



# Associations between nicotine dependence, anhedonia, urgency and smoking motives

Melanie Roys<sup>a,b</sup>, Keri Weed<sup>a</sup>, Maureen Carrigan<sup>a,\*</sup>, James MacKillop<sup>c</sup>

<sup>a</sup> University of South Carolina Aiken, 471 University Pkwy, Aiken, SC 29801, United States

<sup>b</sup> Louisiana State University, 318 Audubon Hall, Baton Rouge, LA 70803, United States

<sup>c</sup> Peter Boris Centre for Addictions Research, McMaster University/St. Joseph's Healthcare Hamilton, 100 West 5th Street, Hamilton, Ontario L8P 3R2, Canada

## HIGHLIGHTS

- Mediated and moderated relationships between urgency, anhedonia, smoking motives, and nicotine dependence were explored.
- Tolerance, craving, cue exposure and positive reinforcement mediated the relationship between urgency and dependence.
- Anhedonia moderated the relationship between urgency and dependence.
- Targeted variables, along with age, student status, and gender, accounted for 65% of the variance in nicotine dependence.

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## ABSTRACT

Models of nicotine dependence have suggested that the association between urgency, a subconstruct of impulsivity, and smoking behaviors may be mediated by motivations. Motives that are driven by expectations that smoking will relieve negative affect or increase positive affect may be especially salient in persons who have depression symptoms such as anhedonia. Support for associations between symptoms of depression, urgency, and addiction has been found for alcohol dependence, but empirical analysis is lacking for an interactive effect of urgency and depression symptoms on nicotine dependence. The current study investigated relationships among the urgency facet of impulsivity, anhedonia, smoking motives, and nicotine dependence with secondary analyses of a sample of 1084 daily smokers using simultaneous moderation and multiple mediation analyses. The moderation analysis revealed that although urgency was significantly associated with smoking at average or higher levels of anhedonia, it was unrelated to smoking when few anhedonia symptoms were endorsed. Further, multiple mediation analyses revealed that the smoking motives of craving, cue exposure, positive reinforcement, and tolerance significantly mediated the relationship between urgency and nicotine dependence. Results suggest that models of alcohol addiction that include an interactive effect of urgency and certain symptoms of depression may be applied to nicotine dependence. Examination of the multiple mediational pathways between urgency and nicotine dependence suggests directions for intervention efforts.

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## 1. Associations between nicotine dependence, anhedonia, urgency and smoking motives

Impulsivity has been linked to severity of nicotine dependence (Pang et al., 2014), to higher levels of craving after a period of nicotine abstinence (VanderVeen, Cohen, Cukrowicz, & Trotter, 2008), smoking to relieve negative affect (Doran et al., 2006), and to faster smoking relapse following a cessation attempt (Doran, Spring, McChargue, Pergadia, & Richmond, 2004). Conceptualized as a multidimensional

personality construct, impulsivity remains somewhat stable from childhood to adulthood (Caspi & Silva, 1995). The defining feature of impulsivity is acting on impulse without first thinking through the consequences of behaviors or decisions. Greater impulsivity has been associated with problem behaviors in childhood, risky decision making during adolescence, and addictive behaviors during adolescence and adulthood (de Wit, 2008).

Whiteside, Lynam, Miller, and Reynolds (2005) used factor analysis to identify four specific dimensions of impulsivity in a young adult sample: urgency, sensation seeking, lack of perseverance, and lack of premeditation. Urgency reflects the tendency to respond rashly and without thought to cravings and temptations especially in the context

\* Corresponding author.

E-mail address: [maureec@usca.edu](mailto:maureec@usca.edu) (M. Carrigan).

of negative emotions including anger and distress (Whiteside et al., 2005). Of the four dimensions of impulsivity identified, urgency has appeared to be especially predictive of nicotine dependence: Higher levels of urgency have been found to be predictive of higher levels of cravings (Billieux, Van der Linden, & Ceschi, 2007), of increased risk of being a daily smoker (Lee, Peters, Adams, Milich, & Lynam, 2015), and of nicotine dependence severity (Pang et al., 2014).

Although individuals higher in urgency are more likely to develop nicotine dependence, additional predictors include motivations acquired through experience (Doran, McChargue, & Cohen, 2007; Pang et al., 2014; VanderVeen et al., 2008; Vinci, McVay, Copeland, & Carrigan, 2011). Associations between urgency, emotions, and motivations have been established within the alcohol dependency literature. For example, drinking to cope and negative urgency were both found to mediate the relationship between depression and alcohol problems (Gonzalez, Reynolds, & Skewes, 2011). An interactive relationship such as this has not been confirmed for nicotine dependence. The current study employed simultaneous moderation and multiple mediation analyses to investigate relationships among urgency, anhedonia, smoking motives, and nicotine dependence. We expected that anhedonia would moderate the relationship between urgency and nicotine dependence, with this relationship mediated through smoking motives.

