Published in final edited form as:

Psychol Assess. 2013 June ; 25(2): 416–423. doi:10.1037/a0031232.

Self-Monitoring Effects of Ecological Momentary Assessment on Smokers' Perceived Risk and Worry

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Abstract

Using ecological momentary assessment (EMA), we sought to determine whether differences in reporting would exist for smokers who self-monitored their smoking-related negative thoughts five times daily in comparison to a non-EMA control group. One hundred and seventeen smokers were randomly assigned to two conditions. Eighty-eight smokers carried personal digital assistants (PDAs) for two weeks and monitored negative thoughts each day and 29 smokers did not self-monitor their negative thoughts. All smokers completed pretest and posttest assessments reporting their perceived risk and worry associated with smoking consequences. The data revealed evidence of self-monitoring effects, as smokers in the EMA condition reported less worry after two weeks of self-monitoring compared to smokers in the control condition. The two conditions did not differ in their reports of perceived risk of smoking consequences. These data suggest that EMA procedures asking respondents to self-monitor their thoughts about smoking may influence feelings about their smoking behavior.

Keywords

ecological momentary assessment; EMA; smoking; reactivity; self-monitoring; risk; worry

Smoking researchers attempting to develop a better understanding of behavior often depend on global retrospective reports of thoughts, feelings, and experiences (Shiffman, 2009). However, global recall can be inaccurate and may not capture variability in smoking behavior in real time and over time, making retrospective measures an imperfect source of information (Chandra, Shiffman, Scharf, Dang, & Shadel, 2007). In order to better understand patterns of smoking behavior and under what circumstances or situations smoking is most likely to occur, ecological momentary assessment (EMA), a measurement technique in which people report their thoughts, feelings, and/or behavior as they are

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experienced, has become a common technique in smoking research (e.g., Hedeker, Mermelstein, Berbaum, & Campbell, 2009; Piasecki et al., 2011; Shiffman et al., 2007; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996).

EMA techniques are an important advancement in smoking research; however, there is little consensus regarding the potential for reactivity due to the nature of EMA self-monitoring. Reactivity refers to “the degree to which the intensity, frequency, and/or quality of a dependent variable changes as a function of the assessment itself” (Hufford & Shiffman, 2003, p.79). For example, reactivity may be evidenced by smokers reporting either an increase in smoking or by reporting a decrease in smoking due to EMA procedures. Thus, reactivity refers to a change in the dependent variable, whether that is one’s behavior, thoughts, or feelings, and does not explicitly imply a direction of change.

Of the few studies that have systematically tested the possibility of reactivity from EMA monitoring, most come from alcohol research. Alcohol reactivity data may be the most relevant to smoking reactivity because the two behaviors have similar antecedents and occur in similar situations (McCarthy & Thompson, 2006). To date, three studies have explored reactivity to EMA among drinkers and have found inconsistent outcomes regarding EMA reactivity. Additionally, these investigations are limited by the lack of randomized non-monitoring control groups (Collins et al., 1998; Hufford, Shields, Shiffman, Paty, & Balabanis, 2002; Litt, Cooney, & Morse, 1998), small sample sizes ($n = 27-33$), and concerns with compliance to procedures (Litt et al., 1998).

The investigation of reactivity to EMA in smoking research is similarly inconsistent. EMA in smoking research typically focuses on behavioral outcomes (e.g., smoking cessation, number of cigarettes smoked), and the question of whether EMA is reactive in this context is still open. For example, Shiffman and colleagues (Shiffman et al., 2002) suggested that EMA procedures might reduce smoking behavior, but Rowan and colleagues (Rowan et al., 2007) observed no significant changes in smoking behavior compared to a non-monitoring control group. EMA self-monitoring could also influence the concomitants of smoking behavior (e.g., urges, thoughts, attitudes, motivation), although the investigation into the potential for reactivity for such constructs is limited. For example, Shiffman and colleagues (Shiffman et al., 1997; Shiffman et al., 1996) found that the frequency of EMA episodes did not influence the intensity of reported smoking urges, but less frequent assessments were associated with more reported temptation episodes (i.e., a situation in which an individual was on the brink of smoking). Interestingly, these results were not discussed in regard to reactivity. Additionally, Rowan and colleagues (2007) assessed the extent to which self-monitoring may influence a range of motivational constructs including, among others, self-efficacy of resisting urges associated with different smoking-related circumstances (e.g., diet concerns, social image, pleasure) and situational temptations associated with relapse (e.g., negative affect temptations, social temptations). These authors found that after a one-week monitoring period immediately preceding a quit attempt, those who self-monitored reported greater social image and diet self-efficacy, and greater negative affect temptations.

