiety-relevant consequences (e.g., going crazy). Indeed, evidence suggests the ability to mentalize and think critically about thoughts continues to develop across the course of adolescence (Dumontheil, Apperly, & Blakemore, 2010). Second, the absence of an association between AS mental concerns and self-reported anxiety might be a function of the affect elicitation procedure utilized. It may be the case that the VH elicits robust physical (e.g., racing heart), but not mental (e.g., fear of going crazy) sensations. Indeed, previous work has failed to link the AS mental concerns factor to self-reported anxiety following the VH (Leen-Feldner et

al., 2005). Therefore, a study utilizing a task designed to elicit more cognitive aspects of anxiety (e.g., worry induction; Frala, Mischel, Knapp, Autry, & Leen-Feldner, 2014) may be more likely to obtain significant relations between AS mental concerns and anxious arousal elicited by the task (particularly for girls). Finally, there is a potential measurement concern. In contrast to the adult Anxiety Sensitivity Index (ASI)-3 (Taylor et al., 2007), which includes 6 items on each of the subscales, the CASI includes only 3 items assessing mental concerns (cf., 12 items for physical concerns). The relatively small number of items on the mental concerns subfactor likely contributes to the lower internal consistency observed for this subscale in the current study and in previous work with adolescents (Knapp et al., 2015; Walsh et al., 2004). Future research utilizing an expanded CASI is needed to better understand the potential role of AS-mental concerns as it relates to coping-related smoking motives.

Finally, following Rutter's (1994) recommendation, we proposed tests of non-replication. Such tests are essential for determining the extent to which a hypothesized causal mechanism has been correctly specified. As expected, there was no indirect relation of psychophysiological responding to the VH (i.e., skin conductance) on the relation between the AS factors and coping motives for cigarette smoking. The lack of an association between the AS factors and psychophysiological responding to the VH replicates previous findings (Leen-Feldner et al., 2005), and underscores the idea that it is not the bodily arousal per se (e.g., elevated skin conductance elicited by the challenge), but subjective anxiety in response to the arousal that is driving the indirect effects observed here. In addition, as hypothesized, there was no significant indirect association between the social concerns AS lower order factor and coping motives for cigarette smoking through either self-reported anxiety or physiological responding to the VH. Per Rutter's (1994) suggestion, these findings lay the foundation for testing causally oriented hypotheses, and developing more refined studies designed to evaluate processes directly involved in the development of coping motives for cigarette smoking.

A number of issues merit further consideration. First, the current study did not assess symptoms of nicotine withdrawal. Evidence suggests that AS may be both directly and indirectly related to symptoms of withdrawal through associations with coping motives and negative affect reduction expectancies among adult smokers (Farris, Leventhal, Schmidt, & Zvolensky, 2015). In addition, recent work among adult, treatment seeking daily smokers, demonstrated that AS amplifies the effects of abstinence on subjective nicotine withdrawal symptoms and smoking urges (Zvolensky, Farris, Guillot, & Leventhal, 2014). Further, among adult smokers, AS is indirectly associated with perceived barriers to smoking cessation through its association with "interoceptive threat" in the context of smoking abstinence expectancies (Farris, Langdon, DiBello, & Zvolensky, 2015), suggesting that AS may play a critical role in the cigarette withdrawal and relapse process. Links among AS, cigarette smoking, and withdrawal symptoms among adolescents are less clear. Compared to adults, adolescents report higher levels of tolerance to the negative effects of cigarettes, fewer symptoms of nicotine withdrawal, and less difficulty quitting cigarettes than adults (Strong, Schonbrun, Schaffran, Griesler, & Kandel, 2012). Therefore, although it is not clear whether high-AS female adolescents smoke to cope with symptoms of nicotine withdrawal (as opposed to anxiety-relevant sensations more generally), it is possible that they are at

