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Stimulus and Response Expectancies Influence the Cognitive Effects of Cigarettes

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Abstract

The pharmacological, stimulus expectancy, and response expectancy effects of light cigarettes (0.60 mg yield of nicotine) compared with virtually nicotine-free cigarettes (less than 0.05 mg yield of nicotine) were examined using a between-subjects design. A total of 103 college-student smokers completed tests of cognition before and after smoking one type of cigarette, which was evaluated on a number of dimensions. Cigarettes with nicotine were preferred on most dimensions, and stimulus expectancy partially mediated the relationship between nicotine and subjective effects of the cigarettes. Stimulus expectancy also mediated the effect of nicotine on tension reduction immediately after smoking, but not near the end of the experiment. Response expectancy effects of nicotine were related to predicted and actual recall performance, such that participants who performed well tended to attribute the effect to the cigarette they smoked. Implications for smoking cessation and research studies using non-nicotine cigarettes are discussed.

There is growing consensus that changes in cognitive processing contribute to the reinforcing effects of cigarettes (e.g., Brandon, Herzog, Irvin, & Gwaltney, 2004; Kassel, 1997; Levin, 1992). In college students, for example, smoking behavior increases substantially during periods of intense study (Wesnes, Revell, & Warburton, 1983), and students report increased smoking specifically to increase their level of cognitive arousal (West & Lennox, 1992). Whereas a large, established body of research has focused on the cognitive effects of nicotine (for reviews, see Heishman, Taylor, & Henningfield, 1994; Sherwood, 1993), there is now increasing recognition that numerous factors, including non-pharmacological factors, can play important roles in maintaining smokers' addiction to cigarettes (Johnson, Bickel, & Kirshenbaum, 2004; Perkins, Sayette, Conklin, & Caggiula, 2003; Rose, 2006). The focus of the present study was on the role of expectancy in nicotine's cognitive effects.

The term expectancy denotes two different phenomena in nicotine research. First, participants may hold certain beliefs about the effects of a drug on their own internal state, which can be based on past use of the drug or information received from others. This type of expectancy is more precisely termed "response expectancy," and it has been shown to influence a variety of outcomes, including mood states, memory, and drug use (Kirsch, 1999). Response expectancies related to cigarettes have been shown to be a causal factor in smoking motivation (e.g., Copeland & Brandon, 2000). In addition, Hendricks and Brandon (2008) showed that smokers had different expectancies for cigarettes, which were primarily associated with negative health consequences, compared with nicotine, which was more closely associated with addiction. Both cigarettes and nicotine were equally associated with arousal.

Expectancy can also refer to whether participants expect an active or inactive substance in a study. This variable is more precisely termed “stimulus expectancy” (Kirsch, 1999; Perkins et al., 2004). Stimulus expectancy can be manipulated through instructional sets, in which some participants are told to expect an active drug and others are told to expect an inactive control. In a balanced placebo design, the type of substance expected and received are completely crossed, creating four conditions (two of which are deceptive). To date, four published studies have used a balanced-placebo design with cigarettes (Juliano & Brandon; 2002; Kelemen & Kaighobadi, 2007; Perkins et al., 2004; Perkins et al., 2008), and all have uncovered significant stimulus expectancy effects with cigarettes independent of nicotine itself. However, one difficulty in using balanced placebo designs with cigarettes is maintaining the deception. In the four studies mentioned, participants rates of disbelief ranged from 7%–33%.

Stimulus expectancy typically is ignored in double-blind research designs, because participants are assumed to be naïve as to which condition has been administered. The utility of double-blind procedures has been challenged, however (e.g., Kramer & Shapiro, 1984; Roth et al., 1991; Sutton, 1991). For example, Mooney, White, and Hatsukami (2004) reviewed the literature on nicotine replacement therapy, and they found that the majority of studies did not report any data on the integrity of the blindness procedures. In the small number of studies that did report such data, participants judged the type of substance they received at levels significantly greater than chance in over 70% of cases (12 out of 17 studies). Fortunately, there are procedures to evaluate data from ineffective double-blind designs (e.g., Hughes & Krahn, 1985), although such procedures are rarely applied.

