Published in final edited form as:
Psychol Addict Behav. 2010 September ; 24(3): 446–452. doi:10.1037/a0018545.

Practicing Self-Control Lowers the Risk of Smoking Lapse

Mark Muraven
Department of Psychology, University at Albany, Albany, NY 12222, muraven@albany.edu

Abstract

Recent research has suggested that practicing small acts of self-control can lead to an improvement in self-control performance. Because smoking cessation requires self-control, it was hypothesized that a treatment that builds self-control should help in quitting smoking. One hundred twenty-two smokers either practiced small acts of self-control for two weeks before quitting smoking or practiced a task that increased their awareness of self-control or feelings of confidence without exercising self-control. Their smoking status was assessed using daily telephone calls and biochemically verified. Individuals who practiced self-control remained abstinent longer than those who practiced tasks that did not require self-control. Supplemental analyses suggested that the increased survival times were a product of building self-control strength and were not produced by changes in feelings that practicing should help in cessation, effort exerted on the practice task, or thinking more about self-control while practicing.

Keywords

self-control; smoking cessation; building strength

Self-control is critical to the success of smoking cessation. That is, individuals who are trying to quit smoking and who fail to inhibit their urges, desires, or temptations to smoke may suffer a lapse and return to smoking. There are many successful programs that help individuals quit smoking by reducing the strength of their urges or by teaching them to better deal with temptations. Yet, to date, no treatment program has addressed the key underlying principle that ultimately the individual must inhibit his or her desire, however weak or well managed, to smoke. Because of the critical nature of self-control in smoking cessation, an intervention that increases people's ability to exert self-control should result in much better cessation outcomes.

The self-control strength model (Muraven & Baumeister, 2000) proposes that it may be possible to increase people's capacity for self-control. This model suggests that any and all self-control efforts depend on a limited resource known as self-control strength. That is, any time a person exerts self-control to override, inhibit or stop a thought, emotion, urge, or behavior, he or she draws upon this strength. Individuals who have more self-control strength are more likely to succeed at self-control compared to individuals whose self-control strength is weaker (e.g., Muraven, Collins, Shiffman, & Paty, 2005).

Correspondence concerning this article should be addressed to Mark Muraven, Department of Psychology, University at Albany, Albany, New York 12222. Electronic mail may be sent to muraven@albany.edu.

In the short term, it has been found that exerting self-control depletes this limited resource and hence results in poorer self-control performance. Consistent with the contention that there is a universal self-control resource, multiple studies have found that many forms of exerting self-control result in poorer self-control on a variety of subsequent tasks (for a review, see Baumeister, Vohs, & Tice, 2007). Overall, it appears that self-control outcomes depend on having enough self-control strength to resist the temptation.

In the long term, however, the self-control strength model predicts that the regular practice of small acts of inhibiting or stopping moods, urges, thoughts or feelings when interspersed with rest should increase self-control reserves. That is, it should be possible to build self-control strength by exercising small acts of self-control. This increased self-control strength should generalize to any and all tasks that require self-control and should continue even after the practice has ended. Hence, the particular self-control task being practiced is unimportant, providing it requires the individual to inhibit a response. Practicing any task that requires self-control should lead to general improvement in self-control performance. If this is indeed the case, this could lead to a potent intervention to help individuals quit smoking.

Prior research has provided some evidence to support the conclusion that practicing small acts of self-control leads to a general increase in self-control capacity. For instance, Muraven, Baumeister, and Tice (1999) found that individuals who regulated their eating habits by avoiding unhealthy foods or who inhibited the automatic tendency to have bad posture for two weeks subsequently performed better on a task that required overriding physical discomfort. Other building self-control strength training programs, such as avoiding colloquialisms or cursing while speaking, or using the nondominant hand, have been shown to improve people's ability to regulate their use of stereotypes (Gailliot, Plant, Butz, & Baumeister, 2007). Other research found that people who practiced self-control by forcing themselves to study (Oaten & Cheng, 2006a) or exercise (Oaten & Cheng, 2006b) also exhibited better self-control for at least a month after the practice had ended in domains unrelated to the initial practice task. In short, preliminary research is supportive of the predictions made by the self-control strength model that practicing small acts of inhibition leads to a general and lasting increase in self-control ability.

However, it should be noted that this prior research has several noteworthy shortcomings. Most importantly, these studies failed to account for potential confounds, such as whether practicing self-control leads to increased feelings of self-efficacy or confidence in self-control ability, or greater awareness of self-control. By having people engage in tasks that should increase the saliency of self-control without actually increasing the amount of self-control they exert or tasks that should boost self-efficacy without requiring self-control, the present study should help better establish the critical role of practicing self-control in the process of building self-control strength.

In addition, prior research has investigated behaviors that may be less commonly activated and may involve overcoming a weaker urge (e.g., handgrip squeezing time, thoughts about homosexuals). A stronger test of the building strength idea would require a group of individuals who are highly motivated to change a behavior that is very resistant to change. Smoking cessation is a clear example of this. Moreover, it is crucial to establish the therapeutic properties of the building self-control strength programs if it is to be used in applied settings.

