Factors Predicting Compliance to Ecological Momentary Assessment among Adolescent

Smokers

BY

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THESIS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

BS   Between Subjects

CES-D   Center for Epidemiological Studies – Depression

DSM-IV   Diagnostic and Statistical Manual – IV

EMA   Ecological Momentary Assessment

GPA   Grade Point Average

IVR   Interactive Voice Response

MAR   Missing at Random

MASQ   Mood and Anxiety Symptom Questionnaire

MCAR   Missing Completely at Random

MI   Multiple Imputation

NMAR   Not Missing at Random

NA   Negative Affect

PA   Positive Affect

WS   Within Subject

SUMMARY

Introduction Ecological momentary assessments (EMA) are increasingly used in smoking research to understand contextual and individual differences related to smoking and changes in smoking. To date, there has been little detailed research into the predictors of EMA compliance. However, patterns or predictors of compliance may affect key relationships under investigation and introduce sources of bias in results. The purpose of this study was to investigate predictors of compliance to random prompts among a sample of adolescents who had ever smoked.

Methods Data for this study were drawn from a sample of 461 adolescents (9th and 10th graders at baseline) participating in a longitudinal study of smoking escalation. We examined two outcomes: subject-level EMA compliance (overall rate of compliance over a week-long EMA wave) and in-the-moment prompt-level compliance to the most proximal random prompt. We investigated several covariates including: gender, race, smoking rate, alcohol use, psychological symptomatology, home composition, mood, social context, time in study, inter-prompt interval and location.

Results At the overall subject level, higher mean negative affect, smoking rate, alcohol use, and male gender predicted lower compliance with random EMA prompts. At the prompt level, after controlling for significant subject level predictors of compliance, increased positive affect, being outside of the home, and longer inter-prompt interval predicted lower momentary compliance.

Conclusions This paper identifies several factors associated with overall and momentary EMA compliance among a sample of adolescents participating in a longitudinal study of smoking. We propose a conceptual framework for investigating contextual and momentary predictors of compliance within EMA studies.

1. INTRODUCTION

1.1 **<u>Background</u>**

Ecological momentary assessment (EMA) has become an increasingly favored methodology over traditional "paper and pencil" diary methods. EMA maximizes ecological validity, minimizes recall bias, and allows for the examination of micro-contexts that influence behavior (Shiffman, Stone, & Hufford, 2008). However, EMA compliance remains an important methodological concern. For instance, individuals may not respond to all prompts or cues to report experiences, or may otherwise systematically avoid reporting; both instances may introduce important biases into data collection. This paper sought to examine factors related to EMA compliance among adolescents from a longitudinal study of smoking patterns.

Compliance issues with traditional paper self-report methods have often centered around participants' failure to report behavior and surrounding events at the time of their occurrence, and then retroactively reconstructing these events at the time of data collection (Stone & Shiffman, 2002). Stone, Shiffman, Schwartz, Broderick, and Hufford (2002) have reported that up to 90% of events may be retrospectively back-filled by participants to give the appearance of good compliance. Concern about the falsification of paper diary entries has prompted the development of better diary tools, specifically the development of electronic diaries for EMA. While implementation of EMA methods vary, they all involve the repeated measurement of a subject's behavior and experiences in real time – often using a programmed, time sensitive signaling device and an associated data collection modality such as interactive voice response (IVR), paper diary, or electronic diary.

1.2 <u>**EMA Compliance**</u>

Unlike paper diaries, electronic diaries and IVR enable the use of timestamping, a key feature in improving and assessing compliance. Making participants aware that their electronic diary assessments are electronically timestamped and, by extension, resistant to back-filling should improve momentary compliance with EMA protocols (Hufford & Shiffman, 2003). It is reassuring then that many studies employing electronic diaries for EMA report compliance rates upward of 90% (Cain, Depp, & Jeste, 2009; Hufford & Shiffman, 2003; Stone et al., 2003). Such compliance rates, however, are not universal with some electronic diary studies showing compliance rates below 75% (Jamison et al., 2001). To determine whether such data missingness may bias estimates of aggregated scores it is important to establish first whether specific characteristics of measurement occasions are systematically associated with EMA non-compliance.

1.3 **<u>Data Missingness</u>**

Data missingness is inherent to EMA protocols, and methods for addressing such concerns necessitate an expanded awareness of potential predictors of missingness. Current approaches to managing missing data, such as multiple imputation (MI), typically assume that the data are either missing at random (MAR) or missing completely at random (MCAR) (Schafer & Graham, 2002). That is to say, missing data points are either a random sample from the full dataset (MCAR) or a non-random sample of data where the predictors of missingness are known (MAR). When data missingness cannot be predicted by other variables in the dataset, or are only predicted by the missing variable of interest, it is considered not missing at random (NMAR). While MI for data that are NMAR is possible, currently established MI methods typically underestimate variance for data with more than 5% missingness and should not be used at all when missingness is above 25% (Scheffer, 2002). As the assumption of MCAR is highly restrictive, it is important for EMA researchers to evaluate potential predictors of missingness to better maintain the MAR assumption and avoid biasing their effect estimates.

