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Relationship between momentary affect states and self-efficacy in adolescent smokers

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Abstract

Objective—Relapse to smoking after making a quit attempt is both common and rapid in adolescent smokers. Momentary self-efficacy (SE) – i.e., momentary shifts in one’s confidence in the ability to abstain from smoking - predicts the occurrence and timing of relapse among adolescent smokers. Therefore, it is important to identify factors that are associated with changes in momentary SE early in a quit attempt. This study examined the relationship between affect states (including positive, negative, and nicotine withdrawal states) and momentary SE at various stages of a quit attempt.

Method—Adolescent daily smokers interested in making a quit attempt (n=202) completed ecological momentary assessments (EMA) each day for 1 week leading up to and 2 weeks following a quit attempt. In each assessment, they reported current SE and affect state.

Results—Results of linear mixed models indicated that most of the examined affect states were related to momentary SE. Contrary to expectation, they were related to momentary SE both immediately before and after the quit attempt. Moderation effects were observed for select affect states, where higher baseline SE was related to lower momentary SE in the presence of increasing negative high activation, boredom and difficulty concentrating.

Conclusions—Our findings suggest that both positive and negative affect states are related to SE, and that thereby positive affect enhancement may be a promising, under-utilized treatment target.

Keywords

adolescent smokers; self-efficacy; mood; stages of smoking cessation; ecological momentary assessment

Introduction

The vast majority of adolescent smokers report a desire to quit smoking and most have made an attempt to quit in their lifetime (Bancej, O'Loughlin, Platt, Paradis, & Gervais, 2007; Castrucci & Gerlach, 2005; O'Loughlin, Gervais, Dugas, & Meshefedjian, 2009; Stanton, Lowe, & Gillespie, 1996). These attempts, however, almost always end in relapse; 90–95% of all adolescent quit attempts fail (Killen, Robinson, Ammerman, Hayward, Rogers, Samuels, et al., 2004; Killen, Robinson, Ammerman, Hayward, Rogers, Stone, et al., 2004; Mermelstein, 2003; Sussman, 2002). Adolescent relapse is not only common, it occurs quickly: most relapses occur within the first month after the onset of a quit attempt (Choi, Ahluwalia, & Nazir, 2002), and a third or more of relapses occur in the first week (Bancej et al., 2007).

Due to the rate and speed of cessation failures, it is important to identify factors early in a quit attempt that may predict or cause relapse. Although several studies have characterized the relapse process among adults (e.g., Saul Shiffman, 2005; Saul Shiffman et al., 2006), the same factors that underlie relapse among adult smokers may not apply to adolescent smokers. Treatment efficacy is lower among adolescents than adults (Sussman, 2002; Sussman, Lichtman, Ritt, & Pallonen, 1999), and nicotine dependence is still emerging in adolescent smokers (Zhan, Dierker, Rose, Selya, & Mermelstein, 2012), which suggests that different processes underlie cessation and relapse among adolescents (Colby & Gwaltney, 2007). More generally, adolescents differ from adults in a number of biological, psychological, and social dimensions that may cause them to experience smoking cessation and relapse differently than adults (Chambers, Taylor, & Potenza, 2003; Spear, 2000). Therefore, it is important to examine the process of relapse among adolescents directly and not rely solely on results from studies with adult smokers.

Abstinence self-efficacy (SE), or one's perceived ability to abstain from smoking, may play an important role in determining the outcome of adolescent smoking cessation attempts (Brandon, Herzog, Irvin, & Gwaltney, 2004; Gwaltney, Metrik, Kahler, & Shiffman, 2009). The relationship between SE and smoking cessation outcome is most often examined by predicting whether or not relapse occurs using individual differences in SE collected just before or after the initiation of a quit attempt (e.g., Abrams, Herzog, Emmons, & Linnan, 2000; Dijkstra & Wolde, 2005). A meta-analysis of studies examining this association among adult smokers suggests that the relationship between baseline SE and outcome is quite modest after controlling for smoking behavior at the time of the SE assessment (Gwaltney et al., 2009). Similar associations between individual differences in SE and cessation outcome are seen in adolescent smokers (Van Zundert, Nijhof, & Engels, 2009).

Although it is useful to understand the relationship between individual differences in SE and relapse, social-learning models of relapse suggest that dynamic changes in SE – not static baseline individual differences – are most important in determining the outcome of a cessation attempt. Both the relapse prevention model (Witkiewitz & Marlatt, 2004) and the dynamic regulatory feedback model of relapse (Niaura, Rohsenow, & Binkoff, 1988) suggest that SE is a central mediating variable that transmits the risk associated with other time-varying contexts, such as negative emotions, smoking cues, and craving. In these

social-learning relapse models, SE is a dynamic factor – it changes from moment to moment in response to changing internal and external environments and these momentary SE judgments determine subsequent behavior. Among adult smokers, SE has been shown to vary over time following the initiation of a quit attempt, and this variability predicts subsequent smoking (Gwaltney, Shiffman, Balabanis, & Paty, 2005; Saul Shiffman, 2005). A similar relationship has been observed among adolescent smokers: strength of SE on one day predicts the likelihood of lapsing or relapsing on the following day (Van Zundert, Ferguson, Shiffman, & Engels, 2010). Importantly, following a first lapse among adolescents, daily SE predicts subsequent day-to-day smoking above and beyond concurrent smoking rate (Van Zundert et al., 2010; see also Gwaltney et al., 2005). This suggests that dynamic changes in momentary SE may be an important independent mechanism of change among adolescent smokers and not just a reflection of current behavior (Gwaltney et al., 2009).

Because of the potential importance of dynamic SE judgments in predicting subsequent smoking, it is important to identify factors that may cause SE to change from moment to moment. One such factor may be affect states. Affect states play an important role in the initiation and escalation of smoking. Negative affect and stress are associated with the onset and progression of smoking among adolescents (Brandon et al., 2004; Kassel, Stroud, & Paronis, 2003). Furthermore, adolescents with high levels of negative mood variability (i.e., affect dysregulation) are more likely to escalate their smoking over time than those with less variable negative moods (Weinstein, Mermelstein, Shiffman, & Flay, 2008). Initial episodes of smoking appear to increase positive affect and reduce negative affect among adolescents who will progress to more regular smoking (Hedeker, Mermelstein, Berbaum, & Campbell, 2009). Taken together, this body of research underlines the importance of affects states – particularly negative affect - in adolescent smoking, and suggests that they may be an important factor in smoking cessation.