The present study will therefore investigate whether the regular practice of small acts of self-control does indeed lead to better outcomes in smoking cessation while controlling for confounding variables. In particular, if practicing self-control increases general self-control capacity, and if self-control is critical to the success of quitting smoking, then it follows that practicing self-control should help individuals remain smoke-free. More specifically, smokers

who practice self-control should remain abstinent longer as compared to smokers who practice tasks that do not require self-control but do increase the saliency of self-control or increase their confidence in their ability to quit smoking.

Methods

Participants

One hundred twenty-two individuals (58 females and 64 males, 87% Caucasian, 8% African-American, 5% other or no answer) from the Albany, New York metropolitan area who were interested in quitting smoking were recruited through newspaper ads, flyers hung in meeting places, and radio advertisements. See Figure 1 for participants' flow through the study. The participants were told that they would be taking part in a study designed to improve their self-control, which could help them quit smoking.

To be eligible to participate, volunteers had to meet the following criteria: a) smoke at least 10 cigarettes per day for the past two years (M = 18.25 cigarettes a day, SD = 6.23), b) smoke regularly for the preceding three years (M = 15.0 years smoking, SD = 7.28), c) report high motivation and efficacy to quit (combined score of 150 on the sum of two 1–100 scales that asked how motivated and confident they were to quit smoking, M = 170.68), d) have at least an eighth-grade education level, e) be between 18 and 45 years of age (mean age 31–35), and f) have a working touch-tone phone. These criteria are similar to those used in previous studies on smoking cessation (e.g., Shiffman, et al., 1997). The majority (91.8%) reported at least one prior quit attempt. These quit attempts on average lasted 5.36 months (SD = 8.14). Their average score on the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) was 4.82 (SD = 1.59). The University at Albany Institutional Review Board approved the study protocol.

Procedures

Overview—During the initial session, participants completed several background questionnaires, learned how to use the telephone monitoring system, and received training on an activity that they were to practice. For the next 14 days, participants practiced their assigned task daily. They called an Interactive Voice Response (IVR) system daily to report their compliance with the study's procedures (Perrine, Mundt, Searles, & Lester, 1995; Searles, Perrine, Mundt, & Helzer, 1995). On the day that participants were to quit smoking, after two weeks of practicing their assigned task, they returned to complete additional questionnaires, discuss the next phase of the study, and prepare to quit smoking. At this point, they no longer practiced their assigned task. They continued to call the IVR system daily for the next 28 days to report on their urges to smoke, smoking behavior, and self-control demands. Participants were paid $2 for every call they made, with bonuses for not missing calls, as well as bonuses for completing all six weeks of the study. They also were paid for the laboratory appointments and were given payment for the calls up to that point at these appointments, so they were given strong incentives to maintain regular contact and not miss appointments or calls. They were encouraged to keep calling even if they smoked to reduce pressure to lie about their smoking status.

Building Strength (Practice) Phase—In the building strength phase of the study, participants were assigned to practice one of four tasks for two weeks prior to their attempt to quit smoking: avoiding sweets, handgrip, math problems, or diary. They were assigned completely at random to the condition by a computer program at the start of the first laboratory session. Participants in all groups were told that prior research has suggested that practicing certain activities appears to increase individuals' self-control capacity and, therefore, by regularly and diligently practicing their assigned task, they may be more successful in their

attempts to quit smoking. These instructions should increase participants' motivation to practice their assigned task and should provide equal expectations across experimental groups. The experimenter was not blind to condition, but was unaware of the research hypotheses much like the participants. Participants in all conditions reported their efforts on the practice task daily using the IVR system.

Participants in the building strength (avoiding sweets and handgrip) groups practiced tasks that required inhibiting a behavior. Inhibiting an act, urge, emotion, or thought requires self-control and, therefore, participants in these groups were practicing self-control. Prior research has found that the improvement in self-control performance was related to the amount of self-control practiced, but was not related to the self-control activity itself (Muraven, et al., 1999). However, to further explore this issue and to help determine if a particular component of self-control is critical to practice in order to reduce the risk of smoking (that is, the "active ingredient" of practicing self-control), the present study used two different self-control tasks. These tasks differed in what they emphasized, although there likely was a significant overlap, as both tasks require inhibiting a behavior.

Participants in the *avoiding* sweets group were asked to avoid eating sweets for the two weeks prior to quitting cigarettes. Participants were told to eat as little cake, cookies, pies, candy, and other dessert foods that are high in sugar as possible. Not eating tempting food is a very difficult self-control exercise (e.g., Baumeister, Bratslavsky, Muraven, & Tice, 1998, Experiment 1); hence the avoiding sweets group should have been practicing self-control. They reported their overall success at this task daily on the IVR.

