METHOD MATTERS: CONTEXTUAL FACTORS RELATED TO ATTENTION BIAS AMONG SMOKERS ATTEMPTING TO QUIT SMOKING

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ABSTRACT OF THE DISSERTATION

Method matters: Contextual factors related to attention bias among smokers attempting to quit smoking

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Attention bias, or increased attention to smoking relative to neutral cues, may be a useful marker for relapse risk; however, attention bias has not been consistently documented in continuing smokers which limits its utility for treatment planning. This study assessed attention bias in continuing smokers experiencing a mild stressor. Attention narrowing, or increased attention to smoking relative to other positive cues, was also studied to assess the specificity of distress effects on attention to smoking cues. Analyses also explored the degree to which attention bias and narrowing predicted smoking lapses. In addition, because the mild stressor used was somewhat novel, we tested the degree to which unpredictable noise induced attention bias toward negative cues and subjective distress relative to control. Data were collected in two similar study designs in smokers preparing for a quit attempt. Designs differed in the control conditions against which stress was compared within subjects (*Design* 1 = predictable noise, *Design* 2 = silence). Attention was assessed using a modified Stroop task with neutral, negative, positive, and smoking words. *Design, Stress Order* (whether unpredictable noise was presented first or last), and *Word Order* (whether smoking words were presented first or last) were included in analyses to explore their potential effects on attention. Results indicated that attention bias effects were greater in *Design* 1 than *Design* 2 and when stress was presented first rather than last, although attention bias toward smoking cues was small in magnitude in all conditions. No evidence for attention narrowing was found. Attention bias and narrowing under mild stress were not related to later smoking lapses. Although the stress manipulation did not increase distress relative to control, it corresponded with a negative bias as anticipated. The magnitude of this effect varied across study designs. Overall findings suggest attention bias effects are not robust among continuing smokers experiencing unpredictable noise stress, and effect sizes vary as a function of design elements in important ways. Further research is necessary to determine the optimal context to reliably assess attention bias in continuing smokers.

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Introduction

Smoking remains the leading cause of preventable death among American adults (CDC, 2005) and relapse the most likely outcome of a smoking cessation attempt (Garvey, 1992; Shiffman, Brockwell, Pillitteri, & Gitchell, 2008). One factor that may increase relapse risk is attention bias, or the increased attention towards drug relative to neutral cues (Klinger & Cox, 2004; Field & Cox, 2008). Attention bias toward drug-related cues can predict lapse in smokers (Waters, Shiffman, Sayette, Paty, Gwaltney, & Balabanis, 2003), users of alcohol (Cox, Hogan, Kristian, & Race, 2002), cocaine (Brewer, Worhunsky, Carroll, Rounsaville, & Potenza, 2008; Carpenter, Schreiber, Church, & McDowell, 2006), and heroin (Marissen et al., 2006). Attention bias may prompt smoking by facilitating automatic, habit-based smoking that occurs outside of conscious awareness (Tiffany, 1990) or by blocking the processing of alternative, non-smoking options (Baker et al., 2004; Klinger & Cox, 2004). Selective attention to smoking cues may also increase lapse risk by inducing cravings (Cox, Fadardi, & Pothos, 2006; Field, Munafò, & Franken, 2009; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996). Given these plausible mechanisms that may link attention bias, smoking cues, and increased lapse risk, attention bias may be a useful relapse marker that could identify at-risk smokers. These smokers may then be given tailored treatments like attention bias modification (Attwood, O'Sullivan, Leonards, Mackintosh, & Munafò, 2008; Field, Duka, Tyler, & Schoenmakers, 2009), which may increase their cessation likelihood.

One common method of measuring attention bias is the modified Stroop task (Cox, Fadardi, & Pothos, 2006). Participants are asked to color name the font that a word appears in, rather than read the word itself, for motivationally salient and neutral words.

For smokers, attention bias is operationalized as the difference between response times for smoking and neutral words. Attention bias may result from smokers noticing smoking cues more readily than other cues or it may reflect the difficulty smokers have disengaging from smoking cues (Cisler & Koster, 2010; Cox, Fadardi, & Pothos, 2006). In either case, attention bias may represent a motivational drive to smoke (Cox, Fadardi, & Pothos, 2006; Waters & Feyerabend, 2000) with behavioral consequences.

Attention bias may be a useful marker for smoking relapse that could help identify smokers in need of additional treatment to quit successfully. The literature on attention bias toward smoking cues among smokers is inconsistent, however, and several factors appear to influence the magnitude of observed attention bias. For example, attention bias appears to be greater when smokers are nicotine-deprived (Gross, Jarvik, & Rosenblatt, 1993; Rzetelny, Gilbert, Hammersley, et al., 2008; Waters & Feyerbend, 2000), anticipating an opportunity to smoke (Wertz & Sayette, 2001), or viewing words on a computer screen rather than cards (Kindt, Bierman, & Brosschot, 1996). The influence of these factors on attention bias will be reviewed in greater detail below.

Nicotine deprivation may increase attention bias in smokers. Attention bias does not consistently appear in continuing smokers (Field & Cox, 2008) and may be greater when smokers have been deprived of nicotine for at least 12 hours (Gross, Jarvik, & Rosenblatt, 1993; Rzetelny, Gilbert, Hammersley, et al., 2008; Waters & Feyerbend, 2000). Some studies, however, have failed to detect significant attention biases in nicotine-deprived smokers (Mogg & Bradley, 2002; Munafò, Mogg, Roberts, Bradley & Murphy, 2003; Rusted, Caulfied, King, & Goode, 2000), perhaps due to short deprivation periods (Cox, Fadardi, & Pothos, 2006) or selecting samples with low nicotine dependence levels (Munafò, Mogg, Roberts, et al., 2003; Rusted, Caulfied, King, & Goode, 2000; Zack, Belsito, Scher, Eissenberg, & Corrigall, 2001).

In addition, attention bias studies have not consistently tested deprived smokers when they expect to smoke in the near-term. Smoking opportunity can moderate attention bias effects, such that only smokers anticipating smoking within a laboratory visit exhibit increased color-naming times for smoking versus neutral words when deprived (Wertz & Sayette, 2001). Expecting to smoke may increase the saliency of smoking cues and make them more difficult to ignore.

How the modified Stroop task is administered may also impact attention bias. The way words are presented appears seems to matter, with blocked presentations (when all smoking words are presented together, before or after a block of neutral words) eliciting greater bias than interspersed presentations (when smoking and neutral words are shuffled together) (Waters & Feyerabend, 2000; Waters, Sayette, & Wertz, 2003). Likewise, presenting blocked smoking words before neutral words may reduce attention bias due to carryover effects (Sayette, Griffin & Sayers, 2010). Viewing the smoking words in blocks may induce a craving state that does not wear off before the neutral block is presented (Waters, Sayette, & Wertz, 2003). Mode of presentation also seems to matter, with a larger bias present with computer versus card administration (Kindt, Bierman, & Brosschot, 1996).

As the review above demonstrates, there is still much to be learned about the conditions under which attention bias towards smoking cues can be consistently observed. It seems attention bias is most robust when deprived smokers are anticipating an immediate opportunity to smoke (Field & Cox, 2008). To be a useful marker of future lapse risk, however, attention bias should be measurable prior to a quit attempt (i.e., before smokers are deprived of nicotine). Attention bias under deprivation may not be equally measurable across all smokers. Highly dependent smokers may not be able to abstain from smoking for a 12-hour period, and may appear to have less attention bias than those who succeed in abstaining because deprivation may moderate dependence-attention bias relations. In addition, the ability to abstain for 12-hours pre-quit may be a more accurate identifier of cessation likelihood than the attention bias during abstinence.

Therefore, it is important to determine how to assess attention bias in periods of continuing smoking. Inducing mild distress may amplify attention bias in continuing smokers. According to the reformulated negative reinforcement model of drug motivation, it is affective distress in nicotine withdrawal that motivates smoking (Baker, Piper, McCarthy et al., 2004). During withdrawal, distress may drive attention toward smoking cues that signal an opportunity to smoke and escape from distress. The reformulated model hypothesizes that over time this learning generalizes to non-withdrawal distress, which becomes sufficient to motivate smoking and perhaps increase attention towards smoking cues.

Another existing gap in our knowledge of smoker attention is that most research only assesses attention towards smoking compared with neutral cues. Examining attention bias alone may be insufficient for understanding how smokers interact with their complex environments. Perhaps the degree to which smokers experience attention narrowing, or selective attention to smoking compared to positive cues, may be more informative than attention bias about relapse risk and highlight a potential area for intervention. Attention narrowing may occur as the incentive value of smoking cues is increased while non-smoking cue salience is decreased (Baker et al., 2004; Robinson & Berridge, 1993; Robinson & Berridge, 2001). At present, not much is known about attention narrowing. While studies have examined attention toward positive and negative stimuli in smokers, these studies have not examined attention to appetitive cues relative to smoking stimuli (Drobes, Elibero, & Evans, 2006; Rzetelny et al., 2008; Powell, Tait, & Lessiter, 2002; Powell, Pickering, Dawkins, West & Powell, 2004). A recent study conducted by McCarthy and colleagues (2009) found that electric shock did not increase attention narrowing in smokers relative to non-smokers, and there was some evidence that smokers remained sensitive to reward even under deprivation. Further research is needed to determine the degree to which smokers remain sensitive to positive cues during non-deprivation distress.