increased risk of doing so as they enter adulthood compared to low-AS adolescents. As noted above, future work would benefit from explicitly examining these relations using nicotine administration paradigms. Second, this study was cross-sectional. While correlational, cross-sectional data is useful at this stage of research, it does not allow for causally-oriented hypothesis testing, and it precludes an examination of vulnerability processes over time. Key next steps include manipulation of AS (e.g., Mitchell, Capron, Raines, & Schmidt, 2014) and/or withdrawal symptoms and tracking their inter-relations across time. Third, the current study used a laboratory-based induction of bodily arousal to allow for a multi-modal (e.g., psychophysiological, self-report) assessment of panic-relevant responding. While the VH provides valuable insight into individual differences in anxious reactivity to bodily arousal, it does not reflect actual development of panic symptoms, or naturalistic symptoms of bodily arousal. Incorporating naturalistic methods will allow for a more complete picture of the factors studied here. Fourth, in light of its unique conceptual relevance to anxiety-related processes, coping motives for cigarette smoking were selected as the focus of the current study. Future work would benefit from examining other motives, including weight management, concentration, and identity-related motives. (cf. Guillot, Zvolensky, & Leventhal, 2015), For instance, an intriguing line of work could evaluate links among AS-mental concerns, concentration-related motives for cigarette smoking, and fearful reactivity to bodily arousal. Finally, this sample was homogenous (e.g., primarily Caucasian adolescents) who did not have a history of panic disorder and were paid to take part in a laboratory-based investigation. To improve generalizability of these findings and evaluate study hypotheses in the context of psychopathology, future work should include more diverse as well as clinical samples.

These limitations notwithstanding, the current study extended the literature by examining the relations among AS factors, anxious reactivity to a biological challenge procedure, sex, and coping motives for cigarette smoking among adolescent cigarette smokers. Findings suggested significant indirect associations of subjective anxious reactivity to the challenge (i.e., self-reported anxiety and physical panic attack symptoms) on the relation between AS physical concerns factors and coping motives for cigarette smoking among female adolescents. The results of the current study lay the groundwork for additional research targeted at improving our understanding of specific mechanisms that promote smoking to cope among adolescent cigarette smokers.

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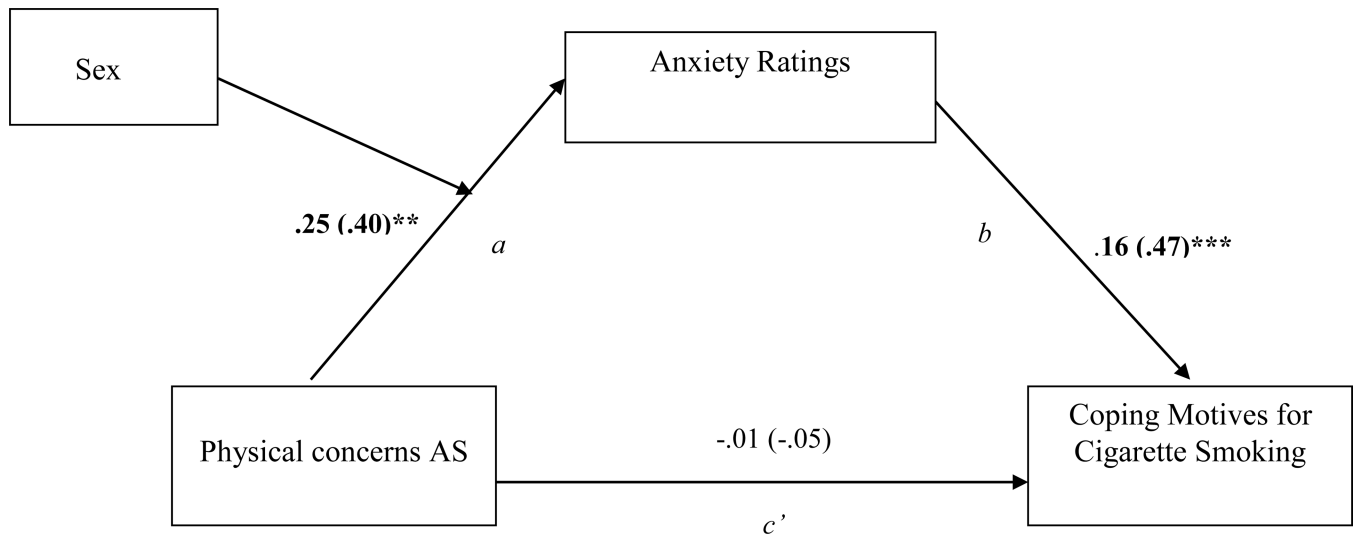