### 1.1. Moderational links between urgency and nicotine dependence

Within the alcohol dependence literature, relationships have been found between depression symptoms and urgency. For instance, Gonzalez et al. (2011) found urgency to partially mediate the relationship between depression and alcohol problems. The authors surmised that negative affect associated with depression impaired short-term decision making processes, leading to problematic drinking associated with affective relief. A similar study investigating the association between depression, impulsivity, and alcohol problems found that sensation seeking, lack of premeditation, and lack of perseverance had an interaction effect in which they enhanced risk for alcohol problems only at specific levels of these impulsivity variables. Only negative urgency had an overall main effect in predicting the level of alcohol problems (King, Karyadi, Luk, & Patock-Peckham, 2011). Despite research that supports complex relationships between depression symptoms and urgency in alcohol dependence, there has been little application of this model to nicotine dependence.

Smoking may be used by individuals with depression to both relieve negative emotions and to enhance positive emotions. For instance, individuals with a history of depression showed more mood enhancement when smoking a cigarette after a positive mood induction than individuals without a history of depression (Spring et al., 2008). Two types of depression symptoms have been found to predict nicotine use in young adults: negative affect and anhedonia (Audrain-McGovern, Rodriguez, Rodgers, & Cuevas, 2010; Schleicher, Harris, Catley, & Nazir, 2009). Anhedonia in depression is defined as decreased interest or pleasure in activities that were formerly enjoyable (American Psychiatric Association, 2013). Both anhedonia and depressed mood impact smoking motivation (Leventhal, Piper, Japuntich, Baker, & Cook, 2014). However, anhedonia appears to be specifically linked to smoking motivation aimed at increasing enjoyment of activities and enhancing positive affect (Audrain-McGovern et al., 2010; Cook, Spring, & McChargue, 2007). In a study comparing the predictive power of anhedonia and depressed mood on smoking cessation outcomes, anhedonia was found to predict smoking cessation failure when controlling for depressed mood, while the reverse was not found to be true (Leventhal et al., 2014). Anhedonia is also more exclusive to depression than other symptoms such as negative affect, which have a high degree of overlap with anxiety disorders (Watson et al., 1995). It is also more related to smoking motivation due to urgency to increase positive affect and decrease negative affect (Leventhal, Waters, Kahler, Ray, & Sussman, 2009).

The current study focused on investigating the moderating role of anhedonia. Limiting our focus to the absence of positive emotions, as opposed to a more inclusive perspective on both anhedonia and negative affectivity, provided a more clear differentiation between the conceptualization of urgency and depressive symptomology. We expected to find that anhedonia amplified the associations between urgency and nicotine dependence.

Individuals differ in what motivates them to initiate nicotine use and to continue its use. Piper et al. (2004) identified 13 distinct, but overlapping, smoking dependence motives based on addiction theory and validated through confirmatory factor analysis. These motives reflect alternative ways people choose to respond to internal states and to the external environment. Motives related to smoking initiation may also differ from those associated with long-term dependence. Three motives (i.e., social goals, cue exposure, and taste) were classified as early-emergent smoking motives and were associated with lighter nicotine use (Piper et al., 2004). Individuals whose smoking is contingent on the smoking of others or specific situations may be motivated by *social goals* while those who appreciate the taste or feel of cigarettes may be motivated by *taste*. *Cue exposure* reflects an associative process during which nonsocial smoking cues come to elicit the desire to smoke. Cue-exposure has been associated with higher levels of craving due to negative affect in individuals higher in urgency (Doran, Cook, McChargue, & Spring, 2009).

Other motives (i.e., craving, automaticity, choice, cognitive enhancement, attachment, and tolerance) were classified as late-emergent due to an exponential negative linear increase with heaviness of nicotine use (Piper et al., 2004). For instance, an emotional *attachment* to smoking and cigarettes takes time to develop as does smoking without awareness or intentions, characteristic of *automaticity*. Further, choosing to smoke despite awareness of negative consequences (i.e., behavioral *choice*), frequent *cravings* for nicotine, and the need for increasing amounts of nicotine to achieve the desired effects (i.e., *tolerance*) were also associated with long-term heavy use of nicotine. Smoking to improve attention or focus (i.e., *cognitive enhancement*) followed this late-emergent pattern (Piper et al., 2004).