In the current investigation, we examined self-monitoring effects on perceived risk and worry associated with one’s smoking as part of a larger study concerned with the daily negative thoughts and worries that cigarette smokers have about their smoking behavior (Koblitz et al., 2009). Perceived risk and worry are related but independent constructs that are generally modestly and positively related (typically around $r = .30$; McCaul & Mullens, 2003), and may independently predict behavior outcomes. Perceived risk refers to the extent to which one believes a particular outcome of some event or behavior is likely to occur (e.g., developing lung cancer due to smoking) while worry refers to the negative feelings associated with these cognitions (e.g., *concern* about developing lung cancer due to

smoking). Greater risk perceptions and worry are both associated with enhanced motivation to change self-protective health behaviors (e.g., Brewer et al., 2007; Hay, McCaul, & Magnan, 2006; Magnan, Koblitz, Zielke, & McCaul, 2009), including smoking behavior (Magnan et al., 2009), and motivation to quit is an important precursor to quitting intentions and plans (Kozlowski et al., 1999). Therefore, understanding how EMA procedures influence motivational constructs such as perceived risk and worry is important in order to better understand how EMA self-monitoring might influence smoking behavior. Reporting one's thoughts about smoking consequences might lead to smokers experiencing more perceived risk and worry about their smoking. Conversely, exposure to these various thoughts might lead smokers to habituate to the negative thoughts and thus experience less perceived risk and worry about their smoking. To the extent that the EMA procedures influence perceived risk and worry, we anticipated that compared to smokers in the control condition, smokers who participated in EMA self-monitoring would report differential perceived risk and worry, without making a specific prediction about the direction of influence.

Method

Overview and Participants

Smokers were randomly assigned to either an EMA or control condition. Smokers in both conditions came to the laboratory a total of three times—at pretest, 1 week later, and 3 weeks later—to complete questionnaires about their smoking during the previous week. Smokers in the EMA condition additionally carried a personal digital assistant (PDA) for one-week, had a one-week break, and then resumed EMA for another week. On the PDA, smokers recorded their negative thoughts and worries about smoking up to five times per day.

Participants were 117 smokers (65 males and 52 females) from a mid-sized Midwest university and surrounding metro area. University students were recruited using a screening questionnaire distributed in psychology classes at the beginning of the semester. Students who reported currently smoking every day were contacted by phone and invited to participate. Participants from the surrounding community were recruited primarily through flyers posted throughout the community, and advertisements placed in local papers, alumni newsletters, and in the faculty/staff email listserv.

Procedure

Participants were randomly assigned to an EMA ($n = 88$) or control ($n = 29$) condition. Random assignment was done using a 3:1 ratio because the primary purpose of the study was to assess daily thoughts using EMA methodology; consequently more smokers were assigned to the EMA condition. Data from the participants in the EMA condition regarding the frequency of their daily thoughts and worries have been reported elsewhere (Koblitz et al., 2009). The current report is based on data collected during the first and last assessment sessions, and a brief 6-month follow-up; thus, the analyses presented here and the inclusion of the participants from the control condition are unique to this paper. All participants provided informed consent and the study protocol was approved by the University's IRB.

Participants were informed that the purpose of the study was to learn about smokers' daily thoughts, and not to change smoking behavior. After completing a pretest assessment, participants in the control condition were dismissed. Participants in the EMA condition learned that they would be carrying PDAs to record their thoughts about smoking for two one-week intervals. Participants in the EMA condition received a one-week break from EMA procedures in order to reduce subject burden and to increase compliance with