1.4 **Purpose of Study**

This study addresses the question of which factors may be associated with compliance to random prompts in an EMA protocol. Although extant literature on predictors of compliance with EMA remains sparse, several studies have examined potentially important empirical predictors of compliance. These studies have focused primarily on background, subject-level factors that might be associated with poor response rates. Adolescents with learning difficulties in school were found to be less compliant with EMA than their peers (Salamon, Johnson, Grondin, & Swendsen, 2009). While Palermo et al. (Palermo, Valenzuela, & Stork, 2004) found significant gender differences in compliance, others have not identified such an effect (Hacker & Ferrans, 2007). Additionally, there is some evidence that substance use, particularly poly-substance use predicts EMA non-compliance (Serre et al., 2012). Although these studies provide some general insights about compliance overall in particular populations, they do not provide much guidance within a given population of interest about what might predict compliance.

In addition to subject level characteristics that may be associated with overall compliance, factors predicting compliance to random prompts at the prompt level may be of equal if not greater empirical interest. EMA studies often examine relationships between momentary contextual variables and a behavior of interest. To the extent that the contextual variables influence an individual's probability of responding to EMA signaled prompts, conclusions about the relationships between these variables may be biased. Courvoisier, Eid and Lischetzke (2012) found that although compliance varied throughout a day and across a study week, individual personality characteristics were not predictive of prompt-level compliance. Additionally, although they did not examine prompt-level compliance directly, Stone et al.

(2003) found that the number of daily prompted diary entries correlated significantly with

increased perceived burdensomeness with electronic diaries (Stone et al., 2003).

2. FACTORS AFFECTING COMPLIANCE: A CONCEPTUAL MODEL

2.1 **Overview**

We were guided by a multi-level ecological and social-cognitive framework to view compliance as a function of (1) background characteristics of an individual, (2) characteristics of the behavior itself, (3) demands of monitoring protocols, and (4) in-the-moment contextual influences. As evidenced previously, most investigations of EMA compliance to date have focused on evaluating the effects that background individual differences may have in predicting compliance. These investigations primarily aimed to establish the representativeness of their data between putative sample subgroups. However, incorporating additional information from the behavioral and contextual level may be useful in identifying systematic biases in compliance.

2.2 **Behavioral Factors**

Problems with EMA compliance at the behavior level may be conceptualized as consequences of the specific research question being addressed and the population being targeted. In their study of treated alcoholics, Litt, Cooney, & Morse (1998) found that drinking alcohol was associated with a failure to respond to subsequent EMA signaling. Additionally, multiple discrepancies were discovered between EMA records and detailed time-line follow back in nearly half of study participants. These results showed a remarkably clear deficit in EMA compliance associated with the very behavior being assessed.

2.3 **Contextual Factors**

Contextual problems with EMA compliance can result from collecting data in real time in naturalistic contexts. Such problems are specific to the different situations in which the EMA is used, independent of the research question. For example, compliance may decrease during specific times of the day, during working hours, or during social situations when recording might be socially inappropriate or embarrassing to participants. Unfortunately, such problems may limit the generalizability of study findings.

Problems with EMA compliance at the contextual level can lead to erroneous and potentially spurious research findings. For example, Kudielka, Broderick, and Kirschbaum (2003) tested how accurately subjects would comply with instructions to collect saliva samples at six specific times during one day. Sample collection times were recorded by participants in a time table, but were also collected covertly and objectively through electronic timestamping in the sample vials. Subjects were divided into two groups, one informed about the covert collection of data and one uninformed. As expected, uninformed subjects significantly over-reported their subjective compliance compared to informed subjects. Additionally, uninformed subjects significantly over-reported their compliance compared to their own covertly recorded compliance levels. Non-compliance among uninformed subjects was limited to assessments early in the morning after waking - which is an empirically and diagnostically interesting period during which cortisol levels spike. Uninformed subjects consistently provided samples after the required time frame, when cortisol levels had dropped. The resulting profiles of salivary cortisol in uninformed subjects thus revealed a significantly muted morning cortisol response, a misleading finding when compared to the profiles of informed subjects. The systematic non-compliance to the data collection procedures threatens the validity of the inferences drawn from

the unrepresentative cortisol profiles and highlights the dangers of interpreting data derived from studies where potential context-level problems with compliance are not fully explored.

Any of a variety of exogenous factors (i.e. social desirability, task burdensomeness, response scheduling, social context, etc.) may cause context-specific difficulties for compliance. While the use of electronic diaries in EMA research has drastically improved compliance, the presence of systematic predictors of non-compliance to electronic diaries may still bias study results.

3. AIMS

This study aimed to identify predictors associated with EMA compliance among adolescents in a natural history study of smoking. We examined (1) the effect of individual difference and behavioral factors in predicting overall level of responding to random prompts over a 7-day monitoring period; and (2) the effect of contextual factors in predicting compliance at the subsequent random prompt assessment point. We selected potential predictors based on a broad consideration of both background individual differences and momentary contextual factors that might affect responding. At the overall subject-level of compliance, we examined the role that gender, race, age, academic performance (Grade Point Average -- GPA), psychological symptoms (depression, anxiety, antisocial behavior), home composition (number of parents in household, number of siblings), overall daily mood, smoking rate, and alcohol use may play in predicting compliance. Likewise, at the prompt level we examined the effects of the most proximal random record of mood (positive and negative affect), hunger, practice/experience (study day), day of week, inter-prompt interval, social context (being with friends), and location. In general, we expected that the following factors would be associated with lower levels of overall compliance: male gender, lower GPA, higher levels of psychological symptoms, more siblings in the household (leading to more distractions), lower overall mood, higher levels of smoking, and greater alcohol use. We did not have specific directional hypotheses for race, age, or number of parents in the household. At the prompt level, we expected that being with friends, being outside home locations, experiencing increased negative affect, and shorter inter-prompt interval (increased participant burden) would be associated with missing the next prompt. We did not have specific directional hypotheses for positive affect or hunger states.