This study seeks to extend previous work investigating attention bias (Gross, Jarvik, & Rosenblatt, 1993; Rzetelny, Gilbert, Hammersley, et al., 2008; Waters & Feyerbend, 2000) by examining attention bias and narrowing in the context of non-deprivation distress. Study data were collected in two similar study designs, both of which assessed color-naming for neutral, smoking, negative, and positive words in modified Stroop tasks among continuing daily smokers preparing to quit in the next one to two weeks. In both designs, the modified Stroop task was completed in the context of unpredictable noise (meant to be mildly stressful) and while expecting an opportunity to smoke within the hour. We also aimed to explore the degree to which attention bias and narrowing in this context could predict smoking during a quit attempt. A secondary goal was to examine the impact of task parameters, such as stress and word order, on affect and attention, given the past research suggestive of important carryover effects (Sayette, Griffin, & Sayers, 2010). We investigated the impact of study design (*Design 1* or *Design 2*, which differed in several respects), *Stress Order* (whether the Stroop task was completed first under stress or the less stressful control condition), or *Word Order* (whether smoking words were presented in the first or last of four word blocks during the modified Stroop).

Hypotheses:

Hypothesis 1: Smokers will demonstrate *attention bias* towards smoking cues relative to neutral cues under mild stress when non-deprived.

Hypothesis 2: Smokers will demonstrate *attention narrowing* towards smoking cues relative to positive cues under mild stress when non-deprived.

Hypothesis 3a: *Attention bias* under stress and non-deprivation will predict time to first lapse (first instance of smoking after the quit attempt initiation) and initial cessation, defined as a full day of abstinence within the first 28 days of quit initiation (Shiffman et al., 2006).

Hypothesis 3b: *Attention narrowing* under stress and non-deprivation will predict time to first lapse and initial cessation.

We anticipated that these results would be similar across the two study designs, stress order, and word order and that we would therefore be able to conduct analyses collapsed across these design factors. To check this assumption, we examined interactions between design factors and the word type contrasts assessing attention bias and narrowing.

Lastly, we aimed to explore the impact of unpredictable noise stress and differing control conditions (*Design 1*= predictable noise, *Design 2*= silence) on affect and attention. This novel stress paradigm has not been extensively tested and has the potential to help researchers' model effects of mild, daily hassles on attention and affective processes that influence smoking or other health behaviors. The control condition was changed when analyses of *Design* 1 indicated participants did not report the unpredictable noise to be distressing relative to predictable noise. Therefore, in *Design* 2, a silent control was used to maximally differentiate between stress and no-stress conditions. These study variations allowed us to explore the magnitude of differences in self-reported affect between the stress and these two control conditions. Our specific hypotheses regarding the unpredictable noise stress manipulation are presented below:

Hypothesis 4a: Non-deprived smokers will display increased attention towards negative words compared to neutral words in the unpredictable noise condition, replicating the finding of Herry and colleagues (2007).

Hypothesis 4b: Unpredictable noise will increase self-reported negative affect compared to the silence control condition in *Design* 2, but not the predictable noise control condition in *Design 1*.

The current research has the potential to replicate and extend our knowledge of attention bias and narrowing in smokers while also generating new information about the effects of research methods on the robustness of attention effects. Because small samples were enrolled in both study designs (*N*=12 in *Design* 1, *N*=18 in *Design* 2), emphasis in analyses and interpretation will be placed on effect sizes rather than null hypothesis significance testing.

Method

Design

This study was completed in two phases. *Design 1* data collection occurred from March to June of 2012. *Design 2* data collection occurred from June 2012 to January 2013. Difficulties in retention in *Design 1* led to simplification and modification of procedures in *Design 2*. In *Design 1*, subjects were asked to complete two study visits prior to a target quit day and were asked to abstain for 24 hours prior to one of these sessions and to continue smoking normally prior to the other session (with session order counterbalanced across subjects). The requirement for smokers to abstain for 24 hours appeared to contribute to high attrition, so this requirement was dropped in *Design 2* in which smokers were asked to smoke normally before the pre-quit session. At each visit, smokers completed the modified Stroop task with neutral, smoking, positive, and negative words (with word order randomly assigned) twice, once during exposure to a mild unpredictable noise stressor and once in a control condition (a predictable noise condition in *Design 1* and a silence condition in *Design 2*). Stress and control condition order was counterbalanced between subjects. All participants were offered four sessions of smoking cessation counseling (described in greater detail below). Smoking status was assessed up to four weeks post-quit. Only data collected during the continuing smoking visit before the quit attempt will be analyzed in this study.

Participants

Men and women of diverse races/ethnicities were recruited from central New Jersey. Electronic communication, radio, fliers, and direct mailings were used to recruit daily smokers motivated to quit smoking and willing to fulfill study requirements. All participants met the following inclusion criteria: at least 18 years of age, literate in English, and smoking at least 10 cigarettes per day for at least the past 6 months.

Exclusion criteria included: uncorrected hearing or vision problems or colorblindness, given the demands of the experiment; current use of non-cigarette tobacco, stop-smoking treatments, or illicit drugs including marijuana; and pregnancy, breast-feeding, or unwillingness to use birth control to prevent pregnancy.

A total of 45 individuals were enrolled in either study design. In *Design 1*, a total of 13 individuals were enrolled and 9 were retained through the follow-up period. Data from one individual in *Design 1* were excluded because the participant reported having narcolepsy and intermittently fell asleep during the modified Stroop task. In *Design 2*, a total of 32 individuals were enrolled and 22 were retained through follow-up. Drop-out rates were similar across study design (30.1% attrition before follow-up in *Design 1*, 31.3% attrition before follow-up in *Design 2*).

The number of subjects available for analysis differed for each hypothesis (ranging from 30 to 43) due to a loss of reaction time and vocal response accuracy data for 15 subjects in *Design 2* (this was the result of a failure of staff or equipment to record vocal responses during the modified Stroop task). This unfortunate loss of data motivated the combination of data from the two study designs to increase power and generate more stable estimates of effect size. Important differences in the two samples emerged in analysis, however, and study design was included as a factor and moderator of effects in all models of attention and smoking. The samples enrolled in *Designs 1* and *2* were comparable in terms of gender, age, household income, nicotine dependence level, and expired-air carbon monoxide (CO) levels at baseline but differed slightly in the racial, ethnic, marital, education, and employment characteristics of the sample (see Table 1).

The samples are too small to attempt to control for these differences in addition to study design in analyses.

Measures

Participants completed questionnaires at multiple points in the laboratory visit. Nicotine dependence was assessed at the end of a pre-quit session with the Fagerström Test of Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerström, 1991). This measure consists of six items and has a maximum score of 10 (see Appendix A). Higher scores indicate greater physical dependence (Fagerström, Heatherton, & Kozlowski, 1990). The internal consistency of the FTND is adequate (Cronbach's α = .61) (Heatherton et al, 1991). Other longitudinal studies found high test-retest correlations for the FTND ranging from .85 to .88 (Etter et al. 1999; Pomerleau et al., 1994). General affect was measured at the start of the session and between every block of words on the modified Stroop task using the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988) (see Appendix B). The negative and positive affect subscales each include ten questions on a five-point scale and have demonstrated strong internal consistency (Cronbach's α = .87 to .88).

The Wisconsin Survey of Withdrawal Symptoms (WSWS) (Welsch et al., 1999) assessed withdrawal symptoms in multiple domains at the start of the session. The scale includes 28 items on a five-point scale. Subscales of interest include sadness, anxiety, anger, and urge. Each subscale was measured with four items. Internal consistencies of subscales range from Cronbach's α = .75 to .90. Six items from the negative affect and craving scales were administered between word blocks (see Appendix C).

Urge to smoke was measured with the Brief Questionnaire on Smoking Urges (QSU-Brief) (Cox, Tiffany, & Christen, 2001) at the start of the session and between word blocks (see Appendix D). Each of the ten items on the scale is rated on a 100-point range, with higher numbers indicating greater urge. The questionnaire has a two-factor structure representing desire to smoke for pleasure or negative reinforcement. Both factors load onto a higher order factor representing urge. The scale has demonstrated excellent internal consistency and Cronbach's α = .87 to .97.

Additional individual difference measures were assessed at the end of the first visit. These included the FTND, the Attention Control Scale (ATTC) which measures an individual's general ability in focusing and shifting attention (Derryberry & Reed, 2002), a list of current medications to assess for drugs which may slow reaction times, the Brief Wisconsin Inventory of Smoking Dependence (WISDM-37) which assesses for individual motivation to smoke (Smith, Piper, Bolt, et al., 2010), and demographics. Given the small sample sizes, power was low to explore main or moderating effects of these individual difference variables on attention or affect and subsequently not examined further in this study.

