

**AN EXAMINATION OF REAL-TIME COVARIATES OF MOTIVATION TO  
QUIT SMOKING**

by

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## ABSTRACT OF THE THESIS

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This study explored the stability of motivation to quit during an assisted smoking cessation attempt and tested the hypothesis that changes in self-efficacy, nicotine withdrawal, and positive smoking expectancies would predict changes in motivation to quit smoking. We used Ecological Momentary Assessment (EMA) data from a randomized clinical trial examining the effects of withdrawal exposure on smoking cessation success. Ninety-three adult smokers trying to quit smoking were randomized to either standard treatment (nicotine patch and individual counseling) or standard treatment plus pre-cessation withdrawal exposure through practice quitting sessions. Participants reported their moment-to-moment willingness to work hard at quitting (motivation), confidence in ability to quit smoking (self-efficacy), positive smoking expectancies, negative affect, and additional withdrawal items. Reports were prompted three times per day, beginning two weeks before the quit date and continuing for one week post-quit. Hierarchical linear models indicated that baseline motivation to quit predicted real-time (time-varying) motivation to quit before, but not after the quit date, regardless of smoking

hours. During the same period, there was significant individual variability in real-time motivational patterns over time. These findings did not appear during the first week post-quit, however. Time-varying self-efficacy predicted contemporaneous real-time motivation to quit pre- and post-quit. Recent smoking was negatively related to motivation to quit after the quit day, but not pre-quit. Withdrawal symptoms and positive smoking expectancies were not significantly related to motivation to quit. Withdrawal exposure treatment also did not show a significant effect on motivation. More research is needed to assess the effect of fluctuations in motivation on cessation success.

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## INTRODUCTION

Smoking is a chronic, intransigent public health challenge. Approximately 19% of Americans smoke currently (CDC, 2011a). Although the number of former smokers has surpassed the number of current smokers since 2002 (CDC, 2011b), six out of ten former smokers report that they were unable to quit on their first try and required multiple cessation attempts to succeed (CDC, 2009). Even with the best available current treatments, quit attempts are successful 35% of the time or less (Garrison & Dugan, 2009). Many smokers find their failed quit attempts discouraging, and evidence suggests that cessation failure is followed by greater depression incidence compared to successful abstinence (Kahler, Spillane, Busch, & Leventhal, 2011). This may make smokers more hesitant to invest additional effort in trying to quit again. Given that successful cessation often requires multiple attempts at quitting (Cohen et al., 1989), the level of motivation and commitment required to change smoking behavior is likely substantial. A deeper understanding of the process of quitting smoking is needed in order to find new, effective ways to reduce its difficulty and increase the number of successful quitters.

Motivation to quit smoking is one construct that has been shown to play a significant role in the smoking cessation process. Baseline self-reported motivation to quit has been significantly associated with registration for quitting services (Kviz, Crittenden, Belzer, & Warnecke, 1991), serious attempts to quit (Royce, Hymowitz, Corbett, & Hartell, 1993; Smit et al., 2014), and successful smoking cessation (Rundmo, Smedslund, & Gotestam, 1997). Evidence also suggests that motivation to quit is positively associated with adherence to smoking cessation treatment (Waldroup et al., 2006), including nicotine patch use (Alterman et al. 1999), which is the best predictor of

smoking cessation treatment outcomes for those who use the nicotine patch (Cummings, Biernbaum, Zevon, Deloughry, & Jaen, 1994). Greater adherence to smoking cessation treatment is, in turn, associated with more positive outcomes in pharmacological treatments (Hitsman, Spring, Borrelli, Niaura, & Papandonatos, 2001; Killen et al., 2000) and psychosocial interventions (Waldroup et al., 2006). Thus, motivation predicts cessation attempts and success, perhaps through mediators such as treatment acceptance and adherence.

Due to the relations between motivation to quit smoking, treatment adherence, and cessation outcomes, further research is needed to explore the factors that influence motivation to quit during a cessation attempt. Numerous factors have been documented as potential predictors of motivation, including attitudes toward smoking and smoking cessation (Rundmo, Smedslund, & Gotestam, 1995), perceived physical and psychological consequences of smoking (Rohsenow et al., 1992), gender, reactions to stress, and past health problems (Rundmo, Smedslund, Gotestam, 1997). Another factor that has attracted attention is smoking cessation self-efficacy, which appears to have a positive relationship with motivation to quit smoking (Boardman, Catley, Mayo, & Ahluwalia, 2005).

Although research has so far shown that baseline motivation predicts success in quitting smoking and identified factors measured at a single time-point that predict motivation to quit, we know that motivation as it is currently conceptualized does not fully capture motivational processes in smoking cessation. The fact that a baseline level of motivation is required for eligibility in many treatment studies (Minami et al., 2014; McCarthy et al., 2010; Vilardaga et al., 2014) and programs reinforces the view that

motivation is a pre-requisite to successful change that does not fluctuate throughout treatment. While requiring a high level of motivation to quit from participants may help reduce attrition and boost cessation rates, this does not address the dynamic and unstable nature of motivation to change. An inconsistency at population levels exists among self-reported motivation to quit smoking (70%), behavioral indices of motivation (40% quit for at least 24 hours annually), and success in quitting (5%) long-term quit rates; CDC, 2002a; CDC, 2002b; CDC, 2002c). We know relatively little about the course of motivation during an attempt to quit smoking or the factors that influence change in motivation over time and experiences.

An examination of the volatility of motivation may further explore a relatively new model of motivation as a flexible and context-varying construct (e.g., self-efficacy theory, Schunk, 1991; situational interest, Hidi et al., 1992) that mediates successful smoking cessation (McCuller et al., 2006). Identifying proximal predictors of motivational fluctuations may inform future treatments by suggesting certain time points or contexts before or after quitting at which smokers are most vulnerable to interventions that might yield reductions in motivation.

It has been previously shown that fluctuations in motivation to smoke occur among young adults whose smoking varies day to day. “Motivational flexibility” has been studied by researchers who found that college students’ reasons for smoking cigarettes change from day to day (Darlow & Lobel, 2012), and that the number of cigarettes smoked day to day fluctuated based on their reasons for smoking on particular days. The current study proposes that, parallel to the view that motivation to smoke is flexible, motivation to quit smoking is also flexible and affected by concurrent variables.