procedures. After training on the PDAs and associated procedures, EMA participants were dismissed from the pretest session. During the EMA monitoring period, EMA participants completed questionnaires on the PDAs five times during the course of each day. Questionnaires were completed (1) following the first cigarette after waking, (2) after 12pm, (3) after 5pm, (4) once in the afternoon when smokers were randomly signaled to complete a questionnaire (between 2pm and 5pm), and (5) at the end of the day before bed. During each EMA questionnaire, participants indicated if they had a negative thought about their smoking. If they indicated that they did have a negative thought, they were presented with a list of 15 thoughts generated largely from the Reasons for Quitting Scale (RFQ; Curry, Grothaus, & McBride, 1997). If participants checked “Yes” to having a particular thought, they were redirected to a new page to report their level of worry about that specific thought (no worry, some worry, a great deal of worry). During the random-signal afternoon questionnaire only, participants were required to read every thought and answer “yes” or “no” to whether they had experienced each of them. At the end of EMA collection, all participants returned to complete a posttest in which they answered questions about their thoughts and worries about smoking. On average, EMA smokers were 84.8% compliant with the EMA procedures ($SD = 13\%$, range: 52 – 100%, median = 86%).

Six months after the posttest, participants were contacted for a brief phone follow-up. Overall, 80 of the 117 participants were successfully contacted for the follow-up assessment (68% overall retention). EMA smokers were more likely to be successfully contacted (66/88: 75% retention) than control smokers (15/29: 52% retention), $\chi^2(1) = 7.20, p = .007$. Of 16 comparisons of demographic and pretest variables among those we were able to reach and those we could not reach, two significant differences emerged: student smokers were more likely to be recontacted than community smokers ($\chi^2(1) = 4.43, p = .04$) and White smokers were more likely to be recontacted than non-White smokers ($\chi^2(1) = 7.82, p = .04$). All other comparisons were non-significant. Other details regarding study procedures are presented elsewhere (Koblitz et al., 2009).

Measures

Demographic information gathered at pretest included age, gender, and ethnicity. All alpha reliability values refer to the current sample investigated ($n = 117$). Participants also indicated how many cigarettes they smoked each day and the age at which they began smoking. We then assessed contemplation to quit smoking (Contemplation Ladder; Biener & Abrams, 1991), intrusive thoughts (intrusive thoughts subscale of the Impact of Event subscale; Horowitz, Wilner, & Alvarez, 1979), and trait worry; (Penn State Worry Questionnaire [PSWQ]; Meyer, Miller, Metzger, & Borkovec, 1990). To measure addiction, participants completed the Fagerström Test of Nicotine Dependence-Revised (FTND-R; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991), $\alpha = .64$. Examples of items are, “How soon after you wake up do you smoke your first cigarette?” and “Which cigarette would you hate most to give up?” The FTND-R yields a single score ranging from 1–10 with higher scores indicating greater nicotine dependence.

Perceived risk and worry were assessed at both pretest and posttest assessments. We first assessed three different types of *perceived risk*: percent risk of smoking, comparative risk of smoking, and risk to others because of smoking. Percent risk of smoking was created by averaging two items ($\alpha = .89$), “What are the chances that you might develop some type of cancer within your lifetime if you continue to smoke?” and “What is the likelihood that you might develop a non-cancerous medical condition (e.g. emphysema, heart disease) in your lifetime if you continue to smoke?” Participants indicated a value between 0% (no chance) and 100% (guaranteed to happen) for both items. Comparative risk of smoking was created by averaging two items in which participants compared their risk to similar others ($\alpha = .70$), “Compared to other people your age who have smoked cigarettes, how would you rate your

chances of developing some type of cancer in your lifetime?” and “Compared to other people your age who have smoked cigarettes, how would you rate your chances of developing a non-cancerous medical condition (e.g. emphysema, heart disease) in your lifetime?” Participants indicated their comparative risk on a 5-point scale (1 = much less than others to 5 = much greater than others). Lastly, risk to others from smoking was created by averaging two items ($r = .55$), “To what extent do you think your smoking bothers non-smokers?” and “To what extent do you think your smoking can be harmful to others?” Participants indicated risk to others on a 7-point scale (1 = not at all to 7 = extremely).

We then assessed two different types of *perceived worry*: worry about medical conditions and worry about harming others due to smoking. Worry about medical conditions was created by averaging two items ($r = .87$), “How worried are you about developing a smoking-related medical condition?” and “How much does thinking about a smoking-related medical condition bother you?” Participants indicated worry about medical conditions on a 7-point scale (1 = not at all to 7 = extremely). Worry about harming others was created by averaging two items ($r = .84$), “How worried are you that your smoking bothers non-smokers?” and “How worried are you that your smoking can be harmful to other people?” Participants indicated worry about harming others on a 7-point scale (1 = not at all to 7 = extremely). All four worry items were averaged for the moderation analyses, $r = .86$.

