THE SCIENCE OF REAL-TIME DATA CAPTURE

Self-Reports in Health Research

Edited by
Arthur A. Stone
Saul Shiffman
Audie A. Atienza
Linda Nebeling

OXFORD UNIVERSITY PRESS
2007
Real-Time Data Capture and
Adolescent Cigarette Smoking:
Moods and Smoking

Robin Mermelstein, Donald Hedeke,
Brian Flay, and Saul Shiffman

Cigarette smoking among adolescents remains a pressing public health challenge, considering the enormous toll smoking takes on health and health care resources. Most adolescents try smoking cigarettes. In 2008, almost 60 percent of twelfth-graders reported ever smoking (Johnston, O'Malley, & Bachman, 2003). However, not all of those who try smoking progress to regular use; 15.8 percent of twelfth-graders report daily smoking, and 8.4 percent report smoking half a pack or more a day (Johnston et al., 2003). Despite more than three decades of research on adolescent smoking, it is surprising how little is known about factors that predict the different trajectories or patterns of cigarette smoking beyond initial experimentation.

This chapter describes the use of Ecological Momentary Assessment (EMA) to help increase our understanding of how the immediate subjective and objective contexts of early trials of cigarette smoking may influence adolescents' patterns and progression of smoking. The objective contexts of smoking include the "who (with whom), what, and where" of smoking episodes. The subjective contexts include moods, perceived physiological sensations following smoking, and perceptions of the social environment, such as perceived peer pressure.

Numerous studies have identified individual difference variables (e.g., peer and parent smoking, temperament) and macro-contextual factors (e.g., tobacco advertising and marketing) as influencing adolescent smoking (e.g., see Conrad, Flay, & Hill, 1992; Turner, Mermelstein, & Flay, 2004, USHDDS, 1994). There are much fewer empirical data, though, about the immediate context in which early trials of smoking occur, and especially about adolescents' moods surrounding early experimentation with cigarettes. Until recently, attempts at investigating initial smoking episodes were limited to highly retrospective, anecdotal reports, gathered either through interviews or paper-and-pencil questionnaires. For example, Friedman and colleagues (1985) conducted structured interviews to explore the situational components of adolescents' first three smoking experiences.
and found that the vast majority (89%) of adolescents in their sample were with others during these times. Eisenberg and Balster (2000) reviewed research on initial tobacco use episodes and similarly concluded that most first smoking experiences occur in small, same-sex peer groups. Although the presence of peers and other smokers are likely common denominators running through the vast majority of first smoking experiences, what is still not known is why a particular context leads to smoking while at other times an apparently similar context does not result in smoking. Both objective situational factors and subjective moods may play a role in determining whether a given situation leads to smoking. Retrospective reports about such differences are likely to lead to a variety of attributional and recall biases. EMA provides a potentially less biased window into understanding differences between smoking and non smoking times.

Although social contexts may play a major role in understanding why adolescents initially try smoking, they may be less important in understanding why some adolescents progress beyond experimentation to more regular use. Recently, researchers have considered that adolescents' physiological responses to nicotine or smoking may be an important predictor of escalation (Eisenberg & Balster, 2000; Pomerleau, Collins, Shiffman, et al., 1993). Physical responses to early trials of smoking may be interpreted by youth as either pleasant or unpleasant sensations, or these physical effects may also result in mood changes. Like adults, adolescent smokers report that they smoke to manage negative moods and stress (Mermelstein, 1999), and there is growing evidence that depression and adolescent smoking are linked (Brown, Lewinsohn, Seeley, et al., 1996; Choi, Patton, Gillin, et al., 1997; Patton, Hibbert, Rosier, et al., 1996). However, there is little direct evidence demonstrating the mood benefits of smoking among adolescents. It may be that adolescents who experience mood benefits from smoking are the ones most likely to escalate in their use.

Rationale for EMA Approach

EMA provides an excellent window into the lives of adolescents and a way to examine specific hypotheses about contextual influences on smoking. EMA captures more accurately than other measurement modalities the frequency, intensity, and tone of social experiences as they occur, as well as the mood associated with those exchanges. Shiffman's work has amply demonstrated both the feasibility and utility of using EMA to study smoking, relapse, and temptations to smoke in adult smokers (e.g., Shiffman, Guay, Richards, Paly, Hickcox, & Kassel, 1996; Shiffman, Paly, Guay, Kassel, & Elash, 1995; Shiffman, Paly, Guay, Kassel, & Hickcox, 1996), and the work of Jamner and colleagues has shown the feasibility of EMA with adolescents (e.g., Whalen, Jamner, Henker, et al., 2001). EMA is well suited for measuring internal, subjective states, intra-individual variability, and small shifts in mood that may play a role in cueing smoking (Shiffman, 1993). Finally, with the use of random assessments that are independent from the occurrence of specific behaviors and situations, EMA can provide useful
comparison information about nontarget events. Thus, EMA can provide an ideal
tool for studying the contextual micro-patterns of cigarette use, the micro-level
antecedents of use, as well as the subjective experience of adolescent smoking.

