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Obsessive-compulsive symptoms and negative affect during tobacco withdrawal in a non-clinical sample of African American smokers

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ABSTRACT

The association between obsessive-compulsive (OC) symptomatology and smoking is poorly understood, particularly in African Americans—a group subject to smoking- and OC-related health disparities. In a non-clinical sample of 253 African American smokers, we tested the negative reinforcement model of OC-smoking comorbidity, purporting that smokers with higher OC symptoms experience greater negative affect (NA) and urge to smoke for NA suppression upon acute tobacco abstinence. Following a baseline visit involving OC assessment, participants completed two counterbalanced experimental visits (non-abstinent vs. 16-h tobacco abstinence) involving affect, smoking urge, and nicotine withdrawal assessment. OC symptom severity predicted larger abstinence-provoked increases in overall NA, anger, anxiety, depression, fatigue, urge to smoke to suppress NA, and composite nicotine withdrawal symptom index. African American smokers with elevated OC symptoms appear to be vulnerable to negative reinforcement-mediated smoking motivation and may benefit from cessation treatments that diminish NA or the urge to quell NA via smoking.

1. Introduction

Obsessive-Compulsive (OC) symptoms—a collection of psychopathological features involving repetitive behaviors or mental acts (i.e., compulsions) that serve to alleviate anxiety or distress caused by persistent, recurrent, and intrusive thoughts, images, or urges (i.e., obsessions; American Psychiatric Association, 2013)—is understudied in the African American population. While prevalence of the Diagnostic and Statistical Manual of Mental Disorders (DSM) obsessive-compulsive disorder (OCD) diagnosis appears to be similar among African Americans and other racial groups (African Americans 2.3% vs. Whites 2.6%, Zhang & Snowden, 1999; African Americans 1.6% vs. Whites 1.6%, Himle et al., 2008; Kessler et al., 2005), African Americans have been demonstrated to experience higher levels of certain OC symptom subtypes (e.g., cleaning, checking, fears of contamination; Wheaton, Berman, Fabricant, & Abramowitz, 2013; Thomas, Turkheimer, & Oltmanns, 2000; Williams & Turkheimer, 2007; Williams, Turkheimer, Magee, & Guterbock, 2008) than other racial groups. Possible racial differences in symptom-level variance by race is important, as OC symptoms have been shown to lie on a continuum in the general population (Mataix-Cols, Rosario-Campos, & Leckman, 2005; Murphy, Timpano, Wheaton, Greenberg, & Miguel, 2010), with a sizeable proportion of the general population endorsing some OC symptoms (without surpassing diagnostic thresholds) and experiencing distress and impairment from subclinical OC symptoms (Apter et al., 1996; Spinella, 2005). On top of differences in symptom expression, African Americans are less likely to receive quality mental healthcare than Whites for OC symptoms (National Survey of American Life; Himle et al., 2008). Hence, understanding the correlates and consequences of variation across the OC symptom continuum in non-clinical samples of African Americans is an important target for health disparities research agendas.

African Americans are also subject to tobacco-related health disparities. Although cigarette consumption rates were consistently found to be much higher among non-Hispanic Whites and other racial/ethnic groups (vs. African Americans; Trinidad et al., 2015; Evans-Polce, Vasilenko, & Lanza, 2015; Herzog & Pokhrel, 2012;

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Jamal et al., 2014), African American smokers are more susceptible to the effects of smoking on tobacco-related disease morbidity and mortality (American Cancer Society, 2016; DeLancey, Thun, Jemal, & Ward, 2008; Haiman et al., 2006; Irvin Vidrine, Reitzel, & Wetter, 2009), are less likely than other racial groups to initiate a quit attempt (Bacio, Guzman, Shapiro, & Ray, 2014; Fu et al., 2008; Hahn, Folsom, Sprafka, & Norsted, 1990; Trinidad, Perez-Stable, White, Emery, & Messer, 2011), appear to be at greater risk of relapse following a cessation attempt (Choi, Okuyemi, Kaur, & Ahluwalia, 2004), and may experience more extensive affective disturbances during acute abstinence (Bello et al., 2016). Moreover, recent literature has illustrated disproportionately higher rates of menthol cigarette smoking among African Americans, with African American menthol smokers being more likely to initiate smoking and less likely to successfully quit smoking than non-Hispanic White non-menthol smokers, despite showing more motivation to quit smoking (Alexander et al., 2016; Keeler et al., 2016; Stahre, Okuyemi, Joseph, & Fu, 2010).