In general, affect states can influence the content and style of thought and evaluative judgments (Clore & Huntsinger, 2007). During smoking cessation, it has been shown that negative affect is a potent, independent cue for lapsing among adult smokers (Saul Shiffman & Gwaltney, 2008; Saul Shiffman & Waters, 2004), and is tied quite closely to momentary self-efficacy to abstain from smoking (Gwaltney, Shiffman, & Sayette, 2005). In adolescents, brain systems supporting emotion are more active and well developed than self-regulatory systems (e.g., Dahl, 2003; Spear, 2000), thereby suggesting that affect states may exert a profound effect on decision making, such as SE judgments and decisions to smoke. Consequently, adolescents may be particularly vulnerable to the effects of affect states on SE judgments, which may make the relationship with SE observed in adults even more robust among adolescents. Further, although the relationship between affect states and lapsing is strong among adults (e.g., Shiffman et al., 1996), an enhanced association between affect and SE may make affect an even more potent trigger for lapsing among adolescents. For example, negative affect may increase the salience and value of immediate rewards, making them more attractive than later, long-term rewards, and this effect may be particularly relevant for adolescents (e.g., Metcalfe & Mischel, 1999; “hot” vs. “cool” cognitive processes).

It remains unclear to what degree such affect states may be responsible for moment-to-moment changes in SE in adolescents. Among adult smokers, negative affect states and craving are associated with momentary SE: SE decreases as negative affect and craving increase (Gwaltney, Shiffman, & Sayette, 2005). External factors, such as alcohol consumption, were less strongly related to SE. The relationship between negative affect/craving and SE was moderated by individual differences in baseline SE, such that SE was much more strongly associated with negative affect and craving among individuals with low baseline SE. In other words, smokers with high confidence were more likely to maintain that confidence in the face of negative emotions and craving than those with low baseline SE.

The relationship between SE and negative affect among adolescent smokers may be complex (Van Zundert, Engels, & Kuntsche, 2011). Momentary ratings of negative affect – operationalized as an average of five affect items tapping nicotine withdrawal – were associated with momentary ratings of SE, such that greater negative affect was associated with lower SE, as expected given findings in adults. A single item measuring whether or not the adolescent had recently experienced a “stressful situation” was also inversely associated with SE. After controlling for craving and external cues (e.g., others smoking, alcohol or coffee consumption), negative affect no longer predicted SE, but the stressful situation item did. This finding suggests that different dimensions of negative affect may have different relationships with SE. The study did not, however, examine unique affect states independently. This is important as affect states have multiple dimensions: according to the circumplex model of affect, affect states are defined by bipolar valence (positive/negative) and arousal dimensions (low/high) (Russell, 1980). In order to better understand the relationship between affect states and SE, it may be useful to examine more specific affect states.

In this study, we examined the relationship between momentary affect states and SE using ecological momentary assessment (EMA) in sample of adolescents undertaking a quit attempt, where we examined both positively and negatively valenced states. Past research on the link between affect states and self-efficacy has largely focused on negative affect. Positive affect, however, is psychometrically distinct from negative affect (Watson & Clark, 1997), with different neural underpinnings (Davidson, Ekman, Saron, Senulis, & Friesen, 1990), and differing psychosocial correlates (Watson & Clark, 1997). Positive affect also plays an important role in smoking cessation: reductions in positive affect have been linked to increased temptation to smoke (Rabois & Haaga, 2003), positive affect cues can reduce craving (Saul Shiffman et al., 2013), and decreases in positive affect on the quit day are associated with a greater risk for smoking relapse (Cook, Spring, McChargue, & Hedeker, 2004; Strong et al., 2011). Given that both negative and positive affect play an important role in smoking cessation, we expected both positively and negatively valenced states to be significantly related to momentary SE, such that negative affect would be inversely associated with SE and positive affect would be positively associated with SE. We expected particularly strong correlations immediately following the quit attempt, as it is during this time we expected participants to be struggling with abstinence, and thereby being particularly vulnerable to time-varying contexts, such as mood. To this end, we examined this relationship separately in three distinct time intervals: pre-quit, quit to first lapse, first lapse to relapse or end of monitoring. We expected SE to be relatively stable in the pre-quit

period when participants were not trying to quit. Therefore, we expected relatively weak associations in this interval.

Method

Participants

Participants were adolescent smokers recruited from the community via information/registration desks in schools, malls, and other public places, flyers, and radio advertisements who met the following eligibility criteria: (1) between 14–18 years old, (2) smoking 1 cigarette per day in the past 30 days, (3) smoking 100 cigarettes in their lifetime, (4) desire to quit smoking within 6 months, (5) strong overall confidence in their ability and motivation to quit smoking (combined score from two 0–100 scales 120, in order to increase the probability that a high proportion of adolescents would attempt to quit), and (6) ability / permission to carry an electronic device at school (if enrolled in the study during the school year; participants received a letter for school officials explaining the nature of the study without disclosing the smoking status of the participant). Exclusion criteria were: (1) use of other tobacco products for 6 days in the past 30 days at screening, (2) college enrollment, and (3) planned or active participation in formal treatments (defined as pharmacotherapy, counseling, or internet websites). If adolescents were 14–17 years old, parental consent was obtained, in addition to participant assent.

After a pre-screen, a total of 222 adolescents were assessed for eligibility, 13 of whom failed the biochemical verification of their initial smoking status (i.e., 8ppm expired breath carbon monoxide and 14 ng/nm salivary cotinine). The remaining 209 were enrolled in the study, 2 of whom withdrew from the study before providing any EMA data; another 7 participants did not provide any EMA data meeting quality cut-off criteria (i.e., completed <60% of random prompts or fewer than 2.5 random prompts per day). The remaining 202 comprise the sample for this study, where not all participants provided data for all phases of the smoking cessation process, as detailed in Figure 1. The sample ($n=202$) was on average 16.5 ($SD=1.2$) years old and was 38.3% female. Participants reported their race as White (95.0%), African American (4.5%), and Asian (0.5%); 6.5% reported being Hispanic.

