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Relations Among Affect, Abstinence Motivation and Confidence, and Daily Smoking Lapse Risk

Haruka Minami
Rutgers, The State University of New Jersey, Institute for Health, Health Care Policy, and Aging Research, New Brunswick, New Jersey, and The Warren Alpert Medical School of Brown University

Vivian M. Yeh
Rutgers, The State University of New Jersey, Institute for Health, Health Care Policy, and Aging Research, New Brunswick, New Jersey, and Mount Sinai School of Medicine

Krysten W. Bold, Gretchen B. Chapman, and Danielle E. McCarthy
Rutgers, The State University of New Jersey and Institute for Health, Health Care Policy, and Aging Research, New Brunswick, New Jersey

This study tested the hypothesis that changes in momentary affect, abstinence motivation, and confidence would predict lapse risk over the next 12–24 hr using Ecological Momentary Assessment (EMA) data from smokers attempting to quit smoking. One hundred and three adult, daily, treatment-seeking smokers recorded their momentary affect, motivation to quit, abstinence confidence, and smoking behaviors in near real time with multiple EMA reports per day using electronic diaries postquit. Multilevel models indicated that initial levels of negative affect were associated with smoking, even after controlling for earlier smoking status, and that short-term increases in negative affect predicted lapses up to 12, but not 24, hr later. Positive affect had significant effects on subsequent abstinence confidence, but not motivation to quit. High levels of motivation appeared to reduce increases in lapse risk that occur over hours although momentary changes in confidence did not predict lapse risk over 12 hr. Negative affect had short-lived effects on lapse risk, whereas higher levels of motivation protected against the risk of lapsing that accumulates over hours. An increase in positive affect was associated with greater confidence to quit, but such changes in confidence did not reduce short-term lapse risk, contrary to expectations. Relations observed among affect, cognitions, and lapse seem to depend critically on the timing of assessments.

Keywords: smoking cessation, affect, motivation, confidence, ecological momentary assessment

Despite the advent and dissemination of effective psychosocial and pharmacological treatments for tobacco dependence (Fiore et al., 2008), relapse (i.e., a return to regular smoking) remains the most common outcome of smoking cessation attempts (Brownell, Marlatt, Lichtenstein, & Wilson, 1986; Shiffman, Brockwell, Pillitteri, & Gitchell, 2008). Although the dynamic process leading to relapse varies greatly across and within individuals (Tindle, Shiffman, Paty, & Dang, 2006), approximately 85%–95% of lapsers ultimately relapse even with an effort to reestablish abstinence (e.g., Brandon, Juliano, & Copeland, 1999; Kenford et al., 1994). Moreover, the majority of single lapse episodes progress to relapse relatively quickly (Brandon, Tiffany, Obremski, & Baker, 1990; Kenford et al., 1994). This is a critical problem with deadly consequences. Studying lapse allows us to examine the initial transition in smoking status from abstinence to smoking that must precede a return to regular smoking (relapse). Identifying the proximal affective and cognitive processes that lead to lapses may help us predict and ultimately prevent the initial lapses that typically culminate in relapse (Gwaltney, Shiffman, Balabanis, & Paty, 2005b; Kassel, Stroud, & Paronis, 2003; Piasecki, Fiore, McCarthy, & Baker, 2002; Shiffman, 2005). The current project focuses on predicting smoking behavior during a

Haruka Minami, Department of Psychology, Rutgers, The State University of New Jersey, Division of Health, Institute for Health, Health Care Policy, and Aging Research, New Brunswick, New Jersey, and Department of Psychiatry and Human Behavior, The Warren Alpert Medical School of Brown University; Vivian M. Yeh, Department of Psychology Rutgers, The State University of New Jersey, Division of Health, Institute for Health, Health Care Policy, and Aging Research, and Department of Oncological Sciences, Mount Sinai School of Medicine; Krysten W. Bold, Gretchen B. Chapman, and Danielle E. McCarthy, Department of Psychology, Rutgers, The State University of New Jersey and Division of Health, Institute for Health, Health Care Policy, and Aging Research.

Haruka Minami is now affiliated with Alpert Medical School of Brown University/Butler Hospital.

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Correspondence concerning this article should be addressed to Haruka Minami, Addictions Research, Alpert Medical School of Brown University/Butler Hospital, 345 Blackstone Boulevard, Providence, RI 02906. E-mail: Haruka_Minami@Brown.edu

quit attempt from proximal reports of both negative and positive affect. More specifically, we test the hypothesis that affect influences smoking during a cessation attempt both directly and indirectly by undermining cessation motivation and confidence.

Negative Affect

The role of negative affect in smoking cessation has been extensively studied. Stress and negative affect often precede lapses during cessation attempts (Marlatt & Gordon, 1980; O'Connell & Martin, 1987; Shiffman, 1982; see Kassel et al., 2003 for a review). A modified negative reinforcement drug motivation model proposed by Baker, Piper, McCarthy, Majeskie, and Fiore (2004) asserts that escape from or avoidance of negative affect plays a central role in the maintenance of addictive behavior. The model also posits that nonwithdrawal aversive affect (e.g., anxiety or distress induced by external events) may trigger the same responses (i.e., craving and smoking) that negative affect from withdrawal does. As such, smokers may smoke to escape aversive affective states even when these states are not related to withdrawal symptoms (Baker et al., 2004). In fact, many individuals identify smoking as their way of dealing with stressful situations (Brandon et al., 1999; Copeland, Brandon, & Quinn, 1995).

Whether part of withdrawal or prompted by stressful events, negative affect plays a significant role in smoking behavior. Yet, the cognitive pathways linking negative affect to smoking outcomes are little studied and poorly understood. It may be that negative affect increases smoking risk directly, as asserted by the reformulated negative affect model (Baker et al., 2004), and indirectly, by altering smoking-relevant cognitions, such as motivation to quit smoking and confidence in one's ability to quit smoking. Affective distress, for example, may erode one's willingness to work at quitting and confidence that one can cope with the stress of quitting to abstain successfully.

Positive Affect

Recent evidence also points to the importance of positive affect in smoking motivation and behavior change processes, independent of negative affect. For example, recent research (Doran, Cook, McChargue, Myers, & Spring, 2008) found that the effect of anhedonia (i.e., diminished capacity to experience pleasure) on heightened urges to smoke postquit is mediated by decreased positive affect rather than increased negative affect. Looking at only negative affect may lead to an incomplete picture of the process of addictive behavior change.

The broaden-and-build model proposed by Fredrickson (2000, 2003) suggests that positive affect sparks changes primarily in cognitive activity, rather than directly influencing physical action (Fredrickson & Branigan, 2001). The positive affect model asserts that openness to novel experiences and an active search for resources promote desired changes (Wagner & Ingersoll, 2008). When a person experiences interest or surprise, his or her attention is broadened and, in turn, he or she is able to consider choices that previously had been disregarded or rejected. Resolution of ambivalence may be facilitated by this increased flexibility in perception which may guide one toward change (Fredrickson & Branigan, 2001).