Given that African Americans may be subject to disparities related to both OC symptom expression and tobacco use, understanding the intersection between OC symptoms and smoking could address a cross-cutting problem that disproportionately burdens the mental and physical health of African Americans. Yet, to our knowledge, we are unware of any studies that have focused on the intersection between OC symptoms and smoking among African Americans. A few studies have demonstrated lower smoking prevalence rates among populations with OC symptomatology (Bejerot & Humble, 1999; Himle, Thyer, & Fischer, 1988; McCabe et al., 2004) and studies utilizing mixed-ethnic samples have shown some evidence of an inverse association between the two conditions (Abramovitch, Pizzagalli, Geller, Reuman, & Wilhelm, 2015; Sharma, Gale, & Fineberg, 2012). This has been hypothesized to be due to a lack of positive reinforcement experienced from nicotine in patients with OCD (Bejerot & Humble, 1999), which may prevent the continuation of smoking behavior following initial experimentation. Yet, amongst individuals for which smoking is already established—the target group for the current study—OC symptoms may play a different role in causing smoking to persist, which has yet to be examined in the African American smoker population.

We propose a negative reinforcement model of the mechanisms whereby OC symptoms contribute to motivation to smoke. By nature, OCD is a disorder of negative reinforcement such that compulsions or mental rituals are performed to reduce acute anxiety and stress caused when obsessions are manifested (Fontenelle, Oostermeijer, Harrison, Pantelis, & Yücel, 2011). Smoking also has been shown to have anxiety and stress-alleviating properties, which negatively reinforces and maintains smoking behavior among nicotine-dependent individuals (Brown, Kahler, Zvolensky, Lejuez, & Ramsey, 2001; Choi, Ota, & Watanuki, 2015; Kassel, Stroud, & Paronis, 2003; Watkins, Koob, & Markou, 2000). In chronic smokers, acute abstinence can be a prominent source of negative affect (NA), as abstinence from smoking produces the expression of neuroadaptations that lead to NA-related nicotine withdrawal symptoms and also is a source of stress triggered by the removal of a key coping mechanism for quelling distress (i.e., smoking; Baker et al., 2013; Parrott, 1999). Given that individuals with elevated OC symptoms are well-practiced in engaging in negatively reinforcing behaviors, it is plausible that smokers with higher (vs. lower) OC symptoms are more vulnerable to developing behavioral cycles of smoking-induced negative reinforcement (Raines, Unruh, Zvolensky, & Schmidt, 2014). Hence, when regular smokers are in a state of acute abstinence from tobacco either as part of a quit attempt or temporary deprivation (e.g., waking after abstaining overnight, restrictions against smoking at work), those with higher levels of OC symptoms may experience stronger abstinence-induced exacerbations in acute NA states and urges to smoke to quell NA. If this were the case, the interactions between OC symptoms, negatively reinforcing (escape) behaviors, and tobacco abstinence effects could prolong and increase smoking levels for smokers with OC symptom elevations. Validation of the aforementioned model of mechanisms linking OC and smoking would have benefits for advancing theories of comorbidity and identifying NA-related withdrawal as a promising cessation treatment target for smokers with OC symptoms. This model may be pertinent across several different ethnic/racial populations, including African American smokers who cite smoking for NA reduction as a motive for smoking at levels equivalent to Whites (Aguirre et al., 2016).

In this laboratory study utilizing experimental manipulation of acute tobacco abstinence (vs. ad libitum smoking), we tested the aforementioned negative reinforcement model of OC-smoking comorbidity in a non-clinical sample of African American smokers. We hypothesized that OC symptom level would be positively associated with the degree of abstinence-provoked exacerbations in NA states, the urge to smoke to suppress NA, and a composite nicotine withdrawal scale which includes numerous NA states and other aversive symptoms (e.g., headaches). We also examined the discriminant validity (i.e., specificity) of this model in two ways. We examined whether OC symptoms were associated with abstinence-induced changes in two states that putatively underlie positive reinforcement-mediated smoking motivation—diminished positive affect and urge to smoke for pleasure. Based on our model, OC symptoms are presumed to play a role in amplifying negative (but not positive) reinforcement smoking motivation; hence, we did not expect OC symptoms to be related with these outcomes. Second, we tested whether associations of OC symptoms with NA and urge to smoke to suppress NA persisted after statistically controlling for severity of tobacco dependence and non-OC emotional symptomatology (i.e., depressive and anxiety symptoms). We expected associations to be robust upon statistical control of these variables, given the expectation that OC is implicated in negative reinforcement smoking not solely because it is a proxy for non-specific psychiatric distress or mere dependency on nicotine.