4. METHODS

4.1 **Participants**

Data for this study come from a longitudinal study examining the social and emotional contexts of adolescent smoking behavior. Participants were recruited from 16 schools in the Chicago metropolitan area. All 9th and 10th grade students in these schools (N = 12,970) completed a screening survey about smoking behaviors and invitations to participate were mailed to eligible students and their parents. Of the 3,654 recruited to participate 1,344 (36.8%) initially agreed and 1,263 (94.0%) completed baseline data collection. All students agreed to participate in several aspects of the longitudinal program project that included paper and pencil questionnaires, in- person interviews, and for a subset of participants, family interviews, psychophysiological assessment, and a week-long EMA event sampling via handheld computers (electronic diaries). We report here on data from the baseline data collection period.

Of those 1,263 students who completed the baseline assessment, a subsample composed only of adolescents who reported smoking at least once during the past 12 months were selected to participate in the electronic diary study; 461 adolescents (55.1% female; 53.2% in 10th grade; 56.8% White, 15.8% Black, 20.0% Hispanic, 2.8% Asian/Pacific Islander, and 4.6% were Other) completed the baseline electronic diary potion of the study. A majority (57.6%) had smoked at least one cigarette in the past month at baseline. Parental consent and student assent was obtained prior to enrollment in the study.

All participants in the electronic diary portion of the study received training on how to use the electronic diaries. The electronic diary was programmed with random prompt interviews and smoking-related interviews (event-recorded; not prompted). Data from this study come from the random prompt interviews. Following training, participants carried the electronic diary for 7

days, with the devices randomly prompting them on average 5-7 times per day. Each random prompt was date- and time-stamped and recorded whether the prompt was completed, missed, delayed, or abandoned. Devices included both suspend and prompt delay features to facilitate compliance. Participants completed a total of 14,105 random prompts (mean 30; range 7-71).

4.2 **Measures**

4.2.1 **Non EMA Self-Report Measures**

Background Variables

Demographics included self-reported gender, age, and race/ethnicity.

Academic Achievement was based on participants' self-reports of their average grade in the

current academic year (GPA).

Home Composition included the number of siblings and biological and step-parents living in

their household.

Psychological Symptomatology included anxiety, depressive, and antisocial behavior symptoms.

　　　　Adolescent *anxiety symptoms* were assessed with twelve items from the Mood and

Anxiety Symptom Questionnaire (Watson & Clark, 1991; Watson et al., 1995). The abbreviated

version used in this study contains items from the anxious arousal subscale. Adolescents rated

the extent to which they felt specific symptoms in the prior week on a 5-point Likert scale,

ranging from 1 (not at all) to 5 (extremely). Individual item scores were summed to create a full

scale score that was highly internally reliable (coefficient α = .81 in the current sample). Prior

research supports the validity of the MASQ in both adult and adolescent samples (Reidy &

Keogh, 1997; Richey, Lonigan, & Phillips).

　　　　Adolescent *depressive symptomatology* was assessed using the Center for

Epidemiological Studies – Depression (Radloff, 1977). The CES-D is a 20 item measure

assessing the weekly frequency of depressive symptoms, ranging from 0 (rarely) to 3 (most or all

of the time). Item responses were summed to create a scale score with high internal reliability

(coefficient α = .89 in the current sample). Prior research supports the validity of the CES-D in

an adolescent sample (Radloff, 1991).

Adolescent *aggressive and antisocial behavior* was assessed using a 22-item survey derived from a reduced set of the 46 item Antisocial Behavior Checklist (Noll, Zucker, Fitzgerald, & Curtis, 1992) and several items from a longitudinal study of adolescent problem behavior (Windle, 1992). The 22 current items tested core aspects of DSM-IV Conduct Disorder aligned across six domains of behavior: aggression, deceit, police contact, rule violation, theft, and vandalism. Participants responded to all items with the following choices: "Never," "Rarely – Once or twice," "Sometimes – 3 to 9 times," "Often – More than 10 times." Sum scores were calculated for the full scale (coefficient α = .88) and all subscales.

Behavioral Variables

Smoking Rate: We created a measure of participant monthly smoking rate by multiplying participant self-reported number of days smoked in prior 30 days by the average number of cigarettes smoked on those days. Smoking rate at the baseline assessment wave ranged between 0 and 450 (representing 15 cigarettes per day on all 30 days). This measure was natural log-transformed to lessen the potential influence of large values on this variable in estimating of its effects.

Alcohol Use: Adolescents' alcohol use was assessed using a 5-item scale asking about alcohol use recency, quantity, lifetime maximum consumption, frequency, and problems. Participants' responses to each item, ranging from 1-8, were scaled based on the values of the respective responses. Item scores were averaged to form a full Alcohol Use scale score that showed high internal consistency (coefficient α = .86).