The roles of positive affect in health behavior and goal-oriented behavior have been demonstrated in various studies. For example, recent prospective studies showed that positive affect responses to a brief exercise trial were associated with more stable motivation to exercise (Kwan & Bryan, 2010) and subsequent exercise behavior (Standage, 2010). That is, those who experienced an increase in positive affect during a bout of exercise were more likely to have steady intentions to exercise and actually exercise in the future. Furthermore, increases in positive affect are associated with confidence and performance (e.g., exercise confidence, Ostir, Leveille, Volpato, Cohen-Mansfield, & Guralnik, 2003; test performance, Nelson & Knight, 2010).

Motivation to Quit

Motivation is a critical determinant of behavior change (Ajzen, 1991; Miller & Rollnick, 2002). In smoking cessation studies, motivation to quit is rarely treated as a dynamic construct, despite the fact that research has shown that motivation levels fluctuate even within a short-term period (e.g., Berman, Forsberg, Durbeej, Kallmen, & Hermansson, 2010; Lavigne, Hauw, Vallerand, Brunel, & Blanchard, 2009). Using ecological momentary assessment (EMA) data, Piasecki, Fiore, McCarthy, and Baker (2002) showed that smokers' motivation to quit following their quit date was dynamic and that abstainers and relapsers showed different growth patterns of motivation over a 7-week postquit period. Despite the conceptual and empirical bases for treating motivation as dynamic, research on real-time relations among affect, motivation to quit, and smoking behavior is lacking. Such research is needed to understand the effects of motivational drives on smoking behavior in naturalistic environments. Assessing changes in motivation following changes in affect during a quit attempt may help identify proximal precipitants of smoking lapses. Such information about predictors of motivational lapses that, in turn, predict behavioral lapses may facilitate intervention development. Just-in-time interventions that bolster motivation to quit may reduce lapse vulnerability during a quit attempt, for example.

Abstinence Confidence

The important roles of cognitions, particularly confidence, in intended behavioral change have been the focus of much research (e.g., Bandura, 1977; Shiffman, 2005) and the role of confidence in successful smoking cessation has been extensively studied (e.g., Condiotte & Lichtenstein, 1981; Shiffman, 2005). Smoking cessation research and treatments shaped by a social learning model of relapse focus on enhancing confidence and maintaining the perceived importance of quitting (Abrams et al., 2003; Marlatt & Donovan, 2005).

Some smoking cessation research has treated confidence as a dynamic construct. For example, Gwaltney, Shiffman, and Sayette (2005a) assessed abstinence confidence and related constructs using EMA and found that heightened cigarette craving and negative affect were related to decreases in confidence, especially in those with low baseline abstinence confidence. Furthermore, Shiffman (2005) demonstrated that day-to-day changes in abstinence confidence predicted relapse following a first lapse and concluded that negative affect predicted smoking behavior, at least partially, through undermining momentary confidence. Taken together, these findings indicate that changes in quitting confidence elicited by situational factors (e.g., affective distress) signal increased risk for smoking during a change attempt.

Roles of Motivation and Confidence in a Cessation Attempt

A recent study that examined the efficacy of sustained-release bupropion as a smoking cessation treatment revealed that motivation and confidence mediated the effect of bupropion SR on smoking outcomes (McCarthy et al., 2008). Moreover, a controlled laboratory study that aimed to assess how drug motivation influences health beliefs indicated that cigarette craving reduces confidence and intention to quit (Nordgren, van der Pligt, & van Harreveld, 2008). Although this was not a smoking cessation study, the finding supports the notion that cognitions related to health behavior are dynamic. Moreover, McCarthy et al. (2008) demonstrated that confidence and motivation to quit smoking changed over the first week postquit, although only the initial level of postquit motivation, not the rate of change, was predictive of abstinence in 1 month. To date, the dynamic nature of motivation to change specific behaviors has been studied primarily by assessing day-to-day changes. The effects of acute motivation change on shorter-term behavioral outcomes are not well understood, however, and are in need of further study.

Study Hypotheses

We tested a complex set of hypotheses regarding the short-term effects of negative and positive affect on smoking behavior within 12 to 24 hr through changes in motivation to quit and quitting confidence in the context of an attempt to quit smoking, as depicted in Figures 1–3. We predicted that increases in negative affect would erode motivation and confidence and positive affect would have the opposite effects on these cognitions. Second, we predicted that declines in momentary confidence and motivation would predict increased risk of a smoking lapse.

Results from the proposed study may add to the literature regarding (a) the time course and mediators of affective influences on smoking lapses and (b) the role of explicit cognitions during a quit attempt, particularly in relation to affect and later smoking.

Method

Participants

For this study, 130 adult smokers were recruited in central New Jersey via mass media calls for smoking cessation research participants. Participants were screened for the following inclusion criteria: 18 years of age or older, English literacy, smoking a minimum of 10 cigarettes per day for at least 6 months, an expired carbon monoxide (CO) level of 8 ppm or greater, motivation to quit smoking of at least 6 on a 10-point scale, and willingness to fulfill study requirements. Exclusion criteria included: living with someone enrolled in the study; contraindications to the use of nicotine lozenges (e.g., recent heart attack or heart surgery, heart disease, angina, irregular heartbeat, pregnancy, breastfeeding, past problems using the lozenge); serious psychiatric conditions (i.e., bipolar disorder or psychosis); and current use of other forms of tobacco, smoking cessation treatments, marijuana, or other illegal drugs.

Procedures

All study procedures were approved by an Institutional Review Board. Interested volunteers responding to mass media were first

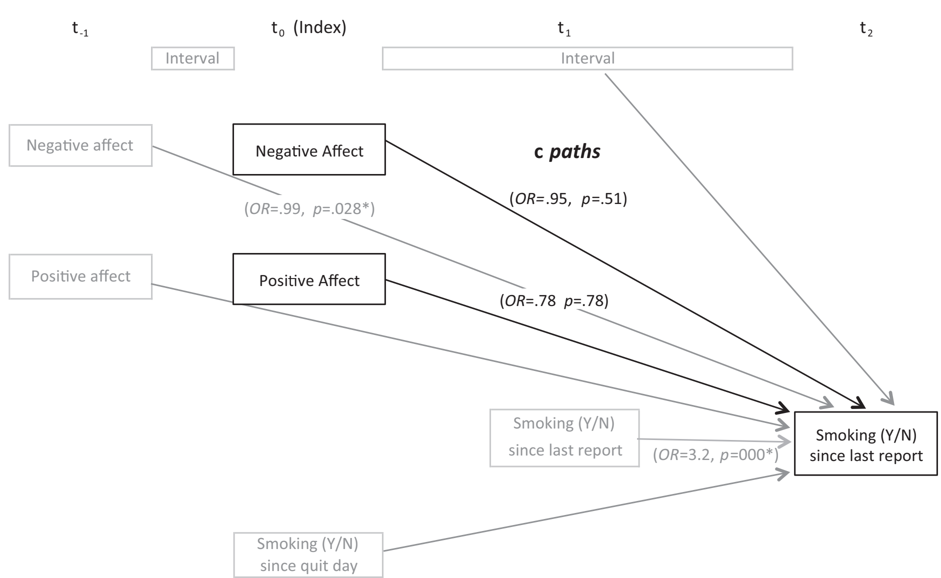

Figure 1. Model of hypothesized relations between negative and positive affect, and smoking lapse (c paths). The model was fit to test the hypothesized direct effects of affect change on smoking behavior using HLM analysis. Odds ratios and p values were indicated only for variables of primary interest (shown in black) and control variables (shown in gray) that were significantly associated with smoking outcomes. * $p < .05$.