2. Methods

2.1. Participants

This study is the first report using data from an ongoing study of individual differences in the expression of tobacco withdrawal among African American smokers. Participants were non-treatment seeking daily cigarette smokers ($N = 253$; $M = 48.2$ years old) recruited from the metropolitan Los Angeles area via word of mouth and paper and online advertisements. Inclusion criteria for the study were: (1) 18 years of age or older; (2) self-reported non-Hispanic African American ancestry in both biological parents (3) daily cigarette smoking for at least the past 2 years; (4) typically smokes ≥10 cigarettes per day; and (5) and fluent in English. The exclusion criteria were: (1) current *DSM-IV* non-nicotine substance dependence; (2) breath carbon monoxide (CO) levels < 10 ppm at intake; (3) desire to substantially cut down or quit smoking in the next 30 days; (4) current use of anti-depressant, psychostimulant, or anti-psychotic medications; (5) use of anxiolytic medications more than once per week; (6) report being pregnant or breast-feeding; and (7) daily use of other non-cigarette tobacco products or nicotine replacement therapy. Participants were compensated $200, and the University of Southern California Internal Review Board reviewed and approved all study procedures.

Table 1
Descriptive Statistics and Correlations of Key Variables.

		Correlations (r)									
Key Variables	M (SD) or%	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Age	48.19 (11.59)	–									
2. Gender (Female)	44.4%	0.09	–								
3. Cigs/day	15.13 (7.32)	0.12	0.07	–							
4. Menthol[a]	59.5%	−0.10	−0.15*	0.001	–						
5. FTND	5.35 (1.95)	0.03	−0.12	0.37****	−0.003	–					
6. Low Annual Income (Less than $15,000)	64.1%	0.05	−0.01	−0.09	0.10	−0.13*	–				
7. Low Education (No College)	85.5%	−0.03	−0.01	−0.10	0.10	−0.20**	0.18**	–			
8. IDAS Panic	1.32 (0.55)	−0.10	−0.02	0.06	0.10	0.14*	−0.09	−0.13*	–		
9. IDAS Depression	1.81 (0.62)	−0.18*	0.02	0.000	0.04	0.03	−0.12	−0.05	0.60****	–	
10. OCI-R Total	12.72 (12.90)	−0.01	−0.0005	0.14*	0.07	0.15*	−0.15*	−0.18**	0.50****	0.52****	–

Note: $N = 253$; Correlations among continuous variables are Pearson correlation coefficients. Correlations between continuous and dichotomous variables are point-biserial correlation coefficients. Correlations among dichotomous variables are phi coefficients. OCI-R = Obsessive-Compulsive Inventory-Revised (range 0–72); Cigs/day = cigarettes per day; FTND = Fagerström Test for Nicotine Dependence (range 0–10); Low Annual Income (Less than $15,000 vs. $15,000 or more); Low Education (No college vs. College degree or higher); IDAS = Inventory of Depression and Anxiety Symptoms (observed ranges for IDAS Depression [1–4.06] and IDAS Panic [1–4.43]; possible ranges 1–5).
[a] Mentholated cigarette preference (vs. non-mentholated cigarette).
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
**** $p < 0.0001$.

2.2. Procedures

After an initial phone screening to determine preliminary eligibility, participants attended an initial session involving additional in-person screening and assessments. The initial session involved informed consent, analysis of breath CO and blood alcohol, completion of the Structured Clinical Interview for *DSM-IV* Research Edition (First, Spitzer, Gibbon, & Williams, 2002) substance use disorder module to determine eligibility, and completion of additional measures. Participants then attended two counterbalanced experimental sessions starting around noon: one abstinent and one non-abstinent (*ad libitum* smoking).

The procedures at both experimental sessions were identical with the following exception: for the non-abstinent session, participants were instructed to smoke as they normally would prior to their visit and then were required to smoke a cigarette of their preferred brand in the laboratory at session outset (to standardize for smoking recency), whereas for the abstinent session, participants were instructed not to smoke after 8 pm the night before their visit (16 h abstinence). Immediately upon arrival (abstinent session) or following smoking their preferred brand of cigarette (non-abstinent session), breath CO and alcohol (BrAC = 0.000 required for session continuation) assessments was conducted. Participants who had CO levels exceeding 9 ppm during their abstinent session ($n = 27$) were considered non-abstinent and were rescheduled for a second attempt to complete their session on another day. Participants who failed to meet CO criteria for abstinence (≤9 ppm) at their second attempt were discontinued from the study ($n = 2$). After CO and alcohol assessment, participants completed self-report measures of affect, withdrawal symptoms, and smoking urges at a single time-point that served as the primary subjective withdrawal outcomes.