The present study was designed as a double-blind investigation of nicotine (0.60 mg) versus no nicotine (less than 0.05 mg) in cigarettes on cognition. The initial focus was on response expectancies for cigarettes regarding cognitive performance. All participants completed a baseline assessment of cognitive tasks, followed by questions about how the cigarette they received would influence their performance on a second round of the same tasks. We also collected confidence ratings during the recall tasks to allow more fine-grained analysis of response expectancy. The main hypothesis was that positive correlations would emerge between participants’ response expectancies and their predicted or actual performance. We assessed the effectiveness of our double-blind design by offering a financial incentive to participants to who correctly identified the type of cigarette they received. To anticipate the results, participants were able correctly identify the presence or absence of nicotine at levels exceeding those predicted by chance. Therefore, additional analyses were conducted to test for stimulus expectancy effects, especially as a potential mediator of nicotine’s cognitive effects.

Method

Participants

Useable data were obtained from 103 students, 41 women and 62 men, at a large urban university in the United States. Data from 5 other participants were discarded due to experimenter errors or because the participants failed to follow instructions. The mean age of participants was 21.6 years old ($SD = 4.7$). Participants were paid \$30 USD each, with a bonus of \$5 USD awarded at the end of the study to those who correctly identified the type of cigarette (nicotine vs. non-nicotine) they had smoked. All participants reported smoking at least 10 king-sized non-mentholated cigarettes per day for the last year and they were not trying to quit smoking. The mean FTND score (Heatherton, Kozlowski, Frecker, & Fagerström, 1991) of participants was 3.3 ($SD = 1.9$) and the mean score on the Cigarette Dependence Scale (Etter, Le Houezec, & Perneger, 2003) was 41.8 ($SD = 8.2$).

Participants were instructed to abstain from smoking for at least 5 hours before the experiment. Upon arrival for testing, all students were tested for abstinence by end tidal carbon monoxide

(CO) analysis. Students were informed in advance that they would be excluded if their expired CO exceeded 15 parts per million. The mean CO level was 6.1 ($SD = 4.0$). Two students slightly exceeded 15 but they were allowed to participate because subtracting the baseline reading of a non-smoker tested at the same time resulted in a reading of 15 or less.

Design

A pretest-posttest design was used. The between-subjects independent variable was type of cigarette. The major dependent variables included subjective ratings of cigarettes, levels of smoking urges, tension and energy, sustained attention performance, and predicted as well as actual memory performance.

Materials

Types of Cigarettes—Two types of cigarettes were used: (a) Quest 1, which delivered 0.6 mg of nicotine per cigarette and (b) Quest 3, which delivered less than 0.05 mg nicotine per cigarette. These cigarettes were identical in tar content (10 mg each), size (85 mm each), and type of filter. The cigarettes were removed from their packages and coded by the author, who had no direct contact with the participants.

Study and Prediction Task—Participants studied 40 pairs of Swahili-English vocabulary items (e.g., Zulia - Carpet) presented twice, in random order, for 5 seconds each. During the second study trial, participants were asked to predict how likely they were to remember each English word given the Swahili word about 20 minutes later, using a scale of 1–100. Half of the ratings were made immediately after the pair was studied the second time (i.e., an immediate prediction) and the other half of the items were rated after all 40 items had been restudied (i.e., a delayed prediction; for rationale see Kelemen & Weaver, 1997; Nelson & Dunlosky, 1991). At the end of this study session, participants predicted how many total words (0–40) they would remember (i.e., make an aggregate prediction). Overall, this task required approximately 10 minutes.

Sustained Attention Task—After the study and prediction task, participants completed a test of sustained attention for 12 minutes. Participants were shown a series of digits on the screen, one at a time, at the rate of 100 per minute (i.e., 100 ms each with an inter-stimulus interval of 500 ms). Participants were asked to press the space bar whenever 3 consecutive odd or even digits appeared, which occurred an average of 8 times per minute.

Memory Recall Task—Immediately after finishing the sustained attention task, participants completed a cued-recall memory test of the Swahili-English word pairs studied earlier. Each Swahili word appeared at the top of the screen one at a time, and participants were asked to type in the English equivalent. Misspellings were counted as correct if the first three letters matched those of the target word.