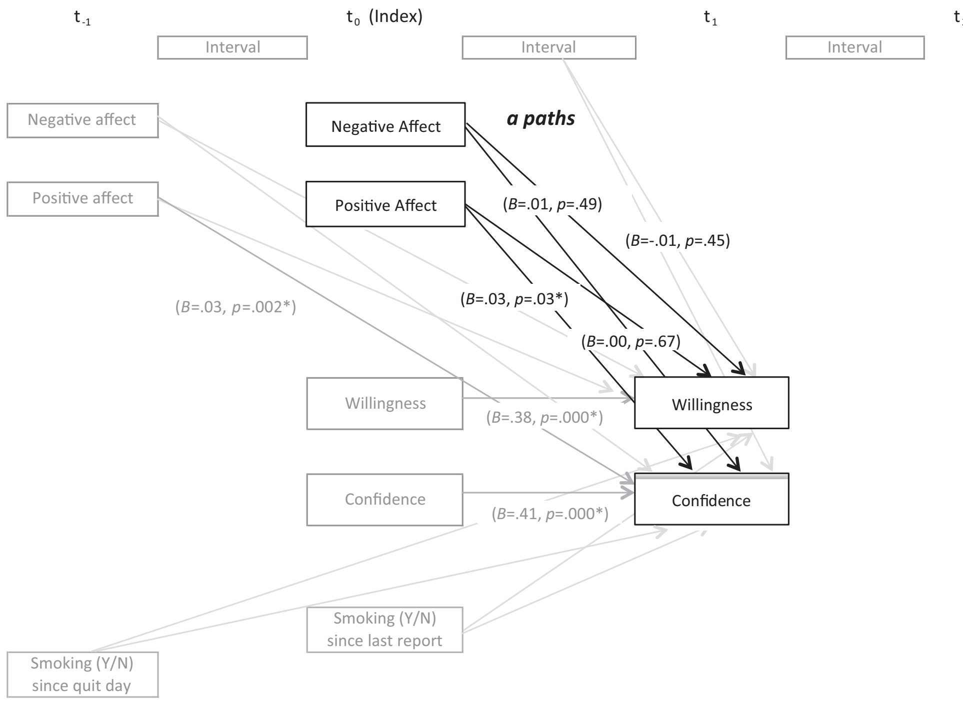

Figure 2. Model of hypothesized relations between negative and positive affect, and cognitions (a paths). The model was fit to test the hypothesized effects of negative and positive affective on willingness to work at quitting and confidence related to quitting using HLM analysis. Unstandardized coefficients and *p* values were indicated only for variables of primary interest (shown in black) and control variables (shown in gray) that were significantly associated with smoking outcomes. * $p < .05$.

screened for eligibility over the telephone. Eligible individuals were invited to a group orientation session at which they received a detailed description of the study and written informed consent was obtained. Baseline data collection, CO testing, and electronic diary (ED) training were also performed at the orientation session. All participants in this study received standard smoking cessation treatment including four brief individual counseling sessions based on the Clinical Practice Guideline *Treating Tobacco Use and Dependence* (Fiore et al., 2008) and the *Treating Tobacco Dependence Handbook* (Abrams et al., 2003) and a 12-week course of nicotine lozenges for use beginning on a target quit day set by the researchers. Participants attended five study visits at weekly intervals beginning 1 week prequit and ending 3 weeks postquit. Fifteen min counseling sessions were offered at the first four office visits and the nicotine lozenges were dispensed 1 week prequit, with instruction to begin lozenge use the morning of the quit day 1 week later. Individuals who smoked within 30 min of waking received 4-mg nicotine lozenges whereas those who waited more than 30 min before smoking received 2-mg lozenges (Shiffman, Dresler, & Rohay, 2004). Participants chose their preferred lozenge flavor (cherry or mint). The key constructs were assessed within a larger battery of assessments.

Participants carried EDs from day −10 to 21, relative to the quit date. CO testing was conducted at all visits and again 12-weeks postquit for participants who reported 7-day point-prevalence abstinence at the 12-week follow-up call. Maximum remuneration for completing the five scheduled office visits, a follow-up call, and a follow-up visit, was $130, contingent upon return of the ED after the recording period (if the ED was not returned, $125 was deducted from participants' compensation). Up to a maximum of $545 were possible in additional rewards depending on participants' performance on behavioral measures of impulsiveness in the laboratory and on the ED. Actual bonuses averaged $317 and ranged from $27 to $513. The total amount of compensation works out to roughly $25 per hr for those who completed all study activities.

Measures

Baseline assessment. At an initial group orientation session, participants provided breath samples for carbon monoxide testing and completed the self-report measures described below. These measures were used as baseline covariates in the current longitudinal models of data.

The Fagerström Test for Nicotine Dependence (FTND) consists of six items (e.g., "How soon after waking do you smoke your first cigarette?") and has a maximum score of 10. A higher score indicates greater physical dependence on nicotine and a score of 5 indicates moderate dependence (Fagerström, Heatherton, & Kozlowski, 1990). The FTND has fair internal consistency (Cronbach's alpha = .61; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) and high test–retest correlations (r = .85 to .88; Etter, Duc, & Perneger, 1999; Pomerleau, Carton, Lutzke, Flessland, & Pomerleau, 1994).