Participants in the *handgrip* group were given commercially available exercise handgrips purchased in a sporting goods store and instructed to hold the handgrip for as long as possible twice a day. Prior research has shown that squeezing and holding a handgrip for as long as possible requires considerable self-control, as the person must inhibit fatigue, pain, and the desire to let go (Muraven, Tice, & Baumeister, 1998; Rethlingshafer, 1942; Thornton, 1939). A person can squeeze the handgrip longer by overriding the desire to release the handgrip. Thus, holding a handgrip should force participants to practice self-control and should lead to an improvement in self-control capacity. They were asked to record their squeezing time and report their performance every day using the IVR system.

Because of the importance of ruling out alternative explanations for any reduction in smoking cessation, two control groups were used to help discount extraneous variables. Participants in the control groups were not practicing self-control, although the tasks were designed to make them think about self-control more, believe they were building self-control strength, and feel like they were working hard. Participants in the *math problem* group practiced a task for two weeks that did not require self-control. In particular, participants in this condition performed simple math problems twice a day. At the initial intake, they were given a packet of problems with the day and time designated on each sheet. The problems were gradated, so they were initially simple (add 2 two-digit numbers together) and became harder over time (multiply 2 three-digit numbers). There were 20 problems on each page, which should take people three to five minutes to solve. Participants in this group practiced a task, but that task does not require overcoming a strong urge and therefore should not require self-control (e.g., Muraven, et al., 1998). This condition should serve as test of the specificity of the practice task; that is, whether practicing any task will lead to better smoking outcomes or whether one must practice tasks that require self-control. Participants reported their compliance using the IVR system.

Participants in the *diary* group also did not practice self-control over the two-week interval. However, they noted any time they resisted a temptation (e.g., wanting a sweet but not having one, craving a drink but not consuming one). They were told to complete the diary as soon as

possible to the exercise of self-control and give enough detail that an outsider could understand what they did. That is, they monitored their self-control behavior. This should make self-control behaviors more salient to the participant, but should not require the person to practice additional self-control. Thus, this condition helps differentiate between monitoring and exerting self-control. This group also returned their diaries to the researchers as well as made calls every day to the IVR to report their compliance with the practice instructions.

Participants called the IVR system daily during this two-week period to report how much they practiced their assigned task, how much effort they felt they exerted on the practice task, how much self-control they exerted on the assigned task, and whether they believed practicing would help them quit smoking. They made these ratings on a 1 (strongly disagree) to 5 (strongly agree) Likert-type scale. At the end of the two-week practice period, participants stopped practicing their assigned task and entered the quit phase.

Quit (Measurement) Phase—Participants returned to the laboratory on their scheduled quit day to discuss their plans to quit and receive instructions on the next phase of the project. They received minimal additional counseling on how to quit. Participants then began a 4-week monitoring period. They called the IVR system daily and answered questions about their smoking behavior, urge to smoke, feelings of self-efficacy, moods, and motivation. Participants were instructed to continue to call the IVR system even if they lapsed, to maximize the data collected and to minimize biases to not report smoking behavior. Participants returned to the laboratory 3, 10, 19, and 28 days after their planned quit date to have their smoking status biochemically verified using an expelled breath carbon monoxide (CO) analysis using the Bedfont EC50 Smokerlyzer (http://www.bedfont.com/). A standard cut-off of greater than 10 ppm exhaled CO was considered evidence of smoking.

Results

Data Quality

Randomization—A chi-square analysis indicated that the groups did not differ in gender or ethnicity. Similarly, using a one-way ANOVA, there were no differences across groups in smoking variables (e.g., previous quit attempts, years smoking, average number of cigarettes smoked a day, motivation and confidence to quit, FTND). These individual difference and smoking history variables also did not moderate the effects of practice on smoking cessation. These variables were therefore not included in the analyses reported below.

Missing data—On average, during the practice phase, participants missed less than 5% of the calls. Overall, 61% of the participants missed no calls; those who missed a call missed one on average and none missed more than three. The number of missed calls did not differ across conditions and was unrelated to demographics or smoking history. People who missed calls did not differ in their perception of the practice task or smoking outcomes from people who completed all required calls. Hence, the data was considered missing completely at random and was treated as no practice in the count of practice or missing in the analyses of perception of practice. Similarly, the intervention was extremely well tolerated, as few dropped out during the practice phase and those dropouts were distributed evenly among conditions (see Figure 1). Again, the dropouts did not differ from the people who continued in smoking history, demographics, or perceptions of the practice task. Multiple attempts to reach the dropouts were typically not successful and hence the reasons for their leaving the study were not ascertainable. In analyses of perception of practice tasks, the dropouts were removed, as keeping them had no effect on the outcomes.