2.3. Baseline session measures

2.3.1. OC symptoms

The Obsessive-Compulsive Inventory-Revised version (OCI-R; Abramowitz & Deacon, 2006; Foa et al., 2002; Wootton et al., 2015) is an 18-item adaptation of the original 42-item OCI (Foa, Kozak, Salkovskis, Coles, & Amir, 1998) that assessed for OCD symptoms across six facets: (1) washing, (2) obsessing, (3) hoarding, (4) ordering, (5) checking, and (6) mental neutralizing. The OCI-R instructed respondents to rate the degree to which they were bothered or distressed by each symptom within the past month on 5-point Likert scales (e.g., "I get upset if objects are not arranged properly"; 0 = *Not at all* to 4 = *Extremely*). The total score based on the summed rating across the 18 items reflects overall OC symptom severity and was utilized as the primary regressor variable in this paper. For descriptive purposes, we also classified participants based on whether they met or exceeded the OCI-R recommended cutoff score of 36, which is indicative of probable OCD diagnosis in African Americans (Williams, Davis, Thibodeau, & Bach, 2013). The OCI-R has been demonstrated to have excellent internal consistency, test-retest reliability, and convergent validity (Foa et al., 2002), and has been validated among African American populations with and without OCD (Williams et al., 2013).

2.3.2. Covariates and sample descriptive measures

To describe the sample and include possible covariates, we administered a study-specific questionnaire assessing demographic and smoking characteristics (e.g., cigs/day, menthol preference). The Fagerström Test of Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) was administered to determine nicotine dependence severity. The Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007) 20-item general depression and 8-item panic subscales (i.e., anxious arousal symptoms) were administered, which asked respondents to rate the extent to which they experienced symptoms during the past two weeks on a 5-point scale (1 = *Not at all* to 5 = *Extremely*); mean rating per item reported for each subscale.

2.4. Experimental sessions measures

2.4.1. The brief questionnaire of smoking urges (QSU; Cox, tiffany, & christen, 2001)

The 10-item QSU includes subscales assessing desire to smoke for pleasure and intention to smoke (Factor 1; e.g., "a cigarette would taste good"; 5 items) and desire to smoke to suppress NA (Factor 2; e.g., "smoking would make me less depressed"; 5 items). Respondents are instructed to respond based on how they felt "right now" by indicating ratings on 6-point Likert scales. Each subscale (Factor 1 and Factor 2) is computed based on mean rating per item within each respective subscale, with Factors 1 and 2 reflecting positive and negative reinforcement processes, respectively.

Table 2
Intercorrelations between Tobacco Withdrawal-Related Outcome Measures.

Intercorrelations (r)													
Outcome Measures	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. QSU-Factor 1	–												
2. QSU-Factor 2	0.65****	–											
3. MNWS	0.27****	0.44****	–										
4. POMS-Anger	0.10	0.23****	0.28****	–									
5. POMS-Anxiety	0.20**	0.30****	0.45****	0.65****	–								
6. POMS-Confusion	0.15*	0.23**	0.25****	0.45****	0.46****	–							
7. POMS-Depression	0.12	0.24****	0.24****	0.71****	0.54****	0.54****	–						
8. POMS-Fatigue	0.0001	0.11	0.28****	0.48****	0.50****	0.41****	0.55****	–					
9. POMS-Elation	−0.13	−0.24****	−0.31****	−0.21****	−0.28****	−0.21**	−0.16*	−0.11	–				
10. POMS-Friendliness	−0.14*	−0.27****	−0.28****	−0.18**	−0.29****	−0.14*	−0.07	−0.03	0.74****	–			
11. POMS-Vigor	−0.05	−0.12	−0.25****	−0.08	−0.16*	−0.12	−0.06	−0.09	0.74****	0.72****	–		
12. POMS-NA Composite	0.15*	0.28****	0.40****	0.72****	0.82****	0.73**	0.80****	0.80****	−0.24****	−0.17*	−0.14*	–	
13. POMS- PA Composite	−0.12	−0.23****	−0.31****	−0.17*	−0.27****	−0.17*	−0.10	−0.08	0.91****	0.91****	0.91****	−0.20**	–

Note: $N = 253$; Correlations among continuous variables are Pearson correlation coefficients. QSU = Questionnaire of Smoking Urges (range 0–5); MNWS = Minnesota Nicotine Withdrawal Scale (range 0–5); POMS = Profile of Mood States (range 0–5). NA = Negative Affect. PA = Positive Affect.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
**** $p < 0.0001$.