Both motivation to smoke and motivation to quit smoking shift as they are influenced by contextual factors. Based on previous research findings associating various constructs with motivation (reviewed below), it is reasonable to believe that several factors, including smoking cessation self-efficacy, nicotine withdrawal, and smoking expectancies, may have a measurable effect on motivation to quit smoking.

### *Self-efficacy*

Smoking abstinence self-efficacy is defined as confidence in one's ability to quit smoking. According to the theory of planned behavior (TPB; Ajzen, 1988, 1991), proximal predictors of a particular behavior include the intention to engage in the behavior (i.e., motivation), and perceived behavioral control (i.e., self-efficacy). Studies of smoking cessation have found that perceived behavioral control is a robust predictor of smoking intention (Norman, Conner, & Bell, 1999; Bierman, 2013). Smoking abstinence self-efficacy has been established as a time-varying construct in past studies using Ecological Momentary Assessment (EMA; Hoeppepner, Kahler, & Gwaltney, 2014; Gwaltney, Shiffman, Balabanis, & Paty, 2005). Evidence suggests that enhanced self-efficacy is positively related to motivation to change health behavior (Latimer & Ginis, 2005). Refusal self-efficacy (i.e. confidence in one's ability to refuse marijuana in a high-risk situation) is positively associated with motivation to quit smoking marijuana (Caviness et al., 2013). Evidence also suggests that self-efficacy moderates the effects of message framing (a persuasive technique) on motivation to quit smoking (Van't Riet, Ruiter, Werrij, and de Vries, 2008), indicating that self-efficacy may facilitate receptivity to change-promotion messages. In one study, addressing self-efficacy using a treatment with a self-determination theory process model that emphasizes autonomy and



competence led to greater abstinence (Williams et al., 2006). Based on the literature, we hypothesized that real-time levels of self-efficacy would be positively associated with contemporaneous ratings of real-time motivation before and after a target quit-smoking date.

### *Nicotine Withdrawal*

Nicotine withdrawal includes symptoms such as irritability, anxiety, trouble concentrating, insomnia, and restlessness, and these symptoms are frequently linked with ability to quit smoking (Swan et al., 1996). Withdrawal reduces the likelihood of a successful quit attempt due to the increased motivation to avoid the aversive withdrawal symptoms (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Xian et al., 2005). Various studies have linked withdrawal with smoking lapse (al’Absi, Hatsukami, Davis, & Wittmers, 2004; Allen, Bade, Hatsukami, & Center, 2008; Piper et al., 2011)..

Negative affect is a key component of withdrawal that has been measured using EMA (Moore et al., 2013; Hoeppepner, Kahler, & Gwaltney, 2014). Consistent with the view that smoking and other forms of drug use may be ways to cope with affective distress, studies suggest that smokers turn to cigarettes to avoid aversive affective states (Baker et al., 2004) and that increases in negative affect often precede lapses during attempts to quit smoking (Shiffman, 1982; O’Connell & Martin, 1987; Minami et al., 2014). Studies utilizing EMA measures in alcohol-dependent and other illicit substance-dependent populations have found that sudden increases in negative affect predict increased likelihood of relapse to smoking after controlling for average levels of negative affect (Moore et al., 2013). Moreover, high levels of negative affect have been associated with acute increases in smoking motivation (Gilbert, 1997; Leventhal et al., 2013). This

suggests that real-time increases in negative affect may have measurable effects on smoking, and it is possible that this is mediated by motivation. It is thus possible that negative affect may be observed as a component of a greater withdrawal syndrome that has measurable effects on smoking behavior that are mediated by motivation.

Based on the literature on negative affect and other withdrawal symptoms, we predicted that withdrawal measured at the same time as motivation would be negatively related to motivation to quit. We expected these contemporaneous relations to hold both before and after the target quit date. We also predicted that, post-quit-date, withdrawal would interact with contemporaneous confidence such that the combination of distress and low confidence would be associated with particularly low contemporaneous motivation to quit.

### *Smoking Expectancies*

Another time-varying covariate of interest that has been explored in EMA studies is positive smoking expectancy (Gwaltney, Shiffman, Balabanis, & Paty, 2005), or the expectancy that smoking will be followed by positive sensory or affective experiences. Expectancy theory posits that the experiences accumulated throughout the lifetime form expectancies about the consequences of an individual's actions, which may then direct future motivation and behavior (Goldman, Darkes, Reigh, & Brandon, 2010; Hendricks, Reich, & Westmaas, 2009). Some evidence suggests that smoking expectancies are formed early in life before smoking initiation (Chassin, Presson, Sherman, & Edwards, 1991; Copeland et al., 2007). It is possible, however, that these expectancies are malleable and may change during a smoking cessation attempt as a result of treatment or experience. Evidence also suggests that expectancies are related to motivation to quit

smoking, such that high positive expectancies are linked with lower readiness to quit (Pulvers et al., 2004). Tobacco use expectancies have been shown to distinguish smokers of varying levels of treatment-seeking behavior and predict treatment outcome (Hendricks, Wood, & Hall, 2009; Brandon, Juliano, & Copeland, 1999). It is also possible that they can distinguish between changing levels of motivation within a single person, and serve as a predictor of such fluctuations. In this study, we predicted that after a target stop smoking date, real-time positive smoking expectancies would be associated with lower contemporaneous motivation.