During the smoking cessation phase, participants were encouraged to call every day, even if they smoked. Despite this, people either missed calls or stopped calling altogether. However,

nearly all these missed calls occurred after a slip had already occurred—81% missed no calls during the critical time before their first lapse. The number of missed calls before the first lapse was not related to treatment group, $F(3, 119) = 2.38$, *ns*. Of those who missed a call, none missed more than one call, as any participant who missed two days in a row was called by project staff and at a minimum his or her smoking status was recorded. No one missed more than two calls total during the cessation phase. Two participants stopped calling before their last scheduled meeting, did not return calls, and did not come to the laboratory despite never reporting smoking. In the analyses, they were considered to lapse at the point of last contact. In total, 91 participants (74.5%) of all participants reported a return to smoking. Out of those, 57 (62.6%) stopped calling after reporting a lapse. Participants who were still abstaining at the last meeting were censored in the analyses (Singer & Willett, 1991). Timeline followbacks were also collected and were found to closely follow the daily reports. Moreover, smoking status was biochemically verified using expelled CO every 3 to 10 days. The correspondence between biochemical smoking status and self-reported smoking status was nearly 100%; the one discrepancy was considered lapsed at the point of biochemical verification.

Perception of Practice Tasks

During the practice phase, on the daily interviews using the IVR system, participants reported how much effort they felt they exerted on their assigned task, how much self-control they used while practicing, and whether they thought practicing would help them quit smoking. These daily reports were averaged for each person (coefficient alpha for each item > .88) and compared across groups using a one-way ANOVA.

Overall compliance was high across all groups. Participants reported not practicing approximately two days during the two-week session (mean days practiced = 11.87, $SD = 3.62$). There were no differences across groups, $F(3, 119) = .66$, *ns* (see Table 1).

Participants in the two building strength groups reported that they exerted as much effort on their assigned task as participants in the two control conditions, $F(3, 119) = .006$, *ns*. This suggests that the control instructions matched the building strength instructions in how much work they required. Hence any difference in smoking outcomes between groups cannot be ascribed to work effort alone. Similarly, although there were some differences across groups, participants who were assigned to a control condition felt that they exerted as much self-control on their assigned task as participants who were assigned to practice a task that required self-control, $F(3, 119) = .565$, *ns*. This suggests that, consistent with the explanation for the study given to them, participants felt that they were exerting self-control, even in the control conditions. Finally, whether they thought the task they were practicing would help them quit smoking did differ across condition, $F(3, 119) = 6.80$, $p < .05$. This difference was entirely driven by the fact that the math problem condition was felt to be less effective at helping cessation, as a focused contrast indicated the diary group did not differ from the two building strength groups, $F(1, 119) = 3.19$, *ns*. These results suggest that at least for the diary group, they felt that they were building self-control and increasing the likelihood of quitting as much as participants in the building strength conditions.

Smoking Outcomes

Survival Times—In the main analysis, participants' time to the first lapse was examined. A lapse was defined to participants as any smoking, even a puff (Ossip-Klien, et al., 1986). Participants' smoking status was analyzed using Cox regression survival analysis (Singer & Willett, 1991). The survival curve is presented in Figure 1 and the mean time to lapse reported in Table 1. Overall, a pooled analyses found that the two building strength groups (avoid sweets and handgrip; 95% confidence interval for mean survival 9.15–16.13 days) differed significantly from the control groups (math problems and diary; 95% confidence interval 4.66–

9.53 days), Wald = 5.93, $p < .025$. That is, the intervention increased the odds of successfully quitting smoking by a factor of 1.56 (95% confidence interval 1.06–2.35). At the end of a month of monitoring, in this sample of self-quitters, 12% of the participants assigned to a control condition were still abstinent, as compared to 27% of those assigned to a building strength condition, $\chi^2(1, N = 122) = 4.78$, $p < .05$.

Further analyses indicated that the survival times for the two building strength groups did not differ from each other, Wald = .015, *ns*, nor did the two control groups differ from each other, Wald = .165, *ns*. It did not matter which task participants practiced; all that mattered was that they practiced self-control.

Supplemental analyses—Participants' reports of how much self-control they felt they exerted on their assigned task, how much effort they exerted on practicing, and whether they felt that the assigned task would help them quit smoking were used as predictors of the time to first lapse. The results were analyzed using Cox regression survival analysis, with the groups pooled into building strength and control. In the analyses, the main effects for practice condition and perception of the practice task were entered first, followed by the interaction.

The perception of practice task variables showed different patterns of results that are consistent with the idea that practice builds self-control strength and inconsistent with the idea that practicing improves self-control by increasing awareness of self-control, feeling that practicing will help, or merely working hard. In particular, as shown in the top panel of Table 2, how much effort participants reported exerting during the practice phase was unrelated to their survival times. Effort did interact with condition, so that participants in the building strength conditions who worked hard while practicing remained abstinent longer than participants in the control conditions. The type of effort matters: working hard at a task that requires self-control increased the time to the first lapse but working hard at a task that does not require self-control had no effect.

The middle section of Table 2 shows that the more self-control participants felt they exerted on the practice task, the longer their smoking survival times. In other words, thinking that one is exerting self-control can help improve smoking outcomes. However, the significant interaction shows that this effect was the largest for participants in the conditions who really did exert self-control. This again suggests that increased saliency of self-control cannot account for the results; it is most effective to think that one is building self-control while actually exerting self-control.[1] These supplemental analyses suggest that increasing the saliency of self-control while practicing, when combined with a task that actually requires self-control, leads to the most success in smoking cessation.