Procedure

Participants met with study staff six times (on study days 0, 1, 7, 8, 14, and 21) at the participant's school, home, a community center, or at the study offices. At enrollment, participants were informed that the general goal of the study was to better understand what happens when adolescents try to quit smoking, and trained to use palm-top computers (Teen Experience Diaries (TED)) to record their thought and feelings for the next three weeks (1 week prior, and 2 weeks after their quit day). Training covered responding to audible prompts, making smoking reports, and putting the TED into 'suspend' (to avoid interruptions in inappropriate locations, such as church) and 'sleep' mode. They were then asked to practice using the TED for one day, at which point they met with study staff again (study day 1) to review their entries and troubleshoot any difficulties. Going forward, participants met with study staff weekly to download and review data, and to provide carbon monoxide and saliva samples to verify claims of abstinence. At the study day 7 visit,

participants were instructed on the use of changed TED functionality once they clicked the “I’m Quit” button. Namely, in the TED’s post-quit mode, the cigarette and quit report buttons were exchanged for “slip” and “temptation” report buttons. As part of the new slip report, participants could indicate that they were no longer trying to quit smoking, at which point the TED reverted into its pre-quit mode. Participants were asked to begin their quit attempt when they woke up on study day 8, but they could initiate the attempt at any time. There was no minimal amount of abstinence required in order for participants to be considered as making a quit attempt. At the study day 8 visit, participants completed computerized tasks unrelated to this paper. At the final visit (study day 21), participants returned their TED. Participants could earn up to \$355 for participating in the study, including a \$20 bonus for every EMA download with 80% compliance. All study procedures were reviewed and approved by the Brown University institutional review board.

Measures

Lapse and Relapse—The first lapse was defined as the first occurrence of smoking after making an “I’ve Quit” entry on the TED. Relapse was defined as smoking at least one cigarette per day for three consecutive days, a common definition of relapse in EMA studies of adults (Gwaltney, Shiffman, Balabanis, et al., 2005) and adolescents (Van Zundert et al., 2010). The participant was considered relapsed at the beginning of this smoking sequence.

Self-efficacy—SE was assessed in each smoking and nonsmoking assessment with a single item - “Confident in ability to abstain (not smoke)” on a 0–10 scale (0=NO!! ; 10=YES!!). Participants were asked to think about how they “feel RIGHT NOW” when answering the question. The use of single-item measures is standard in EMA designs (e.g., Piasecki, McCarthy, Fiore, & Baker, 2008; Saul Shiffman et al., 2000; Van Zundert et al., 2010), and indeed, a single-item measure of self-efficacy has been shown to have superior predictive validity than multiple-item measures in predicting substance use (Hoepfner, Kelly, Urbanoski, & Slaymaker, 2011). Single item SE measures have been used in other EMA studies of adult and adolescent relapse (e.g., Gwaltney, Shiffman, Balabanis, et al., 2005; Van Zundert et al., 2010).

Mood / Affect—Affect items were derived from the circumplex model of affect (e.g., Russell, 1980; Yik et al., 2011). Circumplex models hypothesize that individual affect states can be defined by their position along two orthogonal dimensions. We used the dimensions of valence (pleasant-unpleasant) and activation (activated-deactivated) to generate our list of affect items. We selected items to measure four affect ‘quadrants’: activated/pleasant (excited, cheerful), deactivated/pleasant (calm, relaxed), deactivated/unpleasant (sad, bored), and activated/unpleasant (stressed, irritable, frustrated/angry, fidgety). Participants responded to each item separately (e.g., “How feeling? Excited?”) by using a 0–10 scale.

Factor analysis¹ of the items using multilevel modeling to account for repeated-measures nature of the data and traditional exploratory methods treating observations as independent data points supported this structure, with two exceptions: the “sad” item appeared to load with the activated/unpleasant factor and the “fidgety” item did not load with any factor. Therefore, the “sad” item was included with the activated/unpleasant factor score in

analyses; “bored” was used as the only indicator of deactivated/unpleasant affect. The “fidgety” item was also assessed independently, as restlessness may be an important part of the withdrawal syndrome. Subdomain scores were calculated by averaging the responses for each individual item in the subdomain. In order to address nicotine withdrawal states beyond its affective components, we also analyzed individual items assessing cigarette craving, difficulty concentrating, and hunger.

Baseline SE—In the screening process, a single item was used to assess baseline SE: “On a scale of 0–100, with 0 being not confident at all and 100 being extremely confident, how confident are you in your ability to quit smoking?”

Data Management and Analysis

Prior to analysis, data were cut if they failed to meet quality standards, as in other EMA studies (e.g., S. Shiffman et al., 1996; Tidey et al., 2008; Van Zundert et al., 2010), in order to remove unreliable or potentially biased data: (1) select weeks of data were cut if participants had unacceptable compliance during that week (i.e., completed <60% of random prompts or fewer than 2.5 random prompts per day), and (2) data were cut following the initiation of the quit attempt, if claims of abstinence could not be biochemically verified (see Figure 1).

Our analyses focused on the audible prompt assessments, which occurred at times randomly selected during specific time intervals (i.e., 0:00–3:00, 3:00–6:00, 6:00–9:00, 9:00–12:00, 12:00–15:00, 15:00–18:00, 18:00–21:00, 21:00–24:00). We also included one special audibly prompted report that occurred 1 hour after participants indicated that they had quit. Data were divided into three intervals: (a) pre-quit, (b) quit to first lapse or end of study, and (c) first lapse to relapse or end of study. In each interval, we examined the relationship between affect state and momentary SE using mixed effects models (Proc MIXED in SAS 9.3). We fit models separately for each affect state, because we were specifically interested in the relationship of each affect state with momentary SE. Note that correlations between affect states (as calculated first for each person, and then averaged across persons) were low, with an average absolute value of $r=0.15$. “Negative high activation” had the strongest correlations, with correlations of $r=-0.45$ and $r=0.40$ with “positive low activation” and “fidgety”, respectively.

In these models, momentary SE was the dependent variable, and affect state at that same assessment was the time-varying predictor. As a covariate, we also included time-of-day (8 categories corresponding to the EMA random prompt windows), so as to control for diurnal mood fluctuations (Stone, Smyth, Pickering, & Schwartz, 1996). Observations were nested

¹We initially conducted a four-factor multilevel model that corresponded to the four quadrants of the mood circumplex. This model had correlations close to 1 between the activated/unpleasant and deactivated/negative factors at both within and between subject levels. Indicators from these two factors were combined, and the model was re-estimated. In this model, neither the “fidgety” nor “bored” item loaded on the new “activated/negative” factor. They were removed and the model was re-estimated. This model showed adequate fit, though examination of modification indices indicated several correlated errors among the within-subject model. Modification indices greater than 25 were sequentially freed and the model re-estimated. The final model contained three factors (activated/positive, deactivated/positive, and activated/negative) at both the within- and between-person levels and had 7 correlated errors among the affect predictors. This model showed reasonable fit to the data, $\chi^2(27) 49.29, p=0.005$, RMSEA=0.006, CFI=0.999, TLI=0.997, SRMR-within=0.004, SRMR-between= 0.043.

within persons, where we allowed intercepts to vary from person to person, and used an AR1 structure to model the serial dependence of the data (we ruled out other correlational structures due to lack of parsimony (i.e., unstructured), lack of realism (i.e., compound symmetry), or because model fit indices favored AR1 (i.e., Toplit1). We fit these models separately per phase, so as to estimate the relationship between affect state and SE at each stage of the smoking cessation process.

