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Nicotine Dependence, Internalizing Symptoms, Mood Variability and Daily Tobacco Use among Young Adult Smokers

Cristina B. Bares, Ph.D.¹, Danielle M. Dick, Ph.D.², and Kenneth S. Kendler, M.D.³

¹1080 S. University, Ann Arbor, MI 48109

²Psychology Department, Virginia Commonwealth University, Richmond, VA 23284

³Virginia Institute for Psychiatric and Behavioral Genetics, Virginia Commonwealth University, Richmond, VA 23298

Abstract

Introduction—Cigarette use among young adults continues to rise. As young adults transition to college and assume other adult roles and responsibilities, they are at risk for the development of mental health problems and for the progression of substance use problems. Previous studies suggest that individual differences in negative and positive mood contribute to cigarette use in established college-aged smokers, but less is known whether fluctuations in mood influence daily cigarette use, controlling for trait levels of internalizing symptoms and nicotine dependence.

Methods—Data for this study came from a sample of college students (N=39, 59% female, mean age 20.4 years) who reported regular cigarette use and participated in a 21-day ecological momentary assessment (EMA) study assessing within-individual variation in cigarette use and mood.

Results—A three-level hierarchical linear model accounting for the structure of 1,896 occasions of cigarette use nested within days and individuals indicated that within-individual variability in positive mood was associated with cigarette use at each occasion, after taking into account baseline levels of nicotine dependence and internalizing problems.

Conclusions—Daily shifts in positive moods are importantly associated with consuming cigarettes throughout the day.

Keywords

mood variability; young adult; daily tobacco use; nicotine dependence; internalizing symptoms

As cigarette smoking continues to be the most common form of tobacco use among young adults and a preventable cause of lung cancer (DHHS, 2014), understanding the factors that give rise to the progression of tobacco cigarette use during young adulthood is a public health priority. The majority of adult smokers begin using cigarettes during adolescence and young adulthood, making these developmental periods quite important in understanding the factors that influence individuals to use cigarettes.

To understand how individuals progress to heavy cigarette use and develop nicotine dependence, it is important to identify the experiences associated with continued use. Individuals differ in how sensitive they are to the effects of nicotine (Pomerleau, Collins, Shiffman, & Pomerleau, 1993). For example, individuals that experience positive sensations upon trying their very first cigarette continue to use regularly (Hirschman, Leventhal, & Glynn, 1984; Zabor et al., 2012) due primarily to the pharmacological effects of nicotine (Subramaniam & Dani, 2015). Individuals that experience pleasant sensations when smoking their first cigarette develop symptoms of nicotine dependence at a faster rate than those for whom that first cigarette was not pleasant (DiFranza et al., 2004; Pomerleau, Pomerleau, & Namenek, 1998).

While initial experiences in cigarette use are important and can serve as a proxy for the rewarding effects of nicotine from the moments of initial experimentation, the development of nicotine addiction potentially involves trait-level psychological characteristics as well as momentary experiences during each occasion of using cigarettes. Previous research suggests that cigarette use is determined by multiple factors including various forms of internalizing symptoms. Increases in internalizing (such as symptoms of depression, anxiety) have been reported in young adulthood, particularly while individuals are transitioning from high school to college and take up other adult roles (Guassi Moreira & Telzer, 2015; Samek, Goodman, Erath, McGue, & Iacono, 2016; Taylor, Doane, & Eisenberg, 2014). Internalizing symptoms have been shown to play an important role in cigarette use among college-aged students (Ameringer & Leventhal, 2010; Kenney & Holahan, 2008). A number of prior studies support the association between internalizing symptoms with cigarette use (Cranford, Eisenberg, & Serras, 2009; Dierker, Avenevoli, Merikangas, Flaherty, & Stolar, 2001; Korhonen et al., 2012) and baseline levels of internalizing symptoms increase the likelihood that adults will continue smoking (Forman-Hoffman et al., 2017; Hagman, Delnevo, Hrywna, & Williams, 2008).

