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Do Resisted Temptations During Smoking Cessation Deplete or Augment Self-Control Resources?

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Abstract

A resource depletion model of self-control posits that for some period following performance of a task requiring self-control, self-control will be reduced and thus less available for use in a subsequent task. Using two substantial data sets collected in real time from individuals who were trying to quit smoking (1660 and 9516 temptation episodes collected from 61 and 248 individuals), we evaluated this model by testing the hypotheses that the number, and length of resisted temptations and the intensity of the most recently reported urge during the prior four hours predict decreased self-control and increased likelihood of lapsing. Survival and multilevel regression modeling showed that contrary to the hypothesis, the number of recently resisted temptations predicted a lower risk of lapsing in both samples. Duration of resisted temptations had no significant effect in either sample. Intensity of most recently reported urge predicted lapsing in one data set, but not in the other. Overall, there was little support for the resource depletion model. The protective effect of successfully resisting temptations was an unexpected but provocative finding.

Keywords

smoking cessation; self-control; resource depletion; ecological momentary assessment

It has been nearly 30 years since Marlatt and Gordon's (Marlatt & Gordon, 1980) study of relapse crises launched a field of investigation into the process of drug abuse cessation and relapse. A variety of theories have been used to explain and predict the circumstances under which people who have committed themselves to abstain from addictive behaviors resist or succumb to temptations. They include the abstinence violation effect (Marlatt & Gordon, 1980), reversal theory (Apter, 1982; O'Connell, Schwartz, Gerkovich, Bott, & Shiffman, 2004), and self-medication for negative affect (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Kassel, Stroud, & Paronis, 2003) among others. Most of these formulations explain lapsing or resisting in terms of local variables in the relapse crises themselves, what Shiffman (1989; 2005) called precipitating factors. It is possible, however, that recent cessation experiences occurring prior to the actual temptation situation also influence its outcome (Shiffman, 1989; 2005; Shiffman & Waters, 2004). Although precipitating variables are crucial to understanding lapses, more distal variables operating prior to the lapse episode have also been shown to be influential (Shiffman, 1989). Such variables include fluctuations in attributions, negative affect, and self-efficacy (Curry, Marlatt, & Gordon, 1987; Shiffman et

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al., 2000; Shiffman & Waters, 2004). Research and theorizing by Muraven and Baumeister (2000) suggest that another variable responsible for lapsing during a cessation attempt is self-control strength.

Resource Depletion Model of Self-Control

Muraven and Baumeister (2000) defined self-control as overriding or inhibiting immediate desires or delaying of gratification in order to maximize the individual's long-term best interests. Their model views self-control as a limited, depletable, yet renewable resource. A prediction of the resource depletion model of self-control is that after one difficult attempt at self-control, subsequent attempts at self-control will be less likely to succeed, even if they tap a completely different domain of self-control. For example, Baumeister and his colleagues (Baumeister, Bratslavsky, Muraven, & Tice, 1998) conducted an experiment in which individuals were deprived of food and then exposed to tempting chocolate treats. Some were permitted to eat the treats and others were presented with the chocolate treats plus a bowl of radishes and asked only to eat the radishes, which they complied with. A third group was not exposed to either food. Compared to those who ate the treats and those not exposed to the treats, those who resisted the temptation to eat the treats showed considerable performance decrements in persistence on unsolvable puzzles, a task that the authors assume required self-control to continue despite discouraging and frustrating failure.

Further support for this model has been reported in a variety of other laboratory studies (Baumeister et al., 1998; Muraven, Collins, & Nienhaus, 2002; Muraven & Shmueli, 2006; Muraven, Tice, & Baumeister, 1998; Richeson & Shelton, 2003; Richeson & Trawalter, 2005; Vohs & Heatherton, 2000). A few studies have been done in real-world contexts. Muraven and colleagues (Muraven, Collins, Shiffman, & Paty, 2005) showed that underage social drinkers were more likely to violate their self-imposed drinking limit on days when they had higher demands to regulate their moods, deal with stress, or control their thoughts. Oaten and Cheng (2005) found that students under exam stress showed impaired performance in a laboratory self-control task, increases in unhealthy habits, and decreases in healthy habits compared to another group that was not under exam stress. However, some prior studies have suggested that self-control depletion may be better explained as an expectancy effect that can be manipulated or over-ridden (Martijn, Tenbult, Merckelbach, Dreezens, & de Vries, 2002; Mukhopadhyay & Johar, 2005; Webb & Sheeran, 2003). Muraven and Slessareva (2003) have shown in laboratory studies that monetary or altruistic motives can overcome the effects of self-control depletion.

Thus, there is an impressive research literature reporting considerable, but not universal, support for the resource depletion model of self-control advanced by Muraven and Baumeister (2000). This literature suggests that relatively short exercises of self-control can exhaust resources and lead to failures of self-control in a subsequent test. These findings could describe the challenge facing the smoker or drug user who must engage in numerous instances of self-control throughout a cessation attempt.