Procedure

Upon arrival, participants provided informed consent and completed a CO breath analysis. Participants were informed that later in the study they would be given a cigarette to smoke, which may or may not contain nicotine. They were offered an additional \$5 USD if they could guess whether or not it contained nicotine after smoking it. Then participants completed several questionnaires on an electronic handheld device, including the FTND, cigarette dependence scale, and a smoking consequences questionnaire (responses on this latter questionnaire did not predict performance on any of the dependent measures so it is not discussed further). Next, a baseline measurement smoking urges was obtained using the questionnaire on smoking urges (QSU; Cox, Tiffany, & Christen 2001), and a baseline measure of energy and tension also was

obtained using the activation-deactivation adjective checklist (AD-ACL; Thayer, 1986). Participants then completed baseline assessment of cognitive performance (i.e., the study and prediction phase of the memory test, followed by a test of sustained attention, and then the memory recall phase).

Next, the research assistant escorted participants outside of the building to smoke the cigarette, and neither person knew which type of cigarette was provided. After finishing their cigarette, participants completed the 12-item cigarette evaluation scale (CES; Westman, Levin, & Rose, 1992), guessed whether or not their cigarette contained nicotine, and assessed how it would influence their subsequent cognitive performance. They also completed the QSU and AD-ACL again. Finally, participants returned to the lab to complete the second round of computerized cognitive testing using different stimuli. After the second round of testing was completed, participants completed a posttest measure of smoking urges (QSU), arousal (AD-ACL), and perceived cognitive effects. Following debriefing procedures, participants were paid and dismissed. The entire set of procedures required approximately 2 hours.

Results

All tests of statistical significance were conducted at $p < .05$ unless otherwise noted.

Blindness Check

Participants correctly identified the type of cigarette they smoked with a high degree of accuracy in both the nicotine condition ($M = 71\%$ correct) and non-nicotine condition ($M = 88\%$ correct). Both levels of performance were significantly greater than the 50% level expected by chance using one-sample t -tests, $t(50) = 3.20$ and $t(51) = 8.60$, respectively. Only 21 of the 103 participants misidentified the type of cigarette received: 6 people who received a non-nicotine cigarette thought it did contain nicotine and 15 people who received nicotine thought the cigarette did not.

Because the blindness aspect of the design was compromised, it was difficult to interpret subsequent analyses on the role of nicotine in isolation because those effects could be confounded by stimulus expectancy. To address this concern, two additional types of analyses were included for each dependent measure: (a) a direct test of stimulus expectancy using a subset of the data, that is, when participants received nicotine and reported that it did ($n = 36$) or did not ($n = 15$)¹; and (b) mediation analyses using the full data set, examining whether the relationship between type of gum received and a dependent measure was mediated statistically by participants' stimulus expectancy.

Subjective Effects of Cigarettes

Participants rated the subjective effects of their cigarette on 12 dimensions using the CES. Cigarettes with nicotine were rated significantly higher than cigarettes without nicotine in 10 of 12 dimensions using one-way ANOVAs (see leftmost data in Table 1). To test the role of stimulus expectancy, follow-up one-way ANOVAs were conducted on data from the 51 participants who received nicotine using stimulus expectancy as the independent variable. Participants who believed that they received nicotine rated their cigarettes as significantly higher compared with participants who believed they did not (see rightmost data in Table 1). Stimulus expectancy played a statistically significant role in 80% (8 of 10) of the dimensions that were influenced by nicotine itself. Further, the pattern of means across dimensions is quite clear: participants tended to rate cigarettes highest when they received nicotine and believed

¹Stimulus expectancy was not examined in the non-nicotine condition because only 6 participants believed that non-nicotine cigarettes contained nicotine.

they did, lower when they simply received nicotine (regardless of belief), still lower when they received nicotine but thought they did not, and lowest when they simply did not receive nicotine (regardless of belief).

Several statistical techniques have been proposed to test for simple mediation effects, including the use of regression equations (Baron & Kenny, 1986), a Sobel test, and a bootstrap method for assessing indirect effects (Preacher & Hayes, 2004). In this study, all three types of analyses yielded identical results, so only the Sobel test outcomes are reported here. Using the 12 subjective ratings as dependent measures, Sobel tests confirmed a significant mediation effect of stimulus expectancy on nicotine for the first 9 of the 12 dimensions listed in Table 1 (i.e., ratings of cigarette satisfaction, calming, irritability reduction, enhanced concentration, taste, craving reduction, enhanced awareness, dizziness reduction, and strength; all Z s > 1.98 , all p s $< .05$). No mediation was detected for hunger reduction, nausea induction, or throat and chest sensations. Thus, the outcome of mediation analyses on the full data set was very consistent with the outcome of the one-way ANOVAs noted in Table 1 using only participants who received nicotine; both sets of analyses suggested a strong role of stimulus expectancy in the subjective effects of nicotine in cigarettes.

