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Shared versus specific features of psychological symptoms and cigarettes per day: structural relations and mediation by negative- and positive-reinforcement smoking

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Abstract This study examined the extent to which shared versus specific features across multiple manifestations of psychological symptoms (depression, anxiety, ADHD, aggression, alcohol misuse) associated with cigarettes per day. Subsequently, we investigated whether negative- (i.e., withdrawal relief) and positive- (i.e., pleasure enhancement) reinforcement smoking motivations mediated relations. Adult daily smokers ($N = 338$) completed self-report measures and structural equation modeling was used to construct a 3-factor (low positive affect-negative affect-disinhibition) model of affective and behavioral symptoms and to test relations of each latent factor (shared features) and indicator residual (specific features) to smoking level. Shared dimensions of low positive affect, negative affect, and disinhibition associated with smoking rate. Negative-reinforcement smoking mediated the link between latent negative affect and heavier daily smoking. Specific features of psychological symptoms unique from latent factors were generally not associated with cigarettes per day. Features shared across several forms of psychological symptoms appear to underpin relations between psychological symptoms and smoking rate.

Keywords Positive affect · Negative affect · Disinhibition · Negative reinforcement · Positive reinforcement · Cigarettes per day

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Introduction

The slowing rate of decline in cigarette smoking over the last decade (Centers for Disease Control and Prevention [CDC], 2012) has led to the speculation that a subgroup of smokers exist who are more likely to continue smoking or who have particular difficulties quitting (Irvin & Brandon, 2000), despite tobacco control efforts. Heavy smoking has been identified as a characteristic of this subgroup of smokers (Costa et al., 2010; Emery et al., 2000) due to research showing that heavier smokers are less likely to alter their smoking behavior, lack confidence in quitting, and have reduced cessation success (Hyland et al., 2004; Nordstrom et al., 2000). Heavier smoking is also associated with clinically relevant smoking factors, including more severe craving, withdrawal (Fidler et al., 2011), and nicotine dependence (Kandel & Chen, 2000), as well as risk for several diseases (Bazzano et al., 2003; Cheng et al., 2000; Law et al., 1997). As such, considerable research has sought to identify the correlates of heavier smoking to help develop prevention and treatment efforts to offset the public health burden of smoking.

One robust correlate of cigarettes per day (cigs/day) is psychological symptoms (Greenberg et al., 2012; Johnson et al., 2009; Kenney & Holahan, 2008; Kollins et al., 2005; Lasser et al., 2000). Most research on this relationship has examined psychological covariation with smoking frequency in samples mixed with both daily and non-daily smokers or in samples of daily smokers that include individuals who smoke as little as one cigarette per day. However, non-daily and very light smokers, whose smoking is primarily driven by external motivations (e.g., social purposes, sensory motives), are qualitatively different from heavier smokers who are often driven by internal or pharmacological motivations to smoke (e.g., avoid with-

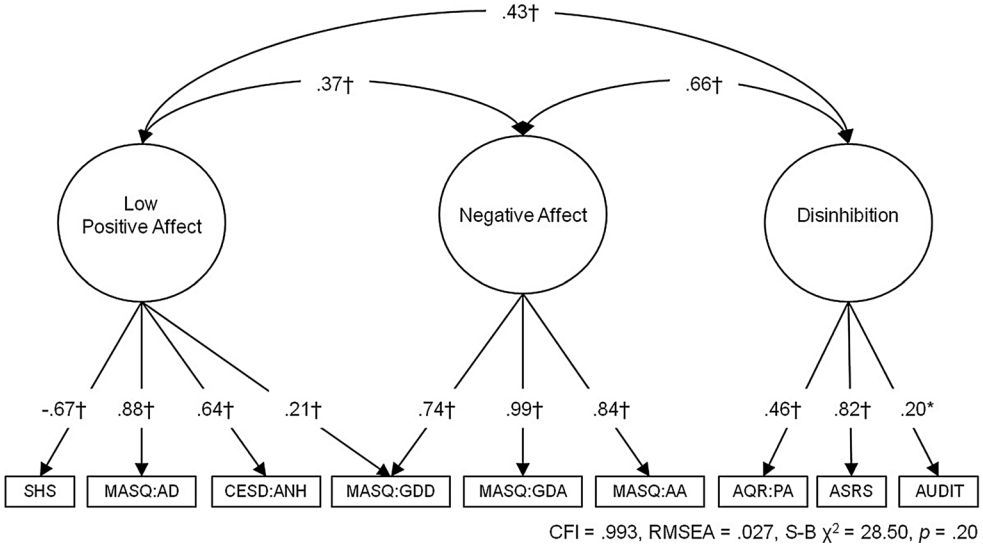

Fig. 1 Three-factor model of psychological symptoms. *SHS* Subjective Happiness Scale; *CESD:ANH* Center for Epidemiologic Studies Depression-Anhedonia Scale; *MASQ* Mood and Anxiety Symptom Questionnaire: *AD* Anhedonic Depression, *GDD* General Distress Depression, *GDA* General Distress Anxious, *AA* Anxious Arousal; *AQR:PA* Aggression Questionnaire Revised-Physical Aggression; *ASRS* Adult ADHD Self-Report Scale; *AUDIT* Alcohol Use Disorders Identification Test. All results are standardized. $*p < .05$, $**p < .01$, $^{\dagger}p < .001$

drawal, automaticity, reduce negative moods) (Shiffman et al., 2012). Therefore, examining relations between psychological symptoms and daily cigarette use specifically among the subgroup of moderate-to-heavy daily smokers (≥10 cigarettes smoked per day) may clarify important individual differences in psychological symptoms relevant to the higher end of the smoking spectrum.