The task of quitting smoking and maintaining abstinence presents quitters with repeated and sustained self-control challenges. Successful quitting requires combating and resisting sometimes frequent, often intense, temptations to smoke (O'Connell et al., 2004; Shiffman, 2005; Shiffman, Engberg et al., 1997). Research has shown that these episodes occur frequently during the early stages of quitting. While such episodes often progress to smoking, the data suggest that many smokers can resist temptations and maintain abstinence (O'Connell & Martin, 1987; O'Connell et al., 2004; Shiffman, 1984; Shiffman, Paty, Gnys, Kassell, & Hickcox, 1996; Shiffman, Read, & Jarvik, 1985). Although previous episodes of smoking during a cessation attempt—referred to as lapses—have been shown to be highly predictive of

eventual relapse (Brandon, Tiffany, Obremski, & Baker, 1990), little research has been done on the effects of previously resisted temptations or on short-term prospective effects of urge levels.

In this study, we sought to apply the resource depletion model of self-control to attempts at smoking cessation carried out by participants in their natural environments with data collected in real time. In these analyses, we focused on testing the key implication of the resource-depletion model, namely that tasks requiring self-control will deplete self-control resources and thus impede subsequent self-control performance. Our “outcome” indicating self-control failure is the occurrence of a lapse episode (i.e., smoking despite commitment to maintain abstinence). We use two substantial data sets to conduct secondary data analyses. We operationalize prior self-control demand in three ways, leading to three specific hypotheses addressed by our analyses:

Hypothesis I

A greater number of recent episodes during which the temptation to smoke is resisted (resists) will be associated with increased lapse risk. Each resist episode is conceptualized as requiring the exercise of self-control to maintain abstinence, and thus to deplete self-control resources.

Hypothesis II

A greater amount of time spent in recent resist episodes will be associated with increased lapse risk. Longer episodes are seen as requiring more extended exercise of self-control and thus to create a greater depletion of self-control resources.

Hypothesis III

Higher urge intensity in the preceding interval will be associated with increased lapse risk. We conceptualize recent urge intensity as an indicator of the demand for self-control effort required to maintain abstinence.

METHOD

In this study we use detailed self-report methods and a prospective correlational design. The first part of this section describes the two studies that generated the data bases used in the project. Then, the statistical procedures used to address the hypotheses are described.

The Data Bases

In order to test the hypotheses derived from the resource depletion model of self-control, we used two unique data sets: (1) Quit (QT), generated in a study conducted by the third author at the University of Pittsburgh; and (2) RESIST, generated in a study conducted by the first author at the University of Kansas Medical Center. The commonalities between the data sets are described first and then the specific features of each data set are discussed.

Commonalities—The data sets to be analyzed in the present study were produced in two similar ecological momentary assessment (EMA) studies. In these studies participants used palmtop computers to answer questions about their experiences during smoking cessation. EMA is defined as the use of monitoring strategies to assess phenomena at the moment they occur in natural settings (Stone & Shiffman, 1994). Table 1 compares significant elements for the two studies. Both used a computer-based data collection system, called the Electronic Diary (ED), developed by Shiffman and his associates (Shiffman et al., 1994). The ED system was implemented on a PSION Organizer II LZ 64 (PSION, Ltd., London, England), a hand-held computer with a 4-line, 20-character per line LCD screen, a clock/calendar, and an audio

speaker. The computer was 5.6 in. by 3.1 in. by 1.1 in., weighed 8.8 oz, and was powered by a 9V battery. Data were recorded on computer chips in the ED. Software was developed specifically for each project.

In this paper, we examine two kinds of episodic events. The term *resist* is used to describe a highly tempting episode in which the participant did not smoke. A *lapse* is a tempting episode when the participant smoked any amount, even a puff, after quitting smoking. The term *temptation episode* encompasses both resists and lapses. While *lapse* is used to describe smoking in a single temptation episode, the term *relapse* is used to describe the resumption of smoking, which was operationalized as either smoking five or more cigarettes on three consecutive days or a total of thirty lapses.

In both studies, participants self-initiated entries soon after they experienced a temptation episode, whether it was a resist or a lapse. In addition to the self-initiated data, both studies periodically collected data on participants' states by beeping them at random about 5 times per day (Csikszentmihalyi & Larson, 1987; Stone & Shiffman, 1994). Participants were not prompted for these random assessments for 15 minutes following a temptation episode. The purpose of the random assessments was to gather data when participants were not experiencing temptations. If the respondents indicated that they were in the process of a resist or lapse or had recently experienced one that was not yet recorded, the random assessment was converted to a temptation episode and the ED administered the appropriate lapse or resist protocol. Otherwise, random assessments were used in the current study only when they provided the most recent prior urge level to the target episode in the statistical analysis of Hypothesis III. We chose the most recently reported prior urge level, even if it occurred during a random prompt, to be indicative of depletion because this indexed the urge intensity that was nearest to, and thus most likely to affect the target episode. For all episodes included in this study, the ED administered a questionnaire. In both studies, the questionnaire included items assessing the duration of temptation episode (on a 7 point ordinal scale ranging from < 1 min to > 1 hour) and the urge level during the temptation episode or just prior to the random assessment (on a 0–10 scale). Computerized data entry significantly reduced missing data.

Differences—The study protocols differed in the range of treatment provided to participants. In the Pittsburgh study (QT), all participants were enrolled in a standard treatment as part of the study protocol, and received uniform behavioral treatment. In the Kansas City study (RESIST), half the participants were enrolled in community treatment (which varied across treatment sites), and half were not receiving treatment for smoking cessation. These differences were unlikely to have an effect on the current study because the smoking cessation treatments did not provide specific training on increasing self-control strength, which, according to the theorists, includes practice in self-control exercises over several days or weeks (Muraven, Baumeister, & Tice, 1999).

