Dynamic Effects of Craving and Negative Affect on Adolescent Smoking Relapse

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Objective: This study examined dynamic effects of daily variations in craving and negative affect on the next-day risk of the first lapse and relapse among 149 adolescent daily smokers who achieved at least 24 hr of abstinence. Method: Participants completed real-time assessments of their smoking, craving, and negative affect 3 times per day during the 3 weeks after their quit attempt. The main outcome measures included the first lapse and relapse after at least 24 hr of abstinence from smoking. Results: Cox regression analyses with time-varying covariates showed that daily increases in craving predicted the risk of lapsing and relapsing on the following day, even after accounting for concurrent smoking and baseline levels of craving and nicotine dependence. Day-to-day variations in negative affect did not predict time to first lapse or relapse. Individual differences in baseline craving, nicotine dependence, and depressive symptoms also did not predict the first lapse or relapse. Conclusions: The findings challenge the significance of adolescents’ negative affect during cessation and emphasize the need to assess dynamic effects of craving in addition to baseline ratings of craving and nicotine dependence, as the latter may not be sufficient to explain adolescent smoking cessation outcomes.

Keywords: craving, negative affect, smoking cessation, adolescents, relapse, ecological momentary assessment

Despite the call for a stronger focus on the cessation and relapse process of adolescent smokers 8 years ago (Mermelstein, 2003), a literature search of the PubMed database (1980–2009) in 2009 by Wong et al. (2011) revealed only 25 articles on adolescent quit attempts and relapse, most of which concerned cross-sectional studies. Up to now, the main focus has been on adult smoking relapse, and very few studies have addressed smoking relapse among adolescents although relapse rates in this age group are alarmingly high. A review of 52 studies on the prevalence, frequency, and/or duration of quit attempts among adolescent smokers between 10 and 19 years of age (Bancej, O’Loughlin, Platt, Paradis, & Gervais, 2007; cf. Abrantes et al., 2009) indicated that the median 6-month, 12-month, and lifetime quit attempt prevalence was 58%, 68%, and 71%, respectively, and the majority had embarked on multiple attempts. However, 34% relapsed within the first week and 89% within the first month after quitting, rising to a total of 92% of adolescents who relapsed within 1 year. These high relapse rates are comparable with those among adults (Piascik, 2006). Given that craving and negative affect are predictors of smoking relapse among adults (Kassel, Stroud, & Paronis, 2003; Shiffman et al., 1997) and that these symptoms are noted as the most salient symptoms after quitting by adolescents (Colby, Tiffany, Shiffman, & Niaura, 2000), the present study investigates the effects of day-to-day variations in craving and negative affect on adolescents’ relapse.

Both adult and adolescent smokers experience craving and negative affect when deprived of nicotine (craving and negative affect are therefore sometimes referred to as withdrawal symptoms; Hughes, 1992; Hurt et al., 2000; Killen et al., 2001; Riedel, Robinson, Klesges, & McLain-Allen, 2003). Negative affect, which is considered a hallmark of nicotine withdrawal (American Psychiatric Association, 1994), refers to mood states marked by feeling angry, frustrated, irritable, sad, depressed, distressed, and so forth (Hughes, 2007; Welsch et al., 1999). The term craving refers to an intense desire (e.g., to smoke), and despite not being part of the criteria for nicotine withdrawal in the Diagnostic and Statistical Manual of Mental Disorders (4th ed.; DSM–IV; American Psychiatric Association, 1994), it is considered to be an essential component of the abstinence withdrawal syndrome (e.g., Hughes, Higgins, & Bickel, 1994) because it strongly increases after smoking deprivation. It is known that individuals display considerable variation in the trajectories and intensity of craving.
and negative affect (Piasecki, Jorenby, Smith, Fiore, & Baker, 2003a, 2003b, 2003c; Sayette et al., 2000), and that these symptoms can vary episodically, for example, in response to exposure to stressors or smoking cues (Ferguson & Shiffman, 2009; McCarthy, Piasecki, Fiore, & Baker, 2006; Shiffman, 2005). When averaged across individuals, however, craving and negative affect typically show a strong increase during the first week of postquit smoking deprivation, after which they gradually revert to baseline or lower levels (Hughes, 1992; Jorenby et al., 1996; Piasecki, Fiore, & Baker, 1998; for an exception, see Shiffman et al., 1997). Among adults, both the course over time and daily variations in craving and negative affect are associated with successful smoking cessation and first lapse (the first lapse refers to the first occasion of smoking after a period of abstinence) and relapse (an extended period of resumed smoking after abstinence; Ferguson, Shiffman, & Gwaltney, 2006; McCarthy et al., 2006; Shiffman et al., 1997).