Finally, merely believing that the practice task should help in quitting smoking was unrelated to smoking survival times (bottom section of Table 2). This again suggests that expectancies of improvement cannot explain the results. In this analysis only the main effect for treatment condition was significant; the lack of interaction between treatment condition and the belief that practice would help suggests that the effects of practicing self-control operate completely outside any expectations that it should help.

[1]The main effect for treatment condition in this analysis likely failed to reach conventional levels of statistical significance because of an overlap between perception of amount of self-control exerted and the actual task practiced. Indeed, if treatment condition was entered first (instead of simultaneously), it was a significant predictor of survival time.

Discussion

Smokers who practiced small acts of self-control were more successful at quitting smoking than those who did not. Those smokers who squeezed a handgrip or avoided sweets for two weeks before quitting cigarettes remained abstinent longer and had fewer lapses overall as compared to smokers who practiced tasks that did not require self-control. This suggests that what is being practiced does not matter, as long as it requires self-control. Overall, the rate of abstinence in the control groups after a month (12%) was close to the lower end of success rates found in a pooling of eight studies of self-quitters (Hughes, Keely, & Naud, 2004), whereas the rate of abstinence in the building strength groups (27%) was close to the top of the range found in self-quitters.

Additional analyses suggested that the effects of practicing a task on smoking cessation was not a product of believing it will help. Similarly, thinking the task required self-control was most effective in helping people quit when combined with a task that actually required self-control. Finally, only the effort exerted practicing self-control was related to smoking outcomes; working hard at a task that does not require self-control was not effective in helping people to quit smoking. These results imply that the active ingredient in the treatment was practicing self-control, and the results cannot be explained by feelings of working hard, thinking it will help, or increased awareness of self-control. Hence other models that suggest the effects of practicing self-control lead to improved self-control through changes in self-awareness, confidence, or expectations that it should help alone are not enough to explain the improvement in smoking outcomes observed in the present study.

Instead, the research is probably best explained by the self-control strength model (Muraven & Baumeister, 2000). This model suggests that practicing self-control should build self-control resources. These increased resources should help in the exertion of self-control, thereby leading to better outcomes. In addition, having additional self-control resources should protect self-control performance against other competing self-control demands (e.g., Muraven, Shmueli, & Burkley, 2006). Thus, by practicing small acts of self-control, self-control in general improves. This replicates and extends previous research that has shown practicing small acts of self-control leads to better self-control overall (Gailliot, Plant, et al., 2007; Muraven, et al., 1999; Oaten & Cheng, 2006a, 2006b). The present study builds upon this previous research by demonstrating the effects of practicing self-control appear to be specifically caused by inhibiting a strong impulse and cannot be explained by merely working hard, thinking more about self-control or believing it should help. Moreover, it tested the idea in an ecological setting using a behavior that is very difficult to change and is also strongly undesired by the participants.

Despite the overall clarity of the results, there are many questions remaining. In particular, the underlying biopsychological effect of practice on self-control requires more research. It is possible that practicing self-control leads to increased efficiency in glucose use in the brain (Gailliot, Baumeister, et al., 2007). Practicing may also lead to greater willingness to use available resources (Muraven & Slessareva, 2003) or tolerate distress (Brown, Lejuez, Kahler, & Strong, 2002). Additional research is needed on how to practice most efficiently and effectively—for example, what tasks are best to practice, how long should they be practiced and how frequently. Moreover, because research has found that self-control resources are limited and depleted by the exertion of self-control (Muraven, et al., 2005), it is important to balance practice against current demands. The dynamics of depletion and building strength need to be clarified to best help individuals self-manage their limited resources and reach long-term goals.

Several shortcomings which may limit the generalizability or interpretability of the effects should be noted as well. First, the present research was conducted on a group of healthy, young smokers who were motivated to quit. It is unclear whether the treatment would be as effective in less motivated people or people who have additional health issues. At least in the present sample, participants found the treatment agreeable, as very few withdrew from treatment. Second, the experimenters were not blind to experimental condition. However, they were blind to the research hypotheses. Moreover, the participants themselves believed that the control interventions were just as efficacious as the experimental instructions. Finally, the reliability of the measures is another concern. As noted above, smoking status was biochemically verified every 3 to 10 days but that allows time for CO levels to return to normal. Based on previous research using IVR systems (Mundt, Perrine, Searles, & Walter, 1995; Searles, Helzer, & Walter, 2000) and the very high concordance in our own sample between biological and self-reports of smoking, we feel confident in our measure of smoking status. The measures of efficacy and confidence in the supplemental analyses also are based on self-reports, and thus could be biased by participants' expectations.