2.4.2. The minnesota nicotine withdrawal scale (MNWS; Hughes & hatsukami, 1986)

The 11-item MNWS instructed participants to rate withdrawal symptoms (i.e., craving, irritability, anxiety, concentration problems, restlessness, impatience, hunger, cardiovascular and autonomic activation, drowsiness, and headaches) experienced "so far today" on 6-point Likert scales and yielded a composite index based on mean response across all items.

2.4.3. The profile of mood states (POMS; McNair, lorr, & droppleman, 1971)

The POMS is an affect check list requiring participants to rate 72 adjectives (e.g., miserable, forgiving, happy, grouchy) as experienced "right now" on a 5-point Likert scale. The POMS yields 5 negative affect (Anger [12 items], Anxiety [8 items], Confusion [7 items], Depression [15 items], and Fatigue [7 items]) and 3 positive affect (Elation [6 items], Friendliness [8 items], and Vigor [8 items]) subscales scores computed based on mean rating per item within respective subscale items. In addition to the individual subscales, we also calculated overall scores for negative affect valence (NA; mean of 5 negative affect subscale scores) and positive affect valence (PA; mean of 6 positive affect subscales), as in prior work (Leventhal et al., 2014).

2.5. Analytical approach

Data were analyzed using IBM SPSS Version 22 (IBM, 2013). The first step in data analyses involved examining correlations of the OCI-R scale with measures of demographics, smoking characteristics, and emotional symptomatology (to determine additional covariates based on association with OCI-R), as well as examining intercorrelations among tobacco withdrawal-related outcome measures. We also investigated whether abstinence status (abstinent vs. non-abstinent) significantly affected each outcome in the overall sample using paired sample *t*-tests. Primary data analyses of the association between OC symptoms and tobacco abstinence symptoms utilized linear regression models. In each model, OCI-R Total was entered a regressor variable, the abstinence-induced change score (difference in score in abstinent condition − score in non-abstinent condition) for each experimental session measure was entered as the outcome variable, and each outcome variable's respective non-abstinence score was entered as a simultaneous regressor (covariate). Separate sets of models were tested for each respective outcome variable (i.e., QSU subscales, POMS subscales, MNWS composite). Each model was re-tested in an adjusted model after additionally entering a priori covariates (i.e., cigarettes per day, low annual income, low education, depressive symptoms, anxious arousal symptoms, nicotine dependence) and other demographic and smoking characteristics that were significantly associated with OCI-R score based on the correlational analysis (i.e., cigarettes per day; see Table 1). Lastly, we conducted supplementary analyses to examine whether individual OCD symptom subscales (i.e., OCI-R washing, obsessing, hoarding, ordering, checking, and neutralizing) would significantly predict abstinence-provoked increases in specific withdrawal-related outcome variables. Results are reported as standardized regression coefficients (β). Significance was set at $p < 0.05$. For the primary outcomes (i.e., QSU-Factor 2, MNWS, POMS NA composite and individual NA subscales), type-I error was controlled using the Benjamini-Hochberg procedure for type-I error correction (Benjamini & Hochberg, 1995).

3. Results

3.1. Initial analyses

Descriptive statistics and correlations amongst demographic and smoking characteristics, depression and anxious arousal levels, and OCI-R Total are reported in Table 1. The *M* (*SD*) OCI-R score was 12.72 (12.90), indicating that participants reported mild levels of OC symptoms on average, yet there was substantial inter-individual variability across the spectrum of OC symptom level. Eight percent (*N* = 21) of the sample met or surpassed recommended cutoffs indicating plausible OCD diagnosis.