Procedures

All study procedures were approved by the Rutgers University Institutional Review Board. The procedures were similar for both study designs, except where noted below.

Screening. Prospective subjects called the laboratory in response to advertisements seeking volunteers for stop smoking studies with free treatment and financial compensation. After assenting to initial screening, callers were asked a series of questions to determine whether they met inclusion/exclusion criteria. Qualifying participants were read a description of the study and interested participants were scheduled for a first laboratory visit. Written informed consent was obtained at the start of the first laboratory visit. Final screening assessing for smoking status was also completed at this time. Participants were required to report smoking at least 10 cigarettes per day in the past week and have an expired-air carbon monoxide (CO) level greater than 10 parts per million [ppm] when assessed in a period of continuing smoking. Once these questionnaires were completed, verbal instructions regarding future smoking were given just before the modified Stroop task to emphasize smoking opportunity (Wertz & Sayette, 2001). All participants were told: "Because you have not yet reached your quit day, you will be able to smoke after this computer task."

Modified Stroop Task. The modified Stroop task was administered on a computer. Participants were asked to color-name words presented in red, green, or blue font as quickly and accurately as possible. Each word was presented for 750 ms in the center of a computer screen with DMDX stimulus control software (Forster & Forster, 2003). For each trial, vocal reaction times were recorded and stimuli were separated by an inter-trial interval of 1000ms.

A training block of 10 words was completed to ensure the directions were understood. Next, participants completed a modified Stroop with four word blocks (smoking, neutral, positive, and negative words). Each block contained a set of 20 words presented twice in random order within blocks. Words in each set (see Table 2) were matched for their frequency in the English language (Brysbaert & New, 2009), word length, and first letter. Positive and negative words were matched on arousal ratings and selected to have extreme valences (Bradley & Lang, 1999). Subjects were randomly assigned to one of four word set orders: 1) smoking, negative, neutral, and positive, 2) smoking, positive, neutral, and negative, 3) negative, neutral, positive, and smoking, and 4) positive, neutral, negative, and smoking. Smoking words were presented either first or last (to assess carry-over effects). Positive and negative words were always separated by neutral words. During inter-block intervals, participants received feedback about their average response time to keep them engaged in the task and completed affective and smoking urge measures.

Mild Stress Induction. Exogenous stress was manipulated within subjects with a mild noise stressor, which has been shown to increase attention bias towards angry versus neutral faces (Herry et al., 2007). This stressor was selected given its compatibility with our research design. Consistent stress can be applied throughout the attention task since unpredictable noise can be presented concurrently with the modified Stroop. Other stress manipulations must occur prior to the modified Stroop (e.g., completed frustration task) or be anticipated at the end of the task (e.g., anticipating public speaking), which may lead to uneven effects of stress over the duration of the 20-minute task. Additionally, unpredictable noise is a mild stressor that in unlikely to have carryover effects after a brief break, which permits stress to be manipulated within subjects within one study visit. Unpredictable noise may also be a better approximation of the mild, daily stressors that smokers face rather than something like electric shock, which may be more intense but also more artificial.

All participants wore headphones that delivered 40 ms 65 dB beeps on a noise carrier frequency of 1kHz during the stress condition of the modified Stroop task. The mean beep spacing was 200 ms and a random jitter was applied to vary the timing of each beep between 140 and 1368 ms using Matlab software (MathWorks, 2011; Version 7.12). Beep duration, decibel level, and carrier frequency were identical to the stress condition.

Treatment. All participants received four 15 to 20 minute sessions of U.S. Public Health Service Clinical Practice Guideline-based individual smoking cessation counseling (Fiore, 2000). Sessions focused on social support, problem-solving, and coping training. Counseling began one week prior to participants' target quit day and occurred weekly thereafter. Treatment was provided to all participants in an attempt to increase initial cessation rates and yield more power for survival analyses by increasing variability in lapsing. In *Design 1*, all counseling sessions were administered over the telephone. In *Design 2*, the first two counseling session were conducted in person and the last two via telephone.

Results

Reliability

Stroop data was assessed for accuracy using Check Vocal, a program designed to facilitate accuracy and timing verification of DMDX response time data (Protopapas, 2007). Accuracy of individual Stroop performance was assessed twice and initial ratings were not referenced during the second rating to reduce potential bias. A total of 252 discrepant trial ratings were flagged and final error status was determined using a manual check of audio responses against the DMDX script which delineated the color answer of each trial. To ensure Check Vocal was operating correctly, three trials for each participant was selected and the Check Vocal responses were verified with a manual check of audio responses against the DMDX script. No discrepancies were found. All error checking was completed by VY, the author of this dissertation. The following trials from the modified Stroop were excluded from data analysis: incorrect responses (208 trials, 2%), very fast (within 200 ms, 157 trials, 1.5%) and very slow (more than 2000 ms, 1 trial, <0.01%) responses, and individual outliers (response times more than 3 SDs above or below the participant's mean, 195 trials, 1.9%).

For the remaining trials, split-half reliability coefficients in each of the four blocks of word stimuli were excellent in the combined samples from *Designs 1* and *2*. Split-half reliabilities ranged between 0.88 and 0.95. Given this, individual trial response times were aggregated to the block level to yield a mean color-naming response (without missing and slow responses and incorrect trials) for each word type for analysis.

Standard Attention Bias and Attention Narrowing Scores

To visually inspect study data we computed standard attention bias and attention narrowing scores and then constructed scatter plots of these scores. The standard attention bias score was computed as the difference between mean color-naming response times for smoking words and the mean response times for neutral words divided by the subject's pooled standard deviation in response times (using only accurate responses). The resulting scatter plot of data as a function of study design, stress order, and word order is shown in Figure 1. A similar strategy was used to calculate attention narrowing by computing the difference between mean response times for smoking and positive words, divided by the pooled standard deviation, and these are plotted in Figure 2. Inspection of these standard difference scores yielded one outlier (*Design 1*, stress first and smoking words last, see Figures 1-2) that was removed from analyses of hypotheses 1-3, dropping the sample size of *Design 1* from 12 to 11.

Attention bias standard difference scores differed across *Design* (*Design 1 M*=0.14, *SE*=0.05, range -0.56-0.58; *Design 2 M*= -0.02, *SE*=0.04, range -0.72-0.51) and the order stress was presented. There was a mean attention bias *d* score of 0.08 (*SE*=0.05, range -0.72-0.53) when stress was presented first and a mean score of -0.01 (*SE*=0.05, range -0.72-0.58) when stress was presented last. Mean attention bias was approximately the same when smoking words were presented first (*M*=0.09, *SE*=0.04, range -0.56-0.53) and last (*M*=0.07, *SE*=0.06, range -0.72-1.16). Standard difference scores of attention narrowing showed little difference across between-subject variables. Mean attention narrowing in *Design 1* (*M*=0.10, *SE*=0.05, range -0.43-0.55) was approximately the same in *Design 2* (*M*=0.07, *SE*=0.05, range -0.65-0.85) and when smoking words were presented first (*M*=0.11, *SE*=0.04, range -0.43-0.73) compared to last (*M*=0.05, *SE*=0.06, range -0.65-0.85). Attention narrowing magnitude did vary somewhat when stress was presented last (*M*=0.13, *SE*=0.04, range -0.41-0.55) compared to when it was presented first (*M*=0.02, *SE*=0.07, range -0.65-0.85).

Repeated Measures ANOVA

A repeated measures ANOVA was run to test the contrast between mean color-naming response times on correct trials for smoking and neutral words (to assess attention bias) and the contrast between smoking and positive words (to assess attention narrowing) in continuing smokers experiencing the unpredictable noise stressor. Between-subjects factors examined as possible moderators of attention bias and narrowing included *Design* (1 vs. 2), *Stress Order* (Stress blocks first vs. last), and *Word Order* (smoking words presented first vs. last). The full factorial model was not run due to small cell sizes (ranging from 1 to 9) in the fully crossed between-subjects factorial design (*Design* X *Stress Order* X *Word Order*). Only the two-way interactions with *Design* were retained, as there was no *a priori* reason to expect *Stress Order* and *Word Order* to influence reaction time grand means or bias effects.

Effect sizes were computed for all analyses. Although Cohen's guidelines depict $\eta_p^2 = 0.01$ as small, 0.06 as medium, and 0.14 as large (Cohen, 1992), we will use higher standards in this work, given the small sample sizes and the tendency for effect sizes to be positively biased. We will focus on effects with η_p^2 of .04 or greater (effect sizes observed in a similar prior study, McCarthy, Gloria, & Curtin, 2009).