### *Static Variables*

In addition to the time-varying covariates of interest, we sought to explore baseline individual differences that have previously been linked to smoking behavior and cessation, such as gender, age, and nicotine dependence. *Gender* differences have been found in various smoking outcomes and behaviors, including likelihood to seek assistance for quitting smoking (Perkins, 2001; Reid et al., 2009), as well as difficulty throughout the cessation process and smoking cessation treatment outcomes (Blake et al., 1989; Perkins, 2001). Evidence suggests that women are less interested, committed, and confident than men in the smoking cessation process (Blake et al, 1989; Perkins, 2001), and it is possible that this gender difference would also appear in motivation to quit smoking. *Age* has also been shown to play a role in smoking behavior, and factors predicting smoking behaviors vary by age (Kviz et al., 1995; Clark, Rakowski, Kviz, & Hogan, 1997). In 2010, the Centers for Disease Control and Prevention reported that 34.6% of smokers aged 65 years or older stopped smoking for more than one day because they were trying to quit, compared with 46-48% of smokers aged 18-44 years (CDC,

2011b), and it is not clear whether this difference is related to a difference in motivation to quit. Finally, *nicotine dependence* predicts long-term abstinence in cigarette smokers (Hyland et al., 2004). Self-reported severity of nicotine dependence is considered one of the most consistent pretreatment predictors of smoking cessation outcomes (Baker et al., 2007; Bolt et al., 2009; Fagerstrom et al., 2012), and it may have an effect on time-varying motivation, as well.

### *The Current Study*

The current study aimed to assess the stability or fluctuation of motivation to quit smoking both before and after a target quit day among participants in a larger clinical trial of a novel behavioral cessation preparation strategy involving progressively longer practice quitting periods prior to a target quit day. Practice quitting sessions were the experimental manipulation of this study, examining the effects of withdrawal exposure on cessation success. Recent evidence suggests that perceived control over withdrawal symptoms, as well as self-efficacy to quit smoking, predicts smoking cessation treatment response (Schnoll et al., 2011). It is possible that treatment with withdrawal exposure may affect perceived control over withdrawal symptoms, and also influence motivation to quit smoking.

We sought to examine the factors that are associated with fluctuations in motivation to quit smoking. Adopting a more recent conceptualization of the construct that reflects motivational flexibility (Darlow & Lobel, 2012) may help us identify the first steps in the path to smoking relapse that take place through decreases in motivation. Data collected from 93 adults enrolled in a randomized clinical trial of a behavioral smoking cessation preparation intervention self-reported quitting motivation, self-efficacy,

negative affect, smoking expectancies, and additional nicotine withdrawal items three times daily for two weeks before and one week after trying to quit with standard smoking cessation treatment. Multilevel models were fit to these Ecological Momentary Assessment (EMA) data to estimate linear and curvilinear growth in motivation pre- and post-quit and to examine relations between motivation and other variables to test the hypotheses outlined above. Results of this descriptive research may help identify baseline and contemporaneous time-varying covariates of motivation to quit and may spur the development of real-time motivational support or enhancement interventions that may help smokers avoid slips and remain smoke-free.

## **Method**

### **Design**

Data for this study were gathered from a randomized controlled clinical trial of a novel behavioral treatment designed to help smokers prepare to quit by practicing abstinence in the weeks preceding an attempt to quit permanently. Participants were randomly assigned to either receive standard smoking cessation treatment (with nicotine patch and counseling, as described below), or standard treatment plus withdrawal exposure through progressively longer periods of abstinence. Participants in both conditions were prompted to complete self-report measures via cell phones three times per day for two weeks before and one week after a target stop-smoking day set by investigators.

### **Participants**

For this study, 93 adult smokers (45 male, 48 female) were recruited in central New Jersey via mass media advertisements for smokers interested in quitting smoking. Participants were screened for the following study eligibility criteria: at least 18 years old, able to read and write in English, smoking at least 10 cigarettes per day, an expired carbon monoxide (CO) level of at least 8 ppm, a self-reported level of motivation to quit smoking of at least six out of 10, and willingness to complete study procedures.

Exclusion criteria included: living with someone currently enrolled in the study; contraindications to the use of nicotine patches; a history of bipolar disorder or psychosis; present use of other forms of tobacco, smoking cessation treatments, marijuana, or other illegal drugs. Participants completed in-person and telephone study assessments. They were compensated up to \$390 for participation in the source study.

*Power.* Effect size for hierarchical linear modeling analyses was estimated using the Optimal Design Plus Software for Power Analysis (Raudenbush et al., 2011). The anticipated number of participants to be included in these analyses was 90 participants. With an intra-class correlation of .3 and a power level of .8, we would detect a medium effect size of .35. With an intra-class correlation of .6 at the same power level, we would detect a large effect size of .5. Our observed intra-class correlations for this study were between .39 and .45 (Rodriguez & Elo, 2003), so we were able to detect a medium-large effect at a power level of .8.

### **Procedures**

All study procedures were approved by the Rutgers University Institutional Review Board. Potential participants responding to media advertisements first completed a telephone eligibility screening. Eligible participants were invited to a group orientation session that consisted of a description of the details of the study, the informed consent process, and then expired CO testing to confirm eligibility. Baseline questionnaires and training in use of an Interactive Voice Response (IVR) system for real-time reporting of motivation were also administered. A one-day IVR training period followed and feedback about call completion was provided the following day. Randomization to treatment condition (with 50% probability of assignment to each condition) occurred following this IVR feedback call. In the withdrawal exposure condition, subjects were instructed to practice quitting for seven progressively longer times every other day over two weeks. Determination of target abstinence period for each of the seven days was tailored based on the longest interval between cigarettes to date for each participant in the experimental condition. Participants in the withdrawal exposure condition were asked to refrain from

smoking between wake-up and a study call that would occur at the end of the practice quitting period on these seven days. Participants in the standard treatment condition were asked to smoke normally, but monitor their smoking, triggers to smoke, and the consequences of smoking for progressively longer periods on seven days between wake-up and later survey calls. At the survey call later in the day, all participants, regardless of condition, completed a battery of assessments over the phone with study staff and reported their longest period of abstinence from smoking that day. Participants also received feedback about IVR completion at each live survey call. Telephone smoking cessation counseling was provided to all participants two days pre-quit, on the quit day, and two days post-quit. All participants were also asked to attend a 30-minute office visit seven days-post-quit to complete CO testing, questionnaires, and the final of four brief individual counseling sessions. The four counseling sessions were based on the Clinical Practice Guideline *Treating Tobacco Use and Dependence* (Fiore et al., 2008) and the *Tobacco Dependence Treatment Handbook* (Abrams et al., 2003). Participants in both conditions received a six-week supply of 21-mg nicotine patches to begin using daily on the target quit day (not pre-quit).