Craving has consistently been reported to be the most salient and severe symptom among adolescents (Colby et al., 2000), with adolescents’ levels of craving, like adults’, increasing as a function of smoking deprivation (Smith, Cavallo, McFetridge, Liss, & Krishnan-Sarin, 2008; Van Zundert, Booger, Vermulst, & Engels, 2009). Previous studies among adults have shown that individual differences in craving affect relapse risk—that is, that if people experience craving, they are more likely to lapse or relapse (Killen, Fortmann, Newman, & Varady, 1991; Shiffman, Paty, Gmys, Kassel, & Hickcox, 1996). However, people also seem more likely to relapse when they experience intense craving. Strong daily urges to smoke predict lapses into smoking the next day, even when baseline urge to smoke is controlled for (Ferguson et al., 2006; Shiffman et al., 1997). (Although some authors distinguish between craving and urge to smoke, the study by Shiffman et al. [1997] demonstrated that both represent the same concept). In a recent study on the same data as those used in the present study, we modeled the natural history of craving among adolescents. This study revealed that higher prequit and quit-day levels of craving decreased the odds of abstinence, whereas the pace with which symptoms declined (slope) did not predict abstinence (Van Zundert et al., 2009). Although this is important information, it does not reveal whether day-to-day variations in craving can predict lapse and relapse the next day. To our knowledge, no study to date has examined the effects of day-to-day variations in craving on relapse among adolescents who have quit smoking.

Increases in negative affect after quitting appear to occur in both adults and adolescents, although the increase among adolescents seems to be less steep compared with that of craving (Hughes, 1992; Van Zundert et al., 2009). Studies using momentary data from adults have revealed that negative affect increases the risk of lapse and relapse the next day (Ferguson et al., 2006; Shiffman et al., 1996), although one study showed that negative affect was only related to same day lapses (and not next day’s lapse) and only among smokers whose lapses were attributed to stress or a bad mood (Shiffman & Waters, 2004). Preliminary findings from a pilot study among 12 adolescents who quit smoking suggest that first lapses were associated with increased negative affect, but the small sample size did not allow for significance testing (Gwaltney, Bartolomei, Colby, & Kahler, 2008). Thus, as with craving, there is a relative absence of research on the dynamic effects of negative affect on relapse in adolescent smokers who try to quit.

Given that daily craving and negative affect are strongly related to more stable individual factors such as nicotine dependence (Benowitz, 2010) and depressive symptoms (Kassel et al., 2003), respectively, and that nicotine dependence and depressive symptoms are related to smoking cessation among adolescents (Kleinjan et al., 2009) and relapse among adults (Kassel et al., 2003; Piasecki et al., 2000; Shiffman et al., 1997), it is possible that the potential effects of daily variations in craving and negative affect on (re)lapse might be fully explained by these traitlike factors. If so, any observed effect of daily craving and negative affect could be an epiphenomenon of individuals’ traitlike or baseline status of nicotine dependence and depression. If such is the case, this would render daily changes in craving and negative affect as less important to address in clinical practice. Alternatively, daily changes in craving and negative affect may be mediating the potential effect of baseline nicotine dependence and depressive symptoms on adolescent smoking relapse. The current literature lacks prospective studies on the effects of nicotine dependence and depressive symptoms on adolescent smoking relapse after a serious quit attempt (for a review, see Curry, Mermelstein, & Sporer, 2009). Thus, examining the direct and indirect effects of nicotine dependence and depressive symptoms adds to the literature significant knowledge on their role in adolescent smoking relapse and on the mechanisms by which they operate.

In summary, the aforementioned studies emphasize that day-to-day dynamics of craving and negative affect are critical to our understanding of the relapse process. Traditional approaches have mainly drawn on single-occasion or weekly measures, which do not allow temporal variations to be captured. Moreover, such methods rely on retrospective recall, which can be problematic (Hammersly, 1994; Stone & Shiffman, 1994). Ecological momentary assessment (EMA; Shiffman, Stone, & Hufford, 2008) comprises methods that focus on collecting real-time data on momentary states in real-world environments. EMA designs typically use intensive repeated sampling with at least one measurement per day that enables investigation of the temporal dynamics that characterize craving and negative affect as well as relapse (Shiffman, 2005). Furthermore, as lapses are often succeeded by more lapses and are very likely to eventually result in relapse, close monitoring is needed to distinguish isolated lapses from relapses, which are considered distinct milestones (Shiffman et al., 2006). Finally, and more generally, an important contribution of real-time data collection methods is that they minimize recall biases (Hammersly, 1994; Shiffman et al., 2008; Stone & Shiffman, 1994).