None of the between-subjects factors had significant main effects at $p < 0.05$ on reaction time grand means (see Table 3). The overall *Design* main effect was small (η_p^2=0.07) and suggestive of longer mean response times in *Design 1* than *Design 2*. This is illustrated in Figure 3 which shows the mean reaction times to the four word types (under the stress condition only) as a function of study design. Overall response times were longer and more variable across word type in *Design 1* than in *Design 2*. Main effects of *Stress Order* and *Word Order* were negligible with effect sizes η_p^2 of .01.

Hypothesis 1. Results of the ANOVA are shown in Table 3. The attention bias contrast of reaction times for smoking versus neutral words was not significant overall, and had a small effect size η_p^2 of .04. There was a non-significant and moderate (η_p^2=.09) interaction between *Design* and the smoking-neutral contrast. This interaction is displayed in Figure 3, which demonstrates a larger attention bias in *Design 1* ($F(1,8)=4.04$, $p=0.08$, $\eta_p^2=0.34$) compared to *Design 2* ($F(1,15)=0.24$, $p=0.63$, $\eta_p^2=0.02$).

There was also a smaller non-significant interaction (η_p^2=.05) between *Stress Order* and the attention bias contrast which shows larger attention bias during unpredictable noise when stress was presented first ($F(1,10)=0.89$, $p=0.37$, $\eta_p^2=0.08$) compared to last ($F(1,13)=0.00$, $p=0.96$, $\eta_p^2=0.00$), collapsed across designs. Given the relatively large difference in attention bias magnitude as a function of *Design*, mean word response times were graphed as a function of stress order and study design (see Figure 4) even though the *Design* X *Stress Order* X *Attention Bias* contrast interaction was not examined in ANOVA due to small cell sizes. Results indicate that the difference between mean reaction times to smoking and neutral words were modest and inconsistent across stress orders and designs. The only group that appeared to show the predicted pattern of reaction times was the 3 individuals who completed the Stroop task under stress first in *Design 1*.

The main effect of word order and the interaction between attention bias and the order in which smoking words were presented were both negligible with an effect size η_p^2 of 0.01 or less. As such, it did not appear as though significant carryover effects occurred when smoking words were presented first.

Hypothesis 2. Results did not support attention narrowing in any context (see Table 3, Figures 3-4). The attention narrowing contrast of reaction times for smoking versus positive words was not significant overall ($\eta_p^2=0.02$). The two-way interactions between the attention narrowing contrast and *Design*, *Stress Order*, and *Word Order* were not present (effect sizes η_p^2 of 0.00).

Hypothesis 3a: Logistic regression was used to estimate the magnitude of attention bias standard difference score relations with initial cessation, defined as abstinence from smoking for at least one day in the 28 days after quitting. An intent-to-treat approach was adopted and individuals who did not complete follow-up were considered cessation failures. In *Design 1*, 55% of subjects reported achieving at least one full calendar day of abstinence within the first 28 days of a quit attempt. In *Design 2*, 50% stopped smoking for at least one day. For the 14 individuals with standard attention bias scores above the median score of 0.09, seven participants (50%) achieved initial cessation. For the 15 individuals below the median split, 8 achieved initial cessation (53%).

Attention bias measured under mild stress in continuing smokers was not strongly predictive of cessation for a full day; the odds ratio (an estimate of effect size) was quite modest, suggesting a 12% (*B* = -0.13*, SE* = 1.98*, Wald* = 0.00*, OR* = 0.88*, 95% CI* = 0.02-43.00) reduction in cessation likelihood with a one standard deviation increase in attention bias (equivalent to a full standard deviation difference in mean reaction times across word blocks when the maximal observed standard bias score in this sample was 0.58). The standard error of this estimate is very large so confidence is low. *Design* had a small relation with cessation (*B* = -0.20*, SE* = 0.82*, Wald* = 0.06*, OR* = 0.82*, 95% CI* = 0.17-4.10), such that the odds of quitting were estimated to be lower in *Design 2* than *Design 1*, although the confidence interval for this effect is also quite large. The odds ratio for the interaction between attention bias *d* and *Design* (*B* = 0.42*, SE* = 2.39*, Wald* = 0.03*, OR*= 1.52*, 95% CI* = 0.01-164.12) is moderate and positive, however, and suggested that the relation between attention bias and cessation may have been stronger in *Design 2* than *1.*

Next, we examined relations between attention bias and latency to a first lapse after the target quit day. A total of 9 subjects lapsed in *Design 1* and 8 lapsed in *Design 2.* Another 3 were lost before reporting a lapse in *Design 1* and 6 were similarly censored in

Design 2. Mean latency to a first lapse was 5.27 days in *Design 1* and 8.61 days in *Design 2*. The median latency to a first lapse was zero days (on the quit day) in both studies. A scatter plot of days to first lapse as a function of the standard attention bias score was created for all uncensored participants who reported a lapse (see Figure 5). The graph shows no clear relationship between standard attention bias score and first lapse. There is a similar spread in attention bias *d* scores among individuals who never quit (lapsed on day 0) and those who never lapsed (presented as lapsed on day 27 in the graph).

To generate rough estimates of effect sizes of relations between attention bias and lapse latency, Cox-survival analyses were conducted to explore the relation between days to first lapse from the attention bias *d* scores. Participants were considered censored at the point at which data was lost if they did not complete assessment, or at the end of the 28 day follow-up, if they never lapsed. In this very small sample, no effects were statistically significant, but the estimates of effect size (odds ratios) for attention bias *d* score *(B*= -1.16*, SE* = 1.20*, Wald* = 0.94*, OR* = 0.31*, 95% CI* = 0.03-3.29), *Design* (*B* = -0.54*, SE* = 0.56*, Wald* = 0.93*, OR* = 0.59*, 95% CI* = 0.20- 1.74), and the interaction between attention bias and *Design* (*B* = 1.53*, SE* = 1.67*, Wald* = 0.84*, OR* = 4.60*, 95% CI* = 0.18-120.05) were moderate to large in size. These findings suggest that, as with the other analyses, differences may exist across the two study designs, either as a function of the differing samples or differing study procedures.

Hypothesis 3b: Given the lack of evidence for attention narrowing, the relations between attention narrowing, initial cessation and latency to lapse were not tested.

Hypothesis 4a: To replicate previous work by Herry and colleagues (2007) indicating increased attention to negative relative to neutral stimuli in the presence of unpredictable noise stress, a contrast examining negative bias (response times to negative versus neutral words) was conducted in a repeated measures ANOVA with the between-subjects variables of *Design* and *Stress Order* (see Table 4). *Word Order* was not included in these analyses as the order in which smoking words appeared was unlikely to impact contrasts among other word sets.

There was a significant negative bias contrast collapsed across *Design* and *Stress Order* with a moderately large effect size (η_p^2 =0.19). There was a small but not statistically significant main effect of *Design* such that response times were longer in *Design 1* than in *Design 2* (η_p^2 =0.06). *Design* and negative bias had a small but non-significant interaction with an effect size of η_p^2 =0.07. A graph of this interaction (see Figure 3) shows that while the negative bias contrast was large and significant under stress in *Design 1* ($F(1,8)=24.16$, $p<0.01$, $\eta_p^2=0.75$) it was small and non-significant in *Design 2* ($F(1,15)=0.84$, $p=0.38$, $\eta_p^2=0.05$). The interaction between negative bias and stress order was not significant (η_p^2 =0.01). An additional analysis comparing the magnitude of the negative bias in the stress versus control conditions failed to detect a difference in the magnitude of negative bias as a function of stress condition (η_p^2=0.03) and this was not moderated by *Design* (η_p^2 =0.02) or *Stress Order* (η_p^2 =0.00). That is, the negative bias appeared to be present in both the stress and control conditions and did not increase markedly as a function of the stress manipulation.

Hypothesis 4b: Repeated measures ANOVAs tested the contrast between mean self-reported distress for negative and neutral words to examine whether or not unpredictable noise increased distress levels relative to the control conditions. Self-reported affect during the control conditions was examined because the sample was larger (*N*=43) than the sample for response time differences (*N*=29). This allows the assessment of whether or not unpredictable noise stress increased self-reported distress relative to the control conditions. *Stress Order* (Stress blocks first vs. last) was also included in analyses, while *Word Order* was dropped given the lack of a theoretical rationale for distress to vary as a function of when smoking words were presented. Two separate measures of distress (NPANAS and WSWS negative affect scales) were examined as dependent variables in these *ANOVA*s and are presented in Table 5.

When NPANAS scores were examined, there were no significant or noteworthy main effects for *Design, Stress Order*, or *Stress*. Figure 6 shows mean NPANAS scores as a function of negative and neutral words in both stress and control conditions. There was a marginal main effect for the negative versus neutral word contrast with a small effect size ($F(1,39)=3.83$, $p=0.06$, $\eta_p^2=0.09$), however, this did not vary between stress and control conditions. Figure 6 suggests that the magnitude of the difference in negative affect ratings after viewing negative versus neutral words may have been slightly stronger in the control condition than in the stress condition, contrary to expectations. Overall, participants reported negative words (*M*=13.72, *SD*=6.60) to be marginally more distressing than neutral words (*M*=13.28, *SD*=6.11). Examination of effect sizes and significance testing showed no interactions between *Design*, *Stress Order*, *Stress*, and the contrast between negative and neutral words.