A third group of motives, including loss of control, negative reinforcement, and positive reinforcement, were similar to late emergent motives in regards to heaviness of use, but lacked a significant linear coefficient (Piper et al., 2004). Individuals motivated by *negative reinforcement* may use nicotine to cope with negative emotions while those motivated by *positive reinforcement* use nicotine to enhance positive emotions or to achieve a 'high'. Others may feel that they have lost *control* over their behavior and are unable to regulate their nicotine intake. Impulsivity has been associated with higher positive and negative reinforcement motives, especially in younger smokers; however these same motivations may also result in continued use due to increased problems with cessation (Doran et al., 2007). In a mediation analysis by Pang et al. (2014), both positive and negative urgency were found to be predictive of severity of nicotine dependence; however, both types of urgency were completely mediated by positive and negative reinforcement motives. Therefore, individuals with high levels of urgency were more motivated to smoke due to greater expectancies that smoking would create affect modulation.

### 1.2. Current study

The current study explored relationships between nicotine dependence, anhedonia, smoking motives, and urgency based on secondary analyses of data from a study that investigated the potential to reduce smoking through the use of behavioral economics (MacKillop et al., 2012). We chose to focus on urgency due to previous findings that urgency was associated with increased cravings (Billieux et al., 2007) and higher levels of nicotine dependence (Pang et al., 2014; Spillane, Smith, & Kahler, 2010). Consistent with the findings of Pang et al. (2014) we expected that smoking motives would mediate the relationship between

urgency and nicotine dependence. However, we extended the scope of smoking motives beyond positive and negative reinforcement motives to include 10 of the motives identified by Piper et al. (2004). We also expected that a symptom of depression, anhedonia, would amplify the relationship between urgency and nicotine dependence based on studies that found strong associations between nicotine dependence and anhedonia (Leventhal et al., 2014; Leventhal et al., 2009) and between urgency, depression, and other addictions (Gonzalez et al., 2011; King et al., 2011).

## 2. Method

### 2.1. Participants

The sample included 1125 adults who reported smoking five or more cigarettes a day. The average number of daily cigarettes smoked by participants was 16.53 ( $SD = 10.99$ ). Complete data was available for 96% of the sample. Participants missing data on any of the variables of interest were eliminated from analyses, resulting in a final sample of 1084. Participants were recruited from three locations in the northeastern and southeastern United States. The sample ranged from age 17 to 70 ( $M = 31.56$ ,  $SD = 12.61$ ). More than one-half were men (60.5%). Just under 40% were currently enrolled in post-secondary education. The sample was predominately White (67.7%), with 24.4% Black and the remaining 7.9% mixed race, Asian, or other. The sample was diverse regarding education with 19% having less than a high school education and 45.7% with some post-secondary education. Participants were not formally screened for psychopathology. All participants were treated in accordance with APA ethical standards and the protocol was approved by the pertinent Institutional Review Board.

### 2.2. Procedure and measures

Following a telephone screening, eligible participants completed several self-report measures in small groups of approximately 10 at university settings (MacKillop et al., 2012). The procedure varied slightly depending on site location. The study lasted for approximately 60 min for community participants who completed the study in Providence, RI. They received \$20 as compensation. Community participants in Athens, GA completed extra measures, which were not utilized in the current study. Therefore, the protocol at this site lasted 90 min and participants received \$30 for completing a more extensive battery. Student participants in Aiken, SC completed the study in 60 min without the extended battery and received partial course credit. The amount and type of incentive depended on the specific protocol of the recruitment site. The complete protocol included an extensive assessment battery as well as collection of expired carbon monoxide at two of the three sites (see MacKillop et al., 2012). The current study relied on data from the following measures.

#### 2.2.1. Nicotine dependence

The Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) is a 6-item scale that measures levels of nicotine dependence. Scores range from 0–10, with higher scores representing higher levels of nicotine dependence. Cronbach's alpha within the current sample was 0.68. Significant correlations between the FTND and alveolar carbon monoxide support the validity of the FTND (Kozlowski, Porter, Orleans, Pope, & Heatherton, 1994).

#### 2.2.2. Anhedonia

The Anhedonic Depression subscale of the Mood and Anxiety Symptoms Questionnaire-Short Form (MASQ-S; Watson et al., 1995) was used to assess anhedonia. This scale contains 8 items related to anhedonia, low energy, and disinterest, and 14 items that represent positive emotional experiences that are reverse scored. Items are rated on a 5-point Likert scale. Internal consistency for the Anhedonic Depression scale in the current study was 0.89.