The aim of the present study was to test the effects of daily craving and negative affect on the first lapse and relapse among daily smoking adolescents. EMA methods were used to gather data from 149 daily smokers aged 15 to 19. Participants were asked to complete an assessment three times a day for 1 week before, and 3 weeks after, embarking on a serious quit attempt. The data were analyzed to examine the following hypotheses:

1. Increases in craving and negative affect were expected to predict the first lapse and relapse the next day after achieving 24-hr abstinence.

2. The hypothesized effects of craving and negative affect on first lapse and relapse were expected to hold while controlling for concurrent smoking and baseline measures of nicotine dependence, craving, and depressive symptoms.
Method

Sample Characteristics

Participants \((n = 176)\) were Dutch adolescent daily smokers recruited for the study by means of community advertisements and newspaper articles. The recruitment materials explicitly stated that intending participants should be motivated to quit smoking and provided contact information of the research team. On contacting the researchers, interested candidates were sent a detailed description of the study and were assessed for eligibility through a telephone screening if they still wanted to participate after reading the study’s specifics. To qualify, candidates had to be between 15 and 19 years of age, smoke at least one cigarette per day, and not be currently enrolled in a cessation program. Of the 176 participants who were eventually enrolled, a sample of 149 participants provided sufficient data for the present analyses (for more details on inclusion criteria, compliance, and attrition, please consult other publications on these data; Van Zundert et al., 2009; Van Zundert, Ferguson, Shiffman, & Engels, 2010). The majority of the sample was female \((63.7\%)\), and the mean age was 17.2 \((SD = 1.2)\). All participants received regular education, and all levels of educational attainment were represented: Lower vocational training \((53.9\%)\), higher vocational training \((14.6\%)\), preuniversity education \((13.8\%)\), and college \((17.7\%)\). The average number of years that participants had been smoking daily was 2.9 \((SD = 1.6)\). At enrollment, smoking rate was distributed as follows: 1–5 cigarettes per day \((11.9\%)\), 6–10 cigarettes per day \((34.3\%)\), 11–20 cigarettes per day \((47.0\%)\), 21–30 cigarettes per day \((3.7\%)\), and 31 or more cigarettes per day \((3.1\%)\). Although use of nicotine replacement was allowed, only 1 participant reported to have used nicotine patches during the study. Regardless of whether they had (re)lapsed, participants received a remuneration of 40 € for completion of the baseline questionnaire and the 4 weeks of monitoring. Neither the participants nor their parents were required to provide written consent. This study was approved with the Dutch Medical–Ethical Committee on Research Involving Human Subjects.

Procedure

Participants were asked to complete a baseline questionnaire after which they were monitored for a total of 4 weeks. The first day of monitoring was always a Monday. Participants started the monitoring period with 7 days of baseline monitoring, during which they were instructed to smoke ad lib. The eighth day was the assigned quit day for each participant. Although the eighth day was the target quit day for everyone, participants were not excluded from the study if they did not manage to achieve 24-hr abstinence on that particular day. We emphasized with the participants that they should try to achieve 24-hr abstinence that day and that if they were not successful they should try again as soon as possible. After the target quit day, participants were monitored for an additional 3 weeks.

On each day of monitoring, participants were asked to complete three Internet-based questionnaires: in the morning (to be completed between 10:00 a.m. and noon), the afternoon (3:00 p.m.–5:00 p.m.), and evening (8:00 p.m.–10:00 p.m.). Each questionnaire was identical and took approximately 3 min to complete. Questionnaires were automatically time-stamped with the time that they were completed online. Participants who failed to complete a questionnaire within the designated sampling window were sent a text message to remind them. If a participant did not have access to the Internet during the sampling window, they were asked to complete a paper version of the questionnaire—which included a question on the date and time at the time of completion—and to transcribe the paper version online as soon as they had access to Internet again.

Participants completed an average of 25 of 28 \((SD = 4.5)\) days of monitoring, during which they completed a total of 10,501 assessments. Compliance with assessment taking was high—participants completed an average of 88.3% of all possible assessments (taking into account that some dropped out of the study prematurely), and 87.2% of participants completed 75% or more of all possible assessments (see Table 1). On average, participants completed 70.5 \((SD = 14.9)\) assessments each during the monitoring period. Most \((83.9\%)\) participants included in the present analyses remained enrolled in the study until the last day of the 4-week period. All data were collected between October 2006 and March 2007.