Additionally, much of the research on psychological dysfunction and smoking heaviness has not accounted for psychological comorbidity (Clark et al., 1995). This creates barriers for interpreting which psychological constructs specifically associate with heavier smoking. Studies indicate that shared, latent liability factors likely account for psychological comorbidity (Brown & Barlow, 2009; Krueger & Markon, 2006). Hence, accounting for latent psychological factors may elucidate the extent to which relations with cigs/day are shared or specific to different manifest psychological symptoms. In prior work, we found that using confirmatory factor analysis, three latent dimensions (low positive affect, negative affect, disinhibition) accounted for the covariance among a set of affective and behavioral symptom scales - low happiness, anhedonia, depression, anxiety, anxious arousal, ADHD symptoms, physical aggression, and alcohol misuse (see Fig. 1; Ameringer, 2014) - for the current study sample.[1] These scales were chosen because they have shown relations with smoking (Audrain-McGovern et al., 2006; Kollins et al., 2005; Leventhal et al., 2008; Nabi et al., 2010) and are important components of different internalizing and externalizing disorders (Babor et al., 2001 [alcohol use]; Brown et al., 1998 [depressive and anxiety]; Fossati et al., 2007 [antisocial]; Gehricke & Shapiro, 2000 [depressive]; Kessler et al., 2005 [ADHD]; Mineka et al., 1998 [anxiety]) that associate with smoking (e.g., Lasser et al., 2000). These scales were also chosen because they overlap to a certain extent, both conceptually and empirically, and this overlap may identify shared latent constructs that are not apparent using the manifest scales. According to Clark's (2005) 3-factor model of psychopathology and personality, these latent factors may represent three temperament systems: (1) positive affect, the tendency to experience a range of positive emotions, which mainly inversely associates with depression (Clark & Watson, 1991), (2) negative affect, the tendency to experience a range of aversive emotions, which underlies a range of psychopathology (Clark & Watson, 1991), and (3) disinhibition, a lack of restraint in response to incoming stimuli, which underlies the externalizing disorders (Krueger & Piasecki, 2002).

Incorporating this model and directly testing associations of the latent factors (shared psychological features) and the residuals of the manifest scales (specific features) with daily cigarette use can help tease apart which components of

[1] In this study, this 3-factor model outperformed a 1-factor (general psychological maladjustment) and a 2-factor (internalizing-externalizing) model. The scales were selected to provide adequate representation of constructs that could map onto any one of these three models. The cross-loading of the general depression scale (MASQ:GDD) on the low positive affect factor in this 3-factor model was based on modification indices output in Mplus v6.

psychological symptoms associate with smoking rate. If results show associations mainly with shared psychological features, this may indicate that underlying liabilities to developing different manifest psychological symptoms (e.g., maladaptive temperament systems) directly associate with smoking rate, irrespective of the influence of a particular manifest syndrome. On the other hand, associations with specific psychological features would provide insight into particular aspects of specific manifest syndromes (e.g., somatic symptoms of anxiety) that may be uniquely important for heavier smoking. This type of analysis is also beneficial because simultaneously testing associations of different types of psychological constructs to smoking rate can reveal suppressor effects, which occur when two correlated predictors have opposing relations with the dependent variable (Paulhus et al., 2004). For example, Paulhus et al. (2004) found that independent relations between guilt and shame with aggression increased in opposite directions (negatively for guilt and positively for shame) when both factors were included in a model as predictors. Thus, including multiple forms of psychological constructs in the same model may unearth links between pure forms of psychological symptoms and smoking level.

It is also important to understand mechanisms underlying links between psychological symptoms and cigs/day to identify factors that can be targeted in treatment. Individuals with more severe psychological symptoms may be motivated to smoke at heavier rates to control their underlying symptoms (Pomerleau & Pomerleau, 1984). This is supported by the ability of nicotine to target a range of affective and behavioral symptoms (e.g., increase arousal, alleviate emotional distress, improve attention and inhibition; Heishman et al., 2010; Picciotto et al., 2002; Potter & Newhouse, 2004). In turn, the successful alleviation of these symptoms may reinforce future and heavier smoking as individuals learn to rely on smoking to manage their symptoms (Eissenberg, 2004; Glautier, 2004). Smoking reinforcement motivations can be broadly classified as either negative (terminating/avoiding negative outcomes; e.g., "Cigarettes help me deal with anxiety or worry") or positive (producing positive outcomes; e.g., "I smoke to get a sense of euphoria") (Pomerleau, Fagerstrom et al., 2003). Studies have found support for a mediational path among these constructs, such that reporting higher motivation to smoke for reinforcement purposes mediated links between more severe psychological symptoms (e.g., depressed mood, trait anxiety) and heavier, more dependent smoking (Audrain et al., 1998; Lerman et al., 1996). However, these studies have not parsed the relative roles of shared versus specific features of psychological symptoms in these relations.

The present study aimed to: (1) use a structural model to investigate the extent to which relations with smoking heaviness are attributable to shared versus specific features of psychological symptoms, and (2) examine whether negative- and positive-reinforcement smoking motivations mediate links between psychological symptoms and daily smoking level. These relations were tested among adult smokers who report moderate to heavy smoking ($\geq$10 cigs/day). Based on prior research illustrating stronger relations between shared (vs. specific) features of internalizing syndromes and alcohol dependence (Kushner et al., 2012), we hypothesized that shared, latent features of psychological symptoms would primarily associate with heavier smoking. Based on studies previously reviewed (Audrain et al., 1998; Lerman et al., 1996), we hypothesized that reinforcement smoking motivations would mediate relations between psychological symptoms and heavier smoking.