A primary goal of the project reported here ("Context and Subjective
Experience of Early Smoking" or "Early Smoking" study) was to increase our
understanding of how adolescents' subjective experience and context of early trials
of cigarette smoking affect their future smoking patterns. We focus here on
addressing two questions: (1) How do the subjective mood contexts of smoking episodes
and nonsmoking decision times differ from random background times? and (2) Do moods
prior to smoking differ by an adolescent's level of smoking experience?

Method

Overview of Study

The data reported in this chapter come from a longitudinal study of the natural
history of smoking among adolescents. The study used a multimethod approach
to assess adolescents at four time points: baseline, 6 months, 12 months, and 18
months. The data collection modalities included a week-long time/event EMA
sampling (through 12 months) via hand-held, palmtop computers (referred to as
"ED" or Electronic Diary), self-report questionnaires, and in-depth interviews.
We report here on the data from the baseline EMA collection.

The design of the "Early Smoking" study involved sampling eighth- and
tenth-graders at baseline who fell into three early stages of cigarette use: (1)
"susceptibles"—youth who had never smoked but who indicated high "suscepti-
bility" to smoking based on questions about intentions; (2) "triers"—youth who
had smoked within the past 90 days and who had no more than 20 cigarettes in
their lifetimes; and (3) "experimenters"—youth who smoked in the past 30
days and smoked between 20 and 99 cigarettes in their lifetimes, and were not yet
daily smokers. Our sampling rationale was based on our desire to follow youth
who might have their first cigarette within the course of the study, as well as those
who were still early in their smoking experiences. Adolescents were invited to
participate in this longitudinal study based on their responses to a self-report
screener. Across 11 middle schools and 7 high schools, 5,278 eighth- and tenth-
graders completed the initial screening questionnaire, and 1,817 of those students
fell into our three identified categories of eligible students. Of those eligible, a sample of 1,437 were invited to participate through a process of mailed
recruitment letters to the adolescents' homes. Active parental consent was required
for participation in the longitudinal study. Of those invited, 562 positively
responded and completed the baseline measurement wave.

Sample Description

For the analyses reported here, we will focus on a subset of the 562 participants,
including only those adolescents who event-reported either a smoking or
nonsmoking decision episode (or both) on the ED during the baseline measurement wave. This analysis sample of 300 participants included 54.0 percent females (n = 162) and 48.3 percent eighth-graders (n = 156). Their ethnic distribution was 69.3 percent White (n = 208), 18.0 percent Hispanic (n = 54); 5.3 percent Black (n = 16); 4.0 percent Asian (n = 12); and 3.3 percent other (n = 10). Just prior to the ED data collection week, 18.3 percent (n = 55) reported never smoking, 15.5 percent (n = 46) reported having less than 6 cigarettes in their lifetimes, 51.0 percent (n = 153) reported having had between 6 and 99 lifetime cigarettes, and 15.3 percent (n = 46) reported having had 100 cigarettes or more. Considering that the baseline ED data collection occurred approximately 2 months after the screening for eligibility, some adolescents progressed in their smoking since screening, thus having had more than 100 cigarettes by the time of the baseline ED measurement.

Momentary Data Collection

TYPE OF SAMPLING

Data collection occurred via hand-held palmtop computers (ED), programmed specifically for our data collection needs, with all other residing programs disabled. Each data collection wave included 7 consecutive days of monitoring. The decision to monitor for 7 consecutive days involved a compromise among multiple factors: our desire to include both weekdays and weekends in order to obtain a more representative sample of the adolescents' daily lives than just weekends or weekdays, and the pragmatic factors of adolescent fatigue at monitoring as well as field issues of the hardware needing to be checked and batteries replaced after a longer time period. Three types of interviews were programmed onto the ED: random prompts, and smoke and "no smoke" events. Participants were trained to turn on the ED upon waking and to "put it to bed" upon going to sleep at night.

Random time prompts were initiated by the device on average five or six times per day. At these times, the ED would beep, signaling the participant to initiate an interview. The beeping noise would get increasingly louder until the participant responded. The participant needed to respond within 3 minutes of the prompt before the interview would be recorded as "missed.” Each random prompt was date- and time-stamped and recorded whether the interview was completed, missed, or disbanded. The random interviews took 60 to 90 seconds to complete and asked about mood, activity (what the adolescent was doing), companionship (with whom or alone), presence of other smokers, where they were, and other behaviors (e.g., eating, drinking, substance use).