Measures

Daily craving and negative affect. Eight items of the Wisconsin Smoking Withdrawal Scale (WSWS) were used to determine adolescents’ daily levels of craving and negative affect (Welsch et al., 1999). The WSWS has been found to show good construct validity with high reliabilities (West, Ussher, Evans, & Rashid, 2006). In addition, the shortened version of 10 items has been successfully applied in previous EMA research on smoking relapse among adults (McCarthy et al., 2006) and showed high factorial validity in an adolescent sample (Van Zundert et al., 2009). At each assessment, participants were asked to report on these symptoms as experienced during the past 30 min. Two WSWS items were used to measure craving (“I have been bothered by the desire to smoke,” and “I had trouble getting cigarettes off my mind”). Six items tapped negative affect (e.g., “I have been bothered by negative moods such as anger, frustration, and irrita-

<table>
<thead>
<tr>
<th>Assessment type</th>
<th>n (%)</th>
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<tbody>
<tr>
<td>All assessments</td>
<td>10,501 (100)</td>
</tr>
<tr>
<td>Completed on the Internet in real time</td>
<td>4,381 (41.7)</td>
</tr>
<tr>
<td>Completed within the allotted assessment window</td>
<td>3,516 (80.3)</td>
</tr>
<tr>
<td>Completed within 3 hr outside the allotted assessment window</td>
<td>865 (19.7)</td>
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<tr>
<td>Completed over 3 hr outside the allotted assessment window</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Completed on paper and entered on the Internet at a later time</td>
<td>5,634 (53.7)</td>
</tr>
<tr>
<td>Reported to be completed within the allotted assessment window</td>
<td>5,002 (88.8)</td>
</tr>
<tr>
<td>Reported to be completed within 3 hr outside the allotted assessment window</td>
<td>632 (11.1)</td>
</tr>
<tr>
<td>Reported to be completed over 3 hr outside the allotted assessment window</td>
<td>5 (0.1)</td>
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<tr>
<td>Entries with no clear indication of time of completion</td>
<td>486 (4.6)</td>
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bility,” and “I felt sad or depressed”). The eight items could be answered on a Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating more intense craving and negative affect. In a previous study on the same data (Van Zundert et al., 2009), the internal consistencies of the craving and negative affect scales were found to be .88 (SD = .04) and .75 (SD = .04), respectively (as computed by calculating Cronbach’s alpha per assessment and then taking the average alpha across all assessments).

Concomitant smoking. Concomitant smoking was also assessed three times daily by means of the question “Have you smoked since the last assessment?” Similar to the construction of the variables craving and negative affect, concomitant smoking was aggregated into a daily variable; 0 = no smoking, and 1 = smoking (at least once during the day).

Nicotine dependence. Nicotine dependence at baseline was assessed with a multidimensional measure of nicotine dependence for adolescents, which has good psychometric properties (Kleinjan et al., 2007). This composition was derived from the modified Fagerström Tolerance Questionnaire (mFTQ; Fagerström & Schneider, 1989) and the Hooked on Nicotine Checklist (HONC; DiFranza et al., 2000). The total 11 items of the three subscales include aspects of emotional and physical symptoms of dependence (irritation, anger, restlessness, etc., during smoking deprivation) and behavioral symptoms of nicotine dependence (e.g., intensity of smoking). Cronbach’s alpha was 0.80. The mean level of baseline nicotine dependence was 2.6 (SD = .49, range 1–4).

Craving. Baseline levels of craving for tobacco were assessed through five items on a 5-point scale that asked about the frequency of missing, desiring, thinking of, or longing for a cigarette; for example, “I desire smoking a cigarette,” and “I miss a cigarette.” Items were scored as 1 (never), 2 (sometimes), 3 (regularly), 4 (often), and 5 (very often; Dijkstra & Borland, 2003). Cronbach’s alpha was 0.85. The mean level of baseline craving was 2.9 (SD = 0.83, range 1–5).

Depressive symptoms. To assess depressive feelings, we used the Depressive Mood List as developed by Kandell and Davies (1982). Six items assessed how often participants felt unhappy, sad, depressed, nervous, tense, or too tired to do things and how often they worried about current issues and the future. This scale has been frequently used, and several studies have shown sufficient psychometric properties in terms of internal consistency, reliability, and stability over time (Kandell & Davies, 1986). Item anchors ranged from 1 (never) to 5 (always). Cronbach’s alpha was 0.77. The mean level of depressive symptoms was 2.7 (SD = 0.66, range 1–5).

Please note that the “baseline” characteristics craving, nicotine dependence, and depressive symptoms refer to these concepts as assessed through the baseline questionnaire and not during the first week of monitoring (which is sometimes also referred to as the “baseline” period).