Methods

This study used a cross-sectional design and is a secondary analysis from an investigation of the relation between psychological symptoms and tobacco deprivation effects (Leventhal et al., 2014).

Participants and procedures

Participants were adult smokers recruited through community advertisements (e.g., newspaper, online advertisements) and referrals. Inclusion criteria were: (1) $\geq$18 years of age, (2) report regular cigarette smoking consistently for at least the past 2 years, (3) currently smoke $\geq$10 cigs/day, (4) normal or corrected-to-normal vision with no color blindness and (5) fluent in English. Exclusion criteria were: (1) active *DSM-IV* non-nicotine substance dependence, (2) current *DSM-IV* mood disorder or psychotic symptoms (to minimize cognition-impairing effects of acute and severe psychiatric dysfunction) based on the Structured Clinical Interview for DSM-IV-Axis I Disorders, Research Version, Non-Patient Edition (SCID-I/NP; First et al., 2002), (3) breath carbon monoxide (CO) levels $<$ 10 ppm at intake, which was used as a biochemical confirmation of smoking status (SRNT Subcommittee on Biochemical Verification, 2002), (4) use of non-cigarette forms of tobacco or nicotine products, (5) use of psychiatric medications, or (6) pregnant. Participants were compensated \$204–\$212 for completing the entire study (range due to performance on tasks not included in this study). The study was approved by the University of Southern California's Institutional Review Board.

Following a phone screen, participants attended an in-person baseline session involving informed consent, breath CO analysis, psychiatric screening interview by a trained research assistant, and self-report measures of psycholog-

ical symptoms and smoking. Of the 515 smokers recruited, 165 were ineligible due to: low baseline CO ($N = 103$), current psychiatric disorder ($N = 39$), or other criteria ($N = 23$). Of the 350 eligible participants, 7 declined to participate and 5 were removed due to inconsistent responses to cigs/day across different measures (see Measures (Dependent variable) section), leaving a final sample of 338 who were included in analyses.

Measures

All measures were self-report and administered once during the study session. A Personal Information Questionnaire was given to collect demographic information (e.g., age, gender, ethnicity).

Independent variables: psychological symptom scales

The Subjective Happiness Scale (SHS; Lyubomirsky & Lepper, 1999) is a 4-item measure of global subjective happiness based on what the participant feels is the most accurate description of them. Items are rated on a 7-point scale. A mean score across the items was computed, with greater scores indicating higher global subjective happiness.

The Center for Epidemiologic Studies Depression Scale: Anhedonia Subscale (CESD:ANH; Radloff, 1977) is a subscale on the 20-item CESD and contains 4 reverse-scored items relating to feelings of happiness and hopefulness, which were averaged to create a mean score. Participants rate how often they have felt a certain way "during the past week" on a 4-point scale. A higher score indicates more severe depressive symptomatology. Confirmatory factor analyses have supported the CESD:ANH subscale (Shafer, 2006) and prior studies have shown this subscale associates with smoking characteristics (Leventhal et al., 2008; Pomerleau, Zucker et al., 2003).

The Mood and Anxiety Symptom Questionnaire-Short Form (MASQ-SF; Watson, Clark, et al., 1995; Watson, Weber, et al., 1995) is a 62-item measure of affective symptoms. Participants rate how much they experienced symptoms "during the past week, including today" (1 = Not at all to 5 = Extremely). The MASQ contains four subscales: (1) Anxious Arousal (MASQ:AA), a measure of somatic tension and hyperarousal, (2) Anhedonic Depression (MASQ:AD), a measure of loss of interest in life, with reverse-keyed items measuring positive affect, (3) General Distress-Depression (MASQ:GDD), a measure of non-specific depressed mood experienced in depression and anxiety, and (4) General Distress-Anxiety (MASQ:GDA), a measure of non-specific anxious mood experienced in anxiety and depression. Sum scores were calculated for the scales, and higher scores reflect greater depressive and anxious symptoms.

The Aggression Questionnaire-Revised: Physical Aggression (AQR:PA; Bryant & Smith, 2001) is a 3-item subscale on the 12-item Aggression Questionnaire-Revised that assesses disposition to physical aggression. Confirmatory factor analysis has supported this subscale (Bryant & Smith, 2001). Participants rate how characteristic statements are of them on a 6-point scale, with higher ratings indicating greater disposition to physical aggression. A mean score across the items was computed.

The Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005) is measure of ADHD symptoms in adults and contains 9 inattentive items and 9 hyperactive-impulsive items. Participants rate how often they have felt and conducted themselves over the past 6 months (1 = Never to 5 = Very often). Following prior work (Kessler et al., 2005), a total mean score was calculated across the 18 items. Greater scores indicate more severe ADHD (inattentive and hyperactive-impulsive) symptoms.

The Alcohol Use Disorders Identification Test (AUDIT; Babor et al., 2001) is a 10-item measure of hazardous alcohol use, alcohol dependence symptoms, and harmful alcohol use and primarily focuses on past-year behaviors and experiences. Response options range from 0 to 4, with higher scores reflecting more problematic alcohol use. Participants received a sum score for the scale.