We then tested for significant differences between phases. Here, we fit the same model as before, but used data from all three phases (i.e., pre-quit, abstinent, and lapsed), where we now included additional predictors: a main effect for phase (using reference coding, where the pre-quit phase served as the reference category), and an interaction-term between phase and mood. We interpreted a significant interaction term as evidence of differing relationships between mood and SE during different phases.

We also tested if the relationship between affect state and momentary SE would be affected by baseline SE. To this end, we used our original linear mixed effects model, and then included baseline SE and its interaction term with affect state as additional predictors. We did so, because in a previous study with adult smokers, the relationship between negative affect and SE was moderated by baseline SE levels, such that the relationship was stronger among those with low baseline SE (Gwaltney, et al., 2005). We interpreted significant interaction terms as evidence of moderation by baseline SE.

To address the problem of multiple significance testing (i.e., 8 affect state descriptors tested in separate models rather than in one multivariate model), we adjusted *p*-values by controlling the expected proportion of falsely rejected hypotheses, that is, the false discovery rate, as described by Benjamini and Hochberg (1995). Namely, for each predictor in the model (e.g., affect, affect*phase, or affect*baseline SE), we calculated adjusted *p*-values based on the eight raw *p*-values we obtained (i.e., one for each affect state model). An alpha of .05 was used for all analyses.

Results

Smoking Characteristics at Baseline

As shown in Table 1, participants smoked on average 11.0 ± 5.5 cigarettes per day, and 73% usually smoked their first cigarette within 30min of waking up. As expected, the majority of these adolescent smokers had made a previous quit attempt (74%). Confidence and motivation to quit smoking were also high, as per the enrollment criteria.

EMA Compliance

EMA monitoring lasted on average 18.3 ± 4.7 days, with a planned 13 days of monitoring following the initiation of the quit attempt, which was achieved by 50.3% of the participants; on average, post-quit follow-up lasted 11.4 ± 2.5 days.

On average, participants completed $88.4 \pm 6.6\%$ of nonsmoking random prompts per day, or 4.8 ± 0.6 random prompts per day. Random prompt completion slightly decreased over time,

with $90.8 \pm 7.1\%$ completion in the seven days leading up to the planned quit attempt, and $86.7 \pm 8.2\%$ in the up to 13 days after the planned quit attempt.

The suspend function was used by 89.2% of the participants, who used it for an average of 140.4 ± 76.3 minutes per day, or roughly 2.3 hours per day. Participants used the sleep function for an average of 10.5 ± 3.4 hours per day.

On average, participants forgot to enter at least one cigarette in real time on $43.8 \pm 0.3\%$ of EMA days; more so prior to the planned quit attempt than afterwards (48% vs. 40% of days). Very few participants (7.4%) never forgot to enter a cigarette in real time. On days on which participants forgot to enter cigarettes, they forgot to enter on average 2.6 ± 2.2 cigarettes per day.

Quit Attempts

All participants self-reported making a quit attempt; seven (3.5%) remained abstinent for the two weeks of EMA monitoring following the quit attempt. For those who resumed smoking, sustained abstinence tended to be of short duration, with a median of 6 hours (average of 17.3 ± 32.1 hours). Relapse, however, was not an inevitable outcome of lapsing, at least not within the 2 weeks of post-quit EMA monitoring. When it did happen ($n=123$, 60.8%), it occurred rapidly, with an average of 49.3 ± 68.7 hours from initiating a quit attempt to beginning the three days of consecutive daily smoking we used as a marker of relapse.

Relationship between Momentary SE and Affect States

The results of the analyses examining the relationship between SE and affect state (Table 2) indicated that most affect states were related to momentary SE, with the exception “bored” and “hungry”. In general, negatively valenced affect states were negatively associated with SE, while positively valenced affect states were positively associated with SE. Similarly, nicotine withdrawal states (i.e., craving, and difficulty concentrating) were negatively associated with SE. This pattern was consistent across all three phases of the smoking cessation process. These models included time of day as a covariate.

Phase Differences in the Relationship between Momentary SE and Affect States

Inspection of the model estimates (Table 2) suggested that variations existed between phases of the smoking cessation processes in terms of the strength of the association between affect states and momentary SE. Consider, for example, “negative high activation”. During the pre-quit phase, the parameter estimate was -0.15 , which means that for each 1 unit increase on the 0–10 scale for “negative high activation”, there was a corresponding 0.15 decrease on the 0–10 scale for momentary SE. In subsequent phases, the size of this parameter estimate was smaller, with $b=-0.12$ in the quit-to-lapse interval, and $b=-0.06$ in the lapse-to-relapse interval.

In formally testing differences between phases in the association of momentary SE and affect state, our results indicated significant differences for four affect states: “negative high activation” ($F(2, 10334)=6.31, p<0.01$), “fidgety” ($F(2, 10719)=4.38, p<0.05$), “craving” ($F(2, 10718)=13.10, p<0.01$) and “difficulty concentrating” ($F(2, 10719)=6.65, p<0.01$). For

each of these affect states, the relationships between affect and SE were significantly smaller during the lapse-to-relapse interval compared to the pre-quit interval, which was the reference category. These effects are illustrated in Figure 2, where we plotted the estimated linear functions per phase. Steeper functions indicate stronger relationships. Phase differences were biggest for “negative high activation” ($b=0.07$ [0.03–0.12]), followed by “craving” ($b=0.07$ [0.04–0.09]), “difficulty concentrating” ($b=0.05$ [0.03–0.08]), and “fidgety” ($b=0.05$ [0.01–0.08]).