The QT protocol and the RESIST protocol differed somewhat in their definitions of a first lapse. The QT protocol required that the respondent be abstinent for 24 hours after quitting before they were “eligible” to have a first lapse. Prior to that time, the ED operated in a pre-quit mode and did not assess lapses in the detail that was used after the 24-hour window. In the RESIST data set, however, the first lapse could occur any time after the respondent had indicated the start of the quit attempt by entering “I Quit” into the computer. Thus, the RESIST study includes more early lapses.

QT Study—The original aims of the QT study included analysis of circumstances surrounding initial lapse episodes and exploration of the association between these situations and baseline smoking patterns. The investigators also evaluated the role of craving in relapse and assessed

how the after-effects of a lapse affect subsequent progression towards relapse, testing components of Marlatt's Abstinence Violation Effect Model (Marlatt, 1985).

Participants: Participants were recruited through radio and newspaper advertisements and editorial coverage of the study. Data from 248 participants are available for analysis. This sample represents a subset of 329 participants who enrolled in the study. Eighty-one participants either dropped out prior to their cessation attempt or were excluded because they did not stop smoking for 24 hours, as required for inclusion in analyses of temptations. Thirty-four (14%) of the participants used the nicotine patch. Table 1 shows the demographic characteristics of the sample.

Procedures: Participants completed a battery of baseline questionnaires. They were enrolled in a smoking cessation program with a scheduled quit date 17 days later, and attended 1-hour group smoking cessation therapy sessions on days 1, 3, 8, 15, 17, 22, 29, 36, and 43. Participants were trained on ED procedures for monitoring ad lib baseline smoking on day 1, and on monitoring quit experience on Day 15. On visits starting on day 3, participants' data were uploaded and reviewed while participants were in treatment sessions, and participants received both group and individual feedback regarding compliance. Participants monitored their ad lib smoking before the quit date (up to day 17), and monitored their experience of quitting for approximately four weeks thereafter. Participants were considered to have quit after having abstained for 24 hours, as recorded by the ED, and confirmed by the participant. Starting at the target quit date, participants were to record resist episodes. Once participants were considered to have quit smoking, participants were also to record lapses. In the QT study, the ED administered a 66-item questionnaire, comprised of several scales, including an item assessing urge level during the temptation episode (during a resist and immediately prior to a lapse) or before the random prompt.

The QT data set consists of over 9,500 temptation episodes—1,597 lapses and 7,919 resists—reported by the 248 participants included in the present analyses. The data set also includes 24,885 random assessments. Numerous publications have been generated from this study (Shiffman, Engberg et al., 1997; Shiffman, Gnys et al., 1996; Shiffman, Hickcox et al., 1996; Shiffman, Hickcox, Paty, Gnys, Kassel et al., 1997; Shiffman, Hickcox, Paty, Gnys, Richards et al., 1997; Shiffman, Hufford et al., 1997; Shiffman, Paty et al., 1996; Shiffman & Waters, 2004). They are summarized by Shiffman (2005). None of these reports have addressed the particular issues examined in the current paper.

RESIST Study—The original aim of RESIST was to use an EMA protocol to address questions concerning the frequency of occurrence of different types of coping strategies and the effect of coping strategy use and reversal theory states (Apter, 1982; 2001) on success in smoking cessation.

Participants: Approximately 292 smokers interested in quitting were informed about the study either during the introductory sessions of smoking cessation classes or when they called in response to radio and print advertisements for smokers interested in quitting on their own. Of those who heard the recruitment presentation, 93 (31.8%) enrolled in the study, 29 (10%) agreed to participate but never appeared for training, and 170 (58%) declined to participate. It is probable that a substantial portion of those who declined had decided not to quit smoking in the next 30 days. Some who were invited during the smoking cessation class had not yet committed to class attendance or to a quit attempt. The radio and print advertisements specified that we were recruiting those who were quitting on their own. However, it was clear that some callers were interested in receiving help in quitting smoking, possibly in the form of free medication, and decided not to enter the study when they learned that such help would not be provided. Of the 93 participants recruited for this study, 61 (66%) were included in the present

analyses. Of the 32 participants who were excluded from the data set, 13 withdrew from the study, 15 were noncompliant with study procedures, and four were excluded for other reasons (use of chewing tobacco, decision to achieve smoking reduction rather than cessation, equipment malfunction, and cessation 13 days prior to starting the study). Of those included, 22 (36%) used nicotine replacement therapy: 9 used nicotine gum alone, 11 used the patch alone, and two used both. See Table 1 for the demographic characteristics of the sample.

Procedures: Participants who agreed to be in the study completed the Baseline Questionnaire and then met with investigators at least two days prior to their quit date for a 2- to 3-hour training session on the use of the ED and the tape recorder. They practiced using the equipment on the days prior to their quitting smoking and entered into the ED their time of quitting. Within 24 hours of their quitting smoking, and again on Day 8 and Day 15, they met with the investigators, who transferred their data from the ED while participants completed questionnaires concerning their anticipatory strategies and their symptoms of depression and gave breath samples for carbon monoxide testing. Participants remained in the study for approximately two weeks (maximum of 18 days) or until they decided to end their attempt to quit smoking whichever occurred first. In the RESIST study, the ED administered a 42-item questionnaire, comprised of several scales, including an item assessing urge level prior to coping or lapsing, or immediately prior to a random prompt.