Mediator variables

The Minnesota Nicotine Reinforcement Questionnaire (MNRQ; Pomerleau, Fagerstrom, et al., 2003) is a 13-item self-report measure of smoking for negative reinforcement (MNRQ:NR; 8 items) and positive reinforcement (MNRQ:PR; 5 items). Participants rate the extent to which they agree with or experience several statements (e.g., "I crave a cigarette to provide relief from withdrawal"—negative reinforcement, or "I smoke because it is pleasurable"—positive reinforcement) on a 4-point scale (0 = Never to 3 = Always). A mean score for each scale was computed. Higher scores indicate greater endorsement of smoking for negative- and positive-reinforcement.

Dependent variable

The Smoking History Questionnaire (Brown et al., 2002) was given to assess self-report number of cigarettes smoked per day. Participants wrote one number in response to the question, "How many cigarettes do you smoke on a normal day?" Participants also completed the FTND (Heatherton et al., 1991), which includes one item that categorically asks participants how many cigarattes per day

they smoke (10 or less, 11–20, 21–30, or 31 or more). We used the continuous cigs/day variable on the *Smoking History Questionnaire* to allow for increased response variability; however, the FTND was used to determine whether individuals inconsistently reported their cigarette use across the measures and should be excluded due to unreliability ($N = 5$).

Data analysis

Preliminary analyses

To examine representativeness and psychological severity of the sample, scale scores were compared to similar samples and the portion that scored above established cut-points on relevant scales (MASQ: mean score ≥1.8 on the MASQ:GDD, MASQ:GDA, and MASQ:AA, and ≥2.3 on the MASQ:AD, Schulte-van Maaren et al., 2012; ASRS: sum score ≥9, Kessler et al., 2005; AUDIT: sum score ≥8, Babor et al., 2001) were calculated. The portion that scored above the cutoff scores is presented to provide descriptive information; continuous scale scores were used in all models.

Because certain psychological symptom scales were added throughout the study, participants in the early months of the study were not administered some of the psychological measures. As a result, there is a range of missing data across these measures. Out of 338, complete *N*s for the scales are: SHS = 324, CESD = 338, MASQ = 324, AQR = 238, ASRS = 220, AUDIT = 178. Independent t-tests for each of the scales revealed no significant differences in cigs/day between those who missed the scale and those who did not miss the scale. Preliminary analyses were performed in SAS v9.2 (2009). To handle missing data for preliminary analyses, multiple imputation (using proc mi and proc mianalyze) with 10 imputations was used to calculate means, standard deviations, and correlations. In order to combine estimated correlation coefficients across the imputations to account for variability, a Fisher's z transformation (Fisher, 1932; Van Buuren, 2012) was applied to the estimated correlation coefficients.

Primary analyses: structural equation models

All structural equation model (SEM) analyses were conducted in Mplus v6 (Muthen & Muthen, 1998–2010), based on the analysis of covariance, and used maximum likelihood (ML) estimation, which is recommended to handle missing data in SEM (Allison, 2003). Hence, the full sample ($N = 338$) was used for primary analyses. Because certain measures were skewed, ML estimation with robust standard errors (MLR) was used to account for potential multivariate non-normality. Acceptable model fit was based on (1) a non-significant Satorra-Bentler scaled Chi square statistic (S–B $\chi 2$; Satorra & Bentler, 1994), which is considered more appropriate when data are not normally distributed (Chou et al., 1991), (2) a comparative fit index (CFI) > .95, and (3) a root mean-square error of approximation (RMSEA) <.06 (Hu & Bentler, 1999).

To test relations between shared features of psychological symptoms and smoking level, paths from the latent factors to cigs/day were included in the model. These paths were first added separately to test their independent relations and then all paths were added simultaneously to examine their unique associations (i.e., relations after adjusting for the covariance among the factors). Next, paths from the residuals of each manifest scale to cigs/day were added, one at a time, to test specific relations between psychological symptoms and smoking rate, after controlling for the influence of the latent factors. Similar to prior work (Kushner et al., 2012; South et al., 2011), we generated the residuals for each scale and regressed cigs/day on the residuals following steps for Mplus (Muthen & Muthen, "Regressing on a Residual," n.d.). After establishing relations between the latent factors and residuals with cigs/day, the reinforcement smoking scales were added to the model to test whether they mediated any links. The model indirect command in Mplus was used to obtain the indirect and total effects. Mplus uses the delta method to calculate the indirect effects (MacKinnon, 2008; Muthen & Muthen, "Delta Method and Sobel," n.d.). Total effects are the combination of the direct and indirect effects. Primary results are reported as standardized beta weights (βs), tests are two-tailed, and significance was set at $p < .05$.

Results

Preliminary results

Participants were an average of 43.7 ($SD = 10.8$) years of age, primarily male (68 %), were: 51 % Black, Non-Hispanic, 30 % White, Non-Hispanic, 4 % Multiracial, Non-Hispanic, 14 % Hispanic, and 1 % Asian, and reported smoking approximately 16.8 ($SD = 6.8$) cigs/day. Although inclusion criteria were to report smoking ≥10 cigs/day on the phone screen and to pass a baseline CO level ≥10 ppm, some individuals ($N = 22$) reported smoking less than 10 cigs/day on the *Smoking History Questionnaire*. This resulted in a reported range of 6–60 cigs/day. Table 1 displays descriptive statistics for the variables in the models. Scores on many of the psychological symptom scales reflected low severity, high

Table 1 Descriptive statistics and correlations of psychological symptom scales, reinforcement smoking scales, and cigarettes per day