Lastly, *motivation to quit and self-reported behavior change* were assessed in several ways. At posttest, participants indicated their motivation to quit in the next 30 days and 6 months, and rated their desire to quit “someday.” Participants responded on 7-point scales (1 = not motivated/no desire, 7 = extremely motivated/strong desire), and these items were averaged ($r = .85$). At posttest, participants also indicated if they had noticed changes in their smoking behavior over the course of the study (y/n) and if they were currently smokers (y/n). At 6-month follow-up, participants indicated if they were currently smokers (y/n), how many cigarettes they smoked in a day, and how many quit attempts they had made since the study ended.

Statistical Analysis

Statistical analyses examining pretest differences between conditions were performed using one-way ANOVAs for continuous variables and chi-square analyses for categorical variables. One-way ANCOVAs compared posttest risk and worry by condition controlling for intrusive thoughts and worry about a medical condition, and corresponding pretest values for each risk and worry variable. Partial correlations for continuous variables and logistic regressions for categorical variables were conducted assessing motivation to quit and self-reported behavior at posttest and follow-up.

Results

Smokers (44.4% female) were 29.6 ($SD = 12.9$) years of age on average. Ninety-five percent of smokers ($n = 111$) were non-minority white individuals; the other 5% were African American (1%, $n = 1$), American Indian/Alaskan Native (3.4%, $n = 4$), and Hispanic (1%, $n = 1$). Participants reported smoking 16.7 cigarettes per day ($SD = 8.27$), and on average, they started smoking at the age of 15.5 ($SD = 3.71$). Table 1 presents the pretest differences between the two conditions. Of sixteen pretest comparisons, a condition difference emerged for worry about a medical condition. EMA smokers reported more worry than control smokers, $t(115) = 2.01$, $p = .05$, partial $\eta^2 = .034$. A small condition difference also emerged for intrusive thoughts. EMA smokers reported more intrusive thoughts than control smokers, $F(1,114) = 3.84$, $p = .053$, partial $\eta^2 = .033$. Subsequent analyses controlled for both variables.

At posttest, no between-group differences emerged for any of the perceived risk variables, all p s > .31, and thus these risk outcomes were not included in further analysis. There was a strong condition difference for worry about developing a medical condition, $F(1,112) = 6.80$, $p = .01$, partial $\eta^2 = .057$. Control participants reported greater worry of developing a medical condition at posttest (adjusted $M = 4.53$, $SE = .23$) than EMA participants (adjusted $M = 3.83$, $SE = .13$). There was a parallel effect for worry about harming others, $F(1,111) = 5.01$, $p = .03$, partial $\eta^2 = .043$, such that control participants reported higher worry about harming others at posttest (adjusted $M = 4.31$, $SE = .26$) than EMA participants (adjusted $M = 3.63$, $SE = .15$). Table 1 presents the unadjusted means and standard deviations from ANCOVA analyses.

Moderators of Posttest Worry

Subsequent analyses were conducted to determine whether worry about smoking at pretest moderated the condition effects on posttest worry about developing a medical condition and posttest worry about harming others. First, we created an average worry about smoking score at pretest comprised of an average of all four worry items. Then, using hierarchical linear regression, we tested the Worry X Condition interaction after entering the worry and condition effects in Step 1, and including intrusive thoughts as a covariate (consistent with previous analyses). The Worry X Condition interaction was not significant for worry about a medical condition ($p = .27$); but it was significant for worry about harming others ($t = 2.00$, $p = .05$). A simple slopes analysis demonstrated that high pretest worriers in the control condition had higher posttest worry about harming others than high pretest worriers in the EMA condition ($t = 3.26$, $p = .002$). There was little difference in posttest worry about harming others for low pretest worriers in either condition.