Previous research has indicated that mood is made up of both positive and negative aspects. Enhancing positive mood or reducing negative mood is a common reason to use cigarettes (Baker, Brandon, & Chassin, 2004). In fact, individuals who hold expectancies that using cigarettes will reduce negative mood show faster increases in cigarette use and faster development of nicotine dependence symptoms (Heinz, Kassel, Berbaum, & Mermelstein, 2010). There is further evidence that smokers use cigarettes to dampen the effects of negative mood (Berg et al., 2011; Brown, Carpenter, & Sutfin, 2011; Morrell, Song, & Halpern-Felsher, 2011) and that negative and positive mood are associated with nicotine dependence (McChargue, Cohen, & Cook, 2004; Parrott & Murphy, 2012).

In addition, mood is thought to fluctuate during the course of a day (Stone, Smyth, Pickering, & Schwartz, 1996). Greater variability in mood has been observed among individuals with internalizing disorders such as major depression (Peeters, Berkhof, Delespaul, Rottenberg, & Nicolson, 2006), but is also important for bipolar disorder (Van Rheenen & Rossell, 2013; Wright & Simms, 2016) and other forms of psychopathology (Houben, Van Den Noortgate, & Kuppens, 2015). Some have argued that greater fluctuations in mood are an important clinical feature of various disorders that may reflect a lack of emotional control (Houben et al., 2016).

Daily fluctuations in mood are further associated with different levels of cigarette use, nicotine cravings, and nicotine withdrawal (Weinstein & Mermelstein, 2013). Compared to non-smokers, infrequent smokers exhibit greater variability in positive mood (Pugach, Hedeker, Richmond, Sokolovsky, & Mermelstein, 2014) and variability in negative mood is associated with increased cigarette use (Weinstein, Mermelstein, Shiffman, & Flay, 2008). Further, emerging evidence suggests that as individuals become addicted to cigarettes during late adolescence and young adulthood fluctuations in both positive and negative mood are a result of within-person changes in nicotine withdrawal symptoms (Piasecki, Hedeker, Dierker, & Mermelstein, 2016).

Accurate assessments of phenomena likely to fluctuate on a daily basis should be measured using real time assessment methods. Ecological momentary assessments (EMA) of health behaviors have been shown to provide greater validity than more standard self-report methodologies and have been appearing in clinical settings for some time now (Shiffman, 2014). Studies using the EMA methodology have found that individuals who are depressed experience greater variability in the daily experience of negative emotions (Silk et al., 2011) and that some individuals smoke to reduce negative affect (Shiffman, Kirchner, Ferguson, & Scharf, 2009). Whether variability in negative and positive moods simultaneously contributes to how much young adults smoke has been less explored.

The Present Study

Real time assessments of smoking behavior among young adult smokers over the course of several weeks might provide a better understanding of the association between symptoms of psychological distress, mood fluctuations, and number of cigarettes smoked. Given that mood fluctuates on a daily basis (Stone et al., 1996) and that mood includes both negative and positive components (Watson, 1988), the aim of the present study was to examine how negative and positive aspects of mood are associated with the number of cigarettes smoked per occasion among young adult smokers controlling for the influence of psychological distress as well as other important factors.

Methods

Sample and Procedure

Participants were recruited from a larger study of college students who were 18 years of age or older at a Mid-Atlantic university; the Spit for Science study (Dick et al., 2014). The Spit for Science, a multi-cohort design study, has been recruiting incoming freshmen each year since 2011 and assesses a number of psychiatric, personality and environmental measures, including substance use. Participants who had taken part in the Spit for Science as freshman or sophomores who reported having smoked in the previous month were contacted and invited to learn more about the present study. Thus, we recruited from a pool of participants in the maintenance stage of smoking (Flay, 1993). To be eligible, participants had to own a smart phone, be current smokers (had smoked in the previous month), and not be using nicotine replacement therapy. Out of the 239 eligible participants from the Spit for Science study, 52 (21.8% response rate) expressed interest in learning more about the present momentary study. Of those who were interested, 39 (75%) enrolled. Informed consent was

obtained from each participant prior to beginning the study. Incentives for participating were graduated based on the level of participation and provided at the completion of the study.