	M (SD)	1	2	3	4	5	6	7	8	9	10	11	12
1. SHS	5.28 (1.07)	(.76)											
2. CESD:ANH	.72 (.65)	−.47†	(.67)										
3. MASQ:AD	52.58 (14.11)	−.68†	.64†	(.89)									
4. MASQ:GDD	17.55 (7.13)	−.35†	.31†	.46†	(.92)								
5. MASQ:GDA	15.15 (5.62)	−.27†	.22†	.32†	.81†	(.87)							
6. MASQ:AA	21.66 (7.04)	−.24†	.19†	.28†	.81†	.83†	(.89)						
7. AQR:PA	1.82 (1.16)	−.15**	.14*	.11	.26†	.31†	.35†	(.77)					
8. ASRS	2.16 (.67)	−.21†	.22†	.34†	.46†	.58†	.53†	.38†	(.92)				
9. AUDIT	3.55 (7.08)	−.03	.12	.01	.08	.05	.08	.27†	.17*	(.88)			
10. MNRQ:NR	1.23 (.61)	−.07	.01	.08	.20†	.28†	.28†	.08	.16*	−.11	(.75)		
11. MNRQ:PR	1.60 (.64)	.12*	−.06	−.13*	.01	.04	.04	.05	−.04	.03	.39†	(.81)	
12. Cigs/Day	16.74 (6.99)	−.13*	.11*	.12*	.12*	.11	.13*	.01	−.07	−.19*	.29†	.22†	–

$N = 338$. M (SD) = mean (SD). Standardized Cronbach's α on the diagonal

SHS Subjective Happiness Scale, *CESD:ANH* Center for Epidemiologic Studies Depression-Anhedonia Scale, *MASQ* Mood and Anxiety Symptom Questionnaire, *AD* Anhedonic Depression Scale, *GDD* General Distress Depression Scale, *GDA* General Distress Anxious Scale, *AA* Anxious Arousal Scale, *AQR:PA* Aggression Questionnaire Revised-Physical Aggression Scale, *ASRS* Adult ADHD Self-Report Scale, *AUDIT* Alcohol Use Disorders Identification Test, *MNRQ* Minnesota Nicotine Reinforcement Questionnaire: *NR* negative reinforcement, *PR* positive reinforcement, *Cigs/Day* number of cigarettes smoked per day

* $p < .05$, ** $p < .01$, † $p < .001$

between-participant variability, and were generally comparable to similar samples (Gerevich et al., 2007 [AQR:PA]; Leventhal et al., 2008 [CESD:ANH]; Lyubomirsky & Lepper, 1999 [SHS]; Watson, Clark et al., 1995 [MASQ]). The percentage of those who scored above established clinically relevant cut-off points on questionnaires were: CESD:ANH = 34.3 %, MASQ:AD = 54.9 %, MASQ:GDD = 19.4 %, MASQ:GDA = 13.36 %, MASQ:AA = 8.0 %, ASRS = 8.7 %, and AUDIT = 9.9 %.

Primary results

When paths from each of the latent factors were entered independently in the model, low positive affect significantly associated with heavier smoking ($\beta = .16, p < .01$); neither negative affect ($\beta = .12$) nor disinhibition ($\beta = .05$) associations were significant. However, when paths from low positive affect, negative affect, and disinhibition were simultaneously included in the model, negative affect became positively associated with cigs/day ($\beta = .24$, $p < .05$) and disinhibition became inversely associated with cigs/day ($\beta = -.31$, $p < .01$). In other words, individuals who reported higher negative affect indicated smoking more cigs/day whereas individuals who reported higher disinhibition, or a lower ability to control behavioral impulses, endorsed smoking fewer cigs/day. This indicates that shared variance among the factors may have suppressed effects between pure, partialled factors of negative affect and disinhibition with smoking rate. Low positive affect maintained significance with daily cigarette use ($\beta = .21$, $p < .05$). When each scale residual was added to the model, only the AUDIT residual significantly (inversely) associated with smoking rate beyond the latent factors. Inclusion of this residual reduced the association between negative affect and heavier smoking to a non-significant trend; relations between low positive affect, disinhibition, and smoking rate remained significant. We kept the path between negative affect and cigs/day in the final model (Fig. 2) since including this path is necessary to account for the potential suppressor effect between negative affect and disinhibition with cigs/day and because the reduction in strength was small. Age, gender, and race (reduced into categories of: White, Black, and Other) were not significantly associated with smoking rate in the structural model and yielded no substantive changes to the results; thus, they were not included as covariates in the final model.

All direct, indirect, and total effects for the reinforcement smoking model are shown in Table 2 and Fig. 3. Low positive affect, disinhibition, and the AUDIT residual did not associate with negative-reinforcement smoking, and no significant indirect effects were found for these paths. On the other hand, negative affect positively associated with negative-reinforcement smoking, which in turn associated with heavier smoking. The indirect effect of this path was significant. Negative affect, disinhibition, and the AUDIT residual did not associate with positive-reinforcement smoking. However, low positive affect inversely associated with positive-reinforcement smoking (i.e., lower positive affect → lower positive-reinforcement smoking), which in