Figure 1.

A diagram of the moderated indirect effect model. The indirect effects model with anxiety ratings examined as a possible factor accounting for the relation between the physical concerns AS interacting with sex and coping motives for cigarette smoking. Unstandardized path coefficients are displayed, with corresponding standardized coefficients in parentheses. Significant paths are bolded.

Table 1

Sample Demographics and Smoking Characteristics by Sex

	Male	Female	Total
<i>N</i>	59	49	108
Age, <i>M (SD)</i>	15.85 (1.13)	15.51 (1.36)	15.69 (1.24)
Race, % Caucasian	81.4%	87.8%	85.0%
Race, % African American	8.5%	8.2%	8.4%
Race, % Native American/Alaska Native	6.8%	2.0%	4.7%
Race, % Other*	3.4%	N/A	1.9%
SES, % with family income of \$25,000 or less	35.7%	44.6%	39.8%
SES, % with family income of \$25,001 to \$45,00	22.1%	22.2%	22.3%
SES, % with family income of \$45,001 to \$75,00	5.1%	28.5%	15.8%
SES, % with family income of \$75,001 to \$99,999	8.5%	0%	4.7%
SES, % with family income of \$100,000 or above	22.1%	4%	13.9%
Number of cigarettes smoked per day, <i>M, (SD)</i>	4.06 (7.04)	4.16 (5.44)	4.11 (6.40)
Age of regular smoking initiation, <i>M, (SD)**</i>	14.23 (1.45)	14.73 (1.58)	14.25 (1.52)
Average number of years as a regular smoker, <i>M, (SD)**</i>	2.06 (1.56)	1.81 (1.09)	1.93 (1.33)
Alcohol Use, % (at least several times/month)	25.5%	26.5%	25.9%
Marijuana Use, % (at least several times/month)	27.2%	30.5%	28.8%
Amphetamine Use, % (at least several times/month)	3.4%	2.0%	2.8%
Hallucinogen Use, % (at least several times/month)	1.7%	0%	0.9%

* Note: 0.9% of participants declined to answer about race. SES: Socio Economic Status

** Note: Only 44 participants considered themselves regular smokers, therefore mean age of onset is only included for 44 participants

Table 2
Descriptive Statistics and Zero Order Correlations among Predictor, Indirect Effect, and Outcome Variables

	1.	2.	3.	4.	5.	6.	7.	8.
1. Baseline SR-A	1	.33***	.27**	.13	.50***	-.02	.12	.12
2. CASI: Physical		1	.59***	.19	.35***	.02	.18	.08
3. CASI: Mental			1	.13	.27**	-.00	.08	.19
4. CASI: Social				1	.05	.16	.09	-.08
5. Post Challenge: SR-A					1	.01	.10	.40***
6. Baseline SCL						1	.84***	.15
7. Post Challenge SCL							1	.20
8. TSMQ								1
<i>M</i>	3.41	16.99	3.80	4.80	12.16	15.40	1.80	1.80
<i>SD</i>	2.63	4.63	1.26	2.94	6.19	6.53	0.97	0.97

Note: N=108. SR-A: Self-Reported Anxiety; CASI: Child Anxiety Sensitivity Index; SCL: Skin Conductance Level; TSMQ: Teen Smoking Motive Questionnaire.

* $p < .05$

** $p < .01$

*** $p < .001$