Data Collection

Study data were collected and managed using REDCap electronic data capture tools (Harris et al., 2009). At random times during the morning (between 8:00 and 9:30 AM), afternoon (between 11:00 AM and 3:00 PM), and evening (between 7:00 and 9:00 PM) of the 21 day study, participants were sent a text message to their smart phone with a url link to a brief (12 questions) online survey. The surveys had a set of core questions that were common across each of the daily messages; two of the surveys (morning and evening) contained additional questions that were specific to that time of day.

Although participants were compensated at the completion of the three-week study, their compensation depended on completing 90% or more of the prompts. Participants' compensation was graduated depending on the week of the study. In the first week participants who completed 90% or more of the prompts were eligible to receive \$10.00, \$15.00 for completing 90% or more of the prompts sent during the second week and \$20.00 for their completion of 90% + of prompts sent in the third week. In total, a participant who completed more than 90% of the prompts during the entire study was eligible to receive \$45.00. Research assistants involved in the study monitored participants' compliance throughout the study. The url invitations expired after two hours of being sent so that participants could not complete a prompt sent in the morning, for instance, at another time of the day.

Measures

The present study included a number of theoretically important time-invariant and time-variant measures.

Time-Invariant Measures

Internalizing Symptoms: Participants' internalizing symptoms were assessed using self-reported answers to the Symptom Checklist (SCL-90 R) (Derogatis, 1977). The larger university survey from which this sample was recruited included only the Depression and Anxiety subscales of the SCL-90. Participants were asked to think back to the previous week and report on the degree to which they were distressed by headaches, felt low in energy, felt critical of others, among other items. The following response options were presented for each of the 19 items “*Not at all*” (0), “*A little bit*” (1), “*Moderately*” (3), “*Quite a bit*” (4) and “*Extremely*” (5) and a composite score was created by adding responses to the items. Higher numbers on the resulting score represented greater symptoms of internalizing and externalizing. The Cronbach's alpha for the internalizing symptoms of the SCL-90 R subscales was 0.91.

Nicotine Dependence: Each participant's level of nicotine dependence was assessed using six items from the Fagerström Test of Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). Participants are presented with items that ask the usual time to first cigarette upon waking, which cigarette they would hate to give up the

most, etc. and a total score is calculated. The Cronbach's alpha for the FTND in this sample was 0.67¹.

Pleasant Experiences at First Cigarette: To assess the sensations experienced when participants first tried a cigarette, they were asked to recall when they smoked their first cigarette and to rate the intensity of a number of sensations including “*Pleasurable rush or buzz*”, and “*Dizziness*” (Pomerleau et al., 1998). Participants were asked to use the following response options for each sensation: “*None*” (1), “*Slight*” (2), “*Moderate*” (3) or “*Intense*” (4). Higher responses to these items indicate experiencing more pleasure at the first experience with cigarettes. A dummy coded variable was created to indicate whether participants had experienced moderate or intense pleasant experiences at first cigarette (coded as 1) while participants who reported experiencing no or slight experiences were coded as 0.

Time-Variant Measures—The measures below were assessed on a momentary basis.

Smoked Within 30 Minutes of Waking: At each morning assessment, participants reported whether they had smoked a cigarette within 30 minutes of waking up (“*Yes*”/“*No*”).

Cigarette Use: At each measurement occasion, participants were asked whether they smoked a cigarette since the last text message and if they indicated that they had smoked, participants were asked to indicate the number of cigarettes that they smoked. The number of cigarettes smoked per occasion was the dependent variable in the present study.

Variability in Positive and Negative Mood: Momentary mood was assessed using a commonly used measure of mood (Shiffman et al., 2002). Participants were presented with the following statement, “*Right now, do you feel...*”, followed by a list of mood adjectives. Each mood adjective (e.g., happy, irritable, miserable, tense) was presented individually on the screen of the device and followed by four answer choices: “*No!!*” (1), “*no??*” (2), “*yes??*” (3), and “*Yes!!*” (4) (Hedeker, Mermelstein, & Demirtas, 2012). Seven of the mood measures (anxious, irritable, tense, sad, miserable, angry) represent negative mood and two of the mood measures (happy, content) represent positive aspects of mood.