Moderation by Baseline Individual Differences in SE

After adding baseline SE and its interaction term with affect state as covariates to the model, significant interaction terms were found for two affect states: negative high activation, during both the quit-to-lapse ($F(1,1030)=15.87$, $p<0.01$) and the lapse-to-relapse ($F(1,2469)=10.75$, $p<0.01$) phase, and difficulty concentrating ($F(1,1057)=10.00$, $p<0.01$) during the quit-to-lapse phase. To understand the directionality of these moderation effects better, we re-fit the model using a median-split dichotomous variable for baseline SE, and graphed the estimated functions for low vs. high baseline SE groups (Figure 3). Here it can be seen that smokers with high levels of SE at baseline generally had a steeper decline of momentary SE as negative affect and withdrawal states became more salient, while slower if not opposite trends were found in the low baseline SE group. This effect was consistent across all three identified moderation effects. Taken together, it appears that moderation effects played little to no role in the pre-quit and quit-to-lapse phase, but were noticeable for select negatively-valenced states immediately following the quit attempt.

Discussion

We examined several affect states that varied by valence and arousal levels, as well as affect states uniquely associated with nicotine withdrawal, as predictors of SE. In general, our results indicated that mood matters. Most of the affect and withdrawal states were related to momentary SE, as would be expected by theoretical models that cast SE in a dynamic role. These findings may be used to inform smoking cessation theory and treatments in this vulnerable population.

Previous research has focused on the relationship between SE and negative affect. Our results, however, suggest that both negative and positive affect states may play an important role in modulating SE and, ultimately, determining the outcome of an attempt to quit smoking. Importantly, positive and negative affect did not simply seem to be mirror images of each other; negative high activation and positive low activation were only moderately correlated in this study, thereby reflecting that these affect states reflect unique experiences rather than being simply inverses of each other, in line with previous research that highlights the distinctness of positive and negative affect (Davidson et al., 1990; Watson & Clark, 1997). Previously, low positive affect has been identified as a risk factor in early relapse after smoking cessation (Leventhal, Ramsey, Brown, LaChance, & Kahler, 2008; Strong et al., 2009). Our findings in adolescents are in line with these findings in that they demonstrate that positive affect, particularly low activation positive states, such as feeling calm and relaxed, are related to SE to quit smoking. As such, our findings suggest that in

designing smoking cessation interventions for adolescent smokers, it might be useful to target both the reduction of negative affect and the enhancement of positive affect. While mood-focused smoking cessation treatments have been developed, and found to be effective in randomized control trials (Hall, Humfleet, Reus, Munoz, & Cullen, 2004; Hall et al., 2002; Hall et al., 2005; Hall et al., 1996; Hall et al., 1998; MacPherson et al., 2010; van der Meer, Willemsen, Smit, Cuijpers, & Schippers, 2010), they have largely targeted negative affect. Our findings suggest that positive affect enhancement is a promising, under-utilized treatment target.

Our findings regarding the timing of the relationship between affect state and momentary SE were somewhat unexpected. We expected SE to be particularly tied to affect states in the time immediately following the quit attempt, during the time when participants are attempting to remain abstinent, and thereby potentially most vulnerable to threats to their SE. While associations between affect state and momentary SE were strong during this time, they were not stronger than during the pre-quit phase. The findings suggest two possibilities: First, the pre-quit SE ratings reflect true appraisals of the participants' confidence as they prepare for and envision their quit attempt. Participants may make judgments about their ability to abstain from smoking in the future, when in that type of affect state. It is also possible, however, that the experience of negative affect has an overall biasing effect, where negative emotions influence all perceptions and ratings negatively. Regardless, momentary SE ratings prior to a quit attempt may be useful indices of relapse vulnerability.

In examining moderation effects with baseline SE, our findings differed from trends observed in adults (Gwaltney, Shiffman, & Sayette, 2005). While adults with high baseline SE tended to be relatively impervious to mood fluctuations, adolescent smokers with high SE tended to be more affected by mood fluctuations than their low SE counterparts. This trend suggests that some of the high SE adolescent smokers may exhibit a bit of overconfidence, where their confidence gets disproportionately shaken as they encounter difficulties. Also of note is that these moderating effects were only found for a few select affect states. Namely, negative affect and withdrawal states showed moderation effects, consistent with the notion that individuals may have difficulty forecasting their reactions to emotionally-charged situations when making those predictions in a neutral environment, an effect known as the "cold-to-hot empathy gap" (Loewenstein, 1996). In smokers, this effect has been demonstrated by showing that smokers underestimate the intensity of their future craving when asked to make the prediction during a non-craving state (Sayette, Loewenstein, Griffin, & Black, 2008). Given that moderation effects were only found for a few affect states and the magnitude of the interaction is somewhat small, we believe that moderation by baseline SE plays less of a role in adolescents seeking to quit smoking.

One of the more surprising findings was that boredom seemed to be relatively unrelated to momentary SE. This finding is surprising, because adolescent smokers oftentimes cite boredom as one of their reasons to smoke (Tuakli, Smith, & Heaton, 1990), and boredom-related smoking outcome expectancies have been found to be related to later smoking status in adolescents (Wahl, Turner, Mermelstein, & Flay, 2005). Although boredom does not appear to influence SE, it may exert its effect on the smoking cessation process in a more direct manner; or possibly, it is simply less relevant to quitting smoking than adolescents

may think. More research is necessary to understand the role of boredom in adolescents' quit attempts.

Strengths and Limitations

This study used ecological momentary assessment, which is ideally suited to delineate the dynamic interplay of key variables during the process of smoking cessation. Particular strengths of this EMA study include its large sample size, and assessment of a large variety of affect states, which were assessed at distinct phases of the smoking cessation process.

At the same time, the results of this study need to be interpreted within the context of some limitations. First, this was a naturalistic observation study, and thus causal inferences cannot be drawn. Relatedly, while almost all participants made a quit attempt, sustained abstinence was often of very short duration. Thus, during the critical time immediately following cessation and prior to the first lapse we only had observations for a subsample (67%) of the participants who quit, and fewer observations per person than during the other phases. As such, while we still had a large overall number of observations during this phase (i.e., 1,289 observations), the generalizability and statistical power for this phase are more limited than for the other phases. All of the participants in this study were self-quitters; therefore, findings of this study may not extend to treatment-seeking populations. It should be kept in mind, however, that the vast majority of adolescents attempt to quit on their own. Also, the selection of highly motivated and confident participants may have impacted our analyses regarding the moderation effect of baseline SE. Finally, it should be noted that compliance with the EMA protocol decreased slightly over time, and that the data from some participants were excluded from analyses if they failed to meet our EMA compliance standards. Thus, to the degree that low compliance is related to individual differences (e.g., nicotine dependence), results may not generalize to all the participants that were targeted by the study.