The RESIST data set consists of 1,660 temptation episodes, which includes 266 lapses and 1,394 resists. In addition, the data set contains 3,652 random assessments. Other results of the study have been reported (Catley, O'Connell, & Shiffman, 2000; O'Connell, Gerkovich, Bott, Cook, & Shiffman, 2002; O'Connell, Hosein, Schwartz, & Leibowitz, 2007; O'Connell et al., 2004). None of these reports have addressed the particular issues examined in this paper.

Data Analyses—QT and RESIST data were analyzed separately. All data reported after the first five lapses of a relapse (defined as smoking 5 or more cigarettes on 3 consecutive days) were excluded from analyses, resulting in truncating the reporting period for one participant from RESIST and 75 participants from QT. Some subjects reported numerous lapses, but never met the criterion for relapse. We suspected that later lapses in these subjects may be influenced by different processes than earlier lapses. They may, for instance, represent a tacit and gradual decision to cut down rather than quit smoking. We arbitrarily decided that smoking 30 or more cigarettes was indicative of such process and excluded all data following a 30th lapse from analyses. Had we not set some upper limit on the number of lapses that one individual could contribute to the analysis, a small number of subjects with a very large number of lapses (3 subjects each reported more than 100 lapses without meeting the criterion for relapse) would have dominated the results. No one in RESIST had data excluded for this reason, but five QT participants had the latter portion of their data excluded. Participation in the QT study lasted 28 days compared to about 14 for the RESIST study. Thus more lapses and relapses were observed among QT participants than among RESIST participants.

Proponents of the resource depletion model of self-control have not been specific about how long it takes to recover from a depleting episode. Most studies have administered the test of self-control depletion within an hour of the depletion manipulation. However, the implication has been that the effects last longer than this and may even require sleep to restore self-control strength (Muraven et al., 2005). In field studies of self-control, the effects were shown to last longer than four hours in that self-control demands during the day were related to violating a drinking limit in the evening (Muraven et al., 2005), and examination stress over several days (Oaten & Cheng, 2005) predicted deterioration of self-control behaviors during that period. After consulting with Muraven and Baumeister, we chose a four-hour time frame to investigate the self-control depleting effects of resisting temptations to smoke. This time-frame allows us to investigate the effects of strong temptations on subsequent lapsing.

The data from both random assessments and temptation episodes were used to construct an event history data set with time-varying covariates covering the entire awake period of each day for each participant. This event history is created by subdividing the entire awake period into smaller periods, defined by a begin-time and end-time, during which the predictors remain constant; each of these periods is assigned a value of 1 if a lapse occurred at the end-time, 0 otherwise. The analyses aimed to predict and model how the risk of lapsing is related to the predictors. In our analyses, the predictors consisted of (1) the number of resist episodes that occurred during the preceding four hours, (2) the cumulative duration of those episodes, and (3) the most recently assessed prior urge level that day. Thus, if a participant had two resist episodes in the preceding four hours, the frequency was two, the duration equaled the sum of the estimated duration times for each episode, and the urge level was that during the most recent random assessment or resist episode.

When a participant had no resist episode during the preceding four hours, the frequency and duration predictors were scored as zero. In defining these variables for the morning hours, we assumed that participants did not experience resist episodes during sleep. In addition, the prior urge level predictor was treated as missing for the period between waking up in the morning and the first temptation episode or random assessment. Because lapses that occur shortly after a previous lapse are likely to be influenced by additional factors (priming, abstinence violation effects, etc), the 4-hour period following a lapse was deleted from the event history; however, random prompts and resist episodes reported during this 4-hour period were used to construct the predictor variables (prior urge level, number of resists, and duration of resists) for the risk period that began 4 hours after the lapse. Of the total awake time, 4.6% and 6.9% was excluded in QT and RESIST, respectively, due to this 4-hour post-lapse exclusion rule. An additional 17.2% and 12.9% of the total awake time, almost all of it in the morning prior to the first report, was excluded due to the absence of a prior urge measure for that day.

All three hypotheses were tested for each data set with a single Cox proportional hazards regression analysis (survival analysis) that allowed modeling of more than one lapse event for the same person (Cox & Oakes, 1984; Kalbfleisch & Prentice, 1980; Tuma & Hannan, 1984). This type of analysis uses the time until an event (i.e., a lapse) occurs, to estimate the extent to which the risk of an event is associated with each predictor. The procedure is able to handle right censoring, such as occurs for the one-third of subjects in each sample who never lapsed during the follow-up period. The risk of lapsing was modeled as a function of the three predictors, and the relative risk associated with a 1-point difference on a predictor is reported as a hazard ratio (HR). Heuristically, survival analysis considers the risk of a lapse occurring at any given moment and estimates proportionately how much greater (or lower) this risk is as a predictor increases in value. SAS was used to construct the event history data set and conduct the analyses (Proc PHREG).