In addition to the random prompts, participants were trained to event-record both smoking and nonsmoking episodes. A smoking episode was defined as any time that a participant smoked, even a puff. Right after smoking, the participant would turn on the ED and initiate a "smoke” interview, which included the same questions as the random prompt, but in addition asked about specific smoking-related items (e.g., how much smoked, how the cigarette was obtained);
perceptions of the supportiveness, friendliness, or "pressuring" of others; and moods both right after smoking ("now") and then "just before" smoking.

A "no smoke" episode was defined as an occasion when the participant had the opportunity to smoke but made an active decision not to smoke. "No smoke" events were not times when the adolescent might have wanted to smoke but couldn't (e.g., in smoking-restricted areas or none available), but rather, active opportunity times. The "no smoke" interviews were similar to the smoke interviews but did not include the specific questions about cigarettes smoked.

TAILORING EMA TO ADOLESCENTS

The ED had several features that made its use feasible for the adolescents. For example, the adolescents had the option to suspend the ED from randomly prompting them for up to 2 hours at a time. The suspension option was useful at times that were impractical for the adolescent to respond, such as during a school exam or while in an athletic event. The ED recorded all suspension times, along with the reason for the suspension. The suspension option did not interfere with the number of prompts answered overall. In addition, upon prompting, the adolescents could also initiate a "delay" option, allowing them to delay responding for up to 20 minutes (in 5-minute intervals) if they were not able to respond immediately. The brief interviews made it realistic for the adolescent to respond and complete the random prompts during the daily activities. The ED was programmed so that a response was required on each interview screen before the participant could move on to the next question. In addition, adolescents could not enter out-of-range values on an item. Thus, within an interview, there were no missing data.

Prior to finalizing all procedures with the ED, we conducted several focus groups of teens and piloted all procedures with teens in the field. Our focus groups covered topics such as what to call the device ("ED" was easiest for the teens), language/wording of questions and mood descriptors for items on the ED, anticipated problems with using the ED in real time and possible solutions, and also very pragmatic issues such as how the teens would actually carry around the ED (e.g., in a backpack, clipped to a belt), and whether they had concerns about their appearance in carrying and using the device. For example, we explored a variety of carrying case options with the teens, having the teens comment on their perceptions of the relative appeal of different options. To our surprise, the teens overwhelmingly preferred the use of seemingly less attractive, well-padded carrying cases, as opposed to the more sleek and aesthetically appealing leather cases. The teens were concerned more about not breaking the hardware and feeling responsible for it than they were about the appearance per se. To the teens, the sense of "coolness" came from being one of the relatively few in a school who were invited to participate in the study, rather than the looks of the devices.

There were also unique challenges to using the ED with adolescents. For example, during pilot work, we learned that we needed to password-protect the ED for initiating "smoke" or "no smoke" events as a way to prevent other adolescents
from entering false data about a participant (as a prank). In addition, we programmed in a "demo" feature that included a very brief interview that allowed the adolescent to show friends, family, or teachers examples of what they were being asked to do. However, we also learned that we needed to limit the number of "demos" to prevent inappropriate overuse of this feature. In addition, following the pilot work, we decreased the number of random prompts per day from 7 to 9 to 5 or 6, after receiving feedback from the teens (and compliance data) about the perceived burden of the number of prompts.

Importantly, we also gained the cooperation and permission of the schools to allow the students to carry and use the ED while they were in school. We prepared the school administrators and teachers for the project through a series of in-person meetings (with administrators and teachers) and letters to teachers describing the study procedures, goals, and how the data collection and ED devices worked. We emphasized that the random prompts would be relatively rare in any one class and that the students had the option to suspend the program if requested. In any given school, data collection occurred during only 1 or 2 weeks in the school year. Students also received ID cards and letters (describing their study responsibilities and noting the permission of the school) to carry with them in case they were questioned about the devices. Data collection occurred throughout the full calendar year, including summer.

Procedures

Training

At the beginning of each measurement wave, adolescents were individually trained on the use of the ED. Training took approximately 45 minutes and occurred either in a private location at the adolescent's school or a community location (e.g., library). Training was standardized with manuals for both the staff trainer and the participant. Training covered not only how to use and respond to the ED, but also role-playing how to deal with potentially awkward situations when the adolescent must either respond to a prompt or event record (e.g., smoking at a party). The trainer helped the adolescents to anticipate and problem-solve any difficulties or concerns they may have had about using the ED. Training reflected not only our suggested solutions to potentially awkward situations, but also suggestions by adolescents who participated in our pilot work and early waves of data collection. In addition, our staff trainers were selected based on their age, similarities to the adolescents, and ability to relate well to adolescents. The trainers underwent extensive training themselves in the use of the protocol, dealing with adolescents, and ways of enhancing compliance.