## Measures

**Baseline assessment.** At the group orientation session, participants provided baseline CO breath samples and completed self-report measures of demographics, smoking history, and nicotine dependence, including the Fagerström Test for Nicotine Dependence, a 6-item measure of physiological nicotine dependence.

Baseline motivation to quit was assessed during the baseline assessment questionnaires by asking how “willing to work hard at quitting smoking” participants



were (rated on a 5-point scale from 1=Not at all willing to 5=Extremely willing). We encountered a variety of operationalizations of the motivation construct in the literature, which assess different levels of commitment to change. Some items assess desire to quit (e.g., “I wish to take part in a smoking-cessation group to be able to quit smoking”, “I wish to quit smoking”; Rundmo, Smedslund, Gotestam, 1997) while others assess the likelihood of maintaining abstinence (e.g., “How likely is it that you will stay off cigarettes after you leave the hospital?”; Sciamanna et al., 2000), which may tap self-efficacy rather than or in addition to motivation. Due to the controversy over the defining characteristics of the construct of motivation and the risks of demand characteristics when asking questions that may elicit embarrassment or disapproval from others (Rasinski, Visser, Zagatsky, & Rickett, 2005) when explicitly including the term “motivation”, we chose to operationalize the construct using a self-report item that captures a higher level of commitment to change, “willingness to work hard at quitting.” This item has been found to achieve greater variance in responses and stronger relations with later abstinence than a “motivated to quit smoking” item (McCarthy et al., 2008; McCarthy et al., 2010). We also used a single item to assess smoking cessation self-efficacy, which refers to confidence in quitting smoking for good. This is consistent with Baer, Holt, and Lichtenstein (1986), who emphasized measuring behavior-specific self-efficacy and found that use of a global index of self-efficacy is consistent with evidence of a unidimensional construct of self-efficacy.

**Ecological Momentary Assessment (EMA).** We utilized EMA (Shiffman, 2009) to collect self-report data in real-time within participants’ natural environments using a cellular telephone with an Interactive Voice Response (IVR) system. The magnitude of

reactivity to EMA is small (Hufford et al., 2002) and varies according to assessment time (Rowan et al., 2007). Evidence suggesting reactivity in other dimensions has failed to find it in a self-report motivation to quit smoking item (McCarthy et al., under review). Compliance with signaled assessments is generally good (Shiffman, 2009). All participants were asked to complete a total of three brief (2-4-minute) EMA reports per day (including at two random times during the waking day and one at bedtime each night) for two weeks pre-quit and one week post-quit. Participants were offered an incentive (a \$50 bonus) to encourage completion of at least 80% of scheduled IVR calls.

*Daytime Report.* Daytime reports were administered twice a day, at one random time in the first half of the waking day and at a random time in the second-half of the waking day. The IVR call system asked participants to use a 5-point scale where 1 is “definitely not” and 5 is “definitely yes” to indicate the extent to which the various statements (listed below) applied to them just before they were prompted for a report. Participants also described where they were and what they were doing when the phone rang. Other “yes or no” questions asked about cigarette and alcohol use since the last call. Those who smoked were asked to report the number of cigarettes smoked.

IVR items assessed negative affect (“sad or depressed”, “irritable or easily angered”, “tense or anxious”), self-efficacy (“confident I can quit smoking for good”), positive smoking expectancies (“smoking would be pleasant now”, “smoking would taste good now”), and motivation (“willing to work hard at quitting smoking”). They also assessed additional nicotine withdrawal items, including restlessness, fatigue, and attentional difficulties (“hard to pay attention”). Item order was randomized at each call.

*Bedtime Report.* These reports were administered every night at the participants' self-reported bedtime. The first set of questions assessing negative affect and motivation was consistent with those in the Daytime Report, but it was followed by additional items that will not be discussed here. The reports asked about number of cigarettes smoked that day (and patches worn, if post-quit).

*Coding of predictors and outcome.* A confirmatory factor analysis of the negative affect and other withdrawal items (excluding urge to smoke which consistently loads on a separate factor) assessed in this study was conducted in Mplus 5.0 (Muthen & Muthen, 1998-2008, Los Angeles, CA) taking into account the nesting of reports within individuals. A well-fitting model ( $RMSEA = .019$ ,  $CFI = .983$ ,  $TLI = .975$ ) indicated that negative affect, fatigue, and attentional withdrawal items loaded onto a single latent factor. We created an index of withdrawal by taking the mean of items loading on this factor: sad or depressed, irritable, tense or anxious, restless, tired or fatigued, and hard to pay attention.

We observed a highly negatively skewed distribution of responses to EMA responses to "willingness to work hard at quitting smoking," with the modal response being 5 on a 5-point scale, which was not successfully corrected by transformation. We therefore recoded the outcome variable from a 5-point scale into a binary variable where 1 = definitely yes and 0 = anything else. This resulted in a balanced distribution of highly motivated (53.6%; 2699 total reports) vs. not highly motivated reports (46.4%; 2337 reports total) reports. Baseline willingness to work hard at quitting (which was used as a level-2 predictor of real-time willingness to work hard at quitting) was coded as a binary variable in the same fashion.

## **Analytic Plan**

The final dataset for analysis was prepared by stripping duplicate and delayed calls using the following criteria: daytime calls were removed if they were before the first random call of the day, if they were incomplete or dropped calls and a complete follow-up call was made within 30 minutes of the prompt, or if they were repeat calls within a 30-minute period following a completed report. Duplicate and delayed bedtime calls were removed if they were before the bedtime prompt, after the study wake-up call the following day, incomplete or dropped calls where a follow-up call was made, or repeat calls after a completed report. After removing all extra reports using these criteria, a total of 3341 daytime reports (2339 pre-quit, 1002 post-quit) and 1695 bedtime reports (1212 pre-quit, 483 post-quit) from 93 participants (93 pre-quit; 86 post-quit daytime, 85 post-quit bedtime) were used for analyses.