The extent to which compliance with the EMA procedures moderated the effects of self-monitoring on worry outcomes was also tested. Because a traditional moderation analysis was not possible (control smokers did not have EMA data), EMA smokers were split into two groups based on their median compliance value (86%), resulting in three groups: low compliance EMA, high compliance EMA, and control. We then conducted two simple contrasts comparing the high and low compliance EMA smokers to the control smokers (controlling for all covariates). Low compliance EMA smokers ($adj. M = 4.07$, $SE = .19$) and control smokers ($adj. M = 4.54$, $SE = .23$) reported similar levels of worry about developing a medical condition at posttest, contrast estimate (est) = .47, $p = .11$. However, high compliance EMA smokers ($adj. M = 3.60$, $SE = .19$) reported significantly lower worry about developing a medical condition at posttest than control smokers, $est = .94$, $p = .002$. A similar pattern occurred for worry about harming others. Low compliance EMA smokers ($adj. M = 4.22$, $SE = .20$) and control smokers ($adj. M = 4.54$, $SE = .23$) reported similar levels of worry about harming others at posttest, $est = 10$, $p = .75$. High compliance EMA smokers ($adj. M = 3.04$, $SE = .20$) reported significantly lower worry about developing a medical condition at posttest than control smokers, $est = 1.28$, $p < .001$.

Motivation to Quit and Self-Reported Behavior Change

To test the effect of monitoring on behavior, we computed several partial correlations between posttest worry, with motivation to quit, and self-reported behavior change. These were conducted separately by condition and controlled for pretest levels of worry (Table 2). There were no significant associations among individuals in the control condition. For EMA smokers, both worry about developing a medical condition, and worry about harming others were significantly positively associated with motivation to quit ($r = .40$ and $.51$, respectively, p s < .001). Additionally, greater worry about harming others at posttest was weakly associated with fewer cigarettes smoked at follow-up ($r = -.27$, $p = .07$).

Logistic regressions were conducted to test for condition effects for the categorical self-reported behavior change outcomes at posttest and follow-up. There was a weak condition effect on changes in smoking behavior at posttest, $\chi^2(1) = 3.63, p = .06$. EMA smokers were 2.3 times more likely to report noticing changes in their smoking behavior compared to control smokers, Wald's $\chi^2(1)$ for condition = 3.45, $p = .06$, OR = 2.33. Overall, smokers reported noticing positive behavior changes. Control smokers ($n = 9$) reported cutting down on their smoking ($n = 5$; 56%), increasing smoking ($n = 2$; 22%), being more aware of health symptoms of smoking ($n = 1$; 11%), or having more motivation to quit smoking ($n = 1$; 11%). EMA smokers ($n = 45$) reported cutting down on their smoking ($n = 28$; 62%), being more aware of their smoking behavior ($n = 7$; 16%), having more negative thoughts about smoking ($n = 5$; 11%), smoking around other people less often ($n = 2$; 4%), more motivation to quit smoking ($n = 2$; 4%, and/or increasing smoking ($n = 2$; 4%). At posttest, all participants in both conditions were continuing smokers, and thus there was no variance to conduct a logistic regression. At follow-up, nearly all participants (90.0%; 72/80) reported being a current smoker, and this did not significantly differ by condition, $\chi^2(1) = .318, p = .57$. Although weak, the evidence suggests that involvement in EMA could be related to smoking behavior, and more certainly, motivation to quit.

Discussion

The purpose of this paper was to extend our knowledge of the potential reactive effects of EMA to perceived risk and worry about smoking. Consistent with a reactive pattern, smokers who monitored their negative thoughts about smoking over a two-week period reported less worry about the consequences of smoking and less worry about harming others due to their smoking. There was no effect of monitoring on the different risk judgments assessed here. The worry data are novel because tests of EMA in other contexts typically find small to no reactive effects (e.g., eating disorders, pain, problem drinking; Cruise, Broderick, Porter, Kaell, & Stone, 1996; Hufford et al., 2002; Stein & Corte, 2003). Additionally, this is one of the few studies to specifically focus on reactivity to EMA self-monitoring in a smoking context that also uses a randomized control group.

The direction of reactivity – EMA smokers reporting less worry – is consistent with the findings from these EMA data reported previously (Koblitz et al., 2009). Mirroring the effects of the current investigation, the frequency of negative thoughts reported did not differ by week, day of the week, or whether it was a weekend or weekday. We also found that the intensity of worry associated with these negative thoughts did not vary by the day of the week or if it was a weekend or weekday, but smokers reported worrying more during the first week of EMA self-monitoring than during the second week. Moreover, these EMA worry ratings were significantly associated with the posttest questionnaire worry outcomes. Posttest worry about developing a medical condition was positively and significantly associated with EMA worry ratings during Week 1 ($r = .54$), Week 2 ($r = .60$), and across both weeks of self-monitoring ($r = .65$), all $ps < .001$. Posttest worry about harming others was also positively and significantly associated with EMA worry ratings during Week 1 ($r = .45$), Week 2 ($r = .49$), and across both weeks of self-monitoring ($r = .54$), all $ps < .001$.