#### 2.2.3. Urgency

The UPPS Impulsive Behavior Scales is a 45-item measure that assesses four facets of impulsivity: urgency, lack of premeditation, lack of perseverance, and sensation seeking (Whiteside et al., 2005). The current research utilized data from the 11 items comprising the Urgency subscale. Six of the items reflect the tendency to act rashly in general (e.g., trouble controlling impulses or resisting craving), while the other five items are framed in the context of negative emotions (e.g., *When I feel bad I act impulsively*). All items are rated on a 4-point Likert scale with higher scores reflecting greater impulsivity. The Urgency subscale had good internal consistency ( $\alpha = 0.85$ ) within the current sample.

#### 2.2.4. Smoking motives

The Wisconsin Inventory of Smoking Dependence Motives (WISDM-68; Piper et al., 2004) is a 68-item measure used to determine smoking motives. There are 13 smoking motives, and items for each subscale are rated on a 7 point Likert scale. The ratings on the scale are averaged to get a total score, so scores range from 1–7. Cronbach's alphas of the 13 subscales ranged from a low of 0.83 for Tolerance to a high of 0.93 for Cognitive Enhancement, indicating adequate reliability.

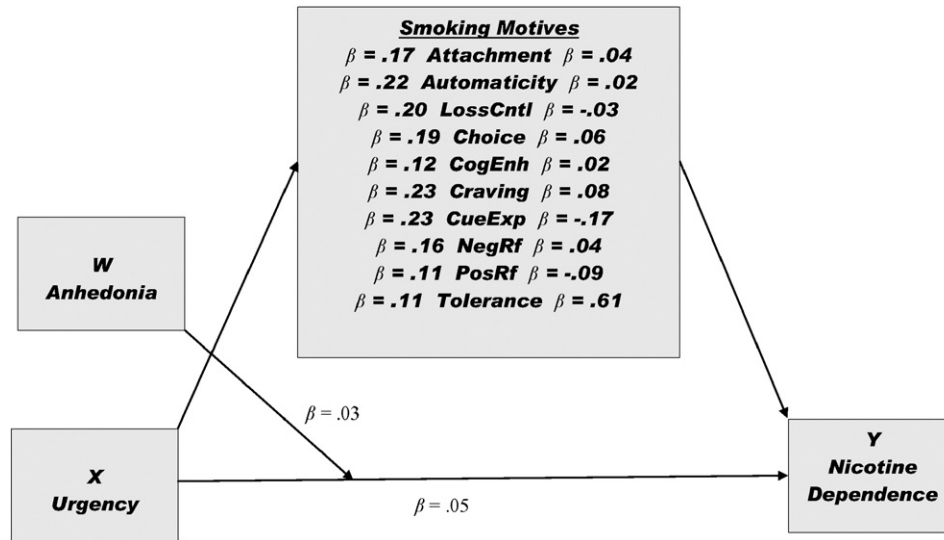
### 2.3. Data analyses

Proposed relationships among variables were tested using Model 5 of Hayes (2012) PROCESS analysis macro for SPSS to combine tests of multiple mediation and moderation (see Fig. 1). PROCESS relies on a bias-corrected bootstrapping approach to test indirect effects of mediators. In contrast to the more traditional product of coefficient approach to mediation (e.g., Baron & Kenny, 1986), bootstrapping estimates the sampling distribution of indirect effects directly rather than relying on assumptions of a normal distribution. Multiple mediation, with mediators operating in parallel, was chosen to explore how smoking motives mediate between urgency and nicotine dependence. Since the model only allows up to 10 mediators to be tested simultaneously, three motives were eliminated after examining the pattern of correlations with nicotine dependence. Seven motives were found to have correlations above 0.30 and were retained: attachment, automaticity, loss of control, behavioral choice, craving, negative reinforcement, and tolerance. In addition, cue exposure, positive reinforcement, and cognitive enhancement were retained due to support from prior research (Pang et al., 2014; Vinci et al., 2011; Doran et al., 2009; Piper et al., 2004).

The moderating effect of anhedonia on the relationship between urgency and nicotine dependence was tested simultaneously with the multiple mediation analysis. Evidence of a significant interaction effect between urgency and the moderator, while controlling for smoking motives and covariates of sex, age, and student status, provides a strong test of a moderating effect of anhedonia on nicotine dependence. Regions of significance for interaction effects were estimated at the mean value of the moderator, anhedonia, and at one standard deviation above the mean, and one standard deviation below the mean (Preacher, Curran, & Bauer, 2006).