Pre-quit data were analyzed separately from post-quit data in order to examine fluctuations in motivation to quit smoking at different stages of the quit attempt. Nightly (bedtime) data were examined separately from real-time (daytime) data due to the assessment period in the different reports (bedtime calls asked participants to think about the past 24 hours, whereas the daytime calls asked about the moment just before the call). Four multilevel Bernoulli models for binary outcomes (highly motivated vs. not highly motivated) were developed using a forward model-building approach in Expectation-Maximization (EM) Laplace-2 estimation and restricted maximum likelihood (RML) estimation in Hierarchical Linear Modeling (HLM) Version 7 software (Raudenbush et al., 2011). Using EM Laplace-2 estimation in order to test for significant improvement in model deviance, we regressed willingness to work hard at quitting (high=1 vs. not

high=0) on IVR ratings of self-efficacy, nicotine withdrawal, and smoking expectancies at level-1, with and without a time-varying covariate capturing smoking (any vs. none) since the last report. We specified random effects in the models to allow regression coefficients to vary across individuals if there was significant variance in the coefficients across persons or if doing so improved model fit (which was tested using Expectation-Maximization (EM) Laplace-2 estimation to assess significant improvements in model fit). This method of estimation yielded very large standard errors, so we then examined the best-fitting models according to EM Laplace-2 estimation with restricted maximum likelihood (RML) estimation. RML yielded smaller standard errors and allowed for the trimming of variables from the best-fitting EM Laplace-2 models that were not significantly related to willingness to work hard at quitting. Baseline willingness to work hard at quitting was introduced as a level-2 predictor of level-1 intercepts and slopes in all models.

## Results

The final dataset included 5,036 total reports. Of the bedtime reports, 1,212 were pre-quit (N=93) and 483 were post-quit (N=85). Of the daytime reports, 2,339 were pre-quit (N=93) and 1,002 were post-quit (N=86). Adherence was computed as the percentage of reports completed out of all scheduled (28 daytime reports and 14 bedtime reports pre-quit and 14 daytime reports and seven bedtime reports post-quit). Technical (brief IVR service interruptions) and environmental obstacles (power outages related to Superstorm Sandy) resulted in some failures to initiate calls to participants, thus actual adherence to successfully prompted reports may be slightly higher than the following estimates. During the two weeks before the target quit date, 78.60% of scheduled daytime reports were completed (an average of 25.15 reports per participant), and 81.45% of the bedtime reports were completed (an average of 13.03 reports per participant). During the week after the target quit date, the 86 participants still active in the study completed approximately 79.15% of scheduled daytime reports (an average of 11.65 reports per participant) and 81.18% of the bedtime reports (an average of 5.68 reports per participant) were completed. Sample demographic characteristics are shown in Table 1.

### **Real-time (daytime) willingness to work hard at quitting smoking**

In the *pre-quit* real-time report analyses (Table 2, top panel), time was coded in days with the intercept at the first day of post-training recording, 14 days pre-quit. The model intercept and slope over days pre-quit were allowed to vary across individuals. Model intercepts were higher (indicating greater log odds of being highly motivated to quit) among those who reported being highly willing to work hard at quitting at baseline, which indicates that baseline willingness to work hard at quitting in the baseline

questionnaire was highly related to initial willingness to work hard at quitting during the EMA assessment period. The log odds of being highly motivated did not change significantly over the 14 days pre-quit, on average, although there was significant variance in this slope across individuals. This variance in slope was not significantly related to treatment condition or to baseline motivation, however. Higher self-efficacy at a given report was associated with increased odds of being highly motivated to work at quitting in the same report (OR=1.949). Smoking since the last report (reported in 82% of pre-quit reports) was not significantly related to real-time willingness to work at quitting pre-quit. Without the smoking covariate in the model, self-efficacy was still significantly associated with willingness to work hard at quitting smoking (OR=1.876, SE=.09,  $p<.001$ ). Contrary to our hypothesis, positive smoking expectancy and nicotine withdrawal as indicated in EMA reports were not significantly related to motivation to quit smoking at the same report and were therefore not included in the final model. Models using EM Laplace-2 estimation yielded similar results, except that model deviance was significantly lower when baseline motivation was entered as a statistical predictor of the random slope in motivation over time, although the estimated coefficient for baseline motivation was not significant.

In the *post-quit* model (Table 2, bottom panel), the intercept was allowed to vary across individuals, as this improved model fit. Baseline willingness to work at quitting was not significantly related to quit-day (intercept) willingness to work at quitting. The slope for time was not significant and adding a quadratic growth term did not improve the model. The variance in slope was not significant and allowing it to vary did not improve the model in restricted maximum likelihood estimation, so this coefficient was treated as

fixed. In EM Laplace-2 models, setting the slope to random improved model fit, but there was still no significant variance in slope and average growth was still not significantly different from zero. As with the pre-quit real-time analyses, the best-fitting post-quit EM Laplace-2 model included time-varying self-efficacy and a binary smoking status covariate. In the restricted maximum likelihood model, real-time self-efficacy that was reported in the post-quit EMA assessment period was significantly positively related to contemporaneous willingness to work hard at quitting smoking (OR=1.912). The smoking covariate was significantly negatively related to willingness to work hard at quitting, such that smoking a cigarette since the last report (endorsed in 21% of reports) was associated with a 58% reduction in the odds of being highly willing to work hard at quitting smoking. Without the smoking covariate in the model, self-efficacy still significantly covaried with willingness to work hard at quitting (OR=2.119, SE=.15,  $p<.001$ ). Positive expectancies and nicotine withdrawal again had no significant relation with being highly willing to work hard at quitting.

### **Nightly (bedtime) willingness to work hard at quitting smoking**

We then examined covariates of willingness to work hard at quitting smoking as prompted in nightly bedtime reports before and after quitting smoking. As with the real-time reports, time pre-quit was coded in days with the intercept at the first day of post-training recording, 14 days pre-quit, and in days since midnight on the target quit day for the post-quit period.