4.2.2 **EMA Collected Measures**

Affect: We created measures of participants' positive and negative affect means and variability by aggregating EMA event-level ratings of affect to the subject-level. Participants rated their mood "Before the signal" by evaluating how strongly they felt about a set of 10 adjectives on a 10-point scale using a visual ladder (i.e. "Before the signal I felt… happy"). Factor analysis identified two distinct factors for positive affect (Happy, Relaxed, Cheerful, Confident, Accepted) and negative affect (Angry, Frustrated, Irritable, Sad, Stressed). Event-level ratings were used to predict compliance in-the-moment while aggregated scores were used to predict compliance at the overall subject-level.

Social Context: Participants reported whether they were or were not currently "with friends." All other social contexts, including being alone or being with non-friend others, were coded as *not* being with friends.

Location: Participants reported their location. We created a categorical variable with levels corresponding to home, school, and an aggregate of all other locations.

Hunger: Participants reported their level of hunger on a 10-point scale using a visual ladder.

Automatically Collected Variables: Day of the week and number of days with the EMA computer (ranging from 1-8) were automatically collected by the electronic diaries. Day of the week was recoded into a categorical variable with levels corresponding to weekdays and weekend days. Inter-prompt interval was calculated from timing data collected by the EMA device.

4.2.3 **Outcome Measures**

Overall Compliance: Overall compliance was measured as the proportion of participants'

completed random EMA prompts to their own total number of prompted EMA events. Delayed

prompts were not counted against the participant's compliance rate and were only counted as one

prompt.

Prompt-Level Compliance: In addition to predicting overall compliance with random prompts,

we were interested in examining whether the most proximal prior contextual variables predicted

whether the next random prompt (within 150 minutes) was completed or missed. We identified

pairs of random prompts that occurred within 150 minutes, with the criteria that the first prompt

of the pair was completed. The outcome was whether the subsequent random prompt was

completed or *missed*. We identified 7,745 total random prompt pairs (456 participants; $M=17.0$

prompts per participant, $SD=5.64$, range: 1-48) that met these criteria. Of these pairs, 6332 were

ones in which the second prompt was competed (complete-complete; 456 participants; $M=13.9$,

$SD=5.7$; range: 1-43), and 1413 were ones in which the second prompt was not completed

(complete-incomplete; 427 participants; $M=3.1$, $SD=1.9$, range: 0-10). Twenty-nine participants

had zero complete-incomplete pairs. Two participants were identified as potential outliers;

excluding these participants did not significantly affect study findings and they are included in

the final results.

4.3 **Analysis Plan**

We analyzed our data in two separate steps: (1) a backwards selection of background and behavioral factors predicting overall compliance (level of completed prompts over the week), and (2) a logistic model of contextual, and significant background and behavioral factors predicting prompt-level compliance (whether the second part of two linked pairs of prompts was missed). First, a general linear model using the backwards method was estimated using the GLMSELECT procedure in SAS 9.2. The GLMSELECT procedure extends the forward, backward, and stepwise methods available in traditional regression analyses to general linear models (Cohen, 2006).

Second, factors predicting compliance in-the-moment were entered together into a logistic mixed model using the GLIMMIX procedure in SAS 9.2. Those individual differences that were found to predict compliance at the overall level were also included at the prompt level. Adolescents' responses/scores on these factors were included at each assessment, using the same score across all EMA events. This strategy both controls for the effects of subject-level predictors of compliance and determines whether these factors affect compliance at the prompt level. We included both the subject-level measures of mean negative and positive affect, as well as the prompt-level deviation of a subject's affect from their own mean in this model. This approach enabled us to estimate both the between subject (BS; mean) and within subject (WS; deviation) effects of mood on compliance. A random subject effect was included in the model to account for the clustering of the prompt-level observations within subjects (Hedeker & Gibbons, 2006). The model was used to estimate those factors which predict *non*-compliance with random prompts. Population-averaged odds ratios for factors predicting non-compliance were calculated from the estimated fixed effects.

5. RESULTS

5.1 **Predicting Overall Level of Compliance**

Overall mean compliance rates were 68.1% (SD=16.9%). The mean time between prompt pairs was 81.6 minutes (SD=34.7) for complete-complete pairs and 85.0 minutes (SD=34.4) for complete-incomplete pairs. Descriptive statistics for demographic, behavioral, mood and psychological symptomatology variables are shown in Table 1. Participants reported smoking 21.1 cigarettes per month on average and reported moderate levels (M=4.05) of alcohol use (1-8 scale; higher scores represent more problems). On average participants completed 30.6 random prompts (SD=8.2); and missed 15.6 (SD=12.6). Bivariate correlations revealed that lower levels of smoking (r =-0.19, p<.001), alcohol use (r =-0.1, p<.001), and antisocial behavior (r =-0.15, p<.001) were associated with higher compliance. Additionally, being male (r =-0.15, p<.001) was associated with lower compliance.

To examine overall level of compliance, all background and behavioral variables were entered simultaneously into a general linear model using the backwards selection method. Significance level to stay (SLS) in the model was defined at p<.10. Parameter estimates for the final selected model are displayed in Table 2. Variables excluded from the final model include race, age, mean positive affect, positive affect variability, negative affect variability, number of siblings in household, number of parents in household, GPA, depression, anxiety, and antisocial behavior. Those effects selected to remain in the model suggest that being female and having lower mean negative affect, less smoking, and less alcohol use predicted higher subject-level compliance with EMA.