These results may have significant clinical implications. Most importantly, practicing small acts of self-control appears to improve general self-control performance. Because so many health problems (e.g., obesity, addiction, inactivity) require self-control to address, an intervention that increases self-control is essential. In addition, the current intervention is easy to implement, costs little and asks little of patients. There appear to be no adverse effects, contraindications, or interactions with other treatments. Future research should look to increase the efficacy of practice and examine whether it helps people deal effectively with addictions.

Acknowledgments

This research was supported by Grant DA015131 provided by the National Institute on Drug Abuse.

References

Baumeister RF, Bratslavsky E, Muraven M, Tice DM. Ego-depletion: Is the active self a limited resource? Journal of Personality and Social Psychology 1998;74:1252–1265. [PubMed: 9599441]

Baumeister RF, Vohs KD, Tice DM. The strength model of self-control. Current Directions in Psychological Science 2007;16:351–355.

Brown RA, Lejuez CW, Kahler CW, Strong DR. Distress tolerance and duration of past smoking cessation attempts. Journal of Abnormal Psychology 2002;111:180–185. [PubMed: 11866171]

Gailliot MT, Baumeister RF, DeWall CN, Maner JK, Plant EA, Tice DM, Brewer LE, Schmeichel BJ. Self-control relies on glucose as a limited energy source: Willpower is more than a metaphor. Journal of Personality and Social Psychology 2007;92:325–336. [PubMed: 17279852]

Gailliot MT, Plant EA, Butz DA, Baumeister RF. Increasing self-regulatory strength can reduce the depleting effect of suppressing stereotypes. Personality and Social Psychology Bulletin 2007;33:281–294. [PubMed: 17259587]

Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO. The Fagerstrom test for nicotine dependence: A revision of the Fagerstrom tolerance questionnaire. British Journal of Addiction 1991;86:1119–1127. [PubMed: 1932883]

Hughes JR, Keely J, Naud S. Shape of the relapse curve and long-term abstinence among untreated smokers. Addiction 2004;99:29. [PubMed: 14678060]

Mundt JC, Perrine MW, Searles JS, Walter D. An application of interactive voice response (ivr) technology to longitudinal studies of daily behavior. Behavior Research Methods, Instruments and Computers 1995;27:351–357.

Muraven M, Baumeister RF. Self-regulation and depletion of limited resources: Does self-control resemble a muscle? Psychological Bulletin 2000;126:247–259. [PubMed: 10748642]

Muraven M, Baumeister RF, Tice DM. Longitudinal improvement of self-regulation through practice: Building self-control strength through repeated exercise. Journal of Social Psychology 1999;139:446–457. [PubMed: 10457761]

Muraven M, Collins RL, Shiffman S, Paty JA. Daily fluctuations in self-control demands and alcohol intake. Psychology of Addictive Behaviors 2005;19:140–147. [PubMed: 16011384]

Muraven M, Shmueli D, Burkley E. Conserving self-control strength. Journal of Personality and Social Psychology 2006;91:524–537. [PubMed: 16938035]

Muraven M, Slessareva E. Mechanisms of self-control failure: Motivation and limited resources. Personality and Social Psychology Bulletin 2003;29:894–906. [PubMed: 15018677]

Muraven M, Tice DM, Baumeister RF. Self-control as a limited resource: Regulatory depletion patterns. Journal of Personality and Social Psychology 1998;74:774–789. [PubMed: 9523419]

Oaten M, Cheng K. Improved self-control: The benefits of a regular program of academic study. Basic and Applied Social Psychology 2006a;28:1–16.

Oaten M, Cheng K. Longitudinal gains in self-regulation from regular physical exercise. British Journal of Health Psychology 2006b;11:717–733. [PubMed: 17032494]

Ossip-Klien DJ, Bigelow G, Parker S, Curry S, Hall SM, Kirkland S. Classification and assessment of smoking behavior. Health Psychology 1986;5:3–11. [PubMed: 3582323]

Perrine MW, Mundt JC, Searles JS, Lester LS. Validation of daily self-reported alcohol consumption using interactive voice response (ivr) technology. Journal of Studies on Alcohol 1995;56:487–490. [PubMed: 7475027]

Rethlingshafer D. Relationship of tests of persistence to other measures of continuance of activities. Journal of Abnormal Social Psychology 1942;37:71–82.

Searles JS, Helzer JE, Walter DE. Comparison of drinking patterns measured by daily reports and timeline follow back. Psychology of Addictive Behaviors 2000;14:277–286. [PubMed: 10998953]

Searles JS, Perrine MW, Mundt JC, Helzer JE. Self-report of drinking using touch-tone telephone: Extending the limits of reliable daily contact. Journal of Studies on Alcohol 1995;56:375–382. [PubMed: 7674671]

Shiffman S, Engberg JB, Paty JA, Perz WG, Gnys M, Kassel JD, Hickcox M. A day at a time: Predicting smoking lapse from daily urge. Journal of Abnormal Psychology 1997;106:104–116. [PubMed: 9103722]

Singer JD, Willett JB. Modeling the days of our lives: Using survival analysis when designing and analyzing longitudinal studies of duration and the timing of events. Psychological Bulletin 1991;110:268–290.