## 3. Results

Means, standard deviations, and intercorrelations for all study variables are included in Table 1. Levels of nicotine dependence within the current sample varied from very low (26.8%), to high (32.1%; Fagerström, Heatherton, & Kozlowski, 1990). Approximately 7.2% of the sample reported elevated symptoms on the Anhedonic Depression subscale of the MASQ-S indicative of clinical levels of depression (i.e., 76 or higher; Buckby, Yung, Cosgrave, & Killackey, 2007). As shown in Table 1, nicotine dependence was significantly and positively related to anhedonia, urgency, and all 10 of the smoking motives. Smoking motives were also significantly related to anhedonia and urgency, and showed a strong pattern of significant intercorrelations.



**Fig. 1.** PROCESS model 5 (Hayes, 2013). Proposed mediational role of the 10 smoking motives on the relationship between urgency and nicotine dependence combined with the moderating influence of anhedonia on the relationships between urgency and nicotine dependence. β = standardized coefficients.

The correlation between urgency and anhedonia was significant, but modest,  $r(1084) = 0.31, p < 0.001$ . Although correlations are presented as descriptive information only, significance levels have been adjusted using Bonferroni’s correction based on the number of correlations conducted.

**3.1. PROCESS model**

The simultaneous moderation and multiple mediation model accounted for a statistically significant portion of the variance of nicotine dependence ( $R^2 = 0.65, p < 0.001$ ). Model coefficients reported below are standardized betas; both standardized and unstandardized coefficients may be found in Tables 2 and 3. The covariates of age ( $\beta = 0.12, p < 0.001$ ), student status ( $\beta = -0.19, p < 0.001$ ), and sex ( $\beta = -0.04, p = 0.02$ ) were all significantly associated with nicotine dependence. Women, younger participants, and current students all had lower levels of nicotine dependence. Further, both urgency ( $\beta = 0.05, p < 0.05$ ), and anhedonia ( $\beta = 0.05, p = 0.02$ ) were positively associated with nicotine dependence. Results of the moderation analysis revealed that nicotine dependence was also associated with the interaction between urgency and anhedonia ( $\beta = 0.03, p = 0.04$ , one-tailed).

Follow-up analyses exploring the relationship between urgency and nicotine dependence at three levels of the moderator (i.e., average levels of anhedonia, 1 SD below the mean, and 1 SD above the mean) revealed that urgency was only related to nicotine dependence at average ( $\beta = 0.05, p < 0.05$ ) and high ( $\beta = 0.08, p < 0.01$ ) levels of anhedonia, but not when anhedonia was low ( $\beta = 0.02, p = 0.43$ ; see Table 2). Within the current sample, approximately 17% had levels of anhedonia less than 1 SD below the mean, so the significant relationship between urgency and nicotine dependence applies to 83% of the sample.

Ten of the 13 smoking motives identified by Piper et al. (2004) were considered as potential mediators of the relationship between urgency and nicotine dependence. Overall, smoking motives significantly mediated the relationship between urgency and nicotine dependence, 95% CI [0.02, 0.10]. Table 3 shows unstandardized and standardized coefficients as well as bootstrapped confidence intervals for the 10 potential mediators. Although all 10 smoking motives were significantly correlated with nicotine dependence (as shown in Table 1), when considered simultaneously only four remained significant predictors. Tolerance ( $\beta = 0.61, p < 0.001$ ) and craving ( $\beta = 0.08, p = 0.03$ ) were positively associated with nicotine dependence, while cue exposure ( $\beta = -0.17, p < 0.001$ ) and positive reinforcement ( $\beta = -0.09, p = 0.02$ ) had negative associations.