Because we were primarily interested in fluctuations in mood, two new variables were created to represent the degree of positive and negative mood variability at each occasion. For each occasion, the standard deviation of each negative mood item score from the average of all negative mood items was calculated. The same was done for the positive mood items. Across all of the positive mood items, the standard deviation represented the degree to which an individual fluctuated at each occasion from their own average positive mood score. Higher values in mood variability indicate the tendency for participants to experience large fluctuations in either positive, or negative, mood.

¹The internal consistency of the FTND of our sample is within the range in the original study (Heatherton et al., 1991) as well as other studies (Haddock, Lando, Klesges, Talcott, & Renaud, 1999).

Demographic Covariates: Participants' self-reported race was included as a covariate. The majority of the sample was White (71.1%), and the remaining 8% were African American, 8% Hispanic, 11% were Asian, and 2.6% of the sample reported their race as unknown. Due to the small proportions of individuals who were not White in this sample race was included in the models as a binary variable with these two categories: White (coded as 1) and Other (coded as 0).

Analysis Plan

Hierarchical Linear Modeling—The hierarchical structure of the data collected for the present study, where momentary text messages are nested within individuals requires accounting for the dependencies within the data. Hierarchical linear modeling (Raudenbush & Bryk, 1986, 1988), also known as the random coefficient model (Hox, 2002), explains variation in a variable measured at one level by variation in a variable at the same, or a higher, level in the model. For example, variation in the number of cigarettes smoked per occasion (Level 1) may arise due to trait levels of psychological distress (Level 3) or fluctuations mood (Level 1). The analyses were conducted in Stata, version 14 (StataCorp, 2015) using the `meglm` command for multilevel mixed effects generalized linear models using the identity link function.

The number of cigarettes smoked at each occasion was the unit of analysis. The occasions (Level 3) were nested within days (Level 2) and days were nested within individuals (Level 1). The first step in the analyses involved examining a fully unconditional model (Level 3) to determine the presence of variability in the outcome at the lowest level explained by clustering. The result of the fully unconditional model is the intra-class correlation; an indicator of the amount of variability at the lowest level that is within days and within individuals. The next step involved adding predictors to the model at Level 3 and Level 1 to determine whether the variability in cigarettes smoked at each occasion was explained by factors at the individual or momentary levels. A total of two multilevel analyses were carried out.

Although the number of individuals in the sample obtained for the present analyses was modest, the number of occasions that were assessed within each day and within individuals provided adequate power to understand variations in cigarette use behavior over the course of several weeks. The present study had a power of over 0.90 to detect a moderate effect size, 0.5, at an alpha of 0.05.

Results

Demographic Characteristics

For the present study data was available for 39 participants (59.0% female) who were on average 20.4 years old ($SD=0.4$). We present descriptive statistics for the overall sample on Table 1 and separately by sex. The majority of the sample was White (71.1%), and 28.9% were of other racial/ethnic groups (see Table 1). Participants reported low levels of internalizing symptoms as measured by the SCL-90.

Regarding regular smoking behavior, before beginning the three-week study participants reported smoking on average for 26.5 days (SD=7.6) in the previous 30 days and they smoked on average 9.4 (SD= 16.3) cigarettes per day. On average, participants reporting having had initiated cigarette use at 15.9 years of age (SD=3.2). Over half (64.9%) of the sample recalled moderately pleasant sensations when they smoked their first cigarette. The total score of participant's nicotine dependence indicated low to moderate levels of dependence. We also present the nicotine dependence (FTND) total score by sex on Table 1 and the total nicotine dependence score as measured by the FTND in categorical form.