In the *pre-quit* nightly bedtime report analyses (Table 3, top panel), the model intercept was allowed to vary across individuals. Setting additional parameters to random did not significantly reduce model deviance. Adding baseline willingness to work hard at



quitting smoking as a statistical predictor of random intercepts improved model fit and was significantly associated with initial real-time willingness to work hard at quitting, such that a high level of baseline willingness to work hard at quitting was associated with a 9-fold increase in the odds of being highly willing ( $OR=9.081$ ) at bedtime. The log odds of being highly willing to work hard at quitting decreased over time pre-quit, such that each day was associated with a 19% reduction in the odds of being highly willing at bedtime, on average. Including a quadratic growth term (time squared) and self-efficacy significantly improved model fit in EM Laplace-2 models and were significant in the final restricted maximum likelihood (RML) model. The positive coefficient for time squared suggested U-shaped growth with a decline in willingness following the initiation of recording and then a recovery of motivation just before the quit day, as displayed in Figure 1. Additionally, age at level-2 was significantly associated with quadratic growth in the odds of being highly motivated to quit. Older participants (coded in decades) exhibited less curvilinear growth in willingness to work hard at quitting over days and less of a rebound in willingness to work hard at quitting in the last days before a quit attempt than did younger participants. Self-efficacy showed a significant positive relationship with willingness to work hard at quitting, where one-point greater nightly self-efficacy was associated with a greater than tripling of the odds of being highly motivated to work at quitting at bedtime ( $OR=3.54$ ). The smoking covariate (smoking in the past day) was endorsed on 97% of reports and was not a significant variable in this model, and removing it did not affect the significance of other covariates of willingness. As in the daytime models, smoking expectancies, nicotine withdrawal, and treatment condition were not significantly related to IVR-reported willingness to work at quitting.

*Post-quit*, the final model (Table 3, bottom panel) included time, self-efficacy, and the binary smoking covariate as fixed variables. Only the intercept was allowed to vary across individuals to improve model fit. This variance was unrelated to baseline willingness to work at quitting, similar to the results for real-time post-quit willingness. Results showed that neither time (over the seven-day post quit period) nor self-efficacy were significantly related to nightly willingness to work hard at quitting smoking post-quit. Without the smoking covariate in the model, self-efficacy was significantly positively associated with willingness to work hard at quitting (OR=1.614, SE=.198,  $p=.016$ ) on the same night. The smoking covariate (smoking in the past day) was endorsed by 66% of subjects and was significantly negatively related to willingness to work hard at quitting, such that smoking in the past day was associated with a 68% reduction in the odds of being highly willing to work hard at quitting smoking at bedtime. Smoking expectancy, nicotine withdrawal, and treatment condition did not improve the model in EM Laplace-2 estimation and were not significantly related to bedtime willingness to work at quitting.

Other level-2 variables and interactions were explored in all four pre- and post-quit models (daytime and bedtime). Gender and FTND score did not improve model deviance for any model. Age was explored for all models, but only improved the model deviance in the pre-quit bedtime model of willingness to work hard at quitting smoking. Two interactions (time x self-efficacy, self-efficacy x withdrawal) were also explored, but did not improve fit in any model.

## Discussion

The aim of this study was to examine fluctuations in motivation to quit smoking and explore the extent to which motivation to quit covaries (two weeks pre-quit and one week post-quit) with contemporaneous self-efficacy, nicotine withdrawal, positive smoking expectancies, and recent smoking in a smoking cessation treatment trial. Analyses also examined the extent to which a practice quitting treatment affected willingness to work hard at quitting among adult daily smokers seeking treatment. Results indicated that real-time motivation changes over the two weeks preceding a quit attempt were variable across subjects, but unrelated to practice quitting treatment. Results also indicated that nightly motivation dipped and then recovered over the two weeks pre-quit, on average, and that the extent of the rebound decreased with age. Results supported the hypothesis that self-efficacy is positively related to motivation, but failed to detect any treatment effects or support the hypotheses that nicotine withdrawal or positive smoking expectancies would be related to real-time or nightly motivation to quit.

*Motivation pattern over time.* Baseline motivation to quit smoking was significantly related to real-time motivation to quit smoking in the pre-quit restricted maximum likelihood models, but not the post-quit models. This may further support the position that motivation to quit is flexible and a single assessment does not significantly predict the course of motivation over time, as suggested by Darlow and Lobel (2012). Past studies have identified relations between motivation to quit smoking at a single time-point and later quit attempts (Royce, Hymowitz, Corbett, and Hartell, 1993; Rundmo, Smedslund, Gotestam, 1997), and examined motivation to quit as a mediator of a tobacco and other substance use prevention and cessation program's effects on cessation

(McCuller et al., 2006). The relationship between baseline motivation to quit and real-time motivation after quitting, however, has not been sufficiently explored. It is possible that, once a quit attempt has been made, other factors become more salient in predicting abstinence motivation than the initial reported level of motivation.

*Self-efficacy.* Results in three of four models supported the hypothesis that increases in self-efficacy would predict increases in willingness to work hard at quitting. Consistent with past research, we found a positive relationship between self-efficacy and motivation (Kelly, Zyzanski, & Alemagno, 1991; Latimer & Ginis, 2005; Caviness et al., 2013). The post-quit nightly (bedtime) model did not reflect a significant relationship between self-efficacy and willingness to work hard at quitting, however. This may be due to the reduction in the number of reports analyzed (483 post-quit bedtime reports, compared to 1,002 post-quit daytime reports) which lowered statistical power in the post-quit bedtime model. It is also possible that recall of post-quit self-efficacy over the past 24 hours was less accurate for the nightly (bedtime) reports than recall for the moment before the report was initiated. The real-time (daytime) reports asked about proximal self-efficacy during a brief period that was more salient than the 24-hour period assessed during the nightly (bedtime) reports, at the time of day when participants engaged in daily activities and likely had more opportunities to exercise and enhance refusal self-efficacy. It is possible that the timing of these reports contributed to the emergence of the relationship between self-efficacy and motivation to quit in the real-time (daytime) model, but not the nightly (bedtime) model.