One of the predictor variables in our models was recent urge intensity, reported during the assessment preceding the target episode, which was conceptualized as draining self-control resources. However, the recent urge intensity could also be associated with lapsing simply because recent experience of intense urges is correlated with *current* experience of intense urges, which in turn promotes lapsing. To test this alternative model, we conducted additional analyses in which we modeled the outcome of a temptation episode (resist/lapse) using the hypothesized predictors (the number and duration of resists that had occurred in the preceding four hours and the urge level reported in the most recent previous report), controlling for the urge level of the target episode. However, Cox proportional hazards regression analyses (survival analyses) are designed to test “prospective effects” and cannot test (or control for) the effect of hypothesized predictors measured at the time of the target event. Therefore, we used an alternative analytic strategy, multi-level logistic regression analysis (Gibbons et al., 1993; Hedeker, Gibbons, & Flay, 1994). In order to verify that there were no major differences

in results that could be attributed to analytic method, we initially conducted a multi-level logistic regression analysis using the same predictors as the survival analysis and treating a current temptation accompanied by a previous resist or random assessment that occurred within the preceding four hours as the unit of analysis. Unlike the survival analysis which tests potential risk factors for lapsing at (almost) any time throughout the waking day, this analysis examines whether the same factors predict the conditional probability of lapsing, given a temptation episode. Multi-level modeling, using the MIXOR software (Hedeker & Gibbons, 1996), was employed to handle the multiple temptations per participant properly (Schwartz & Stone, 1998). Despite the conceptual differences and the difference in the unit of analysis between the two statistical methods, they led to very similar conclusions. We therefore proceeded to control for current urge in the multi-level logistic regression analysis to test whether prior urge has a significant effect independent of current urge.

Because the risk of smoking increases with each lapse, albeit non-linearly, all analyses control for number of prior lapses (log transformed after the addition of a small constant [.17], recommended by Tukey, to deal with zeros). Additional analyses using multiplicative interactions were also carried out to determine whether the effect of any of the primary predictors increased/decreased as the number of prior lapses increased. All statistical tests were two-tailed.

RESULTS

Table 2 shows the results of the survival analyses for both the QT and RESIST data sets, which tested all three hypotheses simultaneously. The multi-level logistic regression analyses that control for the effect of urge level at the time of a temptation episode are reported in Table 3.

Hypothesis I: Effect of number of resist episodes

In the QT data set the survival analyses indicated that the hypothesis that a greater number of resist episodes in the preceding interval will be associated with increased lapse risk was not supported. As the upper left panel of Table 2 indicates, the relative hazard for lapsing *declined* as the number of resists in the prior four hours increased (HR = .89 per resist, $p = .02$). Further investigation of whether there was a threshold number of resists in the prior four hours that affected the risk of lapsing found that with no resists as a reference, the relative hazard of lapsing was about 25% less (HR = .74, CI: .61, .89, $p < .002$) when at least one resist had been reported in the prior four hours. Though not critical to our primary test of this hypothesis, we note that the number of recent prior resist episodes remained a significant predictor of lapses in the logistic regression analysis, where the powerful effect of current urge level was controlled (See Table 3).

The RESIST data showed similar results for this hypothesis. The number of resists in the prior four hours was *protective* (HR = .60 per resist, $p = .002$). We investigated whether there was a threshold number of resists in the prior four hours that affected the risk of lapsing and found that with no resists as a reference, the relative hazard (hazard ratio, HR) of lapsing was about half (HR = .54, CI: .36, .83, $p < .005$) when at least one resist had been reported in the prior four hours. Thus, contrary to the resource depletion model prediction, participants who reported more resist episodes seem to have *stronger* rather than weaker self-control. As Table 3 indicates, this effect was also significant in the logistic regression model that controlled for level of current urge. Thus, this hypothesis was not supported in either study. The analyses showed results that were clearly opposite to what had been predicted, indicating that the occurrence of at least one resist in the prior four hours was significantly predictive of successful resisting in both studies. The effect of number of prior resists did not change as the number of lapses increased; this interaction was nonsignificant when added to each of the models.

Hypothesis II. The effect of duration of resists

The survival analyses for both QT and RESIST data sets yielded no support for the hypothesis that a greater amount of time spent in resist episodes during the preceding four hours will be associated with increased lapse risk (Table 2). While the effect of the duration variable approached statistical significance in the logistic regression analysis for the QT sample (Table 3; OR = 1.01, $p = .08$), it was not at all significant for RESIST. Thus little support is shown for this hypothesis. The duration of resists in the prior four hours does not appear to be independently predictive of lapsing.

Duration of resists and number of resists are, as expected, positively correlated (Pearson r is 0.39 for QT and 0.56 for RESIST). Their rank order correlation is very large (Spearman r is 0.97 for QT and 0.94 for RESIST). What the analyses in Tables 2 and 3 show is number of resists is strongly related to the risk of lapsing when one controls for duration of resists, but the opposite is not true. In additional analyses (not shown), where the effect of each is estimated without controlling for the other, duration of resists during the preceding 4 hours is also associated with a reduced risk of lapsing, but this relationship is not as strong as that for number of resists.