Smoking Urges, Tension, and Energy

Participants' smoking urges were assessed before smoking (baseline), immediately after smoking, and near the end of the experiment. Two difference scores (i.e., levels immediately after smoking minus baseline and levels near the end of the experiment minus baseline) were analyzed using one-way ANOVAs. As expected, nicotine significantly reduced smoking urges immediately after the cigarette (difference score $M = -13.06$, $SEM = 1.76$) compared with non-nicotine cigarettes (difference score $M = -4.33$, $SEM = 1.36$), $F(1, 101) = 15.62$, $\eta^2 = 0.14$; the difference near the end of the experiment did not reach statistical significance, $F(1, 101) = 3.31$, $p = .07$. Thus, cigarettes with nicotine did significantly reduce the urge to smoke, but the effect was short lived. As before, the influence of stimulus expectancy was examined in two ways. First, the type of cigarette participants believed they had did not influence QSU scores when participants received nicotine, F s < 1 , p s $> .30$. Second, the Sobel test of mediation was likewise non-significant, $Z = -1.72$, $p = .09$.

Participants' levels of tension and energy also were assessed at baseline, immediately after smoking, and near the end of the experiment. One-way ANOVAs revealed significant tension reduction in the presence of nicotine (difference score immediately after smoking: $M = -2.20$, $SEM = 0.51$; difference score near end of experiment: $M = -2.47$, $SEM = 0.51$) compared with non-nicotine cigarettes (difference score immediately after smoking: $M = -0.88$, $SEM = 0.31$; difference score near end of experiment: $M = -0.96$, $SEM = 0.43$), $F(1, 102) = 4.88$, $\eta^2 = 0.05$ and $F(1, 102) = 5.20$, $\eta^2 = 0.05$, respectively. Surprisingly, mediation analyses using the Sobel test confirmed a significant effect of stimulus expectancy immediately after smoking, ($Z = -2.46$, $p < .05$) but not near the end of the experiment ($Z = -0.83$, $p > .40$). The identical pattern was observed with the sample of participants who receive nicotine: those who believed they received nicotine had greater tension reduction ($M = -2.92$, $SEM = 0.59$) compared with those who believed they did not ($M = -0.47$; $SEM = 0.87$) immediately after smoking, $F(1, 50) = 5.20$, $\eta^2 = 0.10$, but not near the end of the experiment. For energy, no significant difference due to nicotine was evident and therefore no mediation analyses were conducted.

Cognitive Performance

Difference scores were computed for attention, recall, as well as immediate, delayed, and aggregate predictions of recall by subtracting participants' baseline data from their post-cigarette data (see Table 2). For attention, participants were significantly faster by approximately 50 ms after nicotine compared with non-nicotine cigarettes, $F(1, 102) = 5.90$,

$\eta^2 = 0.06$; both the ANOVA on participants who received nicotine and the Sobel test on the full sample showed that this effect was not mediated by stimulus expectancy. For sustained attention accuracy (as operationalized by *d prime*), no significant differences were observed. In addition, no significant differences were obtained when comparing difference scores for recall and all predictions of performance across nicotine conditions.

Response Expectancies about Nicotine's Cognitive Effects

Pearson correlations were computed to examine the relationship between individuals' beliefs about the effects of smoking (i.e., response expectancies) and their predicted as well as actual performance. Participants were asked to rate the effect of the cigarette on each cognitive task twice after smoking: once before the second round of cognitive tasks (i.e., pre-tasks) and again near the end of the experiment (i.e., post-tasks). An example of the question for a pre-task rating concerning recall was, "Please rate the effect the cigarette will have on your ability to recall the Swahili-English word pairs on a test." For all questions, responses ranged from -10 ("Highly impaired") to 10 ("Highly improved"), with 0 labeled "No effect." Because the questions asked about the effects of the cigarette, and not nicotine per se, mean correlations were computed across all participants. As before, difference scores were used for the dependent measures to control for baseline performance.

In general, correlations between the expected effect of the cigarette and cognitive performance were non-significant before the tasks (see Table 3). In contrast, the correlations were larger and statistically significant in 4 of 5 cases (*rs* ranging from 0.25 – 0.32), when the cigarette effects were evaluated after the tasks. Thus, participants who perceived more positive effects of the cigarette near the end of the experiment tended to show better cognitive performance.