EMA Compliance

On average, participants completed each of the three assessments on 10.6 days (SD=6.1) of the 21-day study. In addition, the average participant compliance across all assessment opportunities was 77.2%. Answering the survey questions sent as a text message within a two-hour window was considered when calculating compliance. In the morning, 58.1% of the sample completed the url within the two-hour window frame and 71.1% of participants complied with the afternoon text message. In the evening, 96.0% of the participants completed the survey questions within the time allowed. Across all occasions, the average time from prompt to completion was 25 minutes (SD=29 minutes). Individuals who complied with the assessments were more likely to be White ($\chi^2=17.65$, $p<0.0001$) and had lower levels of internalizing problems ($\bar{x}=1.52$) than individuals who did not comply with all assessments ($\bar{x}=1.84$, $p<0.0001$). Differences in compliance were not observed between males and females ($\chi^2=0.49$, $p=ns$), in average age ($t=-1.21$, $p=ns$), in number of cigarettes smoked prior to the study ($t=-1.52$, $p=ns$), or age at cigarette smoking initiation ($t=-0.70$, $p=ns$).

Cigarette Use

During the 21-day study, 2,457 occasions were assessed and on 1,896 occasions (77.2%) participants provided reports of cigarette use. Nearly half of the participants (44.4%, see Table 1, Level 2) reported smoking in the morning, more than half in the afternoon (71.6%), and almost three-fourths (77.5%) smoked in the evening assessments. About half of the female sample reported having smoked in the morning but only a third of the males did so. Of those who reported having smoked a cigarette in the morning, 54.7% did so within 30 minutes of waking up. We found that almost three-fourths of the males had smoked within 30 minutes of waking up while less than half of the females did so. Across each morning, afternoon, and evening assessment, participants indicated smoking 1.7 cigarettes (SD=1.8) at each occasion with similar rates reported by males and females.

The fluctuations of negative and positive mood are presented as standard deviations (see Table 1, Level 3). We observed greater negative mood deviations (0.47) than positive mood (0.30) for the entire sample. Both males and females exhibited the same pattern of fluctuations in mood. We also explored the correlation between mood variability and internalizing symptoms, see Table 2. Because the mood items asked about mood at the moment of assessment but cigarette use was reported for the previous interval, lagged same-day mood assessments were used to predict smoking.

Hierarchical Modeling Results

Fully Unconditional Model—The first step in hierarchical linear modeling began with carrying out a fully unconditional model (Table 3, Model 1) that included the outcome variable but did not include any predictors. The result of the fully unconditional model reveals the amount of variability in the dependent variable that is attributable to variability accounted for by factors measured at the same, or higher, levels and allows for the calculation of the intra-class correlation (ICC). In other words, the ICC is the correlation in cigarettes smoked at each occasion for the same day and individual. In the unconditional model, the intra-class correlation was estimated to be 41.0% and suggests that slightly more than 40% of the variability in number of cigarettes used at each occasion is explained by variation due to clustering.

Within-Individual Model—To examine the influence of factors at the highest level (Individual) on number of cigarettes used at each occasion, the second model (Table 3, Model 2) estimated the influence of participants' positive and negative mood variability, smoking within 30 minutes of waking, psychological distress, pleasant experience at first cigarette, and race entered as fixed-effects. The result of the second model indicated that individuals who experienced greater deviations in positive mood reported smoking fewer cigarettes controlling for the influence of the other variables.

Having smoked within 30 minutes of waking was associated with smoking more cigarettes at each occasion. Individuals who smoked within 30 minutes of waking up were found to smoke about one and a third more cigarettes per occasion than individuals who waited longer to smoke their first cigarette of the day.

We found a significant difference by race in the number of cigarettes smoked at each occasion. The effect of race suggests that White individuals smoked slightly more than half a cigarette at each occasion than non-White individuals. Lastly, levels of nicotine dependence as measured by the FTND were positively associated with smoking more cigarettes per occasion. Nicotine dependent individuals smoked a tenth of a cigarette more than individuals with lower levels of FTND-measured nicotine dependence.