The trainers called each participant 1 day into the measurement week to check for potential problems and to reinforce compliance. Throughout the week, research staff were available via an 800 telephone number and pager to respond to any problems or issues (e.g., broken computers that needed to be replaced). At the end of each measurement week, the EDs were collected, and the trainer conducted an in-depth in-person interview with the participant.
During the interview, the trainer printed out a record of the adolescent's use of the ED, including details about compliance, and went over the printout with the adolescent, inquiring about any conflicting "problem reports" (times when the adolescent indicated a missed report). The printout also served as additional training for subsequent waves, for the trainer to review compliance issues or difficulties with the adolescent. During the end-of-the-week interview, the trainer also inquired about potential reactivity, events that were not recorded, and the adolescent's impressions about the week.

**Measures**

To illustrate the use of EMA with one of its more unusual data collection options, we will focus here on the EMA measures of mood/affect. During the random prompt interviews, participants were asked, "Think about how you felt just before the signal." They were then shown a screen with the question stem, "Before signal, I felt . . ." One mood/affect adjective was presented per screen along with a 10-point visual analogue scale. The scale was anchored by "very" at the top, "somewhat" in the middle, and "not at all" at the bottom rung of the visual ladder. Participants used a stylus to point to the level on the scale that represented their response. A series of 12 adjectives (one per screen) was presented to the participants. The 12 adjectives factored into four scales: (a) positive mood scale (cheerful, happy, relaxed; coefficient alpha = .75); (b) negative mood scale (sad, embarrassed, angry, left out, lonely; coefficient alpha = .74); (c) stress/frustration scale (stressed, frustrated; coefficient alpha = .76); and (d) a tired/bored scale (tired, bored; coefficient alpha = .52).

During the "smoke" and "no smoke" event recorded interviews, participants were first asked, "Think about how you feel right now." "Right now, I feel . . ." They were then presented with the same set of adjectives as with the random prompt interview, with the addition of two other adjectives, sick and buzzed, to represent subjective physiological sensations that might be related to smoking. The ratings of feelings "right now" represented post-smoking or post-no smoking decision affect. After responding to the adjectives with the stem about how they felt right now, participants then were asked: "Now think about the time just before you smoked/decided not to smoke." "Just before, I felt . . ." and again, they rated each adjective. These ratings of just before the event represented pre-event affect/mood.

Assessing mood just prior to a smoke or no smoke event presented a measurement challenge. Unlike with adult smokers, who are more likely to be able to anticipate and plan when they smoke (or to add in a delay for recording just prior to the event), we expected that adolescents' decisions to smoke or not during the early stages of experimentation are likely to be far less routine than for adults. In addition, asking an adolescent to interrupt a stream of decisional and real-life situational complexities to complete an ED interview seemed unrealistic. Thus, we opted to have the "pre-event" mood assessment questions occur after the event. In addition, we decided to ask first about mood "now" right after smoking/not smoking, and then ask about mood "just before" smoking or the
decision not to smoke, believing that we would be less likely to introduce any response biases about perceived changes in mood with both this question phrasing and ordering. As a result of our pilot work, we arrived at our final choice of question phrasing and ordering based on both methodological reasons and teens’ perceptions of case of answering specific questions.

DATA MANAGEMENT

The management of the EMA data involved several steps, including documentation, extraction, aggregation, and cleaning. At the subject debriefing at the end of the data collection week, a Microsoft Access database used by the EMA software to store data was uploaded onto a laptop and a report used to assist with debriefing was printed on site. The report contained a listing of random prompt, smoke, and no smoke interviews and a listing of events involving the subject’s interaction with the ED during the week. The report was an important tool used by the trainer at debriefing to gauge compliance and to reinforce good efforts. The Microsoft Access database was split into four files: smoke interviews, no smoke interviews, random prompt interviews, and record events, which included data involving subject interaction and software operation (e.g., compliance record, number of suspends). All ASCII files of a single type of interview or event record were aggregated using MS-DOS batch commands, and the resulting aggregated ASCII was read into SAS and formatted. After cleaning, the four SAS files included all diary information for all subjects during the wave and were ready for analysis.

ANALYTIC APPROACH

The data were analyzed using mixed effects regression models for continuous outcomes (Verbeke & Molenberghs, 2000). These models are well suited for the EMA data since they can handle the repeated assessments within an individual over the measurement week, accounting for the data dependency of observations within an individual. In addition, they allow for the unequal number of observations across individuals. Thus, we did not exclude any subject or data due to level of “completeness,” and neither did we aggregate data across days. Rather, all individual reports were included in the analysis. To address our questions about the effects of event type (random, smoke, or no smoke) and smoking level (<6 cigarettes/lifetime, 6–99 cigarettes; 100+ cigarettes), as well as their interactions, we ran separate mixed effects regression models for the EMA measures of positive and negative affect. Significant effects were followed up with a priori planned contrasts comparing random to smoke events and random to nonsmoking events. Significant interactions were followed up with a priori planned contrasts of random versus smoke events at each smoking level compared to the lowest (i.e., <6 cigarettes vs. 6–99; <6 cigarettes vs. 100+). Similar planned comparisons were made for the random versus nonsmoke events for the smoking level comparisons.
Results