The Positive and Negative Affect Scale (PANAS) is a 20-item self-report measure of affective state (10 items assessing positive

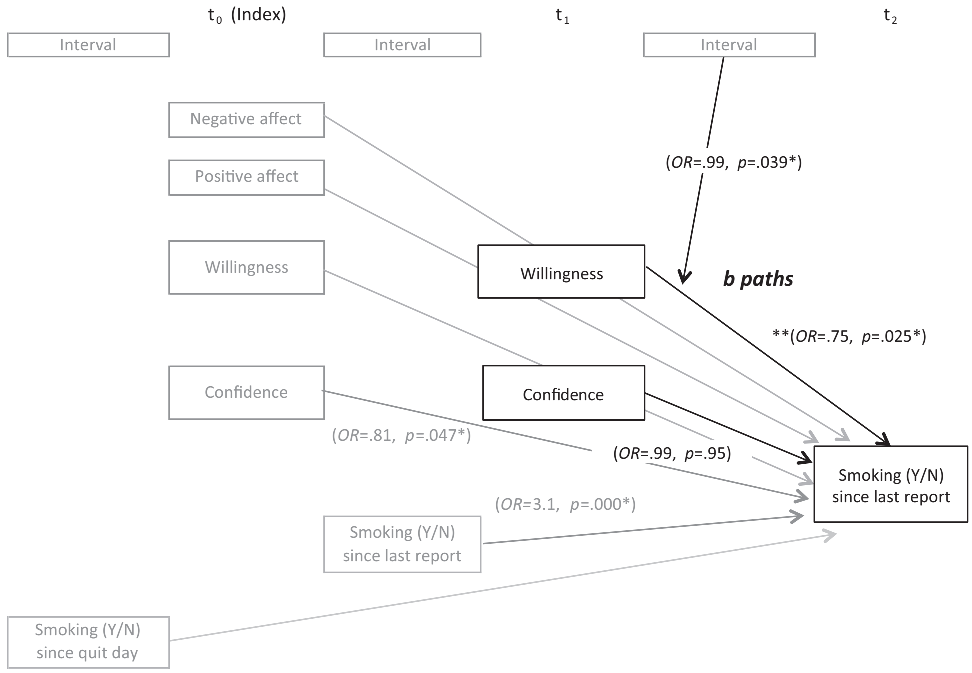

Figure 3. Model of hypothesized relations between cognitions and smoking lapse (b paths). The model was fit to test the hypothesized the effects of willingness to work and confidence at t_1 on smoking behavior using HLM analysis. Odds ratios and p values were indicated only for variables of primary interest (shown in black) and control variables (shown in gray) that were significantly associated with smoking outcomes. * $p < .05$. ** Odds ratio and p value were obtained from the model without a Willingness × Time interaction term.

affect and 10 assessing negative affect) rated on a 5-point scale (ranging from 1 = *very slightly* to 5 = *extremely*) during a specified period of time (e.g., past week). The PANAS has good internal consistency (α = .84 to .90) and validity as a measure of subjective affect (Crawford & Henry, 2004; Watson, Clark, & Tellegen, 1988).

The Wisconsin Smoking Withdrawal Scale (WSWS) is a 28-item scale that taps the central elements of the nicotine withdrawal syndrome. It consists of seven subscales (i.e., anger, anxiety, sadness, concentration, hunger, sleep, and craving). Internal consistencies range from α = .75 to α = .93 for the subscales and α = .90 for the total score (Welsch et al., 1999). Validity analyses also show that the WSWS negative affect scales correlate with the negative affect items of the PANAS (r = .46–.59) and the WSWS scales significantly predict smoking outcomes (Welsch et al., 1999).

Ecological momentary assessment. Participants were asked to carry palmtop computers, or electronic diaries (EDs, Palm Z22 Palmtop Computers, Palm, Inc., Santa Clara, CA) for 31 days, including a 3-day practice period, 1-week prequit, and 3-weeks postquit. Each day during this assessment period, participants were prompted at four pseudorandom times throughout the day (the alarms were set at randomly selected times within four equal intervals between the participant's wake-up and bed times and were at least 30 min apart). We excluded reports that were completed within 15 min of a previous report from the analyses to preserve the temporal separation of reports. The prompts signaled participants to complete a brief delay discounting task before completing reports of negative and positive affect, withdrawal symptoms, craving, restlessness, willingness to work hard at quitting (i.e., motivation to quit), confidence in ability to quit smoking for good, smoking since last report, and use of nicotine lozenges. The ED reports took approximately 3 to 5 min to complete and were time-stamped to indicate starting and completion times. Participants who completed a behavioral measure of impulsiveness after the report could earn up to $1.20 per report, based on their responses. This served as an incentive to complete ED reports. The behavioral measures of impulsiveness were not included in this study.

The ED assessed momentary affect and withdrawal symptoms (in the past 15 min) using items derived from the PANAS and the WSWS. Past factor analyses of items from both PANAS and WSWS assessed in EMA showed that negative affect and cognitive withdrawal symptoms loaded on one factor, whereas cravings to smoke loaded on another, and thoughts about food did not load on either factor (McCarthy et al., 2008). The items included in the current ED reports were selected because they were the top-performing items in a confirmatory factor analysis in a previous unpublished study. The negative affect items included were, from the WSWS: "I have been TENSE or ANXIOUS," "I have felt SAD or DEPRESSED," and "I have felt IMPATIENT" and from the PANAS: "I have felt DISTRESSED" and "I have felt UPSET." Key words were presented in capital letters to facilitate easy comprehension of the question when subjects were completing the ED reports in the field. For momentary positive affect, the PANAS items, "I have felt ENTHUSIASTIC," and "I have felt INTERESTED, " were highly correlated (r = .83 in McCarthy et al., 2008). The timeframe of these questions was the 15 min preceding the prompt and participants rated their agreement on a 5-point scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely)* for the PANAS items and 1 (*disagree*) to 5 (*agree*) for the WSWS items. The validity of such brief EMA measures of negative and positive affect is supported by research showing that stressful event reports predicted an increase in momentary negative affect and a decrease in momentary positive affect (Minami, McCarthy, Jorenby, & Baker, 2011) and that affect ratings change at the outset of a quit attempt (McCarthy, Piasecki, Fiore, & Baker, 2006, McCarthy et al., 2008).

A confirmatory factor analysis of the affect and withdrawal items assessed in this study was conducted in Mplus 5.0 (Muthén & Muthén, 1998–2008, Los Angeles, CA) with weighting of subjects' data based on the number of reports they contributed. A good fitting model (RMSEA = .023, 95% CI [.020, .025]) specified that both the PANAS- and WSWS-derived negative affect items (tense or anxious, sad or depressed, impatient, distressed, and upset) loaded on single latent variable. This factor loaded onto a higher order factor that also comprised low positive affect and high urges to smoke and hunger.

Participants' momentary confidence to quit smoking ("How CONFIDENT are you that you could quit smoking for good?" and motivation ("How WILLING are you TO WORK HARD at quitting smoking?") were assessed using single 7-point scales where 1 = *not at all* and 7 = *extremely*. A past study showed that the latter motivation item was influenced by treatment and predictive of later abstinence (McCarthy et al., 2008).

The number of cigarettes smoked in the last two hr and since the last report was assessed (0–20 cigarettes). Lapse (yes/no) was considered to have occurred if participants reported smoking at least one cigarette since last report.