Discussion

The aim of the present study was to learn about the momentary associations between cigarette use and mood among young adult smokers, as much of what is known about variability in mood and cigarette use comes from adolescent samples. We examined associations between tobacco cigarettes smoked at several occasions during a three-week study and assessed how variability in positive and negative mood as well as symptoms of internalizing problems and other important measures of nicotine dependence were associated with the number of cigarettes smoked.

When asked to recall the number of cigarettes that they had smoked in the previous month in the baseline survey, our college-aged participants reported smoking about a half a pack of cigarettes per day. By following participants over the course of three weeks we found that, consistent with previous EMA studies (Shiffman et al., 2009), on average participants were

smoking about 2 cigarettes at each occasion, or slightly more than 5 cigarettes per day. Although participants in this study smoked daily, they were not heavy smokers.

The variability in how many cigarettes participants smoked at each occasion was explained by both between- and within-individual factors. Individuals who scored higher on the FTND smoked more cigarettes per occasion than those who had lower FTND scores. This finding is consistent with previous studies on the influence of individuals' sensitivity to nicotine on cigarette use (Kandel, Hu, Griesler, & Schaffran, 2007; Pomerleau et al., 1998).

Although previous studies suggest that symptoms of internalizing make young adult smokers vulnerable to smoke cigarettes to relieve feelings of distress (Morrell et al., 2011) when examined in conjunction with variations in mood, it becomes clear that positive mood may be more important contributors to daily changes in cigarette use than internalizing symptoms. The fact that fluctuations in positive mood were significantly associated with cigarettes smoked per occasion but not internalizing disorders might suggest that internalizing symptoms were not elevated enough in this present sample or not correlated enough with daily fluctuations in mood. Alternatively, our findings might suggest that fluctuations in positive mood might be better indices of emotional instability and that it is this instability itself that is responsible for cigarette use. Future studies could examine whether internalizing symptoms lead to greater changes in mood and test the mediating effect of mood on cigarette use.

Further, we found two ways in which aspects of nicotine dependence are associated with cigarette use per occasion. The time-invariant measure of nicotine dependence (measured at the outset of the study and included as a person-level variable) was associated with smoking more cigarettes per occasion, as was smoking within 30 minutes of waking. Our findings are consistent with previous research. For instance, greater between-individual differences in nicotine dependence (as measured by the FTND) leads to increases in cigarette use because an individual who is more dependent will consistently smoke cigarettes than an individual who is less dependent on nicotine. However, when considering variations within individuals across a number of days and times throughout the day, within-individual differences in how soon upon waking one smokes a cigarette may lead to reductions in use. Depending on how that first morning cigarette is smoked (Russell, Wilson, Patel, Feyerabend, & Cole, 1975) or on within-individual differences in the metabolism of nicotine (Benowitz & Jacob, 1994), individuals who smoke first thing in the morning may need to smoke fewer subsequent cigarettes throughout the day to maintain plasma cotinine levels (Brody et al., 2006).

The present study further suggests that within-individual differences in positive mood contribute to quantity of cigarettes smoked. In this study young adults who reported larger fluctuations in positive mood reported smoking fewer cigarettes, which fits with previous research in this area (Pugach et al., 2014) but not all (Piasecki et al., 2016; Weinstein & Mermelstein, 2013). Although negative mood variability has been previously linked with internalizing symptoms (Silk et al., 2011), in this study the influence of variability in negative mood did not contribute to quantity of cigarettes smoked among established young adult smokers. Previous research has established that both negative mood and positive mood are important features of internalizing problems (Clark, Watson, & Mineka, 1994; Peeters et

al., 2006). In our study, once we control for the influence of internalizing problems variability in positive moods, but not negative moods, appear to play an important role in individual differences in cigarette use. The finding that greater variability in positive mood is associated with using fewer cigarettes may suggest that individuals have experienced an alleviation of their mood as a consequence of smoking.

Clinical Implications

The findings of the present study have implications for how to conceptualize the relationship between mood and cigarette use but also the association between nicotine dependence and cigarette use. Mood fluctuations are important clinical components of various psychological disorders and mood instability is an important feature of daily experience and may be a mechanism to explain cigarette use. The picture that arises about the important factors to consider in designing smoking cessation interventions is that smoking has to do both with nicotine dependence and mood.