Compliance

As one might expect with adolescents, there was some data loss due to damage to the equipment or to equipment loss. At our baseline wave, we had usable ED data from 516 of the 562 participants (92%). At the 6-month data collection, 15 adolescents declined to participate in the ED component of the study, and at 12 months, a total of 23 adolescents declined the ED component. For the most part, these adolescents found the ED component too difficult to complete given their other life commitments, or in a few cases, were not allowed to complete that component, given their multiple hardware losses. The level of usable data from the ED increased slightly at 6 and 12 months to 93.5 percent and 92.1 percent, respectively. Overall dropout from the study was relatively minimal; at 12 months, we retained 90.2 percent of the participants in the study.

Compliance with the ED among those with usable data (n = 516) was excellent. Table 6-1 shows various indices of compliance. As can be seen from the table, compliance remained relatively high and stable over time, with only very slight declines in the percent of random prompts answered. However, the total number of prompts answered remained the same, if not slightly higher, at 12 months. The number of times the participant “suspended” the ED is another measure of compliance. Overall, the amount of “suspension” time seemed reasonable within the context of adolescents’ lives, averaging once per day for slightly over an hour.

We also examined compliance by calendar day (e.g., Monday–Sunday) and by study day (e.g., first day–seventh day of monitoring). As a note, the majority of initial training and study “first” days occurred on Tuesdays, Wednesdays, and Thursdays, with no study first days on Friday through Sunday. Table 6-2 presents compliance data (percentage of prompts answered, suspension data) by day of the week, and Table 6-3 presents these data by study day (monitoring day). As can be seen in Table 6-2, compliance was the best during the mid-week days (Tuesday through Thursday), which also were most frequently the first and second day of the monitoring period, and compliance with random prompts dropped off slightly over the weekend (Saturday and Sunday). Table 6-3 shows that there is an initial high level of responding to random prompts during the

<table>
<thead>
<tr>
<th>Table 6-1. Compliance variables over time.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Mean no. random prompts answered (SD)</td>
</tr>
<tr>
<td>Mean no. missed prompts (SD)</td>
</tr>
<tr>
<td>Mean % random prompts answered (SD)</td>
</tr>
<tr>
<td>Mean total no. suspends/week (SD)</td>
</tr>
<tr>
<td>Mean minutes per suspend (SD)</td>
</tr>
</tbody>
</table>
very first 2 days of the monitoring period at baseline, and then levels off to a narrower range after that. Over the subsequent measurement waves (6 and 12 months), the variability in compliance decreased and remained fairly stable across all days. For example, at the 6- and 12-month waves, the percentage of prompts answered ranged from approximately 82 to 86 percent regardless of whether one considers day of the week or day of the study.

Compliance with event-recording the “smoke” and “no smoke” interviews was assessed during the end-of-week in-person interviews, as well as with written responses to questionnaires. Although the adolescents acknowledged occasionally not recording an event, these omissions were relatively rare (accounting for approximately less than 3% of all events). Our end-of-the-week paper-and-pencil measure of smoking during the 7 days covering the ED monitoring period correlated highly (.75) with the number of smoke events recorded on the ED.

One potential validity check on adolescents’ compliance with event-recording smoking events is to examine the frequency of these events by day of the week. Anecdotal and paper-and-pencil measures of adolescent smoking frequently note that adolescents smoke more on the weekends than during the week. Figure 6-1 plots the percentage of smoke reports on the ED by day of the week,

<table>
<thead>
<tr>
<th>Table 6-2. Compliance by day of week at baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Prompts answered (SD)</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Monday</td>
</tr>
<tr>
<td>Tuesday</td>
</tr>
<tr>
<td>Wednesday</td>
</tr>
<tr>
<td>Thursday</td>
</tr>
<tr>
<td>Friday</td>
</tr>
<tr>
<td>Saturday</td>
</tr>
<tr>
<td>Sunday</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 6-3. Compliance by study day at baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Prompts answered (SD)</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Day 1</td>
</tr>
<tr>
<td>Day 2</td>
</tr>
<tr>
<td>Day 3</td>
</tr>
<tr>
<td>Day 4</td>
</tr>
<tr>
<td>Day 5</td>
</tr>
<tr>
<td>Day 6</td>
</tr>
<tr>
<td>Day 7</td>
</tr>
</tbody>
</table>
along with the percentage of random events reports over the 7-day baseline period. We would expect that the percentage of random prompt responses should be relatively flat and stable over days of the week, given that the number of prompts does not vary by day, and indeed as can be seen in the figure, the percentage of random prompts responded to is relatively stable over the week. However, as can be seen in the figure, adolescents reported more smoking Wednesday through Saturday and a much lower percentage of smoking (of the total smoke reports) on Sunday or Monday.