Discussion

The results of this study demonstrated significant effects of both stimulus expectancy and response expectancy in the subjective and cognitive effects of cigarettes. Stimulus expectancy typically is ignored in research intended to be double-blind, such as the present study, but this practice is questionable because it has proven difficult to implement effective double-blind procedures in nicotine research (Mooney et al., 2004). We conducted a strong test of our own procedures by offering financial incentives for participants to correctly identify their condition, and smokers were able to determine the presence or absence of nicotine in their cigarettes with a high level of success. Thus, it was essential to examine the role of stimulus expectancy, which did in fact play a substantial role in the subjective effects of the cigarettes.

Consistent with past research (Cohn, Cobb, Ali, & Juliano, 2004; Strasser, Lerman, Sanborn, Pickworth, & Feldman, 2007), nicotine cigarettes were preferred on a number of dimensions. However, participants' expectancies about the type of cigarette they received partially mediated these drug effects. This finding was multifaceted for smokers' tension levels, where stimulus expectancy mediated the effects of nicotine immediately after smoking but not approximately 30 minutes later (near the end of the experiment). From a theoretical perspective, these results represent a small step toward the larger goal of establishing direct versus indirect (i.e., mediated) effects of nicotine on behavior, which has been identified as a major goal of basic research in this area (Waters & Sutton, 2000). From an applied perspective, these findings have implications for some cessation studies of reduced-nicotine cigarettes, especially recent research on the effectiveness of such cigarettes administered with various nicotine replacement therapies (e.g., Becker, Rose, & Albino, 2008; Rezaishiraz, Hyland, Mahoney, O'Connor & Cummings; 2007; Rose, Behm, Westman, & Kukovich, 2006). For example, Becker et al. (2008) examined a combined treatment of reduced-nicotine cigarettes and nicotine patches in a clinical trial; they concluded that this combination "offers promise as a new smoking cessation treatment" (p. 1139). Because that study used a double-blind design, the role of stimulus

expectancy was not examined. The present results, however, suggest the possibility that smokers' beliefs about their actual condition could have contributed to the perceived benefits of the treatment. If so, the efficacy of the combined treatment might be reduced in the real world, when participants are aware that their cigarette contains little or no nicotine.

The present study also examined the role of response expectancy in cigarette smoking, that is, whether or not individuals who believed nicotine had positive cognitive effects would show better performance or more confidence in their performance. The results here also were affirmative, but qualified. Significant positive correlations were observed between memory performance (both predicted and actual) and response expectancies assessed near the end of the experiment. The non-significant correlations between pre-task response expectancies and the cognitive measures cast doubt on the possibility that response expectancies played a causal role in performance. Still, the possibility that participants who performed well on the tasks might have attributed their performance to the effects of the cigarettes post-hoc is troubling, especially because nicotine itself affected attention but not memory. Thus, these data might illustrate the formation of new response expectancies in regard to these laboratory cognitive tasks, especially because the tasks may have been novel to the participants. Smokers do have established expectancies about cigarettes on other aspects of behavior, and such response expectancies are important in smoking motivation (Copeland & Brandon, 2000).

Several limitations were present in this study. First, the role of stimulus expectancy was assessed entirely post-hoc, and the sample sizes of groups who expected one type of cigarette but received the other were small. Because only 6 people reported that their cigarette contained nicotine when it did not, it was impossible to look at the role of stimulus expectancy in the non-nicotine condition. Still, the finding of stimulus expectancy effects in the group that received nicotine cigarettes is noteworthy: it demonstrates that expectancy can operate even in the presence of an active drug. A benefit of examining stimulus expectancy post hoc is that no deceptive conditions existed, which have been problematic in balanced-placebo studies (Juliano & Brandon, 2002; Kelemen & Kaighobadi, 2007; Perkins et al., 2004; Perkins et al., 2008).