Table 1
*Demographic Characteristics of Final Sample (*N = *103)*

Variable	Value	*n* (%)
Sex (*N* = 103)	Female	50 (48.5%)
Race/ethnicity (*N* = 103)	Hispanic	6 (5.9%)
	White	68 (66.0%)
	African American	23 (22.3%)
	Asian, Pacific Islander	6 (5.8%)
	American Indian	1 (1.0%)
	Other	4 (3.9%)
Marital status (*N* = 103)	Married	40 (38.8%)
	Divorced	11 (10.7%)
	Never married	29 (28.2%)
	Cohabitating	10 (9.7%)
	Separated	7 (6.8%)
	Widowed	6 (5.8%)
Education (*N* = 103)	< High school graduate	1 (1.0%)
	High school graduate	25 (24.3%)
	Some college	45 (43.7%)
	College degree	32 (31.1%)
Employment status (*N* = 103)	Employed for wages	58 (56.3%)
	Self-employed	12 (11.7%)
	Unemployed < 1 year	12 (11.7%)
	Unemployed > 1 year	8 (7.8 %)
	Homemaker	3 (2.9%)
	Student	10 (9.7%)
	Retired	5 (4.9%)
	Disabled	9 (8.7%)
Household income (*N* = 100)	< $25,000	33 (33.0%)
	$25,00–$34,999	6 (6.0%)
	$35,000–$49,999	13 (13.0%)
	$50,000–$74.999	20 (20.0%)
	> $75.000	28 (28.0%)
		M (SD)
Age (*N* = 103)		45.1 (12.0)
Age at first cigarette (*N* = 103)		15.1 (3.77)
Cigarettes smoked per day (*N* = 103)		18.6 (6.81)
Previous quit attempts (*N* = 103)		4.33 (9.77)
Baseline CO level (*N* = 103)		21.7 (11.3)
Baseline FTND Score (*N* = 103)		5.32 (1.92)

Final Sample

For the current study, 103 (79.2% out of 130 enrolled) participants who attended the quit day visit and provided at least 3 postquit reports were included in the analyses. Demographic characteristics of the 103 individuals included in the analyses are summarized in Table 1. During the postquit period, these participants provided 6,351 random report records (an average of 61.7 reports per person, or three out of four reports per day in the 21-day postquit assessment period). There were no differences between the excluded and included participants in terms of age, gender, minority status, cigarettes smoked per day, years smoking, baseline CO level, or number of past quit attempts (all $ps > .05$). A total of 94 participants (91.3%) reported at least one smoking lapse during the postquit assessment period. These subjects reported a total of 1,467 reports (an average of 15.61 lapse reports per person, *range* = 1–80, *SD* = 18.97). A total of 103 subjects had sufficient data to be included in the analysis.

Analytic Plan

A series of multilevel random coefficient models was tested using Hierarchical Linear Modeling (HLM) Version 6.08 software (Raudenbush, Bryk, & Congdon, 2007). In this study, random reports (i.e., reports of positive and negative affect, confidence to quit for good, willingness to work hard at quitting, and smoking) made up the first level of data nested within individuals at the second level. Continuous predictors (i.e., positive and negative affect, confidence level, and willingness to work hard at quitting) were centered around the grand means prior to entry in the models. As such, when all other predictors are zero, estimated coefficients reflect the probability of lapsing at the overall average level of cognitive variables and positive and negative affect.

Three sets of models were fit to test the hypothesized relations shown in Figures 1–3. Variables and paths of primary interest are shown in black whereas control variables are shown in gray. First, the direct effects of affect change on smoking behavior 12 (t_1) to 24 (t_2) hr later were assessed (separately for negative and positive affect), controlling for previous affect (at t_{-1}) and smoking (both at the last report and to that point in the quit attempt). These are the *c* paths shown in Figure 1. A Bernoulli distribution was specified, as smoking was coded as a dichotomous outcome (smoke free = 0, any smoking = 1) in nonlinear models. Second, models of negative and positive affective influences on willingness to work at quitting and confidence related to quitting up to 12 hr later (between t_0 and t_1) were fit to the data. These are the *a* paths shown in Figure 2. These models controlled for previous levels of affect (t_{-1}) and cognition (t_0) and smoking status at the last report and up to that point in the quit attempt. Third, willingness to work and confidence at t_1 were added to the *c* path models in order to test the *b* paths hypothesized, controlling for initial affect, earlier cognitions, and smoking status (see Figure 3). Random effects were specified to allow regression coefficients to vary across individuals, as long as doing so improved model fit. Deviance statistics for the models were compared in order to determine which models better fit the data (Raudenbush & Bryk, 2002). A significant reduction in deviance in a model, relative to another, indicates an improvement in model fit.

Power to detect the hypothesized relations among affect, cognitions, and smoking is difficult to estimate, particularly for the binary smoking outcomes of greatest interest. Power estimation for multilevel models is complex and guidelines are unclear. Power to detect relations between affect and cognition (treated as continuously scaled in this analysis) was moderate. An analysis with Power IN Two-level designs (PINT) software (Bosker, Snijders, & Guldemond, 2003) indicated that 103 subjects with an average of 60 reports per subject should be sufficient to detect small size effects with power = .80 at α = .05 (two-tailed). Power to detect relations between affect or cognition and later smoking is likely to be lower, given the binary nature of these data.

Results

Affect and Lapse Risk (c Paths)

First, we examined whether affect at the index report, controlling for affect at the previous report, prospectively predicted lapse risk between 0.5 and 24 hr later. Time (in min) between the index report (t_0) and report at t_2 (M = 758, SD = 333) was included to control for the effect of time on lapse risk (see Figure 1). Only the model intercept was allowed to vary across individuals because setting additional parameters (i.e., negative and positive affect) to random did not significantly reduce deviance (10.74 df = 5, p = .06), indicating no improvement to model fit. Results showed that neither changes in negative nor positive affect predicted changes in lapse risk within 24 hr, contrary to our hypothesis (Table 2, top panel). However, higher background negative affect assessed at t_{-1}, but not positive affect, was significantly associated with greater risk of lapse risk, controlling for recent smoking. Moreover, no significant time by affect (positive and negative) interaction effect was observed, indicating that the impact of changes in negative or positive affect on later lapse risk did not differ as a linear function of time.[1] Significant Level-2 variables for the intercept indicated that those with higher baseline nicotine withdrawal (assessed by WSWS) and baseline CO level had a significantly higher likelihood of smoking. Baseline nicotine dependence (assessed by FTND) was not related with smoking odds, after controlling for baseline CO.

Although changes in negative and positive affect did not predict a lapse within 24 hr, analyses indicated that negative affect changes had shorter-lived effects on lapse risk for up to 12 hr (i.e., the interval between reports t_1 and t_2). A Bernoulli distribution was specified and the same time-varying covariates were entered along with previous negative and positive affect levels. Results revealed that an increase in negative affect at t_1 predicted greater lapse risk in the next report t_2 whereas change in positive affect was not related to change in lapse risk (Table 2, bottom panel).