The findings of the present study could be used to develop potentially useful treatment strategies for cigarette use that incorporate participant's mood variability from ecological assessments. Previous studies have used text messages to change cigarette use behavior and encourage cessation as well as in changing other health behaviors (Hall, Cole-Lewis, & Bernhardt, 2015; Whittaker et al., 2009; Whittaker et al., 2012). Using text messages tailored to participants' baseline smoking characteristics have been shown to reduce number of cigarettes smoked (Haug, Schaub, Venzin, Meyer, & John, 2013) and to improve long-term quit rates (Skov-Ettrup et al., 2014). To date, studies delivering feedback through text messages and other technology based on participants' disease-relevant characteristics have been conducted for psychiatric disorders (Shapiro et al., 2010) including substance use (Ondersma, Grekin, & Svikis, 2011). Technology-enhanced treatments, including text messages, for substance use disorders benefit from feedback about quit progress (Free et al., 2011) or factors that might predict lapses in abstinence (Chih et al., 2014). In addition, as an adjunct to psychological treatments, text messaging has been shown to increase individual's ability to manage disorders associated with mood regulation (Agyapong et al., 2016). The findings of the present study suggest that future research in this area might also benefit from examining whether feedback about mood-related triggers or feedback about larger than typical variability in mood could be useful intervention targets.

Further, although we did not include in our sample individuals who were interested in quitting smoking, our findings also suggest that nicotine addiction may be involved in creating large daily mood fluctuations. It is possible that fluctuations in negative and positive aspects of mood act as a barrier among individuals who are interested in quitting (Hoepfner, Kahler, & Gwaltney, 2014; Shiffman & Gwaltney, 2008) and could be used to alert individuals interested in quitting that one of the consequences of nicotine withdrawal may be fluctuations in mood. Discussing how fluctuations in mood may reduce a smoker's ability to remain committed to quitting may also prove useful in smoking cessation interventions.

Limitations

The results of the present study should be taken with the following limitations in mind. First, we did not assess for other forms of tobacco use common among young adults (such as electronic cigarettes or hookahs), other contributors to cigarette use behavior among young adult smokers such as living in disadvantaged areas (Diez Roux, Merkin, Hannan, Jacobs, & Kiefe, 2003) or which momentary cues triggered a smoking episode (Carpenter et al., 2014). Future studies might consider examining whether variations in mood and internalizing symptoms similarly predict the use of electronic cigarettes or other forms of tobacco use and examine contextual predictors. A second limitation has to do with having only measured cigarette use at random occasions instead of requesting that participants initiate entries when they smoked a cigarette. However, previous studies that have used prompted and self-initiated assessments find no difference between these two measures of occasional cigarette use and associations with mood variability (Piasecki et al., 2016). Further, in this study we did not directly assess when participants had smoked preventing our ability to test the influence of the exact time interval between smoking events and assessments of mood. Lastly, the sample we obtained for this study, predominantly White college students, reduced the generalizability of the findings of our study. Future studies might consider recruiting more diverse samples from a variety of settings (i.e., clinics, established smokers) to test the generalizability of the present findings.

Despite these limitations the present study adds to the literature by being among the first to examine within-individual fluctuations in both positive and negative mood, while including a number of other important predictors of quantity of cigarettes smoked that differ between and within young adult smokers. Mood variability is an important construct to understand in the continued use of tobacco, has previously been linked with problematic behaviors (Wills, Simons, Sussman, & Knight, 2016), and might be a malleable point of intervention and smoking cessation efforts (Hoepfner et al., 2014; Ruscio, Muench, Brede, & Waters, 2016).