Conclusions

Taken together, our findings suggest that affect states are associated with SE among adolescents and may play an important role throughout the process of smoking cessation in this population. Both negative and positive affect states were meaningfully associated with confidence to abstain from smoking. It might be useful to consider both negative and positive affect as intervention targets.

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References

- Abrams DB, Herzog TA, Emmons KM, Linnan L. Stages of change versus addiction: A replication and extension. *Nicotine & Tobacco Research*. 2000; 2(3):223–229. [PubMed: 11082822]

- Bancej C, O'Loughlin J, Platt RW, Paradis G, Gervais A. Smoking cessation attempts among adolescent smokers: a systematic review of prevalence studies. *Tob Control*. 2007; 16(6):e8. [PubMed: 18048598]
- Brandon TH, Herzog TA, Irvin JE, Gwaltney CJ. Cognitive and social learning models of drug dependence: implications for the assessment of tobacco dependence in adolescents. *Addiction*. 2004; 99 Suppl 1:51–77. [PubMed: 15128380]
- Castrucci BC, Gerlach KK. The association between adolescent smokers' desire and intentions to quit smoking and their views of parents' attitudes and opinions about smoking. *Matern Child Health J*. 2005; 9(4):377–384. [PubMed: 16328708]
- Chambers RA, Taylor JR, Potenza MN. Developmental neurocircuitry of motivation in adolescence: a critical period of addiction vulnerability. *Am J Psychiatry*. 2003; 160(6):1041–1052. [PubMed: 12777258]
- Choi WS, Ahluwalia JS, Nazir N. Adolescent smoking cessation: implications for relapse-sensitive interventions. *Arch Pediatr Adolesc Med*. 2002; 156(6):625–626. [PubMed: 12038898]
- Clore GL, Huntsinger JR. How emotions inform judgment and regulate thought. *Trends Cogn Sci*. 2007; 11(9):393–399. [PubMed: 17698405]
- Colby SM, Gwaltney CJ. Pharmacotherapy for adolescent smoking cessation. *JAMA*. 2007; 298(18):2182–2184. [PubMed: 18027441]
- Cook JW, Spring B, McChargue D, Hedeker D. Hedonic capacity, cigarette craving, and diminished positive mood. *Nicotine Tob Res*. 2004; 6(1):39–47. [PubMed: 14982686]
- Dahl RE. The development of affect regulation: bringing together basic and clinical perspectives. *Ann N Y Acad Sci*. 2003; 1008:183–188. [PubMed: 14998884]
- Davidson RJ, Ekman P, Saron CD, Senulis JA, Friesen WV. Approach-withdrawal and cerebral asymmetry: emotional expression and brain physiology. I. *J Pers Soc Psychol*. 1990; 58(2):330–341. [PubMed: 2319445]
- Dijkstra A, Wolde GT. Ongoing interpretations of accomplishments in smoking cessation: Positive and negative self-efficacy interpretations. *Addictive Behaviors*. 2005; 30(2):219–234. [PubMed: 15621394]
- Gwaltney CJ, Metrik J, Kahler CW, Shiffman S. Self-efficacy and smoking cessation: a meta-analysis. *Psychol Addict Behav*. 2009; 23(1):56–66. [PubMed: 19290690]
- Gwaltney CJ, Shiffman S, Balabanis MH, Paty JA. Dynamic self-efficacy and outcome expectancies: prediction of smoking lapse and relapse. *J Abnorm Psychol*. 2005; 114(4):661–675. [PubMed: 16351387]
- Gwaltney CJ, Shiffman S, Sayette MA. Situational correlates of abstinence self-efficacy. *Journal of Abnormal Psychology*. Special Issue: Toward a Dimensionally Based Taxonomy of Psychopathology. 2005; 114(4):649–660.
- Hall SM, Humfleet GL, Reus VI, Munoz RF, Cullen J. Extended nortriptyline and psychological treatment for cigarette smoking. *Am J Psychiatry*. 2004; 161(11):2100–2107. [PubMed: 15514412]
- Hall SM, Humfleet GL, Reus VI, Munoz RF, Hartz DT, Maude-Griffin R. Psychological intervention and antidepressant treatment in smoking cessation. *Arch Gen Psychiatry*. 2002; 59(10):930–936. [PubMed: 12365880]
- Hall SM, Lightwood JM, Humfleet GL, Bostrom A, Reus VI, Munoz R. Costeffectiveness of bupropion, nortriptyline, and psychological intervention in smoking cessation. *J Behav Health Serv Res*. 2005; 32(4):381–392. [PubMed: 16215448]
- Hall SM, Munoz RF, Reus VI, Sees KL, Duncan C, Humfleet GL, Hartz DT. Mood management and nicotine gum in smoking treatment: a therapeutic contact and placebo-controlled study. *J Consult Clin Psychol*. 1996; 64(5):1003–1009. [PubMed: 8916629]
- Hall SM, Reus VI, Munoz RF, Sees KL, Humfleet G, Hartz DT, Triffleman E. Nortriptyline and cognitive-behavioral therapy in the treatment of cigarette smoking. *Arch Gen Psychiatry*. 1998; 55(8):683–690. [PubMed: 9707377]
- Hedeker D, Mermelstein RJ, Berbaum ML, Campbell RT. Modeling mood variation associated with smoking: An application of a heterogeneous mixed-effects model for analysis of ecological momentary assessment (EMA) data. *Addiction*. 2009; 104(2):297–307. [PubMed: 19149827]