Outcomes: First Lapse and Relapse

Two outcomes of interest were analyzed: the occurrence of the first lapse and the occurrence of relapse (e.g., Gwaltney et al., 2005; Shiffman et al., 2000; Shiffman et al., 2006). A participant’s first lapse day was defined by any report of smoking (even if only a puff) after having quit—that is, after having accomplished 24 hr of abstinence (Shiffman et al., 2006)—and the analysis modeled the risk of a first lapse starting from the day that participants reached 24 hr of abstinence. Relapse was defined as smoking at least one cigarette per day on 3 consecutive days. The first day of the relapse episode was counted as the relapse day, and the analysis modeled the risk of relapse starting from the day of the first lapse.

Analytic Plan

To assess the associations between baseline questionnaire craving, nicotine dependence, and depressive symptoms, and progression to lapse and relapse, we used Cox proportional hazards survival analysis (Cox, 1972). Such analyses evaluate the risk of a target event (lapses or relapse) occurring per unit of time while taking into account that some observations are censored because participants’ status after a study is unknown. Subsequently, we tested the univariate dynamic effects of craving and negative affect on the risk of lapse and relapse by means of proportional hazards regression survival analyses with time-varying covariates. These analyses used days as the primary unit of analysis; a study day was defined as the period between two consecutive morning reports. We computed daily averages from the three daily assessments for craving and negative affect and used these values as time-varying covariates in the Cox regression to test whether daily variations in craving and negative affect predicted the following day’s risk of lapsing or relapsing. In a second step, we examined the effects of daily craving and daily negative affect on lapse and relapse while controlling for one another. The final model for daily craving included the static covariates baseline craving and nicotine dependence and the time-varying covariate daily negative affect. The final model for daily negative affect included static covariate depressive symptoms and time-varying covariate craving (see Tables 2 and 3). For the relapse analyses, concomitant smoking (also measured daily) was included as a time-varying covariate in the final models because, among adults, it has been found to be a strong predictor of further postquit smoking and relapse (Gwaltney, Metrik, Kahler, & Shiffman, 2009; Piasecki, 2006; Shiffman et al., 2000).

Results

Attrition Analyses

Of the included 149 participants, 14 participants failed to complete and/or to successfully return the baseline questionnaire. These 14 participants are excluded from the analyses in which we examine the effects of baseline craving, nicotine dependence, and depressive symptoms on lapse and relapse risk. Attrition analyses between those 14 participants and those who were included in the analyses showed no differences in smoking rates during the first week of ad lib smoking or in relapse rates. We conducted all analyses using SAS Version 9.1.3.

Descriptive Statistics

The majority of the participants reached 24-hr abstinence on the target quit day (72.5%, n = 108 of 149). The majority of the participants (71.8%, n = 107 of 149) experienced at least one lapse.
during monitoring, typically soon after achieving initial abstinence ($M = 4.0$ days, $Mdn = 3$, $SD = 3.4$, range = 0–20 days). Relapse occurred for 52 participants (34.9%, $n = 52$ of 149). For more than half of the participants who lapsed (59.6%), the first lapse marked the beginning of a relapse. The average number of days between the initial lapse day and relapse was 4.7 ($Mdn = 4$, $SD = 3.3$, range = 1–12 days).

All three baseline individual characteristics were significantly correlated (Pearson correlations). Baseline levels of craving and nicotine dependence were positively correlated ($r = .67$, $p < .001$), and both variables were positively associated with depressive symptoms ($r = .34$, $p < .001$; and $r = .31$, $p < .001$, respectively). Thus, those with high levels of nicotine dependence and craving were more likely to report depressive symptoms.

**Progression to a First Lapse**

**Individual differences in baseline characteristics as static predictors of lapse risk.** We first tested whether the baseline questionnaire measures of nicotine dependence, craving, and depressive symptoms univariately predicted the risk of a first lapse. None of these measures predicted time to first lapse (see Table 2). Age at baseline was also not a significant predictor of lapse risk.

**Daily craving and negative affect as predictors of lapse risk.** To test whether daily measures of craving and negative affect predicted the risk of a first lapse the following day, we entered daily measures of craving and negative affect as time-varying covariates in univariate analyses. Increments in daily craving significantly predicted a first lapse on the subsequent day—for each 1-point increase in craving, the risk of lapsing the following day