**Findings Related to Mood and Events**

We were interested in the question of whether moods just prior to smoking or making a decision not to smoke differed from random times and also whether these differences varied by level of smoking experience. For the current analyses, we focused on the mood ratings just before the smoke or no smoke events compared to the random events. To be included in these analyses, adolescents needed to event-report either a smoking or a nonsmoking event (n = 300). Adolescents who responded only to random prompts and who did not report either smoking or making a nonsmoking decision were thus not included in these analyses.

Among the 300 participants for these analyses, there were three different possible patterns of data types: (1) random events and smoke events only (n = 40; 1,359 random events and 166 smoke events); (2) random events and no smoke events only (n = 148; 4,838 random events and 353 no smoke events); and (3) random events and both smoke and no smoke events (n = 112; 3,903
random events, 388 smoke events, and 331 no smoke events. To account for these different combinations of data, we controlled for data type in the analyses. Thus, for analyses comparing random to smoke events, data from 152 participants were used, which included comparisons of 5,262 random prompts and 554 smoke events. For comparisons of random to no smoke events, data from 188 participants were used, including 8,741 random prompts and 683 no smoke events.

Positive Mood

The random effects regression model with event type, smoking level, and the interactions of event type with smoking levels revealed a significant effect for event type (chi-square = 41.26, df = 2, p < 0.0001), and for the interaction of event type by smoking level (chi-square = 12.72, df = 4, p < 0.02). Overall, adolescents reported significantly higher positive moods during random times (M = 6.75, SD = 2.19) than just prior to smoking (M = 6.3, SD = 2.39). In addition, positive moods just prior to making a nonsmoking decision were significantly higher than moods at random times (M = 6.93, SD = 2.25 vs. M = 6.75, SD = 2.19). Examining the a priori planned contrasts for the interaction effect revealed that the difference in positive moods between random and smoke times was significantly greater for adolescents with the least smoking experience (<6 cigarettes) compared to those with either the middle level of experience (6–99 cigarettes in lifetime; estimate = -0.90, SE = 0.28, z = -3.24, p < 0.002) or to those with the most experience (100+ cigarettes in lifetime; estimate = -0.92, SE = 0.27, z = -3.41, p < 0.0001). These estimates mean that on average, the difference in positive moods between random and smoke times is .90 scale points greater for the lowest compared to the mid-level of smoking experience, and .92 scale points greater for the lowest compared to the highest level of smoking experience.

Figure 6-2 shows the mean values for the positive mood scale scores for the random and smoke events by smoking level. As can be seen, the difference between positive moods just prior to smoking and random times is greatest for the adolescents with the least smoking experience and is significantly different from the pattern for adolescents with more smoking experience. The adolescents with the least smoking experience feel significantly less positive just before smoking, compared to their random times. However, for adolescents with more smoking experience, there is not as great a difference in positive moods between random and smoke times; indeed, for the most experienced adolescents, positive moods before smoking are relatively high and equivalent to those of random times. There were no significant differences between positive mood prior to making a nonsmoking decision and random times by smoking level. The figure also shows the clear dose–response relationship between positive mood prior to smoking and smoking experience. As noted earlier, across all smoking levels, moods prior to deciding not to smoke were significantly higher at nonsmoking decision times than at random times.
Negative Mood

The random effects regression model for negative mood with event type, smoking level, and the interactions between event types and smoking level revealed significant effects for event type (chi square = 44.86, df = 2, \( p < 0.0001 \)) and for the interaction between event type and smoking level (chi square = 14.28, df = 4, \( p < 0.007 \)). Negative moods just prior to smoking were significantly higher (worse) than moods at random times (M = 2.82, SD = 1.99 vs. M = 2.56, SD = 1.64), and negative moods just prior to making a decision not to smoke were also significantly higher (worse) than negative moods at random times (M = 2.73, SD = 1.72 vs. M = 2.46, SD = 1.56). Our a priori planned contrasts revealed that the significant interaction effect could be explained by differences in negative mood between random and smoking times for adolescents at the highest level of smoking compared to those at the two other levels of smoking. For adolescents at the highest level (100+ cigarettes in lifetime), the difference in negative mood between random and smoking times was significantly less than that for either the lowest smoking level (<6 cigarettes; estimate = .63, SE = .19, \( z = 3.28, \ p < 0.002 \)) or for the middle level of smoking experience (6 to 99 cigarettes in lifetime; estimate = .32, SE = .13, \( z = 2.46, \ p < 0.02 \)). In other words, the difference in negative mood scores between random and smoking times was approximately .63 points greater for adolescents in the lowest level of smoking compared to the highest level, and approximately .32 points greater for adolescents in the mid-level compared to the highest level of smoking.