- Hoepfner BB, Kelly JF, Urbanoski KA, Slaymaker V. Comparative utility of a single-item versus multiple-item measure of self-efficacy in predicting relapse among young adults. *J Subst Abuse Treat.* 2011; 41(3):305–312. [PubMed: 21700411]
- Kassel JD, Stroud LR, Paronis CA. Smoking, stress, and negative affect: correlation, causation, and context across stages of smoking. *Psychol Bull.* 2003; 129(2):270–304. [PubMed: 12696841]
- Killen JD, Robinson TN, Ammerman S, Hayward C, Rogers J, Samuels D, Schatzberg AF. Major depression among adolescent smokers undergoing treatment for nicotine dependence. *Addict Behav.* 2004; 29(8):1517–1526. [PubMed: 15451121]
- Killen JD, Robinson TN, Ammerman S, Hayward C, Rogers J, Stone C, Schatzberg AF. Randomized clinical trial of the efficacy of bupropion combined with nicotine patch in the treatment of adolescent smokers. *J Consult Clin Psychol.* 2004; 72(4):729–735. [PubMed: 15301658]
- Leventhal AM, Ramsey SE, Brown RA, LaChance HR, Kahler CW. Dimensions of depressive symptoms and smoking cessation. *Nicotine Tob Res.* 2008; 10(3):507–517. [PubMed: 18324570]
- Loewenstein G. Out of control: Visceral influences on behavior. *Organizational Behavior and Human Decision Processes.* 1996; 65(3):272–292.
- MacPherson L, Tull MT, Matusiewicz AK, Rodman S, Strong DR, Kahler CW, Lejuez CW. Randomized controlled trial of behavioral activation smoking cessation treatment for smokers with elevated depressive symptoms. *J Consult Clin Psychol.* 2010; 78(1):55–61. [PubMed: 20099950]
- Mermelstein R. Teen smoking cessation. *Tob Control.* 2003; 12(Suppl 1):i25–i34. [PubMed: 12773783]
- Metcalfe J, Mischel W. A hot/cool-system analysis of delay of gratification: dynamics of willpower. *Psychol Rev.* 1999; 106(1):3–19. [PubMed: 10197361]
- Niaura RS, Rohsenow DJ, Binkoff JA. Relevance of cue reactivity to understanding alcohol and smoking relapse. *Journal of Abnormal Psychology.* 1988; 97(2):133–152. [PubMed: 3290304]
- O'Loughlin J, Gervais A, Dugas E, Meshefedjian G. Milestones in the process of cessation among novice adolescent smokers. *Am J Public Health.* 2009; 99(3):499–504. [PubMed: 18633080]
- Piasecki TM, McCarthy DE, Fiore MC, Baker TB. Alcohol consumption, smoking urge, and the reinforcing effects of cigarettes: An ecological study. *Psychology of Addictive Behaviors.* 2008; 22(2):230–239. [PubMed: 18540720]
- Rabois D, Haaga DA. The influence of cognitive coping and mood on smokers' self-efficacy and temptation. *Addict Behav.* 2003; 28(3):561–573. [PubMed: 12628627]
- Russell JA. A circumplex model of affect. *Journal of Personality and Social Psychology.* 1980; 39(6):1161–1178.
- Sayette MA, Loewenstein G, Griffin KM, Black JJ. Exploring the cold-to-hot empathy gap in smokers. *Psychol Sci.* 2008; 19(9):926–932. [PubMed: 18947359]
- Shiffman S. Dynamic influences on smoking relapse process. *Journal of Personality. Special Issue: Advances in Personality and Daily Experience.* 2005; 73(6):1–34.
- Shiffman S, Balabanis MH, Paty JA, Engberg J, Gwaltney CJ, Liu KS, Paton SM. Dynamic effects of self-efficacy on smoking lapse and relapse. *Health Psychol.* 2000; 19(4):315–323. [PubMed: 10907649]
- Shiffman S, Dunbar MS, Kirchner TR, Li X, Tindle HA, Anderson SJ, Ferguson SG. Cue reactivity in non-daily smokers: effects on craving and on smoking behavior. *Psychopharmacology (Berl).* 2013; 226(2):321–333. [PubMed: 23142992]
- Shiffman S, Gwaltney CJ. Does heightened affect make smoking cues more salient? *Journal of Abnormal Psychology.* 2008; 117(3):618–624. [PubMed: 18729613]
- Shiffman S, Hickcox M, Paty JA, Gnys M, Kassel JD, Richards TJ. Progression from a smoking lapse to relapse: prediction from abstinence violation effects, nicotine dependence, and lapse characteristics. *J Consult Clin Psychol.* 1996; 64(5):993–1002. [PubMed: 8916628]
- Shiffman S, Scharf DM, Shadel WG, Gwaltney CJ, Dang Q, Paton SM, Clark DB. Analyzing Milestones in Smoking Cessation: Illustration in a Nicotine Patch Trial in Adult Smokers. *Journal of Consulting and Clinical Psychology.* 2006; 74(2):276–285. [PubMed: 16649872]
- Shiffman S, Waters AJ. Negative affect and smoking lapses: a prospective analysis. *J Consult Clin Psychol.* 2004; 72(2):192–201. [PubMed: 15065954]