**Table 1**  
Means, standard deviations, and intercorrelations for study variables.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. FTND	–												
2. Anhedonia	0.24	–											
3. Urgency	0.12	0.31	–										
4. Attachment	0.46	0.25	0.16	–									
5. Automatic	0.52	0.18	0.22	0.59	–								
6. LossCntl	0.54	0.22	0.19	0.66	0.67	–							
7. Choice	0.51	0.28	0.19	0.85	0.65	0.69	–						
8. CogEnh	0.28	0.08	0.12	0.58	0.51	0.47	0.67	–					
9. Craving	0.54	0.23	0.23	0.64	0.70	0.76	0.75	0.55	–				
10. CueExp	0.24	0.12	0.24	0.54	0.56	0.59	0.64	0.58	0.70	–			
11. NegRf	0.31	0.11	0.17	0.59	0.57	0.54	0.72	0.72	0.69	0.73	–		
12. PosRf	0.26	0.06	0.12	0.61	0.48	0.48	0.73	0.70	0.59	0.66	0.83	–	
13. Tolerance	0.73	0.16	0.11	0.57	0.68	0.70	0.66	0.47	0.73	0.52	0.54	0.50	–
M	4.18	54.02	2.55	2.98	3.92	3.61	3.42	3.71	4.18	4.64	4.46	4.25	4.21
SD	2.48	14.36	0.62	1.73	1.69	1.71	1.56	1.71	1.63	1.38	1.46	1.49	1.67

Note.  $N = 1084$ . All correlations over 0.08 are significant at  $p < 0.05$  (after application of Bonferroni correction for the number of correlations). FTND = Fagerström Test of Nicotine Dependence; Attachment = affiliative attachment; Automatic = automaticity; LossCntl = loss of control; Choice = behavioral choice/melioration; CogEnh = Cognitive enhancement; CueExp = cue exposure/associative processes; NegRf = negative reinforcement; PosRf = positive reinforcement.



**Table 2**  
Direct and indirect effects of smoking motives on smoking behaviors.

Smoking motive	Direct			Indirect			LLCI	ULCI
	B	SE	$\beta$	B	SE	$\beta$		
Affiliative attachment	0.05	0.05	0.04	0.03	0.03	0.01	−0.02	0.08
Automaticity	0.04	0.04	0.02	0.02	0.03	0.01	−0.03	0.07
Loss of control	−0.04	0.05	−0.03	−0.02	0.03	−0.01	−0.08	0.03
Behavioral choice	0.10	0.07	0.06	0.05	0.04	0.01	−0.02	0.12
Cognitive enhancement	0.02	0.04	0.02	0.01	0.01	0.00	−0.02	0.04
Craving	0.12*	0.06	0.08	0.07*	0.04	0.02	0.01	0.14
Cue exposure	−0.32***	0.05	−0.17	−0.16*	0.04	−0.04	−0.24	−0.10
Negative reinforcement	0.07	0.07	0.04	0.03	0.03	0.01	−0.02	0.08
Positive reinforcement	−0.14*	0.06	−0.09	−0.04*	0.02	−0.01	−0.09	−0.01
Tolerance	0.90***	0.05	0.61	0.27*	0.07	0.07	0.13	0.42

Note.  $N = 1084$ .  $B$  = unstandardized beta.  $\beta$  = standardized beta. LLCI = lower limit confidence interval; ULCI = upper limit confidence interval.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < 0.001$ .

#### 4. Discussion

Nicotine dependence was well explained by the mediational and moderational variables examined. The relationship between urgency and nicotine dependence was significantly mediated by smoking motives of tolerance, craving, cue exposure and positive reinforcement. In addition, the relationship between urgency and dependence was enhanced with moderate to high levels of anhedonia. Collectively, these variables, in addition to age, student status, and gender, accounted for 65% of the variance in nicotine dependence.

As predicted, moderate to high levels of anhedonia amplified the relationship between urgency and nicotine dependence. At the lowest levels of anhedonia, there was little relationship between urgency and nicotine dependence, but as symptoms of anhedonia increased the relationship between urgency and nicotine dependence became stronger. As urgency is partially defined by strong impulses to act within the context of distressing emotions, moderation by negative affectivity would have been expected. However, the moderational role of anhedonia, or the absence of positive emotions, was less certain. In a study conducted by Leventhal et al. (2009) individuals with high levels of anhedonia showed a significant desire and urge to smoke after a period of nicotine deprivation, while individuals low in anhedonia did not have a significant desire for smoking or anticipation of pleasure due to smoking. Therefore, the authors concluded that individuals who have a high level of anhedonia are more sensitive to smoking urges (Leventhal et al., 2009). While the current study did not manipulate smoking deprivation, we found similar findings that the relationship between urgency and nicotine dependence is stronger in individuals who report higher anhedonia.