Affect and Cognitive Mediators (a Paths)

Multilevel models were built in which confidence and willingness to work hard (t_1) were regressed on positive and negative affect recorded in the previous reports (t_0) completed within the past 12 hr (at least 15 min apart). The mean interval between these reports was 273 min (SD = 172). Previous (t_0) levels of cognitive variables were included as control variables in the model in order to assess changes in cognitive variables following changes in affect (see Figure 2). Other time-varying covariates included: smoking status since the quit date (t_0), recent smoking (t_1), and the time interval between the index (t_0) and second (t_1) reports. No significant interaction effects between time interval and positive or negative affect were found in either the confidence or motivation models.

Motivation

In the *a* path model for willingness to work hard at quitting, the intercept (within-individual average level of willingness to work hard at t_1) and the coefficient for earlier willingness at t_0 were allowed to vary across individuals. This model yielded a statistically significant reduction in deviance (552, df = 2, p = .000) relative to the model in which only the intercept was specified as random, indicating an improvement of fit. Neither negative nor positive affect predicted willingness at the next report (Table 3, top panel). Male gender, greater baseline willingness to work hard, and higher baseline positive affect (Level 2-individual variables) predicted higher average willingness postquit.

Confidence

The intercept (within-individual average confidence level at t_1) and the coefficient for the confidence level at t_0 were allowed to vary across individuals in this model. Deviance for this model was 6,622.04, which represents a statistically significant reduction in deviance (change in deviance = 305.51 df = 2, p = .000) from the model in which only the intercept was specified as random, indicating a superior fit to the data. Results (Table 3, bottom panel) indicated that an increase in positive affect at the index report was positively associated with an increase in confidence level at the next report within 12 hr although a change in negative affect was not associated with changes in confidence at the next report. Moreover, higher baseline confidence level (Level 2) predicted greater average ED confidence level.

[1] The time lag between the index and t_2 reports clustered around 6 and 12 hr (a bimodal distribution). This may reflect the differences in the time of day that the reports were completed. The last reports of a day will inevitably have a longer delay till the next report due to suspension of recording during the overnight hours. In order to take this difference into account, an interaction term between a binary variable for time of day (capturing whether a report occurred within 8 hr of waking or more than 8 hr after waking) and the time lag between reports was entered in this model. However, no significant main effect of time of day or interaction effect was observed and these terms were pruned from the final model. Thus, it did not appear as though relations between affect and lapsing depended on the time of day reports were completed or the interaction between this and the interval between reports.

Table 2
Trimmed HLM Analysis of the Effects of Changes in Negative and Positive Affect (T_0) on Lapse Risk Over 24 Hr (T_2) and Over 12 Hr (T_2)

Predictor	Odds ratio	95% CI	Approx. *df*	*P*-value
Direct effect *c* path (24 hr)				
Mean P (Smoking) 30 min–24hr from index[**]*a*	0.034	[0.014, 0.082]	100	0.000[*]
Baseline CO	1.053	[1.017, 1.089]	100	0.005[*]
Baseline WSWS	1.027	[1.009, 1.152]	100	0.043[*]
Recent smoking (between index to t_1:Y/N)	3.191	[2.549, 3.994]	4,582	0.000[*]
Negative affect preceded index (t_{-1})	1.283	[1.103, 1.491]	4,582	0.002[*]
Index negative affect (t_0)	0.950	[0.815, 1.109]	4,582	0.518
Positive affect preceded index (t_{-1})	1.081	[0.926, 1.261]	4,582	0.326
Index positive affect (t_0)	0.978	[0.837, 1.144]	4,582	0.783
Direct effect *c* path (12 hr)				
Mean P (Smoking) 30 min–24hr from index[**]*b*	0.037	[0.016, 0.086]	98	0.000[*]
Baseline CO	1.053	[1.018, 1.090]	98	0.004[*]
Baseline WSWS	1.029	[1.002, 1.056]	98	0.036[*]
Recent smoking (between index to t_1: Y/N)	3.280	[2.537, 4.239]	3,646	0.000[*]
Index negative affect (t_0)	0.916	[0.770, 1.090]	3,646	0.325
Negative affect (t_1) w/in 12 hr of index	1.297	[1.087, 1.548]	3,646	0.004[*]
Index positive affect (t_0)	0.942	[0.788, 1.126]	3,646	0.511
Positive affect (t_1) w/in 12 hr of index	1.151	[0.961, 1.379]	3,646	0.125
Time interval (from t_1 to t_2)	1.001	[1.001, 1.002]	3,646	0.000[*]

Note. All other predictors were treated as fixed to facilitate model convergence. CO: expired carbon monoxide; WSWS: Wisconsin Smoking Withdrawal Scale. t_{-1} = Report preceding index report; t_0 = Index report; t_1 = Next report within 12 hours of index report. t_2 = Next report within 12 hours of t_{-1} report (and within 24 hours of index report).
[**] *a* Random coefficient, *df* = 100, reliability = .805. [**] *b* Random coefficient, *df* = 98, reliability = .775.
[*] $p < .05$.

Cognitive Variables and Lapse Risk (b Paths)

Changes in confidence and willingness to work hard at t_1 were simultaneously entered in the model as predictors of lapse likelihood within 12 hr along with the following covariates: recent smoking (t_1), smoking status since quit date (t_0), and time (min) between the t_1 and t_2 reports (see Figure 3). A Bernoulli distribution was specified for this model and the intercept was allowed to vary across individuals given that allowing additional parameters (i.e., confidence and willingness at t_1) did not significantly reduce deviance (6.3 *df* = 5, p = .28), indicating no improvement in model fit. As in the direct model (*c* paths), higher baseline CO (Level 2-individual variables) predicted greater lapse risk, but nicotine withdrawal scores (WSWS) no longer predicted smoking lapse (see Table 4). Greater time elapsed since the previous reports (t_1) and recent smoking (between index and t_1) were associated with greater lapse risk between t_1 and t_2. Inclusion of cognitive mediators did not change the nonsignificant relations between affect at t_0 and lapse risk at t_2.

Motivation

Results revealed a significant main effect of changes in willingness on later lapse risk (p = .025). A significant interaction between willingness to work hard at quitting at t_1 and the time interval between t_1 to t_2 (see Table 4) was also found. The protective effects of willingness on lapse risk emerged only as more time elapsed (see Figure 4). That is, motivation mattered less when there was less opportunity to lapse (because less time had elapsed), but became more protective with more time (and presumably greater opportunity to smoke).