There are several possible explanations for the current outcomes. First, reporting negative consequences of smoking five times a day for two one-week intervals may have resulted in habituation to the consequence statements. Through repeated exposure to the consequences, the smokers may have become less worried about the consequences of smoking. In contrast, control smokers only answered questions about their worry and perceived risk during the global questionnaire assessments and thus would likely not have experienced any habituation. Second, reporting one's negative thoughts and worries about smoking several times daily is novel – smokers are not often asked to do this. It is possible that the initial

novelty of reporting about negative consequences of smoking experienced during the pretest assessment resulted in artificially high levels of worry, and that these artificially high reports declined over time with repeated exposures. Third, EMA smokers may have simply reduced their perceptions of worry after reporting on their negative thoughts about smoking repeatedly. If the EMA smokers completed their PDA assessments at times when they were less likely to be thinking negative thoughts, then using those instances as the basis for their retrospective recall during the questionnaire assessments could lead to underreporting of worry at posttest. Each of these three explanations suggests that EMA participants were underreporting worry.

It is just as likely, however, that EMA participants were *more accurate* about their worry than control participants by the posttest. Through self-monitoring, EMA smokers may have come to realize that they do not worry all that much about their smoking behavior – that even if they occasionally worry a great deal, they do not worry often. One could thus argue that their self-monitoring about smoking thoughts during the week transferred to a more accurate portrayal of that week on the worry assessment at the end-of-week questionnaires. That is, because they monitored their thoughts and worries, they recalled their worry over the past week more accurately, and it was control participants who overestimated their worry. Support for the possibility that EMA smokers became more accurate in their worry estimates comes from the moderation analyses. High pretest worriers in the control condition had higher posttest worry about harming others than high pretest worriers in the EMA condition, but there were no differences between conditions for low pretest worriers. This effect suggests that self-monitoring may have led EMA smokers who initially reported high worry to realize that they do not actually worry very much or very often. Even more evidence supporting this possibility came from the compliance data. Specifically, more compliant EMA smokers (i.e., those who did more self-monitoring) reported less worry about smoking at posttest compared to control smokers, whereas less compliant EMA smokers reported similar levels of worry as control smokers. Final, and important, support for the accuracy hypothesis is provided by the relationships of posttest worry outcomes with the behavioral measures. Greater posttest worry about smoking was associated with motivation to quit, and weakly associated with fewer cigarettes smoked – but these effects were only observed among the EMA smokers. Thus, although EMA smokers reported less worry at posttest, the self-monitoring procedures did not reduce interest in quitting. Additionally, although our findings are not conclusive, they do provide some evidence that perceptions of worry resulting from self-monitoring could be related to positive changes in smoking behavior (e.g., fewer cigarettes smoked).

It is interesting that the EMA procedures influenced worry about smoking but not perceived risk. Research in decision-making openly acknowledges the difference between cognition and affect in predicting outcomes. For example, in dual-process theories of information processing (Kahneman & Frederick, 2002), affect is one of the central components in the experiential system. The experiential system, relative to the analytic system, is a rapid information processing system, taking into account affective experiences (such as worry), intuition or instinct, past experience, and associations when making decisions. Conversely, the analytical system is a slow, rational decision making process (Slovic, Peters, Finucane, & MacGregor, 2005). As was previously demonstrated with the EMA smokers in this sample (Koblitz et al., 2009), the most frequent thoughts reported during EMA monitoring were not the thoughts that smokers reported worrying about most. Thus, it is feasible that the act of daily self-monitoring in this study differentially influenced the experiential (emotional) system leading to changes in perceptions of worry but did not influence the cognitive (analytical) system.