<table>
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<tr>
<th>Table 2</th>
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<tr>
<td><strong>Survival Analysis Models of First Lapse Using Static Measures of Baseline Craving, Nicotine Dependence, and Depressive Symptoms and Time-Varying Measures of Daily Craving and Negative Affect</strong></td>
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<tr>
<td>First-lapse variable</td>
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<tr>
<td>Univariate models of static covariates</td>
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<tr>
<td>Nicotine dependence (ND)</td>
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<td>Baseline craving (BC)</td>
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<td>Depressive symptoms (DS)</td>
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<td>Univariate models of time-varying covariates</td>
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<tr>
<td>Daily craving (CRAV)</td>
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<td>Daily negative affect (NA)</td>
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<tr>
<td>Multivariate models controlling for time-varying covariates</td>
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<tr>
<td>Daily CRAV, controlling for daily NA</td>
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<td>Daily NA, controlling for daily CRAV</td>
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<tr>
<td>Final multivariate model controlling for time-varying and static covariates</td>
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<tr>
<td>Daily CRAV, controlling for ND + BC + daily NA</td>
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<td>Daily NA, controlling for DS + daily CRAV</td>
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<th>Table 3</th>
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<tr>
<td><strong>Survival Analyses Models of Relapse Using Static Measures of Baseline Craving, Nicotine Dependence, and Depressive Symptoms and Time-Varying Measures of Daily Craving, Negative Affect, and Concomitant Smoking</strong></td>
</tr>
<tr>
<td>Relapse variable</td>
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<td>Univariate models of static covariates</td>
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<td>Nicotine dependence (ND)</td>
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<td>Daily craving (CRAV)</td>
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<td>Daily CRAV, controlling for daily NA</td>
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<td>Daily NA, controlling for daily CRAV</td>
</tr>
<tr>
<td>Final multivariate model controlling for time-varying and static covariates</td>
</tr>
<tr>
<td>Daily CRAV, controlling for ND + BC + daily NA + concomitant smoking</td>
</tr>
<tr>
<td>Daily NA, controlling for DS + daily CRAV + concomitant smoking</td>
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increased by 24% (see Table 2). Although daily increases in negative affect showed a trend effect on the first lapse, the effect was not statistically significant (see Table 2). When daily craving and daily negative affect were simultaneously included in a multivariate analysis, craving still predicted the first lapse (see Table 2). Finally, entering baseline characteristics into the multivariate analysis of daily craving and negative affect reduced the effect of craving to a trend effect and the association between negative affect and the first lapse remained unchanged (see Table 2).

Progression From First Lapse to Relapse
Baseline characteristics as static predictors of relapse risk. Baseline questionnaire nicotine dependence, craving, and depressive symptoms scores did not predict relapse risk (see Table 3).\(^1\)

Daily craving and negative affect as dynamic predictors of relapse. Daily increases in craving significantly predicted relapse—for each 1-point increase in daily craving, the risk of relapsing the following day increased by 57% (see Table 3). Daily increases in negative affect did not predict progression to mild relapse (see Table 3). When daily craving and daily negative affect were included in a multivariate analysis, craving still predicted relapse (see Table 3). Finally, when the baseline covariates and concomitant smoking were entered into the multivariate analysis of daily craving and negative affect, the effect of craving still held and the association between negative affect and relapse remained largely unchanged (see Table 3).

Discussion
The present study examined dynamic effects of daily increases in craving and negative affect on the first lapse and relapse the next day, among adolescent daily smokers who achieved 24-hr abstinence. The main findings show that daily increases in craving predict the first lapse as well as progression to relapse into smoking, beyond baseline levels of craving and nicotine dependence, and concurrent smoking. Day-to-day increases in negative affect did not predict next day’s first lapse or relapse. Individual differences in baseline craving, nicotine dependence and depressive symptoms did not predict the first lapse or relapse either.

Baseline Craving and Nicotine Dependence
Individual differences in craving and nicotine dependence did not discriminate abstainers from those who lapsed or relapsed, which is somewhat surprising given that research shows that adolescents’ nicotine dependence poses a substantial barrier to successful cessation (Colby et al., 2000; Horn, Fernandes, Dino, Massey, & Kalsekar, 2003; Kleinjan et al., 2009). These discrepancies with previous studies may be explained by the fact that the aforementioned studies used a wider range of adolescent smokers including monthly, weekly, and daily smokers. Our sample consisted only of daily smokers, and it is possible that we found limited support for the effect of nicotine dependence on relapse outcomes because of a restricted range of variation. Alternatively, it might just mean that within the specific group of daily smoking adolescents, baseline levels of nicotine dependence are less important and other processes are at play. This is important information considering that the lack of understanding how nicotine dependence affects adolescent smoking cessation still constitutes a critical gap in the adolescent smoking literature. It also shows that using static (i.e., one-time) measures of individual differences in nicotine dependence (and craving) is not sufficient to explain adolescent relapse and that study of day-to-day variations is required.