Figure 6-3 shows the negative mood scores for both random and smoking times by smoking level. As can be seen, the difference in negative moods just
prior to smoking and random times is greatest for the adolescents with the least
smoking experience, and this difference between smoke and random times
diminishes as smoking level increases, showing a clear dose–response relationship.
Thus, adolescents with little smoking experience feel significantly worse just prior
to smoking than they do at other times. For the most experienced smokers, there
is no difference in negative moods between random times and pre-smoke times.
There was no difference by smoking level between negative moods at random
and nonsmoking decision times. For all smoking levels, negative moods were sig-
ificantly higher (worse) at nonsmoking decision times than at random times.

Discussion

We addressed two primary questions with the EMA data: (1) Do moods just prior
to smoking or prior to making a decision not to smoke differ from those of random,
background times? and (2) Do the mood contexts of smoking and non-smoking
decision times differ by level of smoking experience? We had hypothesized that,
in general, moods prior to smoking would be less positive and more negative
than those of random times. Our hypothesis was confirmed for the least experi-
enced smokers; for adolescents who had smoked fewer than six cigarettes in
their lifetimes, their moods just prior to smoking were significantly less positive
and more negative than random times. However, for more experienced smokers,
there was no difference in either positive or negative moods before smoking and
at random times.
These findings suggest that for youth with little smoking experience, the subjective mood context of smoking events may be one of social discomfort—feeling lonely, sad, left out, and perhaps embarrassed. For these youth, smoking may be motivated by a desire to feel more positive about their immediate situation. Just prior to smoking, they also feel less happy, less cheerful, and less relaxed than they do at other times. However, for youth with substantially more smoking experience, smoking times are not less positive or more negative than other times. Indeed, there is no suggestion that adolescents with more smoking experience smoke at times that are affectively or subjectively different on a positive/negative dimension than other times. Importantly, the overall level of positive and negative moods at random times did not differ by smoking level.

Non-smoking decision times for all of the adolescents were a curious combination of moods, somewhat more negative than random times, but also more positive than random times. Recall that the non-smoking events reflected a time when adolescents actively considered smoking, had the opportunity to do so, but decided not to smoke. These may indeed be times when the adolescent’s somewhat higher negative moods reflect a potentially awkward social situation. However, these times are different from smoking times in that the adolescent’s overall positive mood is very high, more so than at random times. It may be that this overall positive affect in the moment buffers the adolescents against any perceived social pressures, allowing them to make a decision not to smoke.

Insights Gained from a Real-Time Approach

The real-time data collection allowed us to examine adolescents’ moods immediately prior to smoking in a way that has not been captured before with more retrospective, paper-and-pencil or interview methods. In addition, because we were gathering adolescents’ reports in real time, we were able to obtain more fine-grained subjective mood ratings along both a positive and negative affect dimension than is usually found with more retrospective methodologies. These data are unique, too, in that we captured non-smoking decision times as well as smoking times. As difficult as it may be for adolescents to recall retrospectively months or years after an event how they felt in the early stages of smoking, it is even more difficult for them to recall moods surrounding specific cognitions or decisions that are not necessarily marked by overt behaviors. The EMA method allowed us to capture moods surrounding these more cognitive events.

Our data are provocative in that they point to the importance of examining moods surrounding smoking as a function of the level of experience that the adolescent has with smoking. Our findings also suggest that the emotional contexts surrounding smoking for novice smokers are very different from the emotional contexts of smoking for more experienced adolescent smokers. Contrary to expectations and more retrospective adolescent reports (e.g., Mermelstein, 1999), more experienced adolescent smokers are not smoking at times when they feel “down” or more negative than their norm.
Our analyses here focused on the mood experience of adolescents just prior to smoking or making a nonsmoking decision. We did not present adolescents' subjective mood responses following smoking or following a decision not to smoke. Thus, it is possible that adolescents who continue to experiment with smoking beyond the first few trials experience a mood boost following smoking even if their smoking was not initially preceded by subjectively negative mood states. It is also possible that adolescents who fail to experience mood relief following smoking are the ones who do not progress in their habit and stop "experimenting." Alternatively, one could also hypothesize that as adolescents progress in their smoking, they become more comfortable in what might otherwise be a socially difficult or awkward moment when they perceive a norm to smoke. Our sample of adolescents with little smoking experience is likely to be a heterogeneous one in that some of these youth will discontinue their smoking, while others will go on to become more regular smokers. The mood aftermath of smoking may be critical to predicting progression. Similarly, subjective affect following a decision not to smoke may also be important to understanding an adolescent's ability to continue to reject smoking or not. The data presented in this chapter are cross-sectional and as such do not allow us to make inferences yet about how moods both prior to and after smoking and not smoking relate to progression.