The finding that self-monitoring one's negative thoughts and concerns about smoking resulted in lower reports of worry about smoking is important because worry has been positively associated with motivation to quit smoking and quit attempts (Dijkstra & Brosschot, 2003; Magnan et al., 2009). Indeed, in the current investigation, worry about the health consequences of smoking and worry about harming others at posttest were positively correlated with motivation to quit at posttest, although only among the EMA smokers. On one level, researchers should be aware of the possibility that EMA self-monitoring could reduce worry (and thereby possibly reduce motivation to quit). Thus, while there are new and exciting technologies available for self-monitoring investigations, researchers should remain cautious about the potential reactive effects of these methods. Moreover, when choosing to utilize EMA technology, researchers might benefit from critically thinking about the outcome variables of interest. In this study, the EMA approach did not influence risk perceptions, and had we not also inquired about feelings of worry, we would not have identified reactive effects. However, our findings may be attributable to the specific methods used. Specifically, while monitoring participants were not asked to think about the consequences of their smoking, but to simply list the thoughts they had experienced. It is feasible that instructions encouraging smokers to think about the meaning of the statements may result in increased worry, as we have found when using EMA to present smoking messages to smokers (Magnan et al., 2009). Additionally, smokers were forced to attend to each thought only once a day during data collection.

This study is different from other investigations of EMA reactivity. First, we were interested in reactivity of motivational constructs of risk perceptions and worry as opposed to behavioral or affective reactivity (e.g., change in smoking behavior, change in urges). Moreover, our definition of reactivity was based on the degree of change in intensity of one's worry or risk perceptions (i.e., worrying more/less intensely) rather than on the degree of change in the *frequency* of one's worry and risk perceptions (i.e., worrying more/less often). The latter operationalization is more typical of reactivity work (but see also Rowan et al., 2007). Second, we included a non-EMA control group to which outcomes could be compared. Many other investigations of EMA that find some evidence for reactivity do not include a control group (e.g., Shiffman, 1996; 1997) but rather compare pretest to posttest changes in behavior or other constructs. Without a control group, it is difficult to determine if the change in behavior is due to the EMA procedures or some other facet of the study (e.g., completing multiple questionnaires about their behavior in the lab). Additionally, as opposed to monitoring their behavior or smoking urges, smokers listed the negative thoughts they had about smoking up to five times daily. This procedure could have specifically targeted worry perceptions and resulted in reactivity, whereas other EMA procedures may not.

Limitations and Conclusions

Importantly, although smokers reported their motivation to quit and if they noticed a change in their smoking behavior at the weekly assessments, we did not ask smokers to monitor every cigarette they smoked, to respond to assessments regarding their negative thoughts after every cigarette, or to report their smoking behavior during the course of the study. Thus, we cannot answer the question of *behavioral* reactivity to EMA self-monitoring. Additionally, although we found some evidence that the effect of self-monitoring on the subjective experience of worrying about smoking may translate to a change in motivation to quit and smoking behavior, we are cautious about placing too much emphasis on these relationships. Ultimately, further work is needed to specifically address the question of behavioral reactivity to EMA procedures and whether the act of self-monitoring will translate to smoking behavior change.

Another issue is that the control group in this study did not engage in self-monitoring during the course of the study. Thus, it is unclear whether it is self-monitoring of negative thoughts about smoking that led to the current outcomes or if it is something unique to self-monitoring generally. One solution to this problem would be to include a third group that also self-monitored about something other than smoking. Relatedly, because control smokers did not engage in self-monitoring, they do not have EMA data which prohibits comparisons of EMA data between the two conditions. Rather, we relied on the global questionnaire assessments of perceived risk and worry. Because EMA data were not used, the sample size could have been a limiting factor. It is also tempting to attribute the current findings to the frequency with which smokers were required to engage in self-monitoring (up to five times daily). However, the frequency of self-monitoring in the current investigation was low relative to other research addressing EMA reactivity. For example, Litt et al. (1998) had drinkers attend to eight random prompts daily for 21 days, Collins et al., (1998) had heavy drinkers complete questionnaires after six daily random prompts, one morning assessment, and before and after each drinking episode for eight weeks. Hufford et al. (2002) had undergraduate drinkers answer questions after five daily random prompts, once in the morning and end of day of each day, and before and after a drinking event or experiencing temptations to drink. Within the smoking EMA literature, Rowan et al (2007) had smokers attend to EMA questionnaires after four random prompts each day for up to six weeks, and Shiffman et al. (1996) had ex-smokers answer questions after approximately five random prompts per day, and after each lapse and temptation episodes for four weeks.