Daily Increases in Craving and Negative Affect
The finding on daily increases in craving mirrors previous findings among adults in which increases in craving on a given day significantly predicted lapsing the next day (Ferguson et al., 2006; Shiffman et al., 1997). It is also in line with the consistent finding that craving is the most commonly cited withdrawal symptom among adolescents who refrain from smoking for some period of time (Colby et al., 2000). Although this is important information, it has been shown that urge experiences after quitting are rather episodic and not constantly present or elevated (Ferguson & Shiffman, 2009; Shiffman et al., 1997). In addition, various aspects of urge episodes such as intensity, frequency, and duration are known to have differential effects on relapse (Shiffman et al., 1997; West, Hajek, & Belcher, 1989). As we used three fixed assessment windows per day that only assessed the intensity of craving at the present moment, and not duration and frequency of other urge peaks (if any) throughout the day, we cannot verify whether acute urges provoked relapse or whether the frequency and duration of cravings were important determinants of the lapse and relapse that followed. Ideally, future EMA studies on adolescent smoking relapse should use designs that include random prompts several times a day and that require participants to initiate a report when they experience a “temptation episode” (i.e., acute increases in urge to smoke or when they feel they have come to the brink of smoking regardless of subjective urges; cf. Gwaltney et al., 2008; Shiffman et al., 1996). This will help to determine which factors discriminate temptation situations from lapse and relapse situations.

Unlike craving, daily variations in negative affect did not predict lapse or relapse, not even when tested univariately in relation to these milestones. This is in contrast with two other studies analyzing diary data from adults (Ferguson et al., 2006; Shiffman et al., 1996), but it is in line with one other study that did not find negative affect to predict lapse risk the next day either (Shiffman & Waters, 2004). The study by Ferguson et al. (2006) showed that negative affect predicted a lapse the next day in a univariate analysis, but this effect diminished when daily craving was controlled for (Ferguson et al., 2006). Although our results do not suggest the presence of such an effect, they do suggest that craving may be a more significant risk factor for next day’s relapse than negative affect among adolescents as well. However, another study demonstrated that increases in negative affect only preceded lapse on the same day—not the next day, and only under certain cir-

\(^1\) Given that the nicotine dependence item “time to first cigarette after waking” (from the mFTQ; Fagerström & Schneider, 1989) has been consistently shown to be the most robust predictor of smoking cessation outcomes, even when the overall scale shows no effects, we checked whether this item alone predicted (re)lapse, but this was not the case. For first lapse, hazard ratio (HR) = 1.12; 95% confidence interval (CI) = 0.90, 1.39; \(p = 0.323\). For relapse, HR = 1.26; CI = 0.93, 1.70; \(p = .136\).
circumstances such as under stress—possibly because negative affect may fluctuate too rapidly to be captured by even very intensive sampling (five to six assessments per day in the study by Shiffman & Waters, 2004). Shiffman and Waters (2004) also noted that some participants showed sharp and abruptly emerging spikes of negative affect at the moment of the lapse. In an earlier study, many of the lapsers who reported the most extreme levels of negative affect reported that they had had an argument at the time of the lapse (Shiffman et al., 1996). An argument can arise quickly and prompt a person into lapsing rapidly; this process would not lend itself to being predicted from the previous day’s mood, or even mood hours earlier. As such, the highly volatile nature of affect poses a barrier to what can be practically measured if monitoring is not carried out continuously. This may especially be the case for adolescents, given that they are well known for their mood swings (Buchanan, Eccles, & Becker, 1992).

It is also possible that positive affect rather than negative affect plays a significant role in adolescent relapse. Some authors have suggested that positive and negative affects do not represent the outer ends of one affect continuum but are distinct constructs of their own (e.g., Watson & Tellegen, 1985). Ferguson et al. (2006) examined positive affect as well and found that daily increases in positive affect increased lapse risk the next day, independent of negative affect. Moreover, studies on longitudinal patterns of daily affect in adolescents suggest that normative mood declines in adolescence may be driven by deteriorations in positive affect rather than increases in negative affect (Weinstein, Mermelstein, Hankin, Hedeker, & Flay, 2007). Last, we note that the effects of smoking on adolescents’ negative and positive affect may differ across contexts. It is, for example, possible that in the context of being with friends or at a party, smoking has a cumulative effect on positive affect rather than decreasing negative affect. This would advocate examining the association between positive affect and adolescent smoking relapse. Summarizing, these findings show that negative affect and craving play differential roles in the day-to-day processes involved in adolescents’ smoking relapse.