Results of mediational analyses provide a process oriented explanation to explain why urgency might be associated with nicotine dependence. To understand the process it is important to attend to both the magnitude and direction of the mediators. Beta coefficients allow direct comparisons between mediators to explain differences in magnitude while the sign of the coefficient indicates whether the mediator is related to higher (positive coefficient) or lower (negative coefficient) nicotine dependence (MacKinnon, Krull, & Lockwood, 2000). In addition, a variable is considered to be a mediator if the sign of the effect matches

**Table 3**  
Conditional direct effects of urgency on smoking behavior at low, average, and high levels of anhedonia.

Anhedonia	B	SE	$\beta$	t	p	LLCI	ULCI
Low ( $M = 39.66$ )	0.08	0.10	0.02	0.79	0.43	−0.12	0.27
Average ( $M = 54.02$ )	0.20	0.08	0.05	2.50	0.01	0.04	0.35
High ( $M = 68.38$ )	0.32	0.11	0.08	2.95	<0.01	0.11	0.53

Note.  $N = 1084$ .  $B$  = unstandardized beta.  $\beta$  = standardized beta. LLCI = lower limit confidence interval; ULCI = upper limit confidence interval.

the direction of the total effect. However, when an indirect effect has the opposite sign, the variable is considered a suppressing variable since it weakens the observed relationship by its omission (Rucker, Preacher, Tormala, & Petty, 2011). In other words, inclusion of a suppressing variable with a sign opposite to the total effect amplifies the magnitude of the coefficient of existing mediators, while the omission of this suppressing variable attenuates the magnitude.

The current multiple mediation analysis revealed that the smoking motives of craving and tolerance were found to mediate the relationship between urgency and nicotine dependence, whereas positive reinforcement and cue exposure were suppressing variables. The strongest mediational pathway was through tolerance indicating that smokers with high levels of urgency tend to persist in smoking due to the buildup of tolerance and to cravings in the absence of nicotine. This process model might have been obscured if motives associated with positive reinforcement and cue exposure were not simultaneously observed and accounted for. Motives for smoking that include positive reinforcement and cue exposure have typically been associated with lower levels of dependence and earlier stages of addiction (Fagerström, Jimenez-Ruiz, Mochales, & Gilljam, 2007; Piper et al., 2004). If these motives were left unmeasured, the mediational role of cravings and tolerance could have been masked or attenuated.

Negative coefficients associated with positive reinforcement and cue exposure may also suggest that these motives are of more relevance for lighter levels of nicotine dependence. Research has shown that at the initiation of smoking, individuals are more influenced by positive reinforcement due to the expectation that smoking will be appetitively rewarding (Doran et al., 2007). However, as tolerance to nicotine develops, individuals experience less of the positive effects of nicotine, and instead experience more withdrawal symptoms (Baker, Brandon, & Chassin, 2004). These withdrawal symptoms are then responsible for producing cravings. When individuals experience craving states, they become more concerned with reducing negative affect than with seeking out positive reinforcement (Billieux et al., 2007). Studies that have found a link between positive reinforcement and smoking have tended to use college samples with mainly low to moderate levels of dependence (e.g., Spillane et al., 2010). Since close to 50% of the current sample were classified as moderately to highly nicotine dependent based on the FTND, the finding that positive reinforcement was a suppressor variable is consistent with the literature that heavier smokers are less influenced by positive reinforcement. The sample of heavier smokers could also explain why tolerance and cravings served as significant mediators in the relationship between urgency and nicotine dependence. Both craving and tolerance are classified as late emergent smoking motives, in that they are more often associated with individuals who smoke for a longer period of time and more heavily (Piper et al., 2004). However, higher levels of impulsivity may also cause an increase in craving level (VanderVeen et al., 2008).

Cue exposure was also found to have a suppression effect indicating that this motive was related to lower levels of dependence; its inclusion in the mediational model may have accounted for variance that could have partially obscured mediational links through tolerance and cravings (MacKinnon et al., 2000). In a study by Doran et al. (2009), participants were not allowed to smoke following a cue-exposure. Individuals who were higher in sensation seeking had more appetitive cravings, whereas those with higher levels of urgency had more negative affect cravings. The authors theorized that those with higher sensation seeking had more motivation for positive reinforcement, whereas those with higher levels of urgency had more motivation for negative reinforcement. It appears that as smokers become more dependent there is a shift in motivation from contextual factors, to internal factors such as negative moods and urges (Piper et al., 2004). For instance, external cues only served as smoking motives for beginning smokers and not for smokers with greater levels of dependence (Piper et al., 2004). This shift from external to internal motives may be especially salient for individuals with depression who are already more internally focused on feelings of negative affect and lack of positive affect.