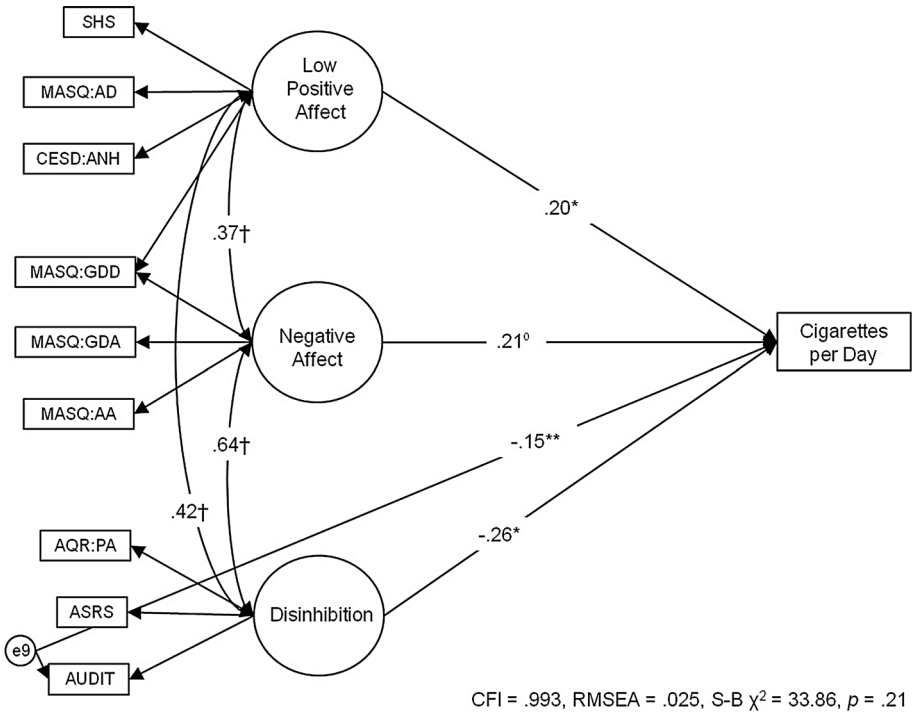

Fig. 2 Final model of relations between latent factors and residuals with cigarettes per day. *SHS* Subjective Happiness Scale; *CESD:ANH* Center for Epidemiologic Studies Depression-Anhedonia Scale; *MASQ* Mood and Anxiety Symptom Questionnaire: *AD* Anhedonic Depression, *GDD* General Distress Depression, *GDA* General Distress Anxious, *AA* Anxious Arousal; *AQR:PA* Aggression Questionnaire Revised-Physical Aggression Scale; *ASRS* Adult ADHD Self-Report Scale; *AUDIT* Alcohol Use Disorders Identification Test. *E9* residual term for the AUDIT. All results are standardized. Paths that were not applicable or were omitted by the final model are not shown. $^{\circ}p < .10$, $^{*}p < .05$, $^{**}p < .01$, $^{\dagger}p < .001$

turn associated with heavier smoking. Accounting for this mediator strengthened the relation between low positive affect and cigs/day, indicating that smoking for positive reinforcement may have suppressed a stronger link between low positive affect and heavier smoking.

Discussion

Shared and specific relationships between psychological symptoms and cigarettes per day

Consistent with our hypothesis, shared (versus specific) features of psychological symptoms primarily associated with cigarettes per day. Lower positive affect and higher negative affect associated with heavier smoking, although the later relation dropped below significance after including the residual of the alcohol use disorder scale in the model. Because none of their respective indicators associated with smoking rate, it appears that the latent dimensions of low positive and high negative affect associated with smoking level regardless of the impact of any specific manifest internalizing symptom. These results suggest that underlying maladaptive positive and negative temperament systems may directly influence heavier smoking and provide an important context for interpreting prior studies that found that several different forms of manifest affective and anxious symptoms associated with heavier smoking (Greenberg et al., 2012; Johnson et al., 2009; Kenney & Holahan, 2008; Lasser et al., 2000). As such, focusing on the underlying dimensions of internalizing symptoms, instead of the many manifest internalizing symptoms, may provide a more fundamental and parsimonious way to interpret and to address this relationship.

After accounting for the influence of low positive affect and negative affect, disinhibition inversely associated with smoking rate, indicating that as individuals reported higher disinhibition, or less constraint in response to incoming stimuli, they reported smoking *fewer* cigs/day. Given that the latent disinhibition factor is hypothesized to underlie the externalizing disorders (Kreuger & Piasecki, 2002), this finding is surprising since studies have generally shown positive associations between different externalizing symptoms and cigs/day (Grano et al., 2004 [alcohol use]; Kollins et al., 2005 [ADHD symptoms]; Shekelle et al., 1983 [hostility]). Two key differences between this study and these studies may account for the discrepant findings.

Table 2 Direct, indirect, and total effect results from the reinforcement smoking mediation model

Predictors	Outcomes		
	MNRQ:NR β	MNRQ:PR β	Cigs/Day β
Low positive affect			
Direct effect	−.04	**−.17***	**.23****
Indirect effect → NR	–	–	−.01
Indirect effect → PR	–	–	−.03
Total effect	−.04	**−.17***	**.20***
Negative affect			
Direct effect	**.25****	.14	.12
Indirect effect → NR	–	–	**.05***
Indirect effect → PR	–	–	.02
Total effect	**.25****	.14	.20
Disinhibition			
Direct effect	.06	−.05	**−.26***
Indirect effect → NR	–	–	.01
Indirect effect → PR	–	–	−.01
Total effect	.06	−.05	**−.25***
AUDIT residual			
Direct effect	−.10	.05	**−.14****
Indirect effect → NR	–	–	−.02
Indirect effect → PR	–	–	.01
Total effect	−.10	.05	**−.15****
MNRQ:NR	–	**.39**†	**.21**†
MNRQ:PR	**.39**†	–	**.16****
R^2	**.09****	.03	**.18**†