Results followed a similar pattern when distress was measured with the WSWS (see Figure 7). The only effect with a notable size was for the overall negative versus neutral word contrast (*F*(1,39)=2.84, *p*=0.10, η_p^2 of 0.07) which did not vary as a function of *Design*, *Stress Order*, or *Stress.* Overall, negative words (*M*=1.09, *SD*=0.88) were reported to be slightly more distressing than neutral words (*M*=1.02, *SD*=0.86).

Discussion

This study sought to measure attention bias and narrowing among smokers anticipating a quit attempt in order to establish increased attention towards smoking cues as a potential marker of elevated lapse risk. Continuing smokers were tested under mild stress in an effort to enhance variance in attention bias and narrowing and, thus, the ability of attention measures to predict cessation. Results indicated that attention bias effects were weak and fragile. Attention bias was only present in the first of the two study designs, and only when the stress condition was presented before the control condition. Attention bias did not appear to be strongly related to success in quitting. No evidence for attention narrowing was found. Study findings suggest a negative bias relative to neutral words during the noise stress manipulation; however, this was present to a much greater extent in the first of the two studies and did not differ markedly across the stress and control conditions. The noise stress manipulation did not increase overall self-reported distress or distress after negative versus neutral words compared to the control conditions.

Overall, these findings suggest that much work is needed to understand when and why attention bias and negative bias vary. Striking differences in reaction times were found across word types, design, and the stress condition order. Although the present small samples may yield unstable estimates of effect size, the results suggest attention bias effects can be readily masked by noise from multiple sources. Given the low power in this study, we will focus on interpreting effect sizes in an effort to understand the potential implications these patterns of results may have for future studies.

Examination of standard attention bias scores (individual differences in mean reaction times to smoking and neutral words divided by the pooled standard deviation) showed attention bias magnitude varied greatly across persons (ranging from -0.72 to 0.58) (see Figure 1) and clustering around zero in most contexts Effect size estimates derived from a repeated measures ANOVA supported this interpretation. Overall attention bias was of small magnitude (η_p^2 =0.04), which was likely driven by larger attention bias in *Design 1* (η_p^2=0.34) that was not present in *Design 2* (η_p^2=0.02) and that could have been driven by just a few subjects in the small sample in *Design 1* (n=11), half of whom showed negligible attention biases. The differences in results across study designs could be attributable to a multitude of confounded factors including design, study sample, control conditions and overall stress. The two designs differed in overall study procedures and requirements for *Design 1* were more time- and effort-intensive than *Design 2*. Consequently, participants in *Design 1* may have had more overall stress from participant burden than did in *Design 2*, and this may have somehow amplified the attention bias noted under unpredictable noise stress. Alternatively, the six subjects driving the overall estimates in *Design 1* may just differ from the other subjects in terms of attention bias in ways unrelated to study manipulations. Effect size estimates also indicated a small attention bias interaction with stress order such that a moderate attention bias was found when stress was presented first (η_p^2=0.08) but not last (η_p^2=0.00). Overall, these results suggest attention bias under non-deprivation stress may be highly sensitive to the overall context in which it is measured, including the impact of a nuisance study factor like stress order, or highly variable across subjects.

There was no evidence for our second hypothesis that attention would be narrowly focused on smoking cues relative to other positively valenced cues in the context of recent smoking and mild stress. Standard attention narrowing scores clustered around zero and no discernible patterns as a function of design, stress order, or word order was found (see Figure 2). Perhaps the stressor did not induce enough distress to motivate smokers towards smoking cues relative to positive cues and a stronger stressor or nicotine deprivation is required for attention narrowing to occur. These null results are similar to those observed in another study (McCarthy, Gloria & Curtin, 2009). To date, the two studies that have examined attention narrowing using a modified Stroop task have failed to yield convincing evidence of attention narrowing toward smoking relative to positive cues.

Given the fragility in attention bias as a function of study manipulations or samples, it is perhaps not surprising that attention bias in the context of unpredictable noise stress was not related to initial cessation or first lapse. If attention biases are influenced by the subtle differences between studies and conditions as our data suggest, then one would not expect a single measure of attention bias to predict distal outcomes across days or weeks of environment changes. We found some evidence that attention bias relations with initial cessation and first lapse differed across designs, however, estimates were highly variable and require replication.

Our results are not consistent with the predictive relationship between attention bias and first lapse reported in Waters, Shiffman, Sayette, et al. (2003). In that study

(*N*=156), daily lapse risk increased by 22% for every 100ms increase in attention bias (*HR* = 1.22, *CI*=0.98-1.53). Another study conducted with the same sample (Waters, Shiffman, Bradley, & Mogg, 2003), however, did not find a predictive relationship between attention bias and first lapse when attention bias was assessed with a dot-probe task under conditions of continuing smoking two weeks before the target quit day. As such, our results echo previous research suggesting that attention-lapse relations do not extend to periods of continuing smoking and may be influenced by how attention is measured.

The evidence supporting the validity of the unpredictable noise stress manipulation is weak. Participants exhibited significant and large negative bias (attention toward negatively valenced vs. neutral words) while exposed to the unpredictable noise across conditions of design and stress order (η_p^2=0.19), but the size of this bias did not differ across the stress and control conditions. Contrary to our expectations, the magnitude of the negative bias under stress appeared larger in *Design 1* (η_p^2=0.75) when the control was predictable noise than in *Design 2* (η_p^2=0.05) when a silent control was used. It thus appears as though the stress manipulation did little to influence attention toward threat cues or self-reported distress, even when we attempted to augment the contrast between the stress and control conditions by using a silence control.

The stress manipulation also failed to influence self-reported affect to a detectable degree. Although self-reported distress appears sensitive to word content during the modified Stroop task, with greater reported distress after negative than neutral words, unpredictable noise stress did not amplify these differences compared to the control conditions (see Figures 9-10). As such, the novel, mild, noise stress manipulation used here appears to have weak or non-existent effects on both subjective negative affect and attention bias and does not appear to be a strong candidate for future research on affect-attention relations.

Limitations

These studies aimed to develop a paradigm that could be used to replicate and extend research about distress effects on attention to illuminate pathways to relapse among smokers attempting to quit. Methodological problems in the first study design, including very high rates of attrition, difficulty adhering to abstinence instructions pre-quit, and null effects of the stress manipulation on self-reported affect prompted major protocol revisions in the second study design. The second design was also beset by high attrition and the limited impact of the stressor. In addition, significant but random loss of reaction time data reduced power in *Design 2* for tests of attention bias and narrowing. These problems and the differences between the two designs require that all the results presented here be treated as preliminary pending replication.

In an effort to use the data from the current study to generate hypotheses for future research, we conducted analyses of the Stroop performance and self-report data common to both study designs. Although we focused on reaction time data collected in both designs under identical circumstances (i.e., during unpredictable noise stress and in periods of continuing smoking), it is possible that other aspects of each design may have influenced results (i.e., unknown participant selection variables, stress control condition, and participant burden). Therefore, while we found some differences in attention as a function of design is unclear which study factors contributed to this.

Future Directions

Additional research is needed to determine how to best measure attention towards smoking cues in non-deprived smokers preparing to quit and how to maximize its predictive validity with lapse. More potent stress manipulations that will be compatible with the modified Stroop task and will enhance both the internal and external validity of research on affect-attention relations are also needed. Researchers must also be careful to consider and examine possible carryover effects in within-subjects designs such as this one. Lastly, an optimal method of measuring attention bias and narrowing in smokers has not been established. Other methods of attention bias assessment (pictorial Stroop, eye tracking during a modified dot-probe task, etc.) may be more sensitive and therefore more suited to measure attention bias and narrowing.

Conclusions

There is insufficient evidence to support attention bias and narrowing during non-deprivation and mild stress as markers of lapse risk. Some attention effects were found, including a smoking attention bias and a bias toward negative relative to neutral words, but these effects were contingent on design variables such as the order in which stress and control conditions were presented. Overall, it appears as though attention biases may be importantly affected by methodological factors we typically treat as nuisance factors and attempt to control through counterbalancing or randomization. These results, and extant literature, suggest that attention bias effects in smokers are not robust across contexts and that the magnitude of observed effects may vary markedly as a function of research design elements. Before attention bias and narrowing in continuing smokers under distress can be evaluated as markers for lapse risk, additional work is needed to optimize research designs for the detection of motivationally significant attention biases.

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Table 1. Sample characteristics as a function of *Design*.