Hypothesis III: Effect of prior urge level

In the QT data set the survival analyses supported the hypothesis that higher urge level in the preceding interval is associated with increased lapse risk. Prior urge level was significantly predictive of lapsing with an 11% increase in the hazard of lapsing *with each one-point increase* in the level of prior urge. Results for the RESIST data replicate those of the QT analyses. Prior urge level was a significant positive predictor of the likelihood of lapsing, with a 12% increase in the hazard of lapsing for each one-point increase in prior urge level. As shown in the bottom panel of Table 2, there was a significant “negative” interaction (HR = .96, $p = .007$) of prior urge level with number of prior lapses in RESIST, indicating that the effect of prior urge on the risk of lapsing declined as the number of lapses increased. None of the interactions reached significance in the QT data set.

As described earlier, we investigated whether prior urge level continued to have an independent effect when current urge level at the time of the target temptation episode was controlled. This was done by conducting parallel analyses using multilevel logistic regression analysis. The analysis predicted whether a temptation episode would be a lapse (versus a resist), using the same predictors as in the survival analyses with the addition of current urge level. As expected, the results of multi-level logistic regression analyses were very similar to that of the survival analysis when current urge was not controlled (results not shown). When current urge, a powerful predictor of whether a temptation will be a lapse, is included in the equation for the QT data (Table 3, left side), the effect of prior urge level becomes nonsignificant. While the effect of prior urge level does not vary by the number of prior lapses (i.e., the interaction between prior urge and number of prior lapses was nonsignificant), an additional analysis not shown in the table revealed that the effect of current urge on the risk of a temptation being a lapse increased as the number of prior lapses increased (i.e. interaction between current urge and number of prior lapses was significant, $p = .01$). The right side of Table 3 shows the results of the parallel multilevel logistic regression analysis for RESIST. When current urge is included in the equation, it is a powerful predictor of whether the temptation is a lapse. Nevertheless, the effect of prior urge level remains statistically significant.

Thus, support for the hypothesis that higher urge level in the preceding interval will be associated with increased lapse risk was ambiguous. Both data sets showed an effect in the survival analyses and in the multi-level logistic regression analyses prior to controlling for

current urge level, but after controlling for the effect of current urge level, prior urge level remained a significant predictor only for the RESIST data.

An issue that arises when analyzing multiple data sets concerns the consistency of findings. Comparing the results of the QT and RESIST studies in both Table 2 and Table 3 reveals that, in almost every case, the confidence intervals for the estimates overlap, indicating that the relationships under investigation are similar in both studies.

DISCUSSION

We tested hypotheses derived from the resource-depletion model (Muraven & Baumeister, 2000) as they apply to smoking lapses. The model posits that using self-control to resist strong temptations temporarily depletes a resource that is needed to resist a subsequent temptation. Using two large data sets representing smoking temptations and lapses in real-world attempts to quit smoking, we have found almost no support for the model. Although the hypothesis related to level of prior urge was significant in one of the data sets, the hypotheses concerning duration and number of resists were not supported.

The lack of support for the hypothesis that longer resists would drain self-control resources to a greater extent may be due to problems measuring duration. The respondents used ordinal level scales with ranges for each alternative to indicate how long the episode lasted. The duration variable was calculated from these reports using the midpoint in the ranges. It may be that respondents who are quitting smoking were unable to estimate accurately the duration of their temptations or that the algorithms for calculating the duration misrepresented the data.

In this study, the most recent prior urge level was used as an index of self-control demand, under the assumption that higher urges require more self-control than lower urges. Both studies show an increase in lapse risk related to recent urge intensity, but this effect persists after controlling current urge only in RESIST. There are at least two ways to interpret these results: (1) that prior high urges make one more vulnerable to future high urges through a causal, perhaps resource depletion, mechanism, or (2) that urge levels are simply serially correlated, and prior urge was only a significant predictor because it is a proxy for current urge. To the extent that one interprets the urge data as evidence of a resource depletion effect, the fact that this measure was based on the most recent previous report rather than a summary of all reports made during any given four-hour period, as the other two variables were, may indicate that the resource depletion effect is in fact a very short-term effect. Unfortunately, the present data do not enable us to empirically distinguish among these interpretations.

The finding, replicated in both studies, that when other predictors are controlled, number of resists in the prior four hours reduces the risk of lapsing is a direct challenge to a resource depletion model of self-control. It suggests that recently resisting the urge to smoke enhances the likelihood of resisting rather than the likelihood of lapsing. It is important to point out here that the effects are not due to between-person differences. Specifically, the results do not suggest that people who report numerous resists are less likely to lapse. Rather they suggest that respondents are less likely to lapse during the four hours following the report of resists than they are at other times during the cessation attempt. This result might be considered an effect of practicing self-control efforts. Muraven and Baumeister (Muraven & Baumeister, 2000) posited that it was possible to increase self-control resources with practice. Indeed, Muraven and his colleagues (Muraven et al., 1999) showed that practicing self-control (in another domain) did limit depletion effects, but the practice time occurred over the prior two weeks, not within the same day. Moreover, positing that short-term practice effects could limit depletion would lead to contradictory hypotheses for the resource depletion model of self-control. Practice effects on increasing self-control resources would not be expected to accrue

within four hours and such effects would not then be expected to dissipate during periods when fewer temptations led the same respondents to lapse.