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Table 1

Descriptive statistics for study variables at each level **

Level 1 (n=39)	Overall		Female		Male	
	Mean (SD)/ Percent		Mean (SD)/ Percent	Range	Mean (SD)/ Percent	Range
Sex (%Female)	59.0%					
Age	20.4 (0.38)		20.4 (0.4)	19.8 – 21	20.4 (0.4)	19.7–21.2
Race (% White)	71.1%		63.6%		81.3%	
Psychological distress	1.59 (0.98)		1.6 (1.0)	0–4	1.5 (1.0)	0–3.34
<i>Substance use</i>						
Days smoked in past 30 days	26.5 (7.6)		27.0 (5.6)	12–30	25.7 (9.8)	0–30
Cigarettes smoked per day	9.43 (16.3)		11.7 (0.5)	2–100	6.1 (4.5)	0–16
Age at smoking onset	15.9 (3.2)		16.5 (1.7)	12–19	15.1 (4.4)	12–19
Moderate pleasant feeling	64.9%		59.1%		73.3%	
FTND - total score	2.6 (1.8)		2.4 (1.8)	1–6	2.9 (1.8)	0–6
FTND - categorical						
Low	56.4%		65.2%		43.8%	
Low to Moderate	20.5%		13.0%		21.4%	
Moderate	23.1%		21.7%		25.0%	
High	no obs.		no obs.		no obs.	
Level 2 (n=819)						
Smoked in the morning						
Yes	44.4%		50.7%		35.5%	
No	55.6%					
Smoked w/in 30 min of waking ¹						
	54.7%		47.6%		69.2%	
Smoked in the afternoon						
Yes	71.6%		75.3%		66.3%	
No	28.4%					
Smoked in the evening						
Yes	77.5%		81.4%		72.1%	

	Overall	Female		Male	
		Mean (SD)/ Percent	Range	Mean (SD)/ Percent	Range
Level 1 (n=39)	No	22.5%			
Level 3 (n=2,457)					
Smoked since last signal					
	Yes	49.7%	52.9%	45.0%	
	No	27.5%	23.8%	32.8%	
	Missing	22.8%	23.3%	22.1%	
Cigarettes smoked since last signal		1.7 (1.8)	1.6 (1.6)	1.7 (2.1)	0–10
<i>Mood</i>					
Negative mood variability		0.47 (0.4)	0.50 (0.4)	0.44 (0.3)	
Positive mood variability		0.30 (0.4)	0.31 (0.5)	0.29 (0.4)	

Notes:

^{**} Level 1 represents the individual, Level 2 represents the day, Level 3 represents the occasions;

^{*} Higher numbers indicate endorsement;

[/] Asked only in the morning assessment.

Table 2

Correlation between mood scales and psychological distress

	1	2	3
1. Internalizing Symptoms	1		
2. Negative Mood Variability	0.06 *	1	
3. Positive Mood Variability	-0.09 **	0.04 ns	1

Note:
* <0.05,
** <0.01

Table 3

Multi-level Associations with Cigarettes Smoked at Each Occasion (n=1,896)

	Coeff.	SE	95% CI	ICC
1. Unconditional Model				
Constant	1.68	0.06	(1.57, 1.79)	41.0%
2. Within-Individual Model				
<i>Level 3 Predictors</i>				
Positive Mood Variability	-0.20	0.09	(-0.39, -0.01)	
Negative Mood Variability	0.15	0.11	(-0.07, 0.38)	
<i>Level 2 Predictor Fixed-effects)</i>				
Smoked w/in 30 minutes of waking	1.34	0.13	(1.08, 1.60)	
<i>Level 1 Predictors Fixed-effects)</i>				
Sex (Ref=Male)	-0.01	0.13	(-0.28, 0.25)	
Race (Ref=Non-White)	0.58	0.13	(0.33, 0.84)	
Pleasant First Cigarette Experience	0.09	0.13	(-0.16, 0.33)	
Psychological Distress	-0.12	0.06	(-0.24, 0.00)	
Age at Smoking Onset	-0.01	0.02	(-0.04, 0.02)	
Past Month Cigarettes Per Day	0.00	0.00	(0.00, 0.01)	
FTND	0.11	0.04	(0.04, 0.18)	

Note:

Bold represents variables significant at $p < .05$; Analyses control for time between text messages