$N = 338$. β = beta weights (standardized regression coefficients)

Indirect effect → NR means the indirect effect of the path through negative reinforcement. Paths that were not applicable or were omitted by the final model are not reported. Significant findings are in bold

MNRQ Minnesota Nicotine Reinforcement Questionnaire, *NR* negative reinforcement, *PR* positive reinforcement, *AUDIT* Alcohol Use Disorders Identification Test, *Residual* portion of the AUDIT that is independent from the latent factors, *Cigs/Day* average number of cigarettes smoked per day. *R* amount of variance explained in the index variable by all of the variables in the model

* $p < .05$, ** $p < .01$, † $p < .001$

First, this study only included smokers who reported at least moderate levels of daily smoking, whereas the other studies included individuals who smoked as little as one cig/day. Thus, it may be that disinhibition, or less control over behavioral impulses, associates with greater cigs/day at lighter smoking levels (e.g., <10 cigs/day) but fewer cigs/day at heavier smoking levels (e.g., ≥10 cigs/day). Future empirical work could address this by examining whether quadratic effects are present between disinhibition and daily cigarette use across the entire range of cigs/day.

Second, these prior studies did not adjust for comorbid psychological symptoms. In this study, relations between disinhibition, negative affect, and daily cigarette use were only significant when paths from all latent factors were in the model. This suggests that covariance among the latent factors may have suppressed these associations and that there may be relations between pure forms of psychological symptoms and smoking that are not apparent until after accounting for psychological comorbidity. For example, individuals with pure features of disinhibition (i.e., features separate from shared covariance with negative or low positive affect, such as compulsivity, poor control, low persistence) may be motivated to smoke in response to specific situations that require increased attention or reduced inhibition (e.g., when completing a task), rather than needing to smoke heavily throughout the day. However, due to the unexpected nature of this finding and limited prior research modeling multiple latent psychological constructs in relation to smoking, it is unclear whether this suppressor effect will replicate in similar samples. This finding should be interpreted with caution prior to future replication.

In addition to disinhibition, the residual of the alcohol use disorder symptom scale inversely related to smoking level, indicating that something particular about this indicator, apart from the shared variance in generalized impulse control with ADHD symptoms and physical aggression, was important for this relation. Potentially, this finding reflects individuals who smoke specifically when drinking and therefore tend to have lighter patterns of daily smoking. However, because alcohol use levels were low, it is unclear how these results will generalize to more severe levels of harmful alcohol use.

Negative- and positive-reinforcement smoking as mediators

Consistent with past research (Cohen et al., 2002; Lerman et al., 1996), negative- reinforcement smoking mediated the link between latent negative affect and heavier smoking. As the negative reinforcement scale in this study mainly assesses nicotine withdrawal symptoms, this mediation model may accord with a withdrawal-based negative reinforcement model. That is, individuals with elevated negative affect may smoke more heavily to avoid or to attenuate withdrawal symptoms (Baker et al., 2004). One reason for a greater motivation to smoke to avoid nicotine withdrawal among individuals with heightened negative affect may be that they are more likely to experience more severe withdrawal (e.g., Breslau et al., 1992; Weinberger et al., 2010).

In contrast to our hypothesis, positive-reinforcement smoking did not mediate any links between psychological