In contrast to research by Pang et al. (2014) negative reinforcement was not found to mediate the relationship between urgency and smoking dependence. Conceptually, however, the craving motive overlaps considerably with negative reinforcement (Piper et al., 2004). Studies that have included broad measures of negative reinforcement may be accounting for craving within their operational definition of negative reinforcement. Further, negative reinforcement motives may only reach conscious awareness when internal changes in negative affect are detected due to decreased nicotine levels (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004). However, when access to nicotine is precluded for some period of time, or if additional stressors increase negative affect, then this higher level of negative affect may come more into conscious awareness and create a cognitive bias towards more impulsive, urgent behavior (Baker, Piper et al., 2004).

Support for complex models involving depression symptoms, motives, and urgency have been found for alcohol problems (Gonzalez et al., 2011; King et al., 2011). Results of the current study suggest that an interactive model can be generalized to smoking dependence. The multiple mediation and moderation analyses allowed for a multidimensional explanation of smoking motives.

#### 4.1. Strengths and limitations

This study makes a unique contribution to the literature in being the first to use simultaneous moderation and multiple mediation analyses to examine the relationship between urgency, smoking motives, anhedonia, and nicotine dependence. The large sample size of the current study allowed the inclusion of multiple smoking motives within the mediation analysis, providing a more complete examination of how these motives may be related to nicotine dependence. Identification of the motives of cue exposure and positive reinforcement as suppression variables provides further direction to refine models of nicotine dependence to account for changes across the smoking lifespan. Further, simultaneous moderation and multiple mediation analyses allowed investigation of the amplifying role of anhedonia on the relationship between urgency and nicotine dependence while controlling for smoking motives and other confounding variables (e.g., age, sex). The inclusion of a wide age range for the study also lends generalizability of the model to individuals across the lifespan.

The cross-sectional design of the current study limits our ability to infer a causal role of urgency or depression symptoms on nicotine dependence. As others have suggested, it is conceivable that long-term nicotine addiction could amplify negative affectivity (Pang et al., 2014; VanderVeen et al., 2008) to produce greater depressive symptomatology. Momentary nicotine cravings could also exaggerate the sense of urgency as reported on the UPPS. This state of urgency may be more strongly felt in long-term smokers denied the opportunity to smoke

while completing the study questionnaires. Longitudinal studies that measure nicotine dependence, urgency, anhedonia, and smoking motives over a period of several years would also help untangle the direction of effects and provide a stronger test of causal relationships.

Another possible limitation was the use of the original conceptualization of the UPPS, in which urgency reflects both the tendency to act rashly in general and also when feeling bad or distressed (Whiteside et al., 2005). Subsequent models further differentiated positive urgency, or the tendency to act rashly in the context of positive emotions, from negative urgency, or the tendency to act rashly in the context of negative emotions (Cyders & Smith, 2008).

The lack of nicotine biomarkers used for confirmation of smoking status in the current study is also a limitation. While the parent study used an expired carbon monoxide test to confirm smoking status in two out of three data collection sites, the current study included all participants regardless of biomarker confirmation. In addition, since the multiple mediation model only allowed inclusion of 10 potential mediators, the smoking motives of social goals, taste, and weight control were not investigated. Future studies could include these motives along with the substantiated motives of tolerance, craving, cue exposure, and positive reinforcement as mediators of the relationship between urgency and dependence to provide a more exhaustive investigation of the role of smoking motives in nicotine dependence.

#### 4.2. Implications

Results of the current study indicate that models of alcohol addiction that consider an interaction between urgency and anhedonia can also be utilized in understanding nicotine dependence. A better understanding of the role of urgency, anhedonia, and the specific smoking motives that mediated this relationship can help guide coping skills training for smoking cessation and relapse prevention. This is consistent with research indicating the benefits of coping strategies for individuals who smoke in general (e.g., Hall, Rugg, Tunstall, & Jones, 1984; O'Connell, Hosein, Schwartz, & Leibowitz, 2007), and in particular for individuals high in anhedonia (Leventhal et al., 2014), a common symptom of depression. Given the established link between depression and smoking outcomes (e.g., Cinciripini et al., 2003), it is critical to bolster smokers' coping resources during quit attempts.

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#### Contributors

Melanie Roys completed the literature review, methodology, and the initial statistical framework for this paper. Keri Weed modified the statistical analyses and completed the results section. Interpretation of the results was completed by Melanie Roys, Keri Weed, and Maureen Carrigan. Maureen Carrigan oversaw the formulation of the study and contributed with writing the implications of the study. She also provided significant input in re-drafting the study. James MacKillop contributed the data set that was analyzed in this study and provided feedback about the paper. All authors have reviewed and approved the final manuscript.

#### Conflict of interest

All authors declare they have no conflict of interest.

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