Thornton GR. A factor analysis of tests designed to measure persistence. Psychological Monographs 1939;51:1–42.

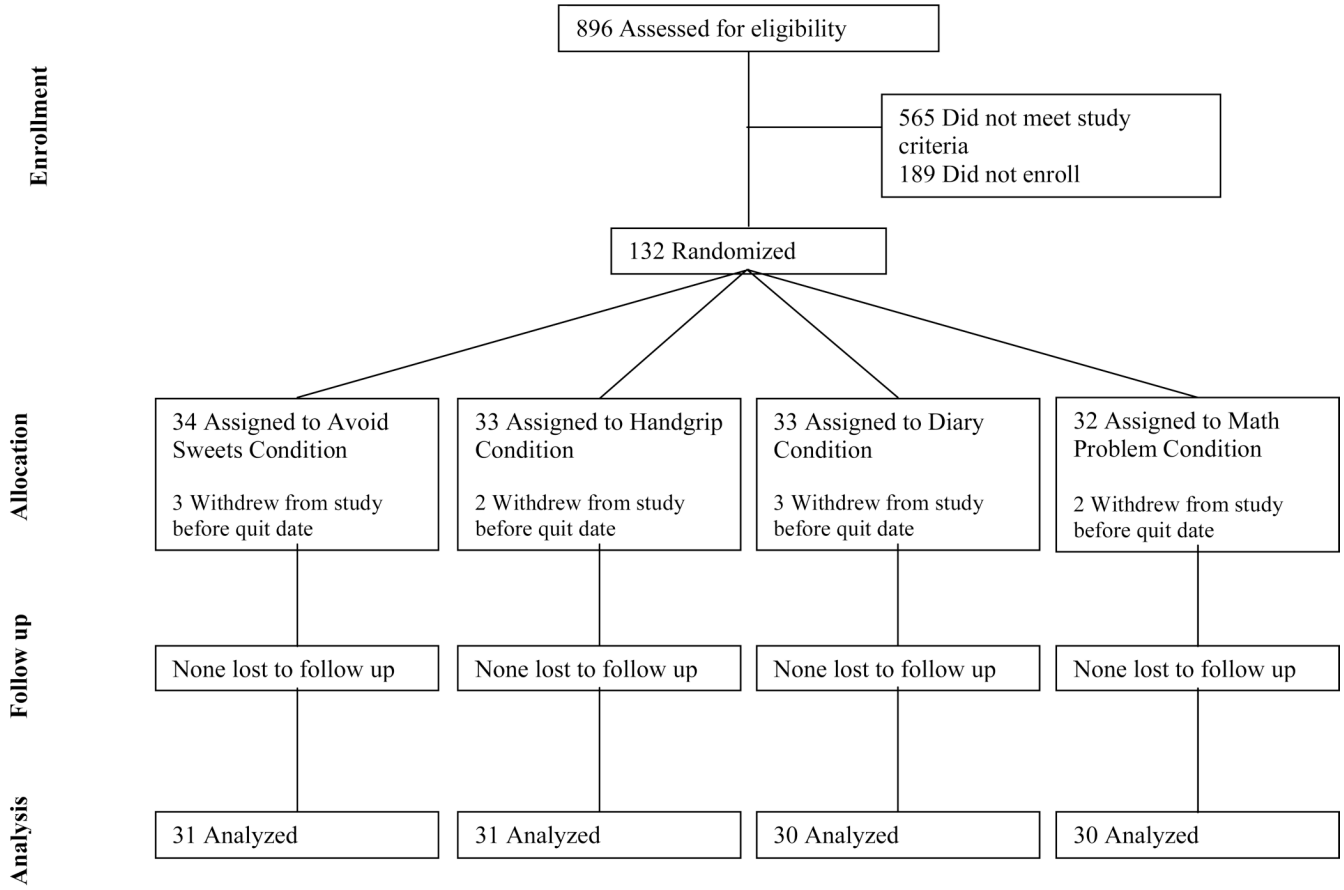

Figure 1.
Participant flow through experiment.