5.2 **Predicting Compliance at the Prompt Level**

The stability of prompt-level predictors was examined by calculating bivariate correlations for predictors between consecutive completed prompts. Predictors were found to be moderately stable across random prompts, ranging from $r=0.50$, $p<.001$ for location to $r=0.65$, $p<.001$ for positive affect, with the exception of hunger ($r=0.38$, $p<.001$). Results from the logistic mixed model examining whether the most proximate prompt within a 150 minute windows predicted next-prompt compliance are presented in Table 3. The fixed effect parameter estimates in the table predict prompt-level *non*-compliance. Those factors found to predict compliance at the overall level of analysis (gender, smoking rate, and alcohol use) were included as covariates in this model. Additionally, both BS (mean negative and positive affect) and WS (subject's in-the-moment deviation from their own mean) measures of affect were included in the model.   These results show that several factors (positive affect WS, location, inter-prompt interval, and gender) are significant determinants of prompt-level *non*-compliance -- that is, failure to respond to the next prompt that occurs within the 150 minute window. One of the four covariates included from the subject-level analysis, gender, significantly predicted prompt-level *non*-compliance. Although alcohol use and smoking rate predicted lower compliance at the overall, subject level, they were not predictive of prompt-level *non*-compliance. Population-averaged odds ratios (ORs) and 95% OR confidence intervals for fixed effects are presented in Table 3.

6. DISCUSSION

6.1 **Overview**

This study identified several factors associated with overall and prompt-level EMA compliance among a sample of adolescents participating in a longitudinal study of smoking. Although EMA methods offer many advantages over traditional retrospective diary or assessment methods, compliance with EMA methods may still present biases in data collection. Electronic data collection methods, however, permit tracking of missing data occurrences in real time, providing potential opportunities to examine momentary predictors of noncompliance.

We considered compliance within a multi-level ecological framework, viewing an adolescent's responsiveness to random prompts as a function of momentary, proximal factors, such as the social context, mood states and location, as well as background contextual influences, including family context, overall psychological and academic functioning and demographics. Unique to this study was our consideration of these multiple levels of influence on compliance within one model. Until now researchers have focused primarily on evaluating only those individual differences that distinguish EMA compliers from non-compliers. While this approach has been useful in identifying potential bias and subgroup differences in compliance, it does not facilitate addressing factors that may contribute to non-compliance in the moment. Our data also provide the first substantive evaluation of random prompt compliance, using the adolescent's own momentary self-reported states to prospectively predict subsequent prompt compliance.

6.2 **Implications for Contextual and Behavioral Predictors**

Our results illustrate the importance that participants' location and mood each have in determining random prompt compliance. Examination of mood data shows that both increased positive affect at the prompt level and higher overall negative affect had deleterious effects on compliance. We believe that adolescents who have higher overall negative affect may be less motivated to respond to EMA prompts across measurement occasions. Additionally, those adolescents who find themselves in relatively more positive emotional states (compared to their average mood) may be emotionally too stimulated and not have the cognitive resources available to fully attend to the EMA protocol. Participants completing random prompts outside the home had significantly greater odds of non-compliance. Many theoretically important events and/or emotional states that may trigger adolescent smoking events occur outside the home and thus may not be fully reported with this protocol. Counter to our expectations, longer inter-prompt intervals predicted greater non-compliance with random prompts. While EMA researchers are frequently concerned with the effects of participant burden on compliance, this finding reflects on the balance that must be drawn between over- and under- utilization of the EMA device. Although having too-frequent prompts may be perceived as burdensome in an adolescent population, too-few prompts may lead to participants disengaging from the device and forgetting to attend to the EMA protocol. Finally, it is important to mention that a subject level factor predicting overall compliance (gender) was also found to predict compliance at the prompt level. These results suggest that additional training or prompt signaling may be indicated for those individuals identified to be at risk for non-compliance.

6.3 **Statistical Implications**

The results of this study have meaningful implications for dealing with missing data when employing EMA methodology. Identifying significant predictors of data missingness at the overall and prompt level helps to maintain the MAR assumption. The possibility that missing data in EMA were only predicted by the actual missing value and thus NMAR is impossible to assess with the observed data. Thus, it is crucial that investigators routinely do analyses to find variables related to missingness. Variables that predict data missingness can then be included as covariates in EMA analyses to better satisfy the MAR assumption. Additionally, researchers may consider including integrated measures predictive of compliance (e.g. GPS for device location during missing prompts). Further investigation may identify other predictors of data missingness that may facilitate variable selection for EMA protocols.

6.4 **Limitations and Summary**

This study's findings are limited in part by examining compliance at only the baseline assessment wave. Because adolescents may develop improved executive functioning skills and coping strategies with age, those effects found to predict compliance in 9th and 10th graders may not be as predictive of compliance in older samples. Indeed, we have continued to follow this sample of adolescents over multiple waves and have found that compliance increases over time, perhaps both as a function of experience with the protocol and increasing maturity. However, compliance in older samples should not be taken for granted. An adequate investigation of factors predicting non-compliance in those samples is needed to identify bias and reveal potential targets for improving responding. We are currently applying the modeling approach used in this article to later data collection waves of this project.