- Spear LP. The adolescent brain and age-related behavioral manifestations. *Neurosci Biobehav Rev.* 2000; 24(4):417–463. [PubMed: 10817843]
- Stanton WR, Lowe JB, Gillespie AM. Adolescents' experiences of smoking cessation. *Drug Alcohol Depend.* 1996; 43(1-2):63–70. [PubMed: 8957144]
- Stone AA, Smyth JM, Pickering T, Schwartz J. Daily mood variability: Form of diurnal patterns and determinants of diurnal patterns. *Journal of Applied Social Psychology.* 1996; 26(14):1286–1305.
- Strong DR, Kahler CW, Leventhal AM, Abrantes AM, Lloyd-Richardson E, Niaura R, Brown RA. Impact of bupropion and cognitive-behavioral treatment for depression on positive affect, negative affect, and urges to smoke during cessation treatment. *Nicotine Tob Res.* 2009; 11(10):1142–1153. [PubMed: 19574407]
- Strong DR, Leventhal AM, Evatt DP, Haber S, Greenberg BD, Abrams D, Niaura R. Positive reactions to tobacco predict relapse after cessation. *J Abnorm Psychol.* 2011; 120(4):999–1005. [PubMed: 21574668]
- Sussman S. Effects of sixty-six adolescent tobacco use cessation trials and seventeen prospective studies of self-initiated quitting. *Tobacco Induced Diseases.* 2002; 1(1):35–81. [PubMed: 19570247]
- Sussman S, Lichtman K, Ritt A, Pallonen UE. Effects of thirty-four adolescent tobacco use cessation and prevention trials on regular users of tobacco products. *Substance Use and Misuse.* 1999; 34:1469–1505. [PubMed: 10468104]
- Tidey JW, Monti PM, Rohsenow DJ, Gwaltney CJ, Miranda RJ, McGeary JE, Paty JA. Moderators of naltrexone's effects on drinking, urge, and alcohol effects in non-treatment-seeking heavy drinkers in the natural environment. *Alcoholism: Clinical and Experimental Research.* 2008; 32(1):58–66.
- Tuakli N, Smith MA, Heaton C. Smoking in adolescence: methods for health education and smoking cessation. A MIRNET study. *J Fam Pract.* 1990; 31(4):369–374. [PubMed: 2212967]
- van der Meer RM, Willemsen MC, Smit F, Cuijpers P, Schippers GM. Effectiveness of a mood management component as an adjunct to a telephone counselling smoking cessation intervention for smokers with a past major depression: a pragmatic randomized controlled trial. *Addiction.* 2010; 105(11):1991–1999. [PubMed: 20735366]
- Van Zundert RMP, Engels RC, Kuntsche E. Contextual correlates of adolescents' self-efficacy after smoking cessation. *Psychol Addict Behav.* 2011; 25(2):301–311. [PubMed: 21517140]
- Van Zundert RMP, Ferguson SG, Shiffman S, Engels RCME. Dynamic effects of self-efficacy on smoking lapses and relapse among adolescents. *Health Psychology.* 2010; 29(3):246–254. [PubMed: 20496978]
- Van Zundert RMP, Nijhof LM, Engels RCME. Testing social cognitive theory as a theoretical framework to predict smoking relapse among daily smoking adolescents. *Addictive Behaviors.* 2009; 34(3):281–286. [PubMed: 19059732]
- Wahl SK, Turner LR, Mermelstein RJ, Flay BR. Adolescents' smoking expectancies: psychometric properties and prediction of behavior change. *Nicotine Tob Res.* 2005; 7(4):613–623. [PubMed: 16085531]
- Watson D, Clark LA. Measurement and mismeasurement of mood: recurrent and emergent issues. *J Pers Assess.* 1997; 68(2):267–296. [PubMed: 16370781]
- Weinstein SM, Mermelstein R, Shiffman S, Flay B. Mood variability and cigarette smoking escalation among adolescents. *Psychology of Addictive Behaviors.* 2008; 22(4):504–513. [PubMed: 19071975]
- Witkiewitz K, Marlatt GA. Relapse Prevention for Alcohol and Drug Problems: That Was Zen, This Is Tao. *American Psychologist.* 2004; 59(4):224–235. [PubMed: 15149263]
- Zhan W, Dierker LC, Rose JS, Selya A, Mermelstein RJ. The natural course of nicotine dependence symptoms among adolescent smokers. *Nicotine Tob Res.* 2012; 14(12):1445–1452. [PubMed: 22422927]

Figure 1. Participant flow

Figure 2. Phase Differences

For each affect state with significant phase differences in the relationship between affect and momentary SE (panels A-D), the estimated functions are plotted, using one line per interval (i.e., prequit, quit-to-lapse, and lapse-to-relapse). The relationship during the pre-quit phase (solid line) was used as the reference category. Steeper lines indicate stronger relationships. For all four affect states, affect was less strongly related to momentary SE during the lapse-to-relapse phase compared to the pre-quit phase.

Figure 3. Moderation by Baseline SE

For each affect state with significant interaction with baseline SE, the estimated functions are plotted for median-split groups of high (black) vs. low (grey) baseline SE, where each phase is plotted in a different panel. Across the three identified moderation effects, the high SE group showed greater declines in SE with increasingly negatively valenced states compared to the low SE group.

Table 1

Demographics and smoking characteristics of study participants who provided data per phase

	<u>Pre-Quit</u>	<u>Quit to Lapse</u>	<u>Lapse to Relapse</u>
	(n=202)	(n=157)	(n=99)
Characteristic	%/mean (SD)	%/mean (SD)	%/mean (SD)
Demographics			
Age	16.5(1.2)	16.5(1.2)	16.6(1.1)
Gender (% female)	38.3	38.2	33.7
Race			
White	95.0	94.3	94.9
Black	4.5	5.1	5.1
Asian	0.5	0.6	0
Hispanic	6.5	6.4	9.2
Education			
Currently in high school	80.6	83.4	78.6
Graduated high school	11.4	8.9	10.2
Not enrolled in any school	8.0	7.6	11.2
Smoking Characteristics at Baseline			
# of cigarettes per day	11.0(5.5)	10.6(5.3)	10.8(5.6)
% who smoke first cigarette within 30min of waking	73.1	72.6	69.4
Age of smoking onset	13.0(1.8)	13.0(1.8)	13.2(1.8)
% used other tobacco products in past 30 days	16.9	19.1	17.4
Previous quit attempt			
% made a previous quit attempt	74.1	73.3	73.5
Average # of previous quit attempts	2.4(2.1)	2.1(2.2)	2.4(2.6)
Confidence to quit smoking (0–100)	77.2(17.4)	78.1(17.8)	76.6(17.3)
Motivation to quit smoking (0–100)	81.7(13.8)	82.5(13.4)	80.4(13.4)

Table 2

Relationship between momentary self-efficacy and mood during different times of the cessation process

	Pre-Quit Interval		Quit to Lapse Interval		Lapse to Relapse Interval	
	Est	95% CI	Est	95% CI	Est	95% CI
	n=201 obs=6,901		n=157 obs=1,289		n=99 obs=2,759	
Mood Factor Scores						
Positive High Activation	0.06	[0.04 – 0.08]**	0.06	[0.02 – 0.09]**	0.05	[0.02 – 0.08]**
Positive Low Activation	0.11	[0.09 – 0.13]**	0.10	[0.06 – 0.14]**	0.07	[0.04 – 0.09]**
Negative High Activation	-0.15	[-0.17 – -0.13]**	-0.12	[-0.17 – -0.08]**	-0.06	[-0.10 – -0.02]**
Unique mood items						
Bored	-0.01	[-0.03 – 0.00]	-0.02	[-0.05 – 0.01]	-0.01	[-0.03 – 0.01]
Fidgety	-0.08	[-0.10 – -0.06]**	-0.04	[-0.08 – -0.01]*	-0.01	[-0.04 – 0.01]
Nicotine withdrawal states						
Craving	-0.11	[-0.13 – -0.10]**	-0.07	[-0.10 – -0.04]**	-0.03	[-0.06 – -0.01]*
Hungry	0.00	[-0.01 – 0.02]	0.00	[-0.02 – 0.03]	-0.01	[-0.03 – 0.01]
Difficulty Concentrating	-0.05	[-0.07 – -0.04]**	-0.02	[-0.06 – 0.01]	0.00	[-0.03 – 0.02]

Note:

* $p < 0.05$,

** $p < 0.01$ after adjusting for false discovery rate (Benjamini & Hochberg, 1995) per phase; all models include time of day as a covariate; all items were measured on a 0–10 scale