Age, gender, and menthol preference did not significantly correlate with OC symptom severity, however, cigarettes per day, nicotine dependence, low annual income, low education, and baseline levels of anxious arousal and general depression were each positively associated with OC symptom level (*r*s = 0.14-0.52, *p*s < 0.05). Therefore, adjusted models controlled for cigarettes per day, nicotine dependence, low annual income, low education, and baseline levels of anxious arousal and general depression. In the overall sample, abstinence significantly affected each withdrawal-related outcome (i.e., abstinence-induced change scores departed from zero; *d*s = −1.48-1.38) in the expected direction, with the exception of depression and fatigue. Intercorrelations among tobacco withdrawal-related outcome measures are illustrated in Table 2.

3.2. Primary analyses

In the baseline model adjusting for only the respective non-abstinent score, OC symptoms were positively associated with larger abstinence-provoked increases in each hypothesized outcome (i.e., urges to smoke to relieve NA, nicotine withdrawal, and POMS Anger, Anxiety, Confusion, Depression, Fatigue, and NA composite; βs = 0.15-0.29; *p*s < 0.05; Table 3). These effects remained significant in models that additionally controlled for depressive symptoms, anxious arousal symptoms, nicotine dependence severity, low annual income, low education, and cigs/day, with the exception of POMS Confusion (Table 3). OC symptoms were not significantly associated with abstinence-induced changes in the discriminant validity outcomes (i.e., urge to smoke for pleasure [QSU-Factor 1], diminished positive affect).

3.3. Supplementary analyses

Supplementary analyses demonstrated that each OCD symptom category strongly predicted varying tobacco withdrawal-related outcomes (i.e., urges to smoke, nicotine withdrawal, specific NA states, see Table 4). Greater washing symptom severity demonstrated a significant predictive effect on POMS Anger, Confusion, Depression, Fatigue, and NA composite (βs = 0.15-0.27; *p*s < 0.05). Severity of obsessing and neutralizing symptoms predicted abstinence-provoked increases in Depression (βs = 0.15-0.22; *p*s < 0.05) and increased severity of hoarding symptoms predicted increased Fatigue (β = 0.15; *p*s < 0.05). Presence of symptom severity for ordering and checking exhibited predictive effects on abstinence-induced exacerbations in intentions/desire to smoke and urges to smoke to relieve NA, nicotine withdrawal, Anger, Anxiety, Depression, Fatigue, and NA Composite (βs = 0.14-0.26; *p*s < 0.05).

4. Discussion

To the best of our knowledge, this study is the first to provide evidence of an association between OC symptom levels and tobacco withdrawal in a sample of African American smokers—a group subject to pervasive mental and physical health disparities (Centers for Disease Control and Prevention, 2005; Hertz, Unger, Cornell, & Saunders, 2005; Hunter & Schmidt, 2010; Jackson, Knight, & Rafferty, 2010) that is virtually unstudied in the OC literature. The results were largely consistent with the negative reinforcement model of OC and smoking outlined above. OC symptom severity was associated with greater exacerbations in various NA states (i.e., Anger, Anxiety, Depression, Fatigue, overall NA composite) as well as the urge to smoke to suppress NA. In support of the discriminant validity of the model, OC symptoms were not associated with possible indicators of vulnerability to the positive reinforcing properties of smoking (i.e., urge to smoke for pleasure, abstinence-induced reductions in PA) and the OC-withdrawal relations extending to NA persisted after controlling for nicotine dependence severity and other factors. Furthermore, OCD symptom subtypes (i.e., washing, obsessing, hoarding, ordering, checking, and mental neutralizing) demonstrated significant associations with particular tobacco withdrawal-related outcomes, however, these results should be interpreted with caution as we did not have sufficient power to compare the strength of the correlations across subtypes (e.g., washing had stronger associations with withdrawal indices compared to neutralizing). Overall, the data suggests a unique link between OC and this qualitatively distinct pattern of tobacco withdrawal symptoms involving hyper-expressed NA and desire to smoke to quell NA during smoking abstinence.