Limitations

Several limitations of the present study should be acknowledged. First, the use of paper-and-pencil diaries constitutes a limitation in the sense that timely reporting cannot be verified and that reports can be completed in bunches after the assessment window or even in advance (Shiffman et al., 2008). However, previous analyses on the timeliness of paper diary entries in this study indicated that the majority of the paper diaries were entered online on the same day and that they were not bunched together at the end of the day (Van Zundert et al., 2010). For the present analyses, we also tested whether results differed if all paper entries were excluded from the analyses. With the one exception that the effect of daily craving on a first lapse the next day decreased to a trend-level effect, all other results for both the first lapse and relapse were essentially similar to the results presented in this article, which is reassuring. Although both the present and previous analyses (Van Zundert et al., 2010) of the validity of the paper entries provided reassuring results, and although the scientific literature shows little evidence of reactivity effects in smoking cessation EMA studies (Rowan et al., 2007; Shiffman et al., 2008), these issues should be borne in mind when interpreting the present results.

Furthermore, as intensive self-monitoring appears so helpful in changing behavior that it is included in behavior-change treatments (Shiffman et al., 2008), this may have affected the relapse rates, which were somewhat lower (34.9% within 3 weeks) than usually found in nonaided adolescents who quit smoking (the median prevalence of relapse within 1 week and 1 month being 34% and 56%, respectively; Bancej et al., 2007). Given that there was no face-to-face contact with participants, there was no biochemical verification of abstinence. However, the fact that 27.5% of the participants did not show 24-hr abstinence on the target quit day (which was part of the study protocol) suggests that participants did not feel pressure to report falsely that they had not smoked. Moreover, several studies among adolescents have indicated that self-reports of smoking and quitting behavior are valid and reliable (Dolcini, Adler, & Ginsberg, 1996; Stanton et al., 1996). A limitation more specific to the present study includes the overrepresentation of the Caucasian ethnicity (95% of the sample). Previous studies have found significant ethnic differences in retrospectively reported withdrawal symptoms during a quit attempt (Breslau, Kilbey, & Andreski, 1992; Riedel et al., 2003), with African Americans reporting significantly fewer withdrawal effects than Caucasians, even after controlling for smoking frequency. The results may therefore not be generalizable to non-White adolescents. Finally, it is possible that the items from the WSWS (Welsch et al., 1999) do not tap symptom intensity per se, given that participants needed to indicate the extent to which they agreed with a statement about their feelings of craving and negative affect rather than directly reporting how strong the craving or negative affect symptoms were.

Clinical Implications and Recommendations

On the basis of the present finding that daily increases in craving robustly predicted lapse and relapse, it seems tempting to recommend that adolescents should be offered pharmacotherapy. Indeed, previous research has demonstrated that withdrawal symptoms can be successfully alleviated by using nicotine patches in adolescents (Smith et al., 1996). However, the efficacy and possible side effects of nicotine replacement therapy (NRT) and bupropion have not been straightforwardly demonstrated in teenagers (Grímshaw & Stanton, 2006). Researchers are thus encouraged to conduct more randomized controlled trials to test the efficacy of several NRT or bupropion applications (nicotine patch, nicotine gum), differential effects of various doses, and the mechanisms behind the potential effectiveness. Additionally, the co-occurrence of two thirds of the relapse occasions with the first lapse occasion implies that, among adolescents, a single cigarette often leads to relapse and that this is a fast process: There is not much time to intervene. This might warrant daily supervision of adolescents after quitting, especially in the first week (most first lapses occurred within 3 days after quitting), and educating adolescents who intend to quit that smoking even “just one cigarette” poses a severe threat to their quit attempt.

Last, as of yet, there are no theoretical models for relapse specifically among adolescents other than those formulated on the basis of adult studies, such as the relapse prevention model (Marlatt & Gordon, 1985; also Witkiewitz & Marlatt, 2004), the two-
affect model (Baker, Morse, & Sherman, 1987), and the dynamic regulatory feedback model (Niaura, 2000; Niaura et al., 1988) to name a few. The aforementioned models stress the importance of proximal and momentary (or phasic) precipitants of relapse, and craving (although sometimes referred to as urge) has been assigned central prominence in most theories of drug use and relapse (Niaura, 2000). With respect to craving, the present findings thus seem to support modern theories of adult relapse. Although the finding that negative affect did not predict (re)lapse may seem to refute the dynamic regulatory feedback model, this model might apply when affect is measured in very close temporal proximity of urges and relapse. However, theories of relapse models are complex and involve (among others) drug-related stimuli, physiological activation, cognitions, and coping efforts (Drummond, 2001), which are thought to exercise their effect on relapse through their interplay with other components. The present study endorses the need for dynamic formulations of adolescent relapse and its antecedents and may be one of the first steps in determining whether adult relapse theories hold for adolescents as well. Future studies are encouraged to use intensive EMA designs to assess drug-related stimuli, urges, affect states, physiological activation, cognitions, and coping efforts and to model the complex interplay of relapse precipitants to construct an integrative theory of adolescent relapse.

References