Variable	*Value*	*Design 1* *n=12 (28.6%)* *n (%)*	*Design 2* *n=30 (71.4%)* *n (%)*	χ^2
Gender	Female	4 (33.3%)	13 (38.9%)	1.52
Ethnicity	Hispanic	1 (8.3%)	0 (0%)	37.10*
Race	Caucasian	7 (58.3%)	21 (70.0%)	46.00*
	African-American	4 (33.3%)	7 (23.3%)	
	Other	0 (0%)	2 (6.7%)	
Marital	Married	5 (41.7%)	13 (43.3%)	28.00*
	Separated or Divorced	4 (33.3%)	6 (20.0%)	
	Widowed	0 (0%)	2 (6.7%)	
	Never married	3 (25%)	7 (23.3%)	
	Cohabitating	0 (0%)	2 (6.7%)	
Education	Less than high school degree	4 (33.3%)	2 (6.7%)	22.76*
	High school	4 (33.3%)	14 (46.7%)	
	Some college	4 (33.3%)	9 (30.0%)	
	College degree or greater	0 (0%)	5 (16.7%)	
Employment Status	Employed	3 (25%)	11 (36.7%)	4.67*
	Unemployed	9 (75%)	19 (63.3%)	
	Homemaker	1 (8.3%)	3 (10.0%)	
	Student	2 (16.7%)	1 (3.3%)	
	Retired	2 (16.7%)	5 (16.7%)	
	Disabled	1 (8.3%)	3 (10.0%)	
Household income	< $25,000	3 (25%)	13 (43.3%)	9.33
	$25,000- $34,999	1 (8.3%)	2 (6.7%)	
	$35,000- $49,999	2 (16.7%)	2 (6.7%)	
	> $50,000	6 (50%)	13 (43.3%)	
		M (*SD*)	*M* (*SD*)	*t-value*
Age		47.8 (13.6)	49.9 (14.4)	-0.44
CO level		21.6 (12.6)	19.5 (9.74)	0.58
FTND total		5.8 (2.5)	5.3 (1.97)	0.62

* $p < 0.05$

Table 2. Stroop word stimuli by word set category.

Neutral	Negative	Positive	Smoking
alley	abuse	adventure	ashtray
basket	bloody	brave	burn
bowl	bomb	beach	butt
chair	crash	champ	carton
circle	coffin	cheer	cigarette
detail	disaster	dollar	drag
fork	flood	famous	filter
fabric	fraud	fantasy	flavor
industry	insult	impressed	inhalation
lamp	loser	laughter	lighter
material	murderer	miracle	matches
method	misery	merry	menthol
nonsense	nasty	nature	nicotine
plain	panic	passion	pack
paint	poison	profit	puff
square	stress	success	smell
shadow	surgery	sunlight	smoke
trumpet	terrified	thrill	tar
theory	terrorist	treasure	taste
taxi	thief	talent	tobacco

Table 3. Stroop trial response times in mixed repeated measures *ANOVA* with *Design*, *Stress Order*, *Word Order*, and contrasts for attention bias and attention narrowing

	df	*Error df*	*F*	*p*	η_p^2
Main effects					
Design	1	25	1.82	0.19	0.07*
Stress Order	1	25	0.14	0.72	0.01
Word Order	1	25	0.29	0.60	0.01
Attention Bias	1	25	1.02	0.32	0.04*
Attention Narrowing	1	25	0.51	0.48	0.02
Interactions					
Design X Attention Bias	1	25	2.38	0.14	0.09*
Stress Order X Attention Bias	1	25	1.17	0.29	0.05*
Word Order X Attention Bias	1	25	0.05	0.83	0.00
Design X Attention Narrowing	1	25	0.11	0.74	0.00
Stress Order X Attention Narrowing	1	25	0.08	0.78	0.00
Word Order X Attention Narrowing	1	25	0.02	0.88	0.00

* $\eta_p^2 > 0.04$

Table 4. Stroop trial response times in mixed repeated measures *ANOVA* with *Design*, *Stress Order*, *Stress*, and a negative bias contrast

	df	*Error df*	*F*	*p*	η_p^2
Main effects					
Design	1	26	1.79	0.19	0.06*
Stress Order	1	26	0.12	0.73	0.01
Negative Bias	1	26	6.05	0.02**	0.19*
Interactions					
Design X Negative Bias	1	26	2.00	0.17	0.07*
Stress Order X Negative Bias	1	26	0.53	0.47	0.02

* $\eta_p^2 > 0.04$
** $p < 0.05$

Table 5. Self-reported distress in mixed repeated measures *ANOVA* with *Design*, *Stress Order*, *Stress* and a contrast between negative and neutral stimuli.

	df	*Error df*	*F*	*p*	η_p^2
Main effects					
Design					
NPANAS	1	39	0.40	0.53	0.01
WSWS	1	39	0.01	0.91	0.00
Stress Order					
NPANAS	1	39	0.06	0.81	0.00
WSWS	1	39	0.10	0.75	0.00
Stress					
NPANAS	1	39	0.35	0.56	0.01
WSWS	1	39	0.01	0.93	0.00
Negative vs. Neutral contrast					
NPANAS	1	39	3.83	0.06	0.09*
WSWS	1	39	2.84	0.10	0.07*
Interactions					
Design X Negative vs. Neutral contrast					
NPANAS	1	39	0.00	0.99	0.00
WSWS	1	39	0.68	0.41	0.02
Stress Order X Negative vs. Neutral contrast					
NPANAS	1	39	0.00	1.00	0.00
WSWS	1	39	0.05	0.82	0.00
Stress X Negative vs. Neutral contrast					
NPANAS	1	39	0.35	0.56	0.01
WSWS	1	39	0.01	0.93	0.00
Design X Stress X Negative vs. Neutral contrast					
NPANAS	1	39	0.14	0.72	0.00
WSWS	1	39	0.00	1.00	0.00
Stress Order X Stress X Negative vs. Neutral contrast					
NPANAS	1	39	0.35	0.56	0.01
WSWS	1	39	0.11	0.75	0.00

*$\eta_p^2 > 0.04$

Figure 1. Attention bias standard difference scores as a function of *Design*, *Stress Order [Stress Blocks Administered First (Str1) vs. Last (Str2)]*, and *Word Order (Smoking Words Presented First (Sm1) vs. Last (Sm4)]*.

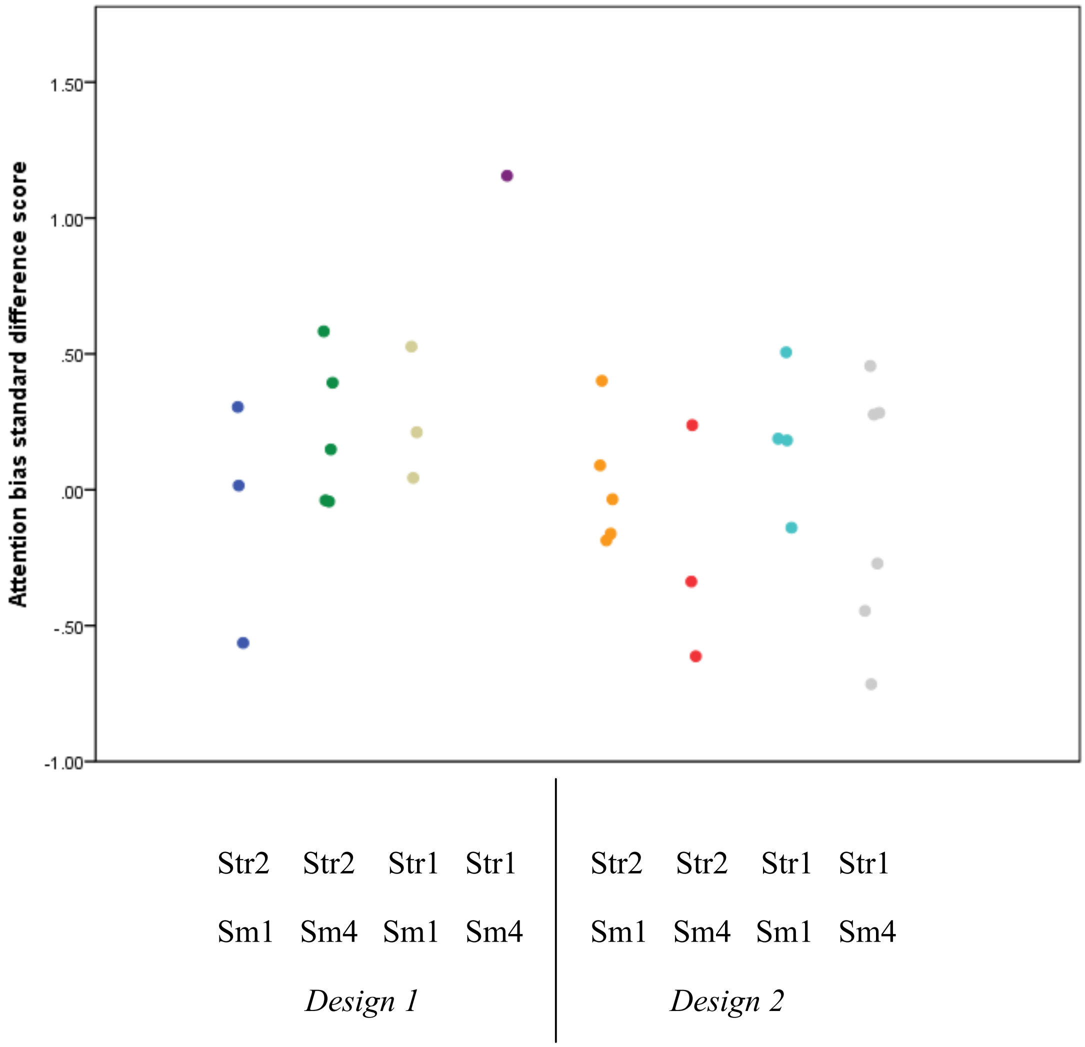


Figure 2. Attention narrowing standard difference scores as a function of *Design*, *Stress Order [Stress Blocks Administered First (Str1) vs. Last (Str2)]*, and *Word Order (Smoking Words Presented First (Sm1) vs. Last (Sm4)]*.