Confidence

Results showed that although lower background confidence (t_0) significantly predicted greater lapse risk, a momentary change in confidence (t_1) was not associated with a change in lapse risk within 12 hr, contrary to our hypothesis (see Table 4). We further examined whether the relation between confidence and later lapse was moderated by baseline level of confidence, affect, or demographic characteristics, and found no such effects. Moreover, a follow-up analysis showed that removing previous confidence level (t_0) from the model resulted in a significant association between confidence (t_1) and lapse risk within 12 hr, confirming that the background levels of confidence (either over the past 12 or 24 hr), rather than hourly fluctuations in confidence, were predictive of smoking.

Discussion

The aim of this study was to prospectively examine the role of abstinence motivation and confidence in relation to earlier changes in negative and positive affect and later smoking behavior during a quit attempt. Results provided mixed support for the model. The direct effect of momentary changes in negative affect on later lapse risk was observed up to 12 hr, but not 24 hr later. An increase in positive affect had a significant effect on confidence within 12 hr, but not on willingness to work hard at quitting. Although time-dependent significant relations between motivation and later lapse risk were found, increases in confidence were not protective against later lapse.

Table 3
Trimmed HLM Analysis of the Effects of Changes in Negative and Positive Affect (T_0) on Willingness to Work Hard and Confidence to Quit Within 12 Hr (T_1)

Fixed effect	Coefficient	Standard error	T-ratio	Approx. *df*	*P*-value
		a paths (Willingness)			
Mean willingness (t_1) 15 min–12 hr from index**a	0.109	0.049	2.223	100	0.028*
Baseline willingness	0.144	0.045	3.181	100	0.002*
Baseline positive affect	0.018	0.007	2.603	100	0.011*
Recent smoking (between index to t_1: Y/N)	−0.080	0.018	−4.499	4,816	0.000*
Index willingness to work hard**	0.380	0.040	9.542	102	0.000*
Positive affect preceded index (t_{-1})	0.010	0.009	1.150	4,816	0.250
Index positive affect (t_0)	0.002	0.001	0.252	4,816	0.801
Negative affect preceded index (t_{-1})	0.004	0.009	0.427	4,816	0.669
Index negative affect (t_0)	−0.008	0.009	−0.761	4,816	0.447
		*a*paths (Confidence)			
Mean confidence (t_1) 15 min–12 hr from index**b	0.042	0.088	0.482	101	0.630
Baseline confidence	0.239	0.063	3.800	101	0.000*
Recent smoking (between index to t_1: Y/N)	−0.063	0.022	−2.793	4,817	0.006*
Index confidence (t_0)**	0.414	0.033	12.514	102	0.000*
Positive affect preceded Index (t_{-1})	0.026	0.011	2.386	4,817	0.017*
Index positive affect (t_0)	0.025	0.011	2.192	4,817	0.028*
Negative affect preceded index (t_{-1})	−0.001	0.011	−0.121	4,817	0.904
Index negative affect (t_0)	0.008	0.012	0.698	4,817	0.485

** *a* Random coefficient, $df = 100/102$. All other predictors were treated as fixed, with $df = 4{,}816$, to facilitate model convergence. Reliability: Intercept = .895, Willingness = .715, $N = 63$. ** *b* Random coefficient, $df = 101/102$. All other predictors were treated as fixed, with $df = 4{,}817$, to facilitate model convergence. Reliability: Intercept = .924, Confidence = .634.
* $p < .05$.

Affect and Smoking Behavior

Models of lagged relations between real-time affect and smoking behavior indicated that spikes in negative affect were associated with short-term elevated risk of smoking in models that controlled for earlier affect and smoking status. The relation between increased negative affect and later risk of lapse seemed to last only 12 hr, as this was not evident in reports as many as 24 hr later. This is consistent with earlier research showing that increases in negative affect over hours, but not days, were predictive of lapsing (Shiffman, 2005). The decay in the strength of the relation between negative affect and later smoking does not appear to be linear, as we did not find an interaction between negative affect and the interval between reports in models predicting lapses. Thus, there seems to be a qualitative difference in the strength of the relation between spikes in affective distress and smoking risk that merits further exploration.

Table 4
HLM Analysis of the Effects of Changes in Confidence and Willingness (T_1) on Lapse Risk Within 12 Hr (T_2)

Predictor	Odds ratio	95% CI	Approx. *df*	*P*-value
	b paths			
Mean P (Smoking) 30 min–24hr from index**	0.025	[0.010, 0.062]	98	0.000*
Baseline CO	1.055	[1.018, 1.093]	98	0.004*
Baseline WSWS	1.024	[0.997, 1.052]	98	0.086
Smoke free (quit date till index: Y/N)	0.857	[0.473, 1.552]	3,643	0.610
Recent smoking (between index to t_1: Y/N)	3.121	[2.409, 4.042]	3,643	0.000*
Index positive affect (t_0)	0.998	[0.838, 1.188]	3,643	0.983
Index negative affect (t_0)	0.978	[0.830, 1151]	3,643	0.786
Time interval (from t_1 to t_2)	1.001	[1.001, 1.002]	3,643	0.000*
Index confidence (t_0)	0.805	[0.649, 0.998]	3,643	0.047*
Confidence (t_1) w/in 12 hr of index	0.993	[0.800, 1.233]	3,643	0.950
Index willingness to work hard	1.063.	[0.820, 1.382]	3,643	0.638
Willingness to work (t_1) w/in 12 hr of index	0.880	[0.652, 1.187]	3,643	0.402
Willingness (t_1) × Interval (from t_1 to t_2)	0.999	[0.999, 1.000]	3,643	0.039*

** Random coefficient, $df = 98$, reliability = .777 All other predictors were treated as fixed to facilitate model convergence.
* $p < .05$.

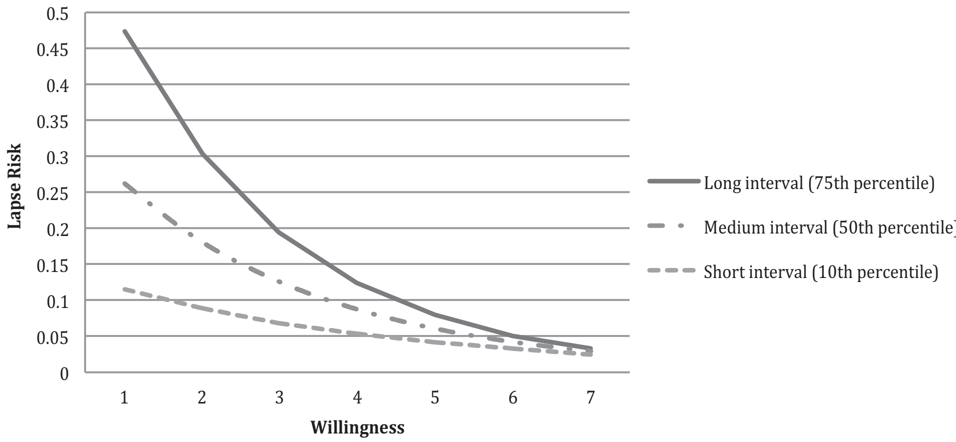

Figure 4. Willingness to Work at Quitting × Time Elapsed interaction effects in model of lapse risk. Moderating effects of time on relations between abstinence motivation and lapse risk (up to 12 hr). Each line represents different time intervals. The protective effect of increases in motivation on lapse risk is observed only with the longer interval. The coefficients used to create this graph were from the HLM analysis of the *b*-path model, controlling for confidence level at the previous report.