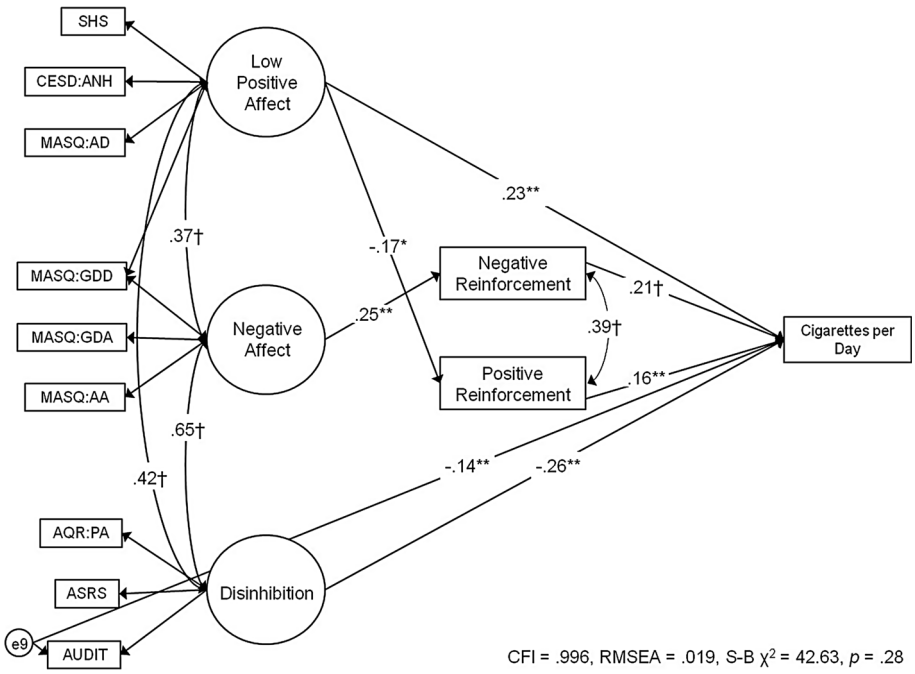

Fig. 3 Reinforcement smoking mediation model. *SHS* Subjective Happiness Scale; *CESD:ANH* Center for Epidemiologic Studies Depression-Anhedonia Scale; *MASQ* Mood and Anxiety Symptom Questionnaire: *AD* Anhedonic Depression, *GDD* General Distress Depression, *GDA* General Distress Anxious, *AA* Anxious Arousal; *AQR:PA* Aggression Questionnaire Revised-Physical Aggression Scale; *ASRS* Adult ADHD Self-Report Scale; *AUDIT* Alcohol Use Disorders Identification Test. *MNRQ* Minnesota Nicotine Reinforcement Questionnaire: *NR* Negative Reinforcement, *PR* Positive Reinforcement. *E9* residual term for the AUDIT. All results are standardized. Paths that were non-significant, not applicable, or were omitted by the final model are not shown. *$p < .05$, **$p < .01$, †$p < .001$

symptoms and daily cigarette use. In fact, this mediator suppressed a more robust relation between low positive affect and heavier smoking. Perhaps individuals with low positive affect perceive experiencing low pleasure from smoking due to their inherent diminished reward capacity and tendency to experience most positive reinforcers, including smoking, as less pleasurable (Hasler et al., 2004; Pizzagalli et al., 2005). However, prior work examining the real-time effects of smoking has shown that anhedonic individuals actually experience greater positive affect enhancement from nicotine (Cook et al., 2007). Research examining whether low positive affect modulates real-time effects of smoking on mood would clarify this. The suppressor effect showed that after partialling out variation due to individuals with low positive affect who reported greater motivation to smoke for positive reinforcement, the relationship between low positive affect and cigs/day became stronger. Hence, it is clear that there are likely other key mediators underlying the link between low positive affect and heavier smoking. For example, it may be that individuals with low positive affect are mainly driven by primary dependence motives (e.g., tolerance automaticity, loss of control) that are associated with heavier smoking patterns (Piper et al., 2008).

Limitations and conclusions

Several limitations should be considered when interpreting these results. First, all measures were self-report and therefore are subject to several biases (e.g., recall and self-awareness). Second, the measures captured different time periods (i.e., in general [AQR:PA], past week [MASQ], longer durations [AUDIT]), and scales which measured past-week symptoms may not be representative of a participant's typical response. Hence, these different timeframes may serve as a threat to validity, such that results may vary as a function of the timeframes assessed. Therefore, interpretations are limited to the timeframes used in this study. Third, the outcome variable was based on a single item: cigs/day. Although smoking rate is of public health importance due to associations with continued smoking behavior and quitting difficulties (Hyland et al., 2004; Nordstrom et al., 2000) and with several types of disease (Bazzano et al., 2003; Cheng et al., 2000; Law et al., 1997), assessments of cigs/day over many days would have been preferable to ensure greater accuracy. Additionally, these results are limited to the moderate-to-heavy end of smoking. Although this provides unique insight into psychological variation across this upper range, these results may not generalize to light smokers.

Fourth, the psychological symptom scales were chosen because they are associated with mental disorders (depressive, anxious, disruptive behavior, alcohol use) that have been linked to smoking (Lasser et al., 2000). However, several different types of symptoms (e.g., cognitive, psychotic, personality) could have been included that may have changed the model structure and subsequent results. Additionally, the loading of the AUDIT on the disinhibition factor was low, indicating this scale provides limited representation of the disinhibition factor. We chose to keep this scale in the model because the model fit well, this scale did not load onto any other indicator, and past research indicates alcohol use disorder loads on a latent externalizing factor (Krueger & Markon, 2006). Fifth, current use of psychiatric medications or current mood or substance dependence excluded individuals from the study, which could have influenced the pattern of results. Hence, conclusions are restricted to the low to moderate range of psychological symptoms. However, past research showing relations between psychological symptoms and smoking at low levels or in individuals that do not have the respective current disorder (e.g., Niaura et al., 2001; Leventhal et al., 2008) illustrates the importance of this subclinical range of symptoms. Sixth, the cross-sectional design of this study does not allow for temporal or causal conclusions. Last, larger sample sizes are ideal for structural equation modeling and should be used to validate the current findings.

Limitations notwithstanding, this type of analysis is important to aid in the development of more efficient screening assessments of psychological variation in regular cigarette smokers. These results suggest that evaluating dimensions of negative and low positive affect, instead of the many different manifest internalizing disorders, may be most parsimonious and informative. Future work to identify assessment algorithms to tap these latent dimensions in smokers is warranted. Relatedly, smoking cessation interventions that seek to alleviate negative affect and enhance positive affect may be effective transdiagnostic strategies for reducing smoking rate. For example, interventions that work to increase tolerance of and manage reactions to aversive internal states (e.g., Brown et al., 2008) may be useful for different internalizing disorders comprised of negative affect. Future work elucidating mechanisms underlying the relation between low positive affect and cigarette use will provide insight into strategies that may offset this link. These results also illustrate the possibility that the influence of externalizing symptoms on smoking rate may not be uniform across the entire range of cigs/day, especially after accounting for comorbid psychological symptoms. Overall, this research highlights the complexity of explaining how a broad spectrum of psychological symptoms may drive heavier smoking and underscores the utility to examining multiple psychopathologies simultaneously in relation to smoking behaviors.

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Conflict of interest Katherine J. Ameringer, Chih-Ping Chou, and Adam M. Leventhal declare no conflicts of interest.

Human rights and Informed Consent All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

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