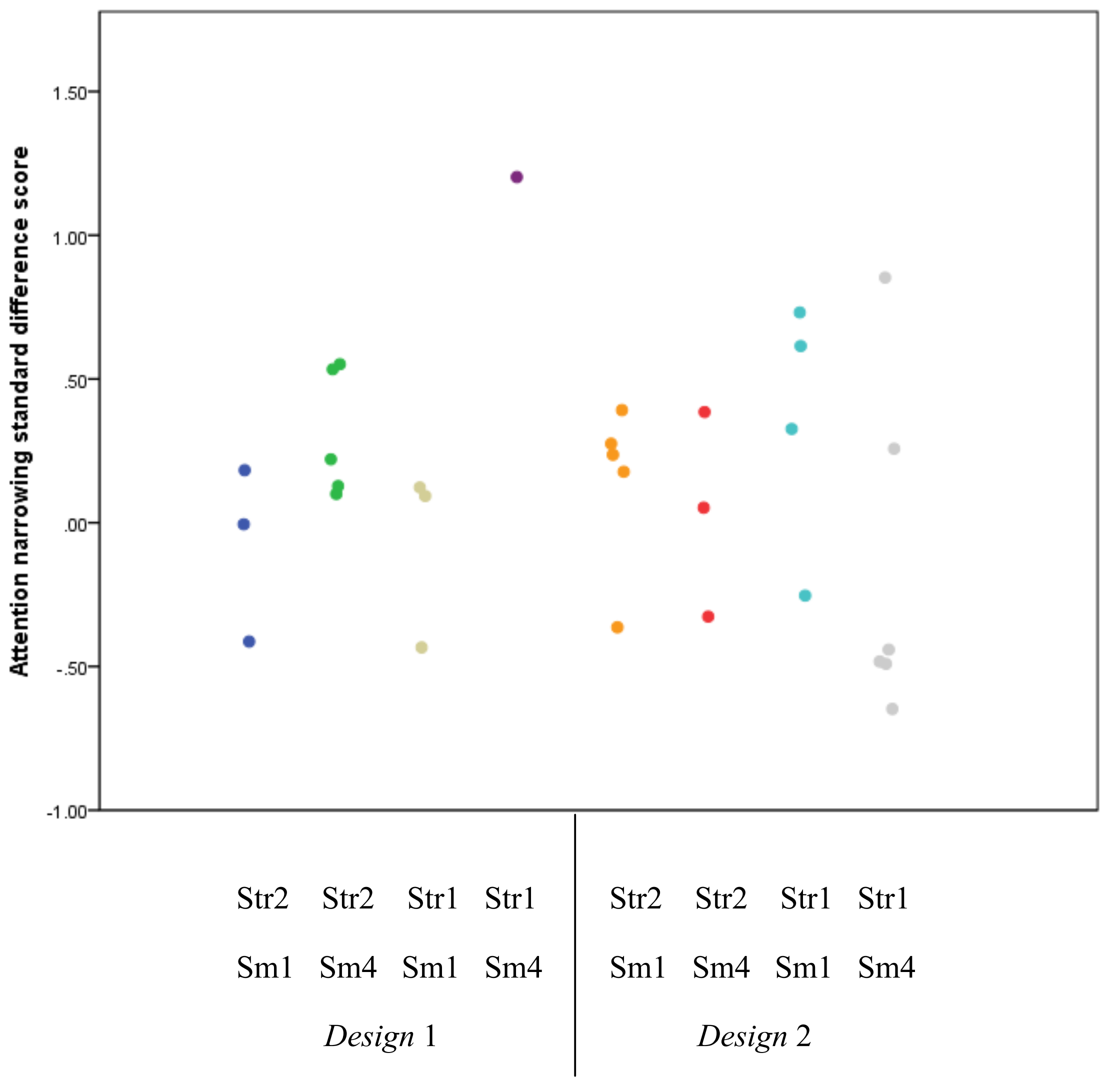


Figure 3. Stroop trial response times as a function of negative, neutral, smoking and positive words and *Design*.

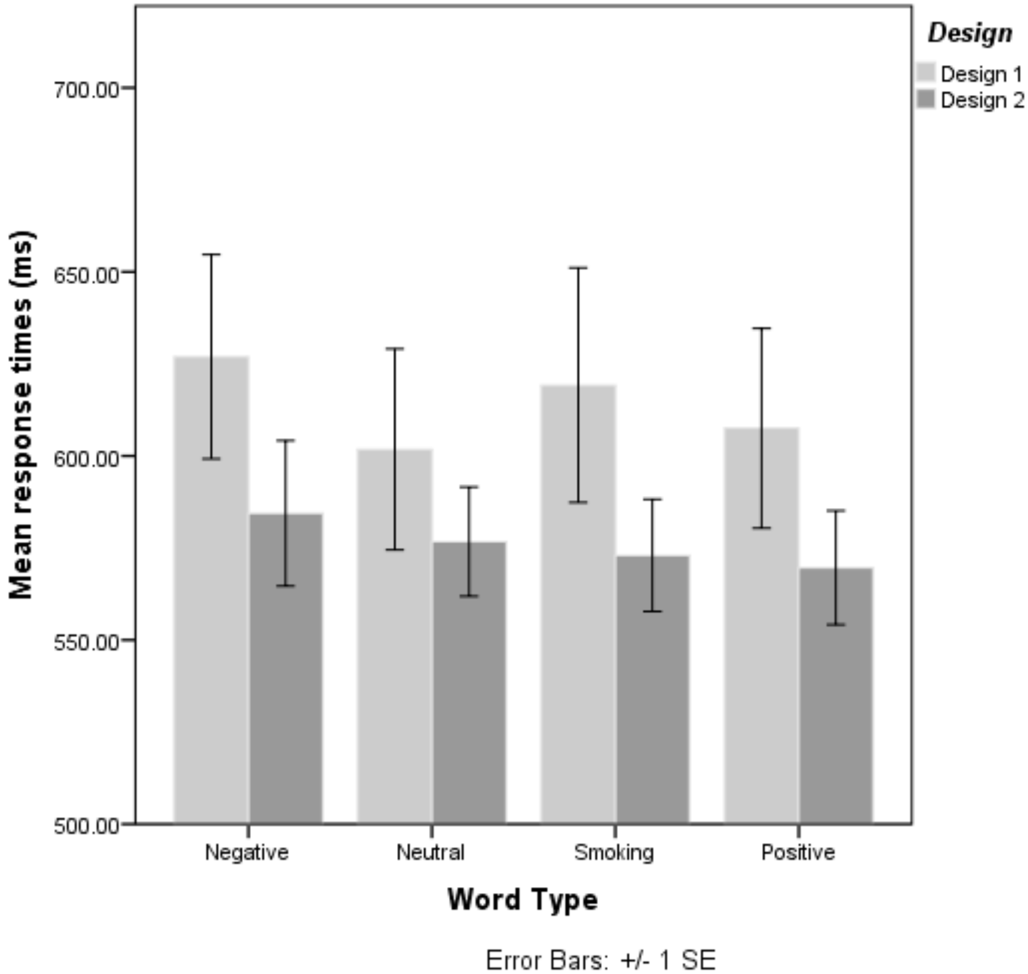


Figure 4. Stroop trial response times as a function of neutral, smoking, and positive words and *Stress Order*, by *Design*.