A notable limitation of our findings about prompt-level compliance is that we assessed momentary factors not immediately in the missed prompt situation (which would not be possible by definition), but in close temporal proximity to the missed event (within prior 150 minutes, 85 minute mean interval). Much can change within that time frame - clearly the context may well change. However, we demonstrated an approach to modeling that may help inform investigations of associations between potential momentary factors and outcomes. In addition, although we included a relatively large number of predictor variables, other key factors associated with noncompliance were not systematically assessed. As this investigation focused exclusively on random prompts, we did not assess whether smoking behavior reported at the prompt level was associated with reduced compliance. Consistent with the deleterious effects of alcohol on compliance, such influences remain a possibility and should be explored with further studies. Additionally, at the end of each data collection wave, we debriefed the participants about their

missed prompts. By far, the most common explanation for the missed prompts was failure to hear the device's signal. Indeed, when participants were in noisy environments or when the device was deep in a participant's filled backpack, it was challenging to hear the device. Thus, non-participant factors also contributed to level of compliance. We also found that compliance can be improved. At subsequent data collection waves, we offered monetary incentives for achieving benchmark levels of compliance with random prompts and compliance levels increased significantly.

In sum, this study highlights an approach to investigating contextual and momentary predictors of compliance within EMA studies and also emphasizes the importance of considering potential biases that exist with missing data. More attention to missing data considerations with EMA data is needed to help further the field.

TABLE I

DESCRIPTIVE STATISTICS FOR DEMOGRAPHIC, BEHAVIORAL, MOOD, AND

PSYCHOLOGICAL SYMPTOMATOLOGY VARIABLES AT BASELINE

Measures	*n*	*Range*	*M*	*SD*
Age	461	13.9 - 17.3	15.7	0.613
GPA	460	2.00 - 5.00	3.39	1.81
30-day smoking rate	460	0 - 450	21.2	57.0
Alcohol use	461	1.00 - 7.10	4.05	1.59
Negative mean affect	456	1.02 - 8.26	3.44	1.45
Negative affect variability	456	-5.39 - 1.62	-0.11	1.11
Positive mean affect	456	2.90 – 10.0	6.82	1.20
Positive affect variability	456	-3.80 – 1.57	-0.09	0.73
Anxiety	461	12 – 55	28.9	8.16
Depression	460	0 – 52	17.4	10.2
Antisocial behavior	461	23 – 74	36.3	8.49
Siblings in household	461	0 – 8	1.66	1.25

Note. Depression was measured using the CES-D on a 0-60 scale; anxiety was measures using the MASQ on a 12-60 scale; antisocial behavior was measured using the Antisocial Behavior Checklist on a 22-80 scale (higher scores on all scales indicate more disordered symptomatology. Negative and positive mood measured by aggregating prompt-level EMA measures. Affect variabilities represent intraindividual standard deviations measured through EMA. 30-day smoking rate represents total number of cigarettes smoked in prior 30 days.

TABLE II

PARAMETER ESTIMATES FOR FINAL SELECTED MODEL PREDICTING SUBJECT-

LEVEL COMPLIANCE

Parameter	*df*	*Estimate*	*SE*	*t value*	*p*
Intercept	1	0.804	0.0281	28.61	<.001
Gender	1	-0.0503	0.0160	-3.15	0.0018
Negative mean affect	1	-0.0113	0.00551	-2.05	0.0409
Log 30 day smoking rate	1	-0.0124	0.00493	-2.51	0.0124
Alcohol use	1	-0.0110	0.00535	-2.05	0.0410

Note. Model estimated using GLMSELECT procedure in SAS 9.2. Gender variable coding: 0 = female; 1 = male.

TABLE III

PARAMETER ESTIMATES FOR FIXED EFFECTS IN LOGISTIC MIXED MODEL PREDICTING PROMPT-LEVEL NON-

COMPLIANCE

Parameter	df	Estimate	SE	t value	p	OR	95% CI	
							Low	High
Intercept	450	-2.82	0.392	-7.20	<.001*	-	-	-
Study day	7280	0.0217	0.0149	1.46	0.144	1.018	0.999	1.037
Weekday	7280	0.0677	0.0736	0.92	0.358	1.067	0.929	1.227
With friends	7280	0.0281	0.0752	0.37	0.709	1.031	0.895	1.189
Positive affect (WS)	7280	0.0625	0.0257	2.44	0.0149*	1.062	1.012	1.115
Negative affect (WS)	7280	-0.0239	0.0226	-1.06	0.289	0.977	0.937	1.020
Positive affect (BS)	7280	0.0189	0.0413	0.46	0.647	1.018	0.942	1.101
Negative affect (BS)	7280	0.0615	0.0351	1.75	0.0793	1.061	0.993	1.134
Inter-prompt interval	7280	0.00255	0.00090	2.84	0.0045*	1.0025	1.0008	1.0042
Hunger	7280	0.0185	0.00997	1.85	0.0642	1.021	0.993	1.050
Gender	7280	0.206	0.0822	2.50	0.0123*	1.219	1.044	1.424

Log 30-day smoking rate	7280	0.0270	0.0255	1.06	0.291	1.026	0.978	1.077
Alcohol use	7280	0.0436	0.0276	1.58	0.115	1.043	0.990	1.099
Location								
School (vs. Home)	7280	0.419	0.0905	4.63	<.001*	1.498	1.262	1.777
Other (vs. Home)	7280	0.351	0.0837	4.19	<.001*	1.402	1.197	1.642

Note. Significant positive estimates indicate greater *non*-compliance. Weekday coding: 0 = weekday; 1 = weekend. With friends coding: 0 = alone; 1 = with friends. Model estimated using GLIMMIX

procedure in SAS 9.2. ORs of continuous variables (positive affect, negative affect, hunger, inter-prompt interval, log smoking rate, alcohol use) are associated with one scale unit offsets from the mean.