Clearly, more research is needed to determine in which situations and contexts reactivity to EMA is most likely. Most reactivity work, including our own, focuses on special populations (e.g., highly addicted smokers, smokers who were attempting a quit attempt, alcoholic or problem drinkers). Thus, it is not clear how generalizable these effects are to other populations. It is feasible that reactivity is different among individuals who have a more invested interest in the behaviors that are being monitored (e.g., experiencing withdrawal, strong urge).

Although potential for reactivity to EMA is something of which researchers should be cautious, there are several advantages to EMA. In addition to problems with recall, global reports of smoking constructs (retrospective, cross-sectional, or prospective) merely allow for the investigation of global relationships and does not capture variability in these experiences. For example, on a global level, a person who experiences a great deal of negative affect may also smoke a great deal. EMA allows researchers to better dissect these global relationships to determine whether negative affect is tied to specific events, situations, or urges. In this way, we can determine what other factors contribute to the likelihood that a craving ultimately leads to a smoking event. EMA is increasingly used in other behavioral domains (alcohol, exercise, eating), and thus, it is important to understand the cognitive and emotional impact of daily self-monitoring as it could have repercussion for behavior change. The current study is one of a few to suggest that EMA may be reactive on a motivational level.

Acknowledgments

The research was supported by grants K05 CA92633 and R21 CA098962 from the National Cancer Institute to Kevin D. McCaul. We wish to thank Josh Smyth for his helpful comments and suggestions on an earlier draft of this manuscript.

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Table 1

Pretest variables and posttest risk and worry items by condition

	Control (n = 29)	EMA (n = 88)
	M (SD)	M (SD)
Age	31.1 (14.01)	29.05 (12.52)
Gender (% female)	51.7% (n = 15)	42.0% (n = 37)
Community Smokers (%)	48.3% (n = 14)	47.7% (n = 42)
White/Caucasian (%)	96.6% (n = 28)	94.3% (n = 83)
Age at smoking initiation	16.17 (4.47)	15.23 (3.41)
Cigarettes per day	17.41 (8.22)	16.45 (8.32)
Number of quit attempts	5.91 (9.90)	5.40 (7.39)
Addiction (FTND-R; 1–10)	4.31 (2.16)	3.81 (2.30)
Intrusive Thoughts (0–35)	6.72 (4.97)	9.51 (7.08)
PSWQ (16–18)	48.83 (14.97)	48.41 (14.84)
Contemplation to quit (0–11)	4.97 (2.50)	5.70 (2.67)
<u>Pretest Perceived Risk</u>		
% risk of developing medical condition	71.6% (22.9)	71.2% (21.7)
Comparative risk (1–7)	3.26 (.79)	3.24 (.64)
Risk to others (1–5)	4.83 (1.17)	4.79 (1.31)
<u>Pretest Worry</u>		
Worry about medical condition (1–7)	3.50 (1.51)	4.16 (1.56)
Worry about harming others (1–7)	3.86 (1.66)	4.02 (1.54)
<u>Posttest Perceived Risk</u>		
% risk of developing medical condition	65.14 (22.8)	68.57 (23.8)
Comparative risk (1–5)	3.24 (.74)	3.14 (.78)
Risk to others (1–7)	4.12 (1.71)	4.21 (1.55)
<u>Posttest Worry</u>		
Worry about medical condition (1–7)	4.14 (1.57)	3.94 (1.65)
Worry about harming others (1–7)	4.15 (1.96)	3.66 (1.66)

Table 2

Partial correlations between risk/worry items and posttest and follow-up outcomes

	Posttest Motivation to Quit		Follow-up Cigs Per Day		Follow-up # of quit attempts	
	<i>r</i>	<i>p</i> (DF)	<i>r</i>	<i>p</i> (DF)	<i>r</i>	<i>p</i> (DF)
Posttest Worry about Medical Condition						
Control	0.21	.28 (26)	−0.09	.80 (9)	0.46	.14 (10)
EMA	0.40	.00 (85)	−0.05	.70 (57)	−0.12	.37 (56)
Posttest Worry about Harming Others						
Control	0.11	.57 (26)	−0.14	.67 (9)	0.14	.67 (10)
EMA	0.51	.00 (85)	−0.24	.07 (57)	0.10	.48 (56)

Note: Each analysis controls for pretest levels of the risk/worry variable.