Our findings suggest generalization of a well-documented trend in the literature whereby smokers with higher emotional pathology experience more severe affective tobacco withdrawal symptoms upon abstinence (Langdon & Leventhal, 2014; Leventhal, Ameringer, Osborn, Zvolensky, & Langdon, 2013; Morissette, Tull, Gulliver, Kamholz, & Zimering, 2007; Piper, Cook, Schlam, Jorenby, & Baker, 2011) to a novel psychopathological syndrome not previously examined in smoking research—OC symptoms. Critically, the OC-withdrawal associations demonstrated herein were robust after controlling for other forms of emotional symptomatology (i.e., depression and anxiety). This pattern of results may indicate that OC symptoms confer vulnerability to affective distress during withdrawal incrementally to the vulnerability accounted for by other psychopathologies. As OC symptoms by nature reflect a pattern of negative reinforcement, it is plausible that these symptoms may be particularly pertinent to negative reinforcement mechanisms that maintain smoking. This inference and the data presented here are similar to a prior study demonstrated that hoarding (which is strongly comorbid with OC symptoms; Samuels et al., 2002; Wheaton, Timpano, LaSalle-Ricci, & Murphy, 2008) was associated with greater endorsement of beliefs that smoking alleviates NA (Raines et al., 2014). The consideration of depressive symptoms (and anxiety symptoms to some extent) as a key clinical factor worthy of assessment in smoking research and treatment settings is becoming increasingly well-accepted (Fiore et al., 2008). Our findings raise the possibility that it may behoove clinicians to consider assessing OC symptoms as well, pending replication and extension of the current results.

We did not have comparison groups of non-African American smokers in this study. Consequently, it is unclear whether the associations demonstrated here are unique to African Americans or are patterns that potentially generalize across racial groups. As described by sociocultural models of anxiety (Hunter & Schmidt, 2010), African Americans (compared to non-minority racial groups) experience more racial discrimination (Borrell, Kiefe, Diez-Roux, Williams, & Gordon-Larsen, 2013; Corral & Landrine, 2012; Kessler & Neighbors, 1986) and poverty (Kessler & Neighbors, 1986; Merkin et al., 2009), which have well-documented negative consequences for mental health (Brondolo, Rieppi, Kelly, & Gerin, 2003; Clark, Anderson, Clark, & Williams, 1999; Kessler & Neighbors, 1986; Paradies, 2006). Hence, while there is no reason to suspect that the

Table 3
Association of OC Symptom Severity with Abstinence-Induced Changes in Tobacco Withdrawal-Related Outcomes.

Outcome[a]	Parameter Estimate for Association of OCI-R with Respective Outcome (β)	
	Baseline models[b]	Fully adjusted models[c]
Primary Outcomes		
POMS-NA Composite	0.25***,†	0.26**,†
POMS-Anger	0.29****,†	0.22**,†
POMS-Anxiety	0.24***,†	0.23**,†
POMS-Confusion	0.18**,†	0.14
POMS-Depression	0.24***,†	0.25**,†
POMS-Fatigue	0.21**,†	0.19*,†
QSU-Factor 2 (Urge to smoke for NA relief)	0.15*,†	0.17*,†
MNWS (Nicotine withdrawal symptoms)	0.20**,†	0.23**,†
Discriminant Outcomes		
QSU-Factor 1 (Urge to smoke for pleasure)	0.03	0.04
POMS-PA Composite	0.08	0.05
POMS-Elation	0.07	0.09
POMS-Friendliness	0.03	−0.01
POMS-Vigor	0.12*	0.07

Note: $N = 253$; OCI-R = Obsessive-Compulsive Inventory-Revised (range 0–72); QSU = Questionnaire of Smoking Urges (range 0–5); MNWS = Minnesota Nicotine Withdrawal Scale (range 0–5); POMS = Profile of Mood States (range 0–5). FTND = Fagerström Test for Nicotine Dependence. NA = Negative Affect. PA = Positive Affect. IDAS = Inventory of Depression and Anxiety Symptoms. [a]Abstinence-induced change scores utilized in analysis. [b]Adjusted for non-abstinent value for respective outcome variable. [c]Models adjusted for cigarettes per day, FTND score, IDAS panic and general depression scales, low annual income, low education, and non-abstinent value for respective outcome variable.

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
**** $p < 0.0001$.
† Statistically significant after Benjamini-Hochberg correction for false discovery rate.

vspace*12pt

Table 4
Association of OCI-R Symptom Subscales with Abstinence-Induced Changes in Tobacco Withdrawal-Related Outcomes.