*p <.05. WS = within subject (subject's momentary deviation in affect from their own mean). BS = between subject (subject's mean affect).

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IRB APPROVAL LETTER

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice
Continuing Review

September 27, 2012

Robin J. Mermelstein, PhD
Psychology
1747 W Roosevelt, Rm 558, M/C 275
Chicago, IL 60612
Phone: (312) 996-1469 / Fax: (312) 413-0474

RE: **Protocol # 2004-0621**
       "Social-Emotional Contexts of Adolescent Smoking - Longitudinal Study"

Dear Dr. Mermelstein:

> Please note that the research training _**will**_ expire on **11/10/2012** for _**Dr. Raul Gonzalez**_ and the research training _**will**_ expire on **11/29/2012** for _**Chi Chris Cho.**_ Both of these individuals must respectively complete a minimum of two hours of continuing education in order to participate in the conduct of the research. You may refer them to the OPRS website, where continuing education offerings are available:
> http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/education/2-2-2/ce_requirements.shtml

Your Continuing Review was reviewed and approved by Members of IRB #3 by the Expedited review process on September 25, 2012. You may now continue your research.

Please note the following information about your approved research protocol:

Protocol Approval Period: October 3, 2012 - October 3, 2013
Approved Subject Enrollment #:   3080
Additional Determinations for Research Involving Minors: The Board determined that this research satisfies 45CFR46.404, research not involving greater than minimal risk. Therefore, in accordance with 45CFR46.408, the IRB determined that only one parent's/legal guardian's permission/signature is needed. Wards of the State may not be enrolled unless the IRB grants specific approval and assures inclusion of additional protections in the research required under 45CFR46.409. If you wish to enroll Wards of the State contact OPRS and refer to the tip sheet.
Performance Sites: UIC, Northwestern University, Loyola University, Georgia State University, University of Wisconsin - Madison, University of Missouri-Columbia, University of Utah, West Virginia University, Wesleyan University
Sponsor: NCI - National Cancer Institute, NIH-National Institutes of Health, NIH/National Cancer Institute, National Cancer Institute, NIDA
PAF#:   -   2009-06591, 2009-01725, 2011-02902, 2010-01561, 2003-02925

Phone: 312-996-1711   http://www.uic.edu/depts/ovcr/oprs/   FAX: 312-413-2929

Grant/Contract No: 3 P01 CA098262-05S1,1 R21 CA140696-01,1F31DA032244-01,2 P01 CA098262-06A1,CA 9862-01A5

Grant/Contract Title: Social-Emotional Contexts of Adolescent Smoking Patterns, Variance Modeling of Smoking-related EMA Data, A Situational Examination of Neurocognition and Affect with Simultaneous Cannabis and Tobacco Use, Social-Emotional Contexts of Adolescent Smoking Patterns, Social-Emotional Contexts of Adolescent Smoking Patterns

Research Protocol(s):

    a) Project 3: Social-Emotional Contexts of Adolescent Smoking-Smoking and Emotions Version 1, 04/05/2011

    b) Project 1, Health Habits, Version 3.0, 05/23/2011

    c) Genetic Marker Project 4, Version 1, 09/24/10

    d) Application for Initial Review (as approved under UIC Amendment #26)

    e) Project 2, Electronic Diary, Version 4.0, 05/21/2012

Recruitment Material(s):

    a) Renewal Enrollment Script: Health Habits and Genetics, Version 2, 03/10/2011

    b) Renewal Web Site Text, Version 4, 02/07/2012

    c) Hard to Reach Participant Recruitment Letter, 1/10/2012, Version 1

    d) Memory and Cognition Recruitment Letter, Version 1.0, 1/10/2012

    e) Memory and Cognition Enrollment Script, Version 1.0, 1/10/2012

Informed Consent(s):

    a) Project 1 Extended Health Habits Consent, Version #2, 09/06/2011

    b) Consent by Phone/Web Script SHORT 5-year Health Habits Version 1, 05/23/2011

    c) Genetic Marker Consent, Version 3, 09/06/2011

    d) Alteration of informed consent [45 CFR 46.116(d)], administered over phone/web, for the short version of the 5-year Health Habits Questionnaire

    e) Memory and Cognition Consent, Version 1.0, 1/10/2012

Your research continues to meet the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific category:

(9) Continuing review of research, not conducted under an investigational new drug application or investigational device exemption where categories two (2) through eight (8) do not apply but IRB has determined and documented at a convened meeting that the research involves no greater than minimal risk and no additional risks have been identified.