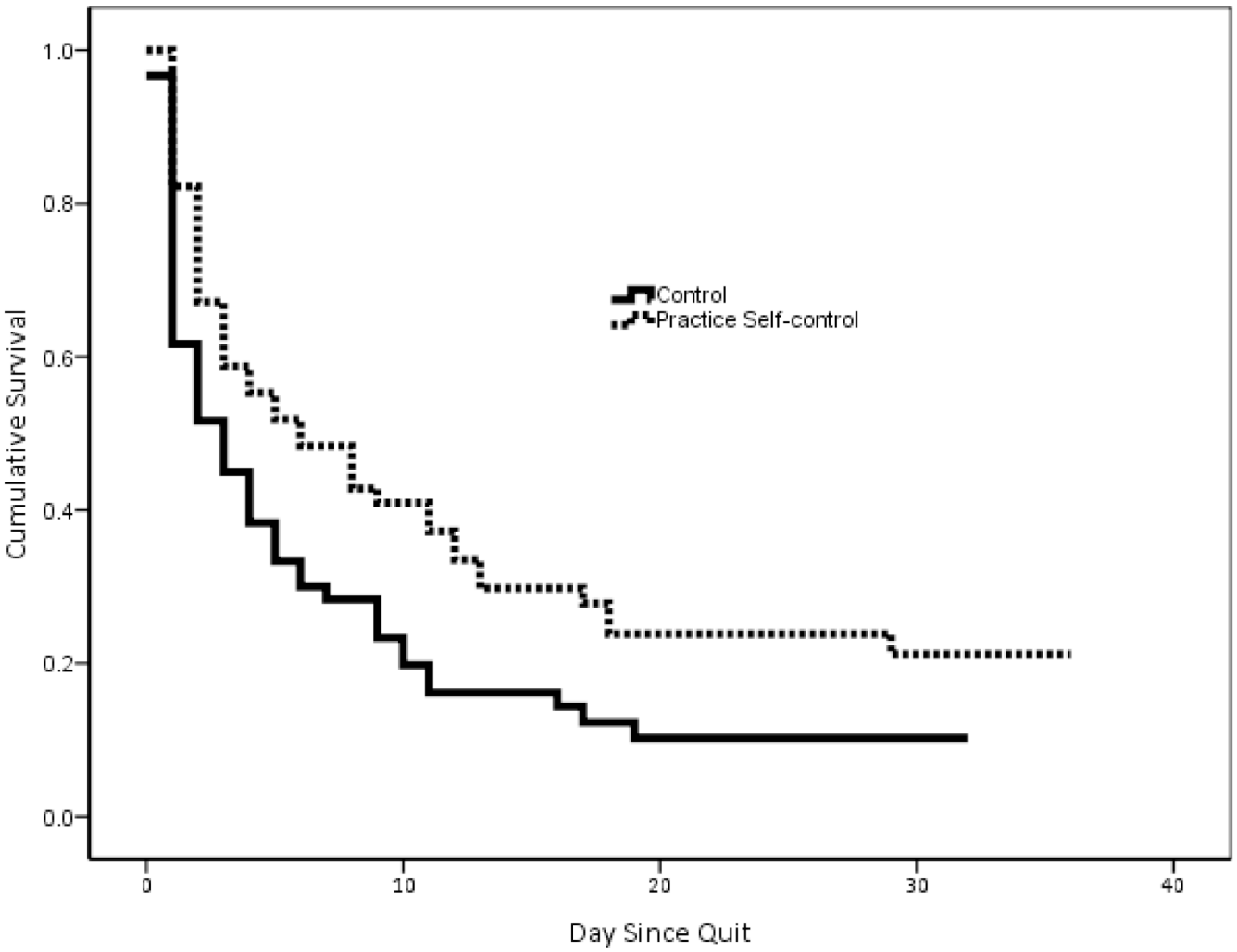

Figure 2.
Cumulative survival for smoking cessation from quit day, based on treatment condition

Table 1

Practice variables and mean survival time across groups.

	Control Conditions				Building Strength Conditions			
	math problems		diary		avoid sweets		handgrip	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Days Practiced	11.76_{a}	4.40	11.17_{a}	3.38_{a}	12.42_{a}	3.34	12.10_{a}	3.38
Effort	3.09_{a}	.74	3.66_{a}	.78	3.47_{a}	.64	3.33_{a}	1.01
SC	3.31_{a}	.71	4.07_{bc}	.72	4.12_{c}	.74	3.51_{ab}	1.15
Help	2.89_{a}	.72	3.71_{b}	.80	3.93_{b}	.72	3.50_{ab}	.98
Days to Lapse	7.43_{a}	1.77	6.90_{a}	1.81	12.10_{b}	1.15	12.32_{b}	2.63

Notes. Effort = effort exerted on assigned task. SC = self-control exerted on assigned task. Help = perception that assigned task will help them quit smoking. Means not sharing a common subscript differ at $p < .05$.

Table 2

Survival analysis of treatment condition and practice perception variables.

	B	SE	Wald
Step 1			
Treatment Condition	.42	.21	3.90*
Effort Exerted on Assigned Task	.11	.12	.84
Step 2			
Interaction	.89	.26	12.05**
Step 1			
Treatment Condition	.34	.21	2.57†
Self-Control Exerted on Assigned Task	.26	.12	4.82*
Step 2			
Interaction	.68	.23	8.84**
Step 1			
Treatment Condition	.42	.22	3.89*
Assigned Task Will Help Them Quit Smoking	.10	.12	.73
Step 2			
Interaction	.09	.24	.13

Note. Treatment condition (0 = control instructions, 1 = building strength instructions)

† $p < .10$.

* $p < .05$.

** $p < .01$.