Outcome	Obsessive Compulsive Inventory-Revised					
	Washing[a] (β)	Obsessing[a] (β)	Hoarding[a] (β)	Ordering[a] (β)	Checking[a] (β)	Neutralizing[a] (β)
QSU-Factor 1	0.002	0.06	−0.01	0.14*	−0.02	−0.03
QSU-Factor 2	0.10	0.15	0.03	0.22**	0.15*	0.04
MNWS	0.13	0.16	0.10	0.26***	0.18*	0.12
POMS						
Anger	0.21**	0.13	0.09	0.23**	0.14*	0.09
Anxiety	0.11	0.14	0.14	0.24**	0.18*	0.14
Confusion	0.19**	0.05	0.03	0.14	0.06	0.09
Depression	0.27***	0.22**	0.05	0.19**	0.16*	0.15*
Fatigue	0.15*	0.12	0.15*	0.17*	0.17*	0.05
Elation	0.07	0.12	0.09	0.06	0.06	0.02
Friendliness	0.04	0.10	0.03	−0.03	−0.13	−0.04
Vigor	0.07	0.14	0.06	0.02	0.04	0.02
NA Composite	0.22**	0.17	0.13	0.23**	0.19*	0.14
PA Composite	0.06	0.13	0.06	0.01	−0.02	−0.01

Note: $N = 253$; OCI-R = Obsessive-Compulsive Inventory-Revised (range 0–72); QSU = Questionnaire of Smoking Urges (range 0–5); MNWS = Minnesota Nicotine Withdrawal Scale (range 0–5); POMS = Profile of Mood States (range 0–5). FTND = Fagerström Test for Nicotine Dependence. NA = Negative Affect. PA = Positive Affect. IDAS = Inventory of Depression and Anxiety Symptoms. [a]Models adjusted for cigarettes per day, FTND score, IDAS panic and general depression scales, low annual income, low education, and non-abstinent value for respective outcome variable.

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
**** $p < 0.0001$.

OC-withdrawal relation does not generalize to other ethnic groups, the socio-contextual factors that intersect with race suggest high relevance of negative reinforcement mechanisms in African American smokers. Future work focused on replication and extension of our findings should consider including comparisons among other racial/ethnic groups (e.g., larger sample of Whites) to enhance generalizability.

The current study had several limitations. First, we excluded individuals who smoked less than 10 cigarettes per day and/or used other non-cigarette tobacco products. Therefore, our findings may not generalize to a significant portion of the African American smoker population, who are light/intermittent smokers (<10 cigs/day; Pulvers et al., 2014) and/or are concurrent users of other tobacco products such as small cigars (Corral, Landrine, Simms, & Bess, 2013). We also excluded participants who currently used psychiatric medications, which may limit the generalizability of our findings to individuals with OC symptoms being treated with pharmacotherapy (Pittenger, Kelmendi, Bloch, Krystal, & Coric, 2005) Second, eight percent of our sample met or exceeded the recommended cutoffs for plausible OCD, which is higher than found in prior work (Himle et al., 2008; Kessler et al., 2005; Zhang & Snowden, 1999). This may be due to our reliance on self-report

measures (i.e., OCI-R), given that self-report symptom checklist measures tend to produce higher scores in African Americans relative to clinician-administered measures (Williams, Wetterneck, & Sawyer, 2015) As such, the inclusion of a more comprehensive measurement of OC symptoms may prove beneficial. Third, although our sample size was large enough to detect whether the magnitude of associations between specific OC symptoms and tobacco withdrawal were significantly different from zero, we had insufficient power to make determinations regarding whether the relative magnitude of associations differ as a function of the OCI-R subscale. Thus, future research should continue to explore OC symptom-specific relations with tobacco withdrawal as well as aim to conduct sufficiently powered head-to-head comparisons in order to determine which OC symptom facets are most strongly associated with tobacco withdrawal symptomatology relative to one another. Moreover, smoking abstinence was experimentally-induced and not part of a self-motivated quit attempt. Thus, our findings may not generalize to the population of smokers who attempt to quit. However, there is some evidence that tobacco withdrawal during experimentally-induced abstinence may predict withdrawal after a self-initiated quit attempt (Strong et al., 2011), which suggests the potential for generalizability of our results. Lastly, the current study utilized a non-treatment seeking community sample of African American smokers who did not have an OCD diagnosis and who had relatively lower levels of psychopathology (i.e., OCI-R and IDAS scores). As such, this may restrict generalizability of our findings to populations with clinically-significant OCD.

5. Conclusions

In a non-clinical sample of African American daily smokers, OC symptom severity was positively associated with greater exacerbations in NA and urge to smoke to suppress NA upon acute tobacco abstinence. Pending replication and extension, one implication of this study is that African American smokers with elevations in OC symptoms should be studied to determine whether smoking cessation treatments that diminish NA and the urge to quell NA reduce relapse risk. Smoking cessation treatment development research and further etiological mechanism studies amongst smokers with elevated OC symptoms are warranted and may aid in reducing the pervasive disparities facing African Americans who smoke and suffer from OC symptoms.

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