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
09/13/2012	Continuing Review	Expedited	09/25/2012	Approved

Please remember to:

→ Use your **research protocol number** (2004-0621) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the enclosure,
 "UIC Investigator Responsibilities, Protection of Human Research Subjects"

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 355-2939. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Jewell Hamilton, MSW
IRB Coordinator, IRB # 3
Office for the Protection of Research Subjects

Enclosure(s):
1. **UIC Investigator Responsibilities, Protection of Human Research Subjects**
2. **Informed Consent Document(s):**
   a) Project 1 Extended Health Habits Consent, Version #2, 09/06/2011
   b) Consent by Phone/Web Script SHORT 5-year Health Habits Version 1, 05/23/2011
   c) Genetic Marker Consent, Version 3, 09/06/2011
   d) Memory and Cognition Consent, Version 1.0, 1/10/2012
3. **Recruiting Material(s):**
   a) Renewal Enrollment Script: Health Habits and Genetics, Version 2, 03/10/2011
   b) Renewal Web Site Text, Version 4, 02/07/2012
   c) Hard to Reach Participant Recruitment Letter, 1/10/2012, Version 1
   d) Memory and Cognition Recruitment Letter, Version 1.0, 1/10/2012
   e) Memory and Cognition Enrollment Script, Version 1.0, 1/10/2012

cc: Joe L. Martinez, Psychology, M/C 285
       OVCR Administration, M/C 672

Doctoral Student   4343 N Clarendon Ave, Unit #2411
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Office: BSB 1080

Education:

- PhD Student, Clinical Psychology, University of Illinois (2011 – present)
- BA, Psychology and Philosophy, Northwestern University (2005 – 2009)

Research Interest

- Ecological momentary assessment
- Mobile technology assessment and intervention
- mHealth
- Smoking identity, stereotyping, and social context

Publications and In Press

Lora, C. M., Sokolovsky, A. W., Touchette, D. R., Jin, J., Hu, X., Gao, W., & Gerber, B. S. (2013). ACE inhibitor and ARB medication use among Medicaid enrollees with diabetes. *Ethn Dis, 23*(2), 189-195.

Meixner, J., Labkovsky, E., Rosenfeld, J.P., Winograd, M., Sokolovsky, A., Weishaar, J., Ullman, T. (In Press). P900: A putative novel ERP component that indexes countermeasure use in the P300-based concealed information test. *Applied Psychophysiology and Biofeedback.*

Sokolovsky, A., Rothenberg, J., Labkovsky, E., Meixner, J., & Rosenfeld, J. P. (2011). A novel countermeasure against the reaction time index of countermeasure use in the P300-based complex trial protocol for detection of concealed information. *International Journal of Psychophysiology, 81*(1), 60-63.

In Preparation and Under Review

Sokolovsky, A., Hedeker, D., Mermelstein, R. (Under Review). Factors Predicting Compliance to Ecological Momentary Assessment Among Adolescent Smoker. *Nicotine and Tobacco Research.*

Sokolovsky, A., Mermelstein, R. Preliminary validation of an abbreviated 14-item version of the Wisconsin Inventory of Smoking Dependence Motives

Conference Presentations

Labkovsky, E., Rosenfeld, J.P., Sokolovsky, A. "Putative Novel ERP Component (P900) as an Indicator of Countermeasure Use in a Modified Complex Trial Protocol (Rosenfeld et al., 2008)." Presentation. Society of Psychophysiology Annual Meeting, Berlin. October, 2009.

Sokolovsky, A., Hedeker, D., Mermelstein, R. "Factors Predicting Compliance with Ecological Momentary Assessment Among Adolescent Smokers." Presentation. Society for Research on Nicotine and Tobacco Annual Meeting, Houston. March, 2012.

Sokolovsky, A., Hedeker, D., Mermelstein, R. "Predictors of Compliance with Ecological Momentary Assessment Among Adolescent Smokers." Presentation. Society of Behavioral Medicine Annual Meeting, New Orleans. April, 2012.

Sokolovsky, A., Mermelstein, R. "Preliminary validation of an abbreviated 14-item version of the Wisconsin Inventory of Smoking Dependence Motives." Presentation. Society for Research on Nicotine and Tobacco Annual Meeting, Boston. March, 2013.

Sokolovsky, A., Rothenberg, J., Meixner, J., Rosenfeld, J.P. "Sequential versus Simultaneous Stimulus Acknowledgement and Countermeasure Response in P300-based Detection of Deception." Presentation. Society of Psychophysiology Research Conference, Berlin. October, 2009.

Torres, LA., Ureste, P., Sokolovsky, A., Gerber, B., Sharp, LK. "Your John Hancock: A Novel Way of Measuring Health Literacy." Presentation. American Medical Student Association Conference. 2010.

Ureste, P., Torres, LA., Sokolovsky, A., Gerber, B., Sharp, LK. "Sign on the Dotted Line: Measuring Health Literacy." Presentation. National Hispanic Medical Association Conference. 2010.

Research Positions Held and Undergraduate Research Experience

Fall 2011 – Present   **Graduate Student Researcher: Social-Emotional Contexts of Adolescent Smoking Patterns**

Working on a research program aimed at exploring the biological, social and emotional contexts of smoking among a cohort of young adults. This research is supported by a grant from the National Cancer Institute (grant number P01 CA098262).

August 2009 –
August 2011

Research Information Specialist: Health Promotion Research

Worked full time assisting with standard research activities at the Institute for Health Research and Policy at UIC. Responsibilities included data analysis, data collection, recruitment, and grant writing and organization.

August 2008 –
July 2009

Undergraduate Student Researcher: Deception Detection Lab

Worked as a researcher and an experimenter for the deception detection laboratory at Northwestern University. Collected, analyzed and published personal research results.

September 2007 –
December 2007

Undergraduate Student Researcher: Social and Cultural Neuroscience Lab Assistant

Worked as a research assistant for the social and cultural neuroscience lab at Northwestern University. Collected, scored, and administered neuropsychological evaluations.

References
Available upon request.