Another limitation was that a low dose of nicotine was administered in the "active" cigarette condition. The current dose (0.60 mg) was quite low by most smokers' standards: the most popular type of cigarette in the United States yields approximately 1.2 mg of nicotine per cigarette (U.S. Centers for Disease Control and Prevention, 2005). This low dose may explain why no significant changes emerged for predicted or actual memory. The problem of administering a dose of nicotine sufficient to induce pharmacological changes while still maintaining double-blind procedures is well known (Hughes & Krahn, 1985), and this study was not able to completely surmount it. Finally, the cognitive effects of nicotine in cigarettes may be somewhat transient. Sakurai and Kanazawa (2002) have shown the levels of nicotine concentration in blood return to baseline within 10 minutes of smoking a cigarette in non-deprived smokers. In the present study, participants would have just finished their questionnaires and been starting their cognitive tasks at the time when the nicotine levels began to wane. Both the issues of dose and timing present continuing challenges for future researchers. Possible solutions include a comparison of high versus low nicotine levels (instead of low levels versus non-nicotine) and the use of repeated smoking bouts during long experimental procedures.

The examination of individual differences in responses to smoking using effective placebo cigarettes has been identified as an important area in need of research (Perkins et al., 2003). The present study showed that both stimulus expectancy and response expectancy can influence the cognitive effects of nicotine in cigarettes. Based on these results, reliance on double-blind administration procedures to control nicotine expectancies clearly is not sufficient. Fortunately,

the effects of both types of expectancy can be assessed, but the results of studies that fail to do so must be interpreted with caution.

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References

- Barone RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality & Social Psychology* 1984;51:1173–1182.
- Becker KM, Rose JE, Albino AP. A randomized trial of nicotine replacement therapy in combination with reduced-nicotine cigarettes for smoking cessation. *Nicotine & Tobacco Research* 2008;10:1139–1148. [PubMed: 18629723]
- Brandon TH, Herzog TA, Irvin JE, Gwaltney CJ. Cognitive and social learning models of drug dependence implications for the assessment of tobacco dependence in adolescents. *Addiction* 2004;99 (Supplement 1):51–77. [PubMed: 15128380]
- Cohn, J.; Cobb, C.; Ali, K.; Juliano, L. Reactions to cigarettes with and without nicotine. Poster session presented at the 84th Annual Convention of the Western Psychological Association; Phoenix, AZ. 2004.
- Copeland AL, Brandon TH. Testing the causal role of expectancies in smoking motivation and behavior. *Addictive Behaviors* 2000;25:445–449. [PubMed: 10890299]
- Cox LS, Tiffany ST, Christen AG. Evaluation of the brief questionnaire of smoking urges (QSU-brief) in laboratory and clinical settings. *Nicotine & Tobacco Research* 2001;3:7–16. [PubMed: 11260806]
- Etter JF, Le Houezec J, Perneger TV. A self-administered questionnaire to measure addiction to cigarettes: The Cigarette Dependence Scale. *Neuropsychopharmacology* 2003;28:359–370. [PubMed: 12589389]
- Heatherton TF, Kozlowski LT, Frecker RC, Fagerström KO. The Fagerström test for nicotine dependence: A revision of the Fagerström tolerance questionnaire. *British Journal of Addiction* 1991;86:1119–1127. [PubMed: 1932883]
- Heishman SJ, Taylor RC, Henningfield JE. Nicotine and smoking: Review of effects on human performance. *Experimental and Clinical Psychopharmacology* 1994;2:345–395.
- Hendricks PS, Brandon TH. Smokers' expectancies for smoking versus nicotine. *Psychology of Addictive Behaviors* 2008;22:235–140.
- Hughes JR, Krahn D. Blindness and the validity of the double-blind procedure. *Journal of Clinical Psychopharmacology* 1985;5:138–142. [PubMed: 3998203]
- Johnson MW, Bickel WK, Kirshenbaum AP. Substitutes for tobacco smoking: A behavioral economic analysis of nicotine gum, denicotinized cigarettes, and nicotine-containing cigarettes. *Drug and Alcohol Dependence* 2004;74:253–264. [PubMed: 15194203]
- Juliano LM, Brandon TH. Effects of nicotine dose, instructional set, and outcome expectancies on the subjective effects of smoking in the presence of a stressor. *Journal of Abnormal Psychology* 2002;111:88–97. [PubMed: 11866182]
- Kassel JD. Smoking and attention: A review and reformulation of the stimulus-filter hypothesis. *Clinical Psychology Review* 1997;17:451–478. [PubMed: 9260037]
- Kelemen WL, Kaighobadi F. Pharmacological and expectancy-related effects of nicotine on cognition using a balanced-placebo design. *Experimental and Clinical Psychopharmacology* 2007;15:93–101. [PubMed: 17295588]
- Kelemen WL, Weaver CA III. Enhanced metamemory at delays: Why do judgments of learning improve over time? *Journal of Experimental Psychology: Learning, Memory, and Cognition* 1997;23:1394–1409.