Affect and Cognitive Variables

Increases in positive affect were significantly associated with increases in confidence to quit, but not willingness to work hard at quitting up to 12 hr later. Neither baseline nor changes in negative affect had detectable impact on confidence or willingness. This may suggest that momentary confidence is more likely to be influenced by positive affect, rather than negative affect. Furthermore, those with higher baseline positive affect reported greater average levels of postquit willingness to work hard at quitting. It seems that stable positive affectivity, rather than acute changes, may influence levels of willingness to work hard toward a goal. Overall, the results indicated that positive affect may have a greater influence on cognitions than negative affect. This is consistent with the models of positive affect which assert that positive emotions expand one's openness to new experience and prompt changes in perspectives and cognitions such as motivation to change (Fredrickson & Branigan, 2001; Wagner & Ingersoll, 2008). Increasing positive affect, rather than merely focusing on reduction or avoidance of negative affect may help enhance confidence and motivation to work toward a specific goal.

Willingness to Work Hard at Quitting

An increase in motivation to quit was protective against lapse, especially when adequate time had elapsed. This suggests that the positive effects of enhanced willingness to work hard during a quit attempt last at least 12 hr. Daily motivational boosters such as reminders of reasons to quit (i.e., negative consequences of smoking, benefits of quitting, values inconsistent with smoking) may counter a decline in motivation over time (i.e., motivation fatigue) that may contribute to an increased risk of relapse (Piasecki et al., 2002).

Confidence to Quit

Contrary to expectations, an increase in confidence did not predict lower lapse risk within 12 hr. This result seems inconsistent with the prevalent notion that abstinence confidence is protective against lapse risk and earlier findings (Gwaltney et al., 2005b; Shiffman, 2005) indicating that lower self-efficacy predicted smoking lapse or relapse over days. However, although these studies prospectively examined relations between dynamic changes in self-efficacy and subsequent lapse/relapse risk, such changes were assessed daily (using average confidence within a day), unlike this study that assessed changes in confidence over hours within a day. In fact, our results showed that levels of abstinence confidence, rather than acute fluctuations in confidence, were predictive of subsequent lapse risk, indicating that higher background confidence is more important in preventing lapse than acute increases in confidence.

Furthermore, a recent review of relations between self-efficacy/confidence and smoking outcomes underscored the importance of considering smoking status at the time of the self-efficacy assessment (Gwaltney, Metrik, Kahler, & Shiffman, 2009). The review found that controlling for smoking status diminished the predictive value of self-efficacy on later smoking risk. Moreover, the bidirectional relations between self-efficacy and smoking status (i.e., abstinence predicts greater confidence although greater confidence predicts abstinence) have been empirically demonstrated (e.g., Perkins, Parzynski, Mercincavage, Conklin, & Fonte, 2012). Given that recent smoking status was controlled in all the models examined in this study, there may have been little unique, residual variance in later smoking to be explained by the part of self-efficacy that was not affected by earlier smoking.

Taken together, our findings highlight the differential roles that affective states may play in smoking cessation and suggest several clinical implications. Positive affect, but not negative affect, appears to influence cognitive determinants of smoking lapse. The important role of positive affect in the process of behavioral change has garnered much attention (e.g., Kwan & Bryan, 2010; Ostir et al., 2003; Standage, 2010) and this study provided support for a potential pathway though which positive affect may impact subsequent behavior. At the same time, negative affect, confidence, and willingness to work hard at quitting seem to have independent relations with subsequent smoking, suggesting that the associations between negative affect and smoking may be independent of smoking-related cognitions. These results suggest the importance of sustained positive affectivity as well as reducing acute increases in negative affect in successful quitting. In addition, given that short-lived spikes in confidence associated with acute increases in positive affect did not have protective effects against lapses, interventions that are designed to both enhance affective states and sustain these over time may improve cessation rates.

Limitations

There are several limitations that warrant caution when interpreting the results. First, the psychometric properties of the data may be limited; the extent to which brief EMA assessments are sensitive to momentary fluctuations in affect and cognition is unclear, although Shiffman and colleagues have shown that changes in affect and confidence assessed by EMA predicted later smoking behaviors (e.g., Gwaltney et al., 2005b; Shiffman, 2005). Second, possible reporting biases should be considered because there is no way to identify systematic missing reports. That is, some individuals may have missed reports only when they were in distress, had just smoked, or were particularly demoralized about quitting smoking. The nonexperimental nature of this study is another limitation. Because none of the variables of interest (e.g., affect, confidence) was manipulated, the interpretation of causal relations should be tempered. Finally, the best time-frames (seconds, minutes, days, etc.) to study the effects of affect on cognitive variables as well as the impact of cognitive variables on smoking behavior is not clear. However, the results from this study suggest that a shorter timeframe (less than 12 hr) is more suitable for studying relations among affect, cognitions, and smoking. Unfortunately, analyses using shorter timeframes were not possible in this study because participants, on average, completed 3–4 reports per day and sufficient reports for the analysis were not available (three consecutive reports were completed within 12 hours less than 47% of the time). Therefore, the time-frame used in this study may not be optimal for the study of cognitive variables during a quit attempt. Further studies investigating the acute impact of affect and cognitions on smoking cessation may be needed to better elucidate these relations. In addition, although extremely low rates of lozenge use were observed in this study—an average of 3.26 lozenges ($SD = 3.13$) per day during the first 6 weeks of the quit attempt—the lack of a no treatment control group is another limitation. Finally, we believe that willingness to participate in the study is a marker of readiness, as participants in this study were treatment seekers who signed up for a study knowing that a quit day would be set for them within 2 weeks. However, it is possible that changes in willingness to work hard at quitting may not fully capture changes in readiness to quit. As such, including additional constructs associated with smoking cessation success such as readiness to quit may improve our understanding of the interrelations among cognitive constructs and their impact on smoking behavior.

Conclusions

This study examined the dynamic relations among affect, confidence, motivation, and smoking behavior of adult smokers during an attempt to quit smoking. Multilevel models supported the general idea that negative and positive affect have detectable short-term effects on cognitions and behavior. The results also indicated, however, that the magnitude of relations among key constructs varies across assessment timeframes. Additional research is needed to identify the optimal timeframes for studying the proximal determinants of lapse risk. Studies of dynamic relations among affect, cognition, and behavior have the potential to provide a better understanding of crucial determinants and time courses of behavioral change that may facilitate the development of effective smoking cessation interventions.

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