One explanation for the finding that prior resists reduce the probability of lapsing is that when participants are experiencing and reporting resists, they may actually be paying more attention to the cessation process. If so, this may also mean that the salience of their quit attempt remains high along with their motivation for quitting. In addition, when respondents are attending to the cessation attempt they are less likely to be caught off guard by a temptation and may be more prepared to use coping strategies, which have been shown to be important in resisting temptations (O'Connell, Fears, Cook, & Gerkovich, 1991; O'Connell et al., 1998; O'Connell et al., 2004; Shiffman, 1984; Shiffman, Paty et al., 1996). Consistent with this, a previous study by Shiffman & Jarvik (1987) reported that smokers were more likely to engage in coping activities during temptation episodes that had been preceded by withdrawal symptoms, perhaps because experiencing symptoms put smokers "on alert" for further challenges. Alternatively, resisting the temptation to smoke may cause an increase in self-efficacy that carries over into the next episode, an interpretation consistent with Bandura's (1997) formulations and the relapse prevention model (Marlatt, 1985). However, studies of resists (Shiffman, Hickcox, Paty, Gnys, Kassel et al., 1997) have not demonstrated the expected boost in self-efficacy.

A possible explanation for the failure of the resource depletion model of self-control to account for our results is that almost all of the prior work on resource depletion has been based on studies in which the depletion manipulation was in a different domain than the outcome test of self-control (Baumeister et al., 1998; Muraven et al., 2002; Muraven & Shmueli, 2006; Muraven et al., 1998; Richeson & Shelton, 2003; Richeson & Trawalter, 2005; Vohs & Heatherton, 2000). For instance, the depletion manipulation might be to resist eating chocolate chip cookies and the outcome test involved persistence on frustrating tasks. In this study, however, the purported depleting event—a temptation to smoke—was exactly the same as the outcome event, except that the outcome could be a failure to resist. It is possible that it is only self-control tasks in different domains that are depleting, an interpretation that does not appear to be consistent with the description of the theory. However, Muraven and Slessareva (2003) have shown in laboratory studies that monetary or altruistic motives can overcome the effects of self-control depletion in different domains. In repeated personally-relevant depletion episodes in the same domain, such as those that were the focus of the present report, other processes, such as high motivation or increased coping may lead respondents to overcome depletion. These processes may not be operating when the depleting activity is in a different domain. It may also be the case that the smoking cessation treatment that most of the subjects received may have helped them to override depletion, perhaps by increasing their motivation. This motivation may be especially salient when respondents were frequently attending to temptation episodes and less salient during time periods when they were not attending to or experiencing temptations.

Limitations

This observational study has several limitations with respect to testing Muraven and Baumeister's resource depletion model of self-control. First, it may be that the four-hour time frame was not ideal for detecting depletion. It may be that self-control recovers in four hours and the effect is only demonstrable within an hour or less, the timeframe that seems to apply in most laboratory studies of the phenomenon. Our data, despite being extraordinarily intensive, are too sparse to allow analysis of the process hour by hour. Thus, the present protocol may be insensitive to detecting appropriate effects. Smokers who are quitting do not seem to experience the majority of temptations in such close proximity, or they may experience them as one long temptation. Even if they did experience many temptations in close proximity, they would probably not be able to take time to report them all during the course of the study. The

average number of temptations reported in a four-hour time frame in this study was 0.36 for QT and 0.47 for RESIST. Thus, the four-hour time frame is probably longer than most laboratory tests of this model. However, in two studies, (Muraven et al., 2005; Oaten & Cheng, 2005), the depleting effects of self-control tasks were shown to last longer than four hours, (e.g. from day time challenges to evening drinking).

Our methods rely substantially on subject compliance with timely reporting of temptation episodes. Failure to report resisted temptations are of special concern. Such failures could be the result of noncompliance with the study protocol or denial that resists are occurring. One explanation for the finding that experiencing a resist in the prior interval is related to lapse *prevention* is that reporting more resists may be indicative of periods when respondents were both better able to resist temptations and more compliant with the study protocol in terms of reporting these resists. Under this explanation one assumes that periods of compliance and noncompliance with the study protocol are associated with an equal likelihood of temptations. It may be that compliance with the study protocol by reporting the temptations is more likely to occur when people are also in the mode of resisting temptations and that noncompliance with the study protocol occurs when participants are prone to lapsing. This explanation assumes that while compliance with resist reporting falls off when one is prone to lapsing, compliance with lapse reporting remains adequate during the same time period. If resist reporting is subject to noncompliance, we suspect that the lapse reporting would be similarly affected. Another explanation for our findings may be subjects' denial that resisted temptations were occurring. Such denial could lead to less active enactment and practice of coping strategies resulting in eventual lapsing. Because it is not possible to document objectively whether participants experienced unreported temptations, it is virtually impossible to empirically rule out these explanations.

Conclusions

The resource depletion model of self-control as proposed by Muraven and Baumeister (Muraven & Baumeister, 2000) has received consistent support in a wide variety of areas. Thus, it is perplexing that the model was not supported in these two data sets documenting extensively the very types of consecutive self-control challenges that are often cited as typical of those faced in the real world and as subject to the effects of depletion. The problem may be that the data we used are not amenable to testing the theory, but it may also be that the theory is not applicable to real world experiences of consecutive self-control challenges.