*Nicotine Withdrawal.* We also hypothesized that nicotine withdrawal would predict lower motivation to quit before and after the target quit date, and that withdrawal

would interact with confidence to have a particularly potent effect on motivation to quit after the quit date. Results did not support these hypotheses. First, a confirmatory factor analysis indicated that both negative affect and the other withdrawal items loaded onto a single latent withdrawal factor. This suggested that our assessments were measuring withdrawal beyond negative affect and that negative affect was not a separate dimension of withdrawal. This withdrawal factor significantly improved model fit for the pre-quit nightly (bedtime) model using EM Laplace-2 estimation, but it was not significantly associated with willingness to work hard at quitting in this or any other EM Laplace-2 or restricted maximum likelihood model. This may reflect the presence of small-magnitude relations with motivation that we were not able to detect in our analyses due to statistical power constraints. Similar results have been found when examining negative affect, showing that neither acute positive nor negative affect predicted willingness to work hard at quitting (Minami et al., 2014). Past studies finding effects of negative affect on smoking behavior have specifically found that smokers who are prone to negative affect have a lower likelihood of achieving abstinence (Brandon, 1994; Carmody, 1992), but have not examined the extent to which motivation is related to affect or broader withdrawal distress. Past research has found links between withdrawal and time to lapse after a quit attempt (Sweitzer, Denlinger, & Donny, 2013), although the direct effect of withdrawal on motivation to quit smoking has not been thoroughly explored. Findings from the current study may suggest that withdrawal may not have a significant effect on willingness to work hard at quitting smoking close to a target quit date. This is consistent with the findings of Minami et al. (2014) that neither baseline nor changes in negative affect had a significant effect on self-efficacy or motivation to quit.

*Smoking Expectancies.* Finally, we hypothesized that positive smoking expectancies would predict decreases in motivation after the quit date. Results did not show that positive smoking expectancies improved model fit in any of the four models examined. Past research had shown that smoking expectancies are related to motivation to quit smoking (Pulvers et al., 2004). However, our data suggested that expectancies do not have significant real-time relations with willingness to work hard at quitting, even when controlling for smoking status. Timing of reports may have impacted this finding, as past studies finding relationships between smoking expectancies and motivation to quit smoking have not examined the relationship on a moment-to-moment basis. In fact, few studies have examined smoking expectancies using EMA (Gwaltney et al., 2005; Colvin & Mermelstein, 2010; Cano et al., 2014), and even fewer have examined positive smoking outcome expectancies (Gwaltney et al., 2005; Cano et al., 2014). While Cano et al. (2014) found significant relations between positive smoking expectancies and urge to smoke, the relationship between positive smoking expectancies and motivation to quit was not tested. Pulvers et al. (2004) found a relationship between smoking expectancies and motivation using surveys at a single timepoint, and thus did not assess the relations between changes in expectancies and changes in motivation. It is possible that, while smoking expectancies have a general effect on motivation to quit smoking, this is a between-subject rather than within-subject effect.

*Level-2 Covariates.* Other variables were examined in the models, including treatment condition, age, gender, baseline FTND score, and baseline willingness to work hard at quitting. Surprisingly, withdrawal exposure did not predict real-time willingness to work hard at quitting pre- or post-quit. Only baseline willingness to work hard at

quitting and age were significant in predicting willingness to work hard at quitting.

Baseline motivation to quit had this effect in the pre-quit models, which is consistent with past research linking motivation to quit with quit attempts (Lee, Catley, & Harris, 2014; Diemert et al., 2013). The interval between baseline assessment and the intercept in the pre-quit models was four to nine days, so we would expect to see this concordance. That baseline motivation was unrelated to quit day motivation is interesting and may suggest that other factors become more influential once a smoker has made a quit attempt. This is consistent with research suggesting that, while baseline intention to quit smoking is related to quit attempts, self-efficacy is the primary factor predicting the success of a quit attempt (Smit et al., 2014). It may also suggest that baseline motivation is not a strong predictor of motivation during the course of a quit attempt and thus not sufficiently predictive of successful cessation (Borland et al., 2010; Hyland et al., 2006).

Age significantly predicted motivation to quit for the pre-quit nightly (bedtime) model. There was an average linear decline in motivation pre-quit, but this was qualified by a quadratic growth component. Age moderated the extent of the quadratic change in slope, such that younger smokers showed more pronounced changes in slope (initially a decline in willingness to work at quitting, followed by an acceleration shortly before the quit day), on average. This pattern was attenuated in older smokers who experienced a slightly more linear drop in willingness over the two-week pre-quit period, as shown in Figure 1. Studies examining the effects of age on readiness to quit smoking and other smoking behaviors have suggested a complex explanation for the effects of age. National data have shown that a smaller proportion of smokers age 50 and older (57%) reported wanting to quit compared with those less than 50 years of age (68%; United States

Department of Health and Human Services [USDHHS], 1990). Older smokers (age 50 years or older) were found to be the least likely to say they plan to quit smoking someday in one study (Kviz et al., 1994). In this study, among the older smokers who did endorse a plan to quit someday, the oldest smokers had the highest likelihood of planning to quit within the next three months (Kviz et al., 1994). Additional analyses have shown that older smokers are more likely than younger smokers to be in the preparation stage, while younger smokers are more likely to be in the contemplation stage (according to the transtheoretical model; Kviz et al., 1995), although the same study did not find significant age effects in attempts to quit or successfully quitting. The relationship found in this study highlights the complexity of the effect of age on smoking behavior, and these findings may not replicate in future studies due to the inconsistent findings in the literature between age and motivation to quit smoking.

*Smoking and Motivation.* All 93 participants in the pre-quit models reported smoking and had the intention to quit on their quit day, whereas 56 participants reported smoking on or after their quit day. In the post-quit models, but not the pre-quit models, we found a significant inverse relationship between a binary smoking covariate and real-time motivation to quit. This may indicate that those with lower motivation to quit smoking were more likely to smoke post-quit, or that the act of smoking lowered motivation to quit smoking. Future examinations of this relationship may need to examine the direction of causality, if one exists, between smoking and motivation to quit smoking before and after a quit attempt.

*Limitations.* There are several limitations to consider when interpreting the results of this study. First, the sample size used for analyses was modest and dropped from 93



participants pre-quit to 86 participants post-quit. The inconsistent significance of some variables in the models may have been affected by the reduced power during the post-quit EMA assessment period.