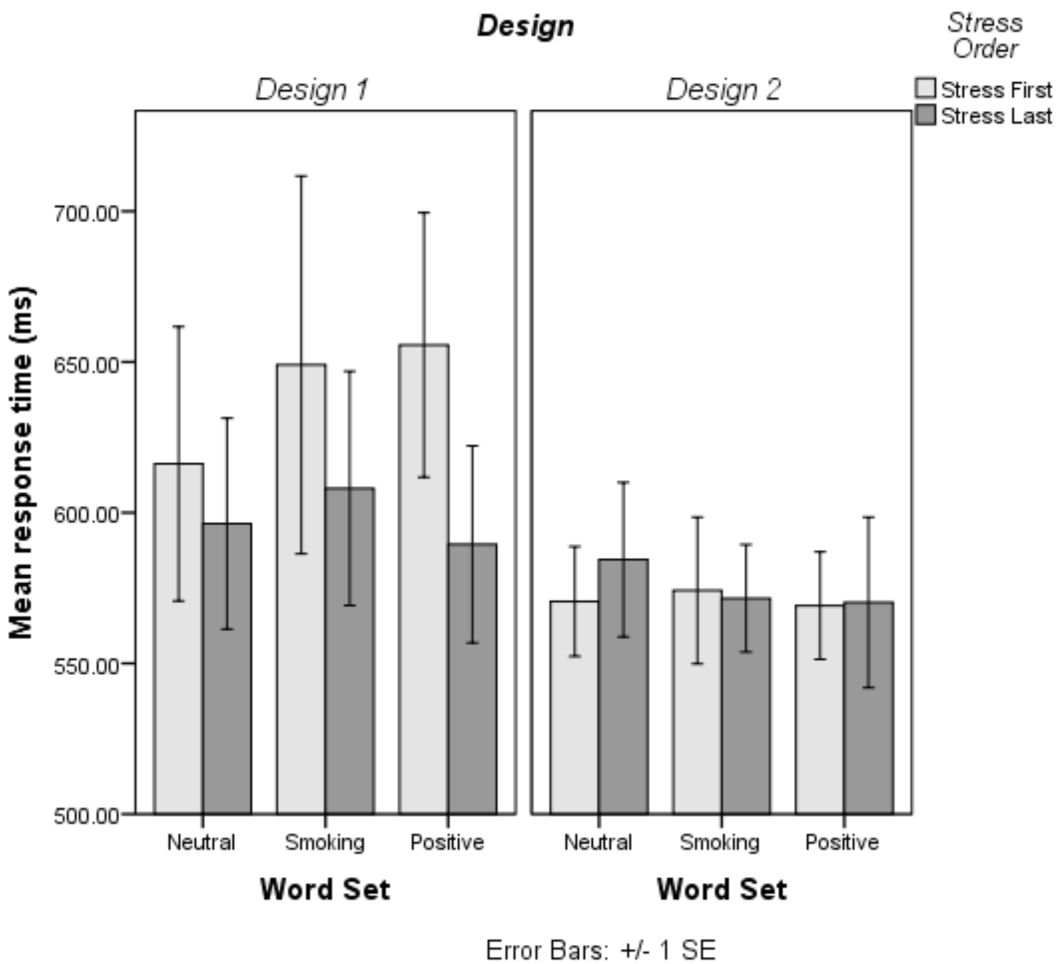


Figure 5. Days to first lapse as a function of attention bias standard difference score.

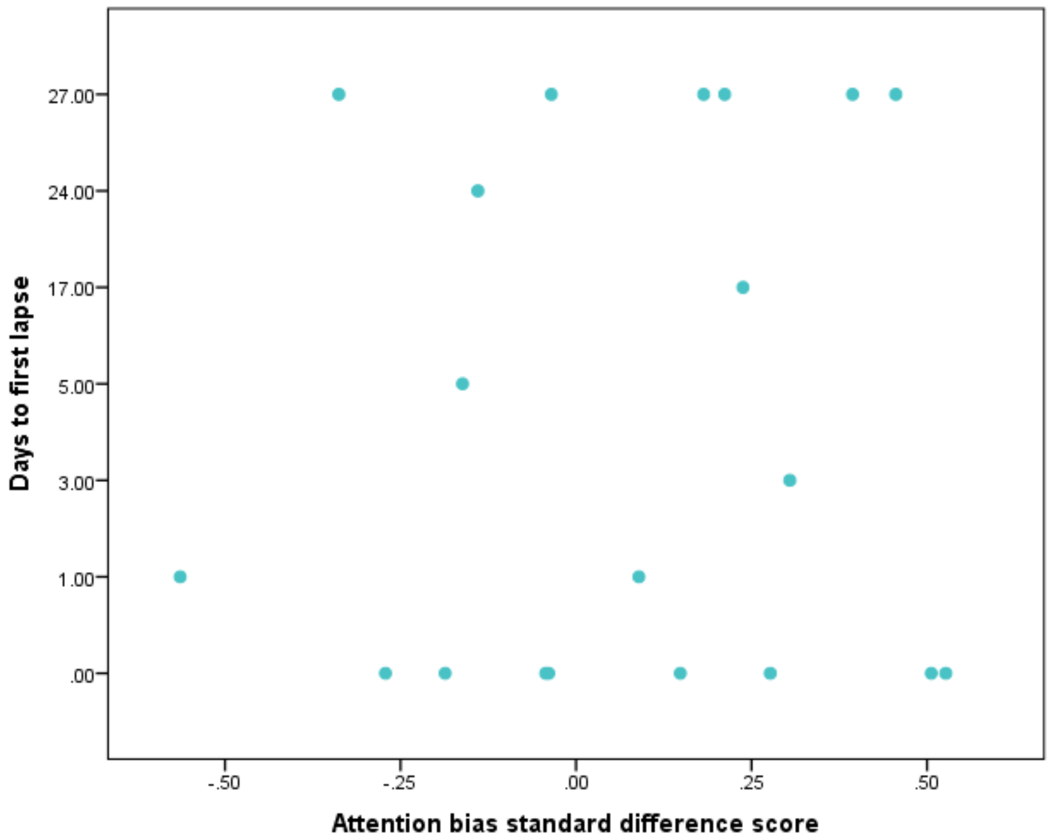


Figure 6. Mean self-reported distress on the NPANAS after neutral and negative words as a function of stress and control conditions.

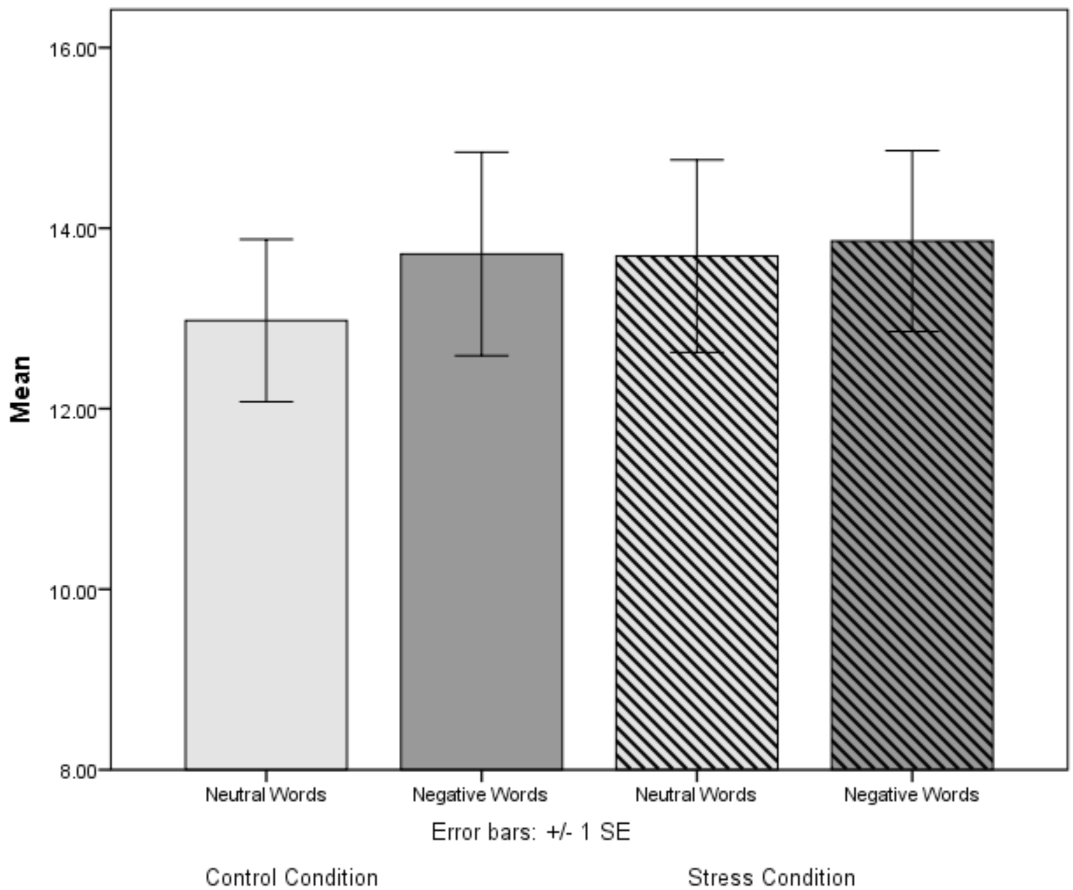