The number of temptation episodes in the prior four hours, considered an index of resource depletion, led to improved self-control outcomes rather than degraded ones. The duration of temptation episodes, also regarded as an index of depletion, was unrelated to subsequent outcome. Only by measuring the most recent urge levels do we find evidence of weakening self-control strength, but even then we find it in only one of the data sets. Moreover, the mechanism of this finding is not clear from our results. The RESIST study showed that urge level of the prior episode was strongly predictive of lapsing even when urge level of the target episode was controlled. Our inability to replicate this finding in the QT dataset suggests that this effect may be due to the temporal stability of urge levels, with high prior urge levels predicting high current urge levels, which are themselves difficult to resist. Such an explanation precludes the need for self-control as an explanatory concept.

On the whole, however, our failure to support a resource depletion model of self-control in smoking cessation may be good news for smokers who wish to succeed in quitting. The theory posited that self-control is limited, consumable, and slow to replenish. The theorists suggest that "rest" is necessary for resources to gain strength. In the context of smoking cessation, however, "rest" may not be available, since temptations occur frequently early in abstinence, and "rest" achieved by temporarily abandoning abstinence in the middle of a smoking cessation

attempt all but dooms the smoker to relapse (Brandon et al., 1990). Sleep is also recommended, but seems an impractical method to replenish one's supply of self-control, especially when such sleep episodes could be needed at various times of the working day.

On the other hand, if our findings on the salutary effects of previous temptations were to be replicated in other work, they would suggest that attending to the smoking cessation process and maintaining awareness of urges/temptations to smoke is actually beneficial for succeeding in a cessation attempt. It may be that such attention enhances the use of coping strategies, increases motivation to continue trying so as not to sacrifice hard-won gains, and makes resisting temptations a habit. Because attention to the smoking cessation process seems to fluctuate, it is not clear how best to help quitters maintain appropriate attention to threats to abstinence, nor what degree of vigilance, maintained over what interval, is optimal for successful cessation.

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Table 1

Characteristics of QT and RESIST Samples

Study Characteristics		
Study Name	QT	RESIST
Data Collection Site	University of Pittsburgh	University of Kansas Medical Center
Dates of Data Collection	6/1/90 to 5/30/95	1/1/97 to 3/31/98
Sample		
N	248	61
% Females	58%	70%
Average age	44	43
% African American	6%	8%
% Hispanic/and other	2%	5%
% White	92%	87%
Smoking History		
Mean # of cigarettes/day	26.5	24.1
Mean # of years smoking	23.1	22.7
% attending smoking cessation program	100%	54%
Maximum Time in Study		
# of days after quitting	40 days	18 days
Episodes		
# resists	7,919	1,394
# lapses	1,597	266
# random assessments	24,885	3,652
Electronic Diary Measures		
Number of items	66	42
Smoking Outcomes		
% Quit for at least 24 hrs	100%, by study design	93%
% Experienced lapses	66%	66%
% With more than 30 lapses	3%	0%
% Who relapsed during study	13%	2%

Results of Survival Analyses Showing Hazard Ratios (HR) of Lapsing for Hypothesized Predictors, Before and After the Inclusion of a Significant Interaction

Table 2

	QT # of lapses = 761			RESIST # of lapses = 170		
	Analysis Without Significant Interaction					
	HR	95% CI	p	HR	95% CI	p
Number of resists (range 0 – 13)	0.89	0.803, 0.980	.02	0.60	0.430, 0.824	.002
Duration of resists (range 0 – 240 min)	1.00	0.996, 1.004	.86	1.00	0.992, 1.010	.86
Prior urge level (range 0 – 10)	1.11	1.084, 1.135	<.0001	1.12	1.061, 1.184	<.0001
Number of prior lapses (log) (range 0 – 30)	2.14	2.026, 2.257	<.0001	1.96	1.719, 2.239	<.0001
Analysis Including Significant Interaction*						
	HR	95% CI	p	HR	95% CI	p
Number of resists (range 0 – 13)				0.58	0.416, 0.798	.0009
Duration of resists (range 0 – 240 min)				1.00	0.991, 1.009	.975
Prior urge level (range 0 – 10)				1.16	1.095, 1.237	<.0001
Number of prior lapses (log) (range 0 – 30)				2.33	1.932, 2.812	<.0001
Prior lapses × prior urge level				0.96	0.924, 0.987	.007

* Only one interaction term was statistically significant for RESIST; none were significant for the QT Study.

Results of Multilevel Logistic Regression Analyses of Study Data: Odds Ratios of Lapsing for Hypothesized Predictors, Controlling Current Urge Level

Table 3

# of resists/lapses	QT			RESIST		
	OR	95% CI	p	OR	95% CI	p
Number of resists	0.60	0.497, 0.727	<.0001	0.52	0.318, 0.834	.007
Duration of resists (range 1 – 7)	1.01	0.999, 1.012	.080	1.01	0.989, 1.028	.38
Prior Urge Level (range 0 – 10)	1.03	0.990, 1.068	.15	1.10	1.017, 1.199	.02
Current Urge Level (range 0 – 10)	1.25	1.105, 1.415	<.0001	1.53	1.388, 1.686	<.0001
Number of prior lapses (log)	3.48	3.078, 3.943	<.0001	1.44	1.161, 1.793	<.0001