- Kirsch, I. Response expectancy: An introduction. In: Kirsch, I., editor. *How Expectancies Shape Experience*. Washington, DC: American Psychological Association; 1999. p. 3-13.
- Kramer MS, Shapiro SH. Scientific challenges in the application of randomized trials. *JAMA: The Journal of the American Medical Association* 1984;252:2739–2745. [PubMed: 6492351]
- Levin ED. Nicotinic systems and cognitive functions. *Psychopharmacology* 1992;108:417– 531. [PubMed: 1357713]
- Mooney M, White T, Hatsukami D. The blind spot in the nicotine replacement therapy literature: Assessment of the double-blind in clinical trials. *Addictive Behaviors* 2004;29:673–684. [PubMed: 15135549]
- Nelson TO, Dunlosky J. When people's judgments of learning (JOLs) are extremely accurate at predicting subsequent recall: The "delayed-JOL effect. *Psychological Science* 1991;2:267–270.
- Perkins K, Sayette M, Conklin C, Caggiula A. Placebo effects of tobacco smoking and other nicotine intake. *Nicotine & Tobacco Research* 2003;5:695–705. [PubMed: 14577986]
- Perkins KA, Jacobs L, Ciccocioppo M, Conklin C, Sayette M, Caggiula A. The influence of instructions and nicotine dose on the subjective and reinforcing effects of smoking. *Experimental and Clinical Psychopharmacology* 2004;12:91–101. [PubMed: 15122953]
- Perkins KA, Ciccocioppo M, Conklin CA, Milanak ME, Grottenhaler A, Sayette MA. Mood influences on acute smoking responses are independent of nicotine intake and dose expectancy. *Journal of Abnormal Psychology* 2008;117:79–93. [PubMed: 18266487]
- Preacher KJ, Hayes AF. SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers* 2004;36:717–731.
- Rezaishiraz H, Hyland A, Mahoney MC, O'Connor RJ, Cummings KM. Treating smokers before the quit date: Can nicotine patches and denicotinized cigarettes reduce cravings? *Nicotine & Tobacco Research* 2007;9:1139–1146. [PubMed: 17978987]
- Rose JE. Nicotine and nonnicotine factors in cigarette addiction. *Psychopharmacology* 2006;184:274–285. [PubMed: 16362402]
- Rose JE, Behm FM, Westman EC, Kukovich P. Precessation treatment with nicotine skin patch facilitates smoking cessation. *Nicotine & Tobacco Research* 2006;8:89–101. [PubMed: 16497603]
- Roth WT, Clark DB, Sheikh J, Agras WS, Taylor CB. How "blind" are double-blind studies? *Journal of Consulting and Clinical Psychology* 1991;59:184–187. [PubMed: 2002136]
- Sakurai Y, Kanazawa I. Acute effects of cigarettes in non-deprived smokers on memory, calculation, and executive function. *Human Psychopharmacology: Clinical and Experimental* 2002;17:369–373. [PubMed: 12415558]
- Sherwood N. Effects of nicotine on human psychomotor performance. *Human Psychopharmacology: Clinical and Experimental* 1993;8:155–184.
- Strasser AA, Lerman C, Sanborn PM, Pickworth WB, Feldman EA. New lower nicotine cigarettes can produce compensatory smoking and increased carbon monoxide exposure. *Drug and Alcohol Dependence* 2007;86:294–300. [PubMed: 16930853]
- Sutton SR. Great expectations: Some suggestions for applying the balanced placebo design to nicotine and smoking. *British Journal of Addiction* 1991;86:659–662. [PubMed: 1859936]
- Thayer RE. Activation-Deactivation Adjective Check List (AD ACL): Current overview and structural analysis. *Psychological Reports* 1986;58:607–614.
- U.S. Centers for Disease Control and Prevention. Tobacco Information and Prevention Source (TIPS). 2005. <http://www.cdc.gov/tobacco/who/usa.htm>. Retrieved on May 5, 2006
- Waters AJ, Sutton SR. Direct and indirect effects of nicotine/smoking on cognition in humans. *Addictive Behaviors* 2000;25:29–43. [PubMed: 10708317]
- Wesnes, K.; Revell, AD.; Warburton, DM. Work and stress as motives for smoking. In: Cimming, G.; Bonsignore, G., editors. *Smoking and the Lung*. New York: Plenum; 1983. p. 233-248.
- West R, Lennox S. Function of cigarette smoking in relation to examinations. *Psychopharmacology* 1992;108:456–459. [PubMed: 1410159]
- Westman E, Levin E, Rose J. Smoking while wearing the nicotine patch: Is smoking satisfying or harmful? *Clinical Research* 1992;40:871A.