These data are invaluable in helping to start to understand why some situations lead to smoking and others do not. Our findings highlight the potential role of positive affect in tipping the balance toward not smoking in a given moment. Positive affect has been a relatively understudied dimension in smoking research, and these findings suggest a need to focus more efforts on both positive and negative emotional domains.

Success and Challenges

Our experience in using EMA with the adolescents to examine the contexts of smoking and nonsmoking has led us to conclude that the successes clearly outweighed the challenges. We have continued to be both surprised and pleased by the richness of the data. The methodology has allowed us to address questions about the immediate contexts surrounding smoking that have not been possible before. For example, by combining the objective data about the presence of other smokers and the subjective mood data, we can ask questions about how subjective moods differ when other smokers are present or not, and whether these differences in context are more likely to lead to a smoking or nonsmoking decision.

Our surprise has been how "well behaved" the data were. One of our concerns prior to initiating this study was that the adolescents would not take the task seriously or that they could not accommodate the demands of the data collection, potentially leading to careless or random responding, or a high rate of noncompliance. None of these have been our experience. We attribute much of this success to careful preparation of the participants in terms of training. From debriefing participants we also learned that participant payment was important, and because
of the payment ($40 for the baseline EMA weeklong, with escalating payments over waves), participants reported treating the task as a "job" and one that they had to take seriously.

One might ask how representative our participants were of the pool of possible candidates. Adolescents who completed the baseline wave did not differ from the broader sample of adolescents who met inclusion criteria in terms of level of smoking experience, but males were slightly less likely than females to respond to our recruitment efforts and nonwhite youth were slightly less likely to respond than white youth (Diviak, Wahl, O'Keefe, et al., 2006). In addition, the more experienced smokers were somewhat less likely to drop out of the study. Anecdotally, the youth with more smoking experience were less busy with competing activities that were nonsmoking youth and had both the time and sense of commitment to the project to follow through (they reported feeling pleased to have been asked to participate). Clearly, not all adolescents can handle the requirements of this intensive data collection and navigate some of the social complexities of interacting with the ED. However, in each school, all students in the grade were aware of the study, and we engendered a sense of "specialness" among students for being invited to participate. It was rare for a student to report negative social reactions to carrying and responding to the ED.

There were additional ethical and pragmatic challenges in using EMA to study adolescent smoking. From an ethical perspective, we needed to include both smokers and nonsmokers in the study to avoid the possible implication that the adolescent participants were all "smokers." Given that smoking among adolescents is frequently a covert and punishable behavior, we were also concerned about participants' potential reluctance both to participate and to event record smoking episodes. Very explicit information to the adolescents, parents, and teachers explaining issues of confidentiality helped to assuage these concerns.

From a pragmatic standpoint, a major challenge was the enormous personnel time that was required to ensure participants' engagement and compliance. Developing a strong sense of a collaborative research relationship between our field staff and the participants, through one-on-one in-person training, personalized follow-up phone calls, and consistency in contact people, was important to the success of the data collection efforts. Anticipating hardware malfunctions and being prepared to respond quickly with replacements was also time-demanding. Finally, there was the occasional reminder that adolescents may indeed act out as adolescents at times and find ways to use the devices to annoy teachers, parents, and study staff.

Prospects for Application of EMA Methods

The EMA methods provide a wealth of opportunities for addressing important questions in the field of adolescent smoking. As noted earlier, the ability to examine concurrently both the objective and subjective components of the context of smoking or nonsmoking decision times allows researchers to answer questions
about adolescent smoking in ways that will greatly increase our understanding of factors that may lead to the progression of smoking.

Longitudinal EMA data will be especially valuable in addressing questions about the development of dependence and changes that occur over time in subjective responses to smoking. For example, we might hypothesize that as an adolescent gains experience with smoking and starts to develop signs of dependence, we might see a decrease in certain subjective responses to smoking (e.g., Hedecker, Mermelstein & Flay, 2006). One might also see changes in situational antecedents over time as adolescents become more established smokers. For example, one might hypothesize that smoking alone, versus social smoking, may be an earlier marker of dependence.

The EMA procedures also potentially produce enormous amounts of data, thus allowing researchers to address within-subject questions of interest that have been difficult to address with other methodologies. For example, one could examine the cross-situational variability (or consistency) in mood changes that might occur with smoking and start to address questions about how situational factors versus intrapersonal factors contribute to emotional responses to smoking.

In sum, EMA methods provide a unique window into studying the contexts and subjective experiences of adolescents as they initially try, experiment, and become dependent on smoking. Our experience has demonstrated the feasibility and value of EMA data in gaining new insights into the antecedents and immediate consequences of both smoking and non-smoking decisions among adolescents relatively early in their smoking "careers." Future work will need to focus on more established smokers as well.

ACKNOWLEDGMENTS

Work on this chapter was funded in part by grant CA100266 from the National Cancer Institute and by a grant from the Oregon Prevention Network, Robert Wood Johnson Foundation.

References