Another limitation for this study involves the controversy in the construct of motivation. Studies assessing motivation for behavior change have defined the construct in varied ways, from “would you like to stop smoking” (Haukkala et al., 2000) to the item used in this study, “how willing are you to work hard at quitting smoking?” Studies on motivation have found inconsistent results in the construct’s relationship with other variables, as well as later behavior change. This means that the findings of this study may not be replicated without the use of the specific self-report item: willingness to work hard at quitting smoking.

Reliance on self-report may have further affected our results. While EMA allows for the collection of self-report data in real-time within participants’ natural environments, the validity of our data may have been compromised due to technological difficulties from dropped calls, distractions that may have occurred during the call, or someone other than the participant completing the call. We aimed to reduce these sources of error through training and frequent feedback regarding report completion times and rates, but there are likely uncontrolled sources of variance in responses in these measures.

Additionally, the source study for this analysis recruited participants with a self-reported motivation to quit smoking level of six or above (out of 10), which resulted in restriction of range in motivation responses in general, and may have contributed to the skewed distribution of motivation to quit responses that was observed in this study. We addressed the skewed distribution by transforming “willingness to work hard at quitting”

into a binary variable; however, the lack of variance in self-reported willingness to work hard at quitting may have suppressed the emergence of significant relationships between the hypothesized covariates of motivation and willingness to work hard at quitting smoking.


*Conclusions.* Evidence from this study suggests that motivation as measured in a single time-point pre-quit is not related to motivation to quit after a target quit day during a cessation attempt. The results also suggest that individuals differ in the stability or instability of their motivation in the weeks leading up to a quit attempt, and age is one factor related to these differences in motivation growth. Results add to data showing that self-efficacy is positively related to motivation to quit smoking. Motivation did not appear to covary with nicotine withdrawal symptoms or positive smoking expectancies, however. Smoking was associated with lower motivation post-quit, but not pre-quit. Overall, results from this study provide evidence that motivation to quit changes as a function of time and engagement in a cessation effort in a way that is variable across individuals. More research is needed to determine the significance of fluctuations in motivation in terms of cessation success and to identify variables that can explain variance in motivation stability pre-quit and variance in motivation levels at the outset of a cessation attempt.

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## APPENDICES

Table 1.

*Demographic Characteristics of Final Sample (N=93)*

<b>Variable</b>	<b>Value</b>	<b><i>n</i> (%)</b>
Sex	Female	48 (51.6)
Race/ethnicity	Hispanic	5 (5.4)
	White	61 (65.6)
	African American	26 (28)
	Asian, Pacific Islander	3 (3.2)
	American Indian	1 (1.1)
	Other	3 (3.2)
Marital status	Married	30 (32.3)
	Divorced	20 (21.5)
	Never married	25 (26.9)
	Cohabiting	5 (5.4)
	Separated	6 (6.5)
	Widowed	7 (7.5)
Education	< High school graduate	3 (3.3)
	High school/GED	27 (29)
	Some college	46 (49.5)
	College degree	17 (18.3)
Employment status	Employed for wages	42 (45.2)

	Self-employed	9 (9.7)
	Unemployed < 1 year	10 (10.8)
	Unemployed > 1 year	9 (9.7)
	Homemaker	5 (5.4)
	Student	9 (9.7)
	Retired	9 (9.7)
	Disabled	11 (11.8)
Household income	< \$25,000	35 (37.7)
	\$25,000-\$34,999	8 (8.6)
	\$35,000-\$49,000	8 (8.6)
	\$50,000-\$74,999	15 (16.1)
	>\$75,000	27 (29)
		<b><i>M (SD)</i></b>
Age		47.76 (12.44)
Age at first cigarette		14.63 (2.65)
Cigarettes smoked per day		18.7 (6.38)
Previous quit attempts		4.74 (10.72)
Baseline CO level		21.6 (10.23)
Baseline FTND Score		5.72 (1.55)

Table 2.

*Trimmed HLM Analysis of the Relations Between Real-time (Daytime) Covariates and  
Motivation to Quit Smoking*

***Pre-Quit***

<b>Variable</b>	<b>Odds ratio</b>	<b>95% CI</b>	<b>Approx. df</b>	<b>P-value</b>
Intercept**	0.713	0.342, 1.484	91	0.362
Baseline motivation	7.602	1.120, 51.592	91	0.038
Time**	1.006	0.952, 1.064	92	0.819
Self-efficacy	1.952	1.620, 2.362	2093	<0.001
Smoked	1.265	0.852, 1.881	2093	0.243

***Post-Quit***

<b>Variable</b>	<b>Odds ratio</b>	<b>95% CI</b>	<b>Approx. df</b>	<b>P-value</b>
Intercept**	3.039	1.407, 6.564	85	0.005
Time	0.953	0.859, 1.057	894	0.358
Self-efficacy	1.912	1.401, 2.611	894	<0.001
Smoked	0.415	0.209, 0.823	894	0.012

*Note.* \*\* Random coefficient

Table 3.

*Trimmed HLM Analysis of the Relations Between Nightly (Bedtime) Covariates and  
Motivation to Quit Smoking*

***Pre-Quit***

Variable		Odds		Approx. df	P-value
		ratio	95% CI		
Intercept**		1.200	0.234, 6.143	91	0.825
	Baseline		1.176,		
motivation		9.081	70.128	91	0.035
Time		0.807	0.693, 0.940	1083	0.006
Time (quadratic)		1.018	1.008, 1.028	1083	<0.001
	Age	0.997	0.995, 0.999	1083	0.012
Smoked		1.130	0.265, 4.813	1083	0.869
Self-efficacy		3.540	2.579, 4.857	1083	<0.001

***Post-Quit***

Variable		Odds		Approx. df	P-value
		ratio	95% CI		
Intercept**		2.289	1.110, 4.717	84	0.025
Time		1.041	0.912, 1.189	387	0.550
Self-efficacy		1.394	0.926, 2.099	387	0.111
Smoked		0.318	0.156, 0.649	387	0.002

Note. \*\* Random coefficient

Figure 1.