Table 1

Mean Ratings on the Cigarette Evaluation Scale by Type of Cigarette and Participants' Judgments about the Type of Cigarette.

Item	Type of Cigarette				Nicotine Cigarette Expectancy			
	Nicotine		No Nicotine		Nicotine		No Nicotine	
	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>Eta</i> ²
The cigarette was satisfying. ^{*,†}	4.79	0.24	1.98	0.16	5.42	0.23	3.33	0.43
The cigarette was calming. ^{*,†}	4.90	0.24	2.33	0.19	5.44	0.26	3.53	0.34
The cigarette reduced my irritability. ^{*,†}	4.35	0.23	2.31	0.18	4.78	0.26	3.20	0.39
The cigarette helped me concentrate. ^{*,†}	3.23	0.22	1.77	0.13	3.56	0.26	2.40	0.36
The cigarette tasted good. ^{*,†}	3.79	0.25	2.00	0.19	4.17	0.30	2.93	0.38
The cigarette reduced my cravings. ^{*,†}	4.02	0.23	2.40	0.20	4.33	0.27	3.20	0.42
The cigarette made me feel awake. ^{*,†}	3.69	0.26	2.17	0.17	4.03	0.32	3.00	0.39
The cigarette made me dizzy. ^{*,†}	2.60	0.26	1.42	0.12	3.06	0.33	1.53	0.27
The cigarette was very strong. ^{*,†}	2.29	0.22	1.35	0.14	2.67	0.29	1.40	0.19
The cigarette reduced my hunger. [*]	3.48	0.28	2.44	0.24	3.75	0.35	2.73	0.38
The cigarette made me feel nauseous.	1.56	0.18	1.50	0.15	1.58	0.23	1.47	N/A
The cigarette gave me throat and chest sensations.	2.63	0.23	2.21	0.20	2.61	0.29	2.73	0.43

Note. *M* indicates ratings; *SEM* indicates standard error of the mean. *Eta*² was included as a measure of effect size when the difference between conditions was statistically significant.

* indicates a statistically significant difference due to the amount of nicotine using an ANOVA, $p < .05$, $N = 103$.

† indicates a statistically significant difference in nicotine cigarettes due to participants' judged presence or absence of nicotine using an ANOVA, $p < .05$, $N = 51$.

Table 2

Difference Scores (Post-cigarette Minus Pre-Cigarette) for Cognitive Performance by Nicotine Condition.

Dependent Measure	Type of Cigarette			
	With Nicotine		Without Nicotine	
	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>
Sustained Attention Accuracy (<i>d'</i>)	0.18	0.04	0.19	0.04
Sustained Attention Response Latency (ms) *	-53.75	16.32	-2.13	13.60
Immediate Prediction Magnitude	-2.85	1.81	-5.05	1.52
Delayed Prediction Magnitude	0.86	1.77	-1.10	1.94
Aggregate Prediction Magnitude	-0.02	0.71	-0.39	0.54
Recall	0.00	0.02	-0.01	0.02

Note. Main entries are mean difference scores.

* indicates a statistically significant difference due to the amount of nicotine using an ANOVA, $p < .05$.

Table 3

Correlations between the Expected Effects of Smoking and Several Measures of Cognitive Performance.

Difference Scores	<i>Pre-Task</i>	<i>Post-Task</i>
Sustained Attention Accuracy (d')	0.00	0.32 ^{**}
Aggregate Prediction Magnitude	0.01	0.25 [*]
Immediate Prediction Magnitude	0.03	0.09
Delayed Prediction Magnitude	0.16	0.23 [*]
Recall	0.01	0.31 ^{**}

Note. Main entries indicate Pearson Product Moment Correlation Coefficients (r).

*
 $p < .05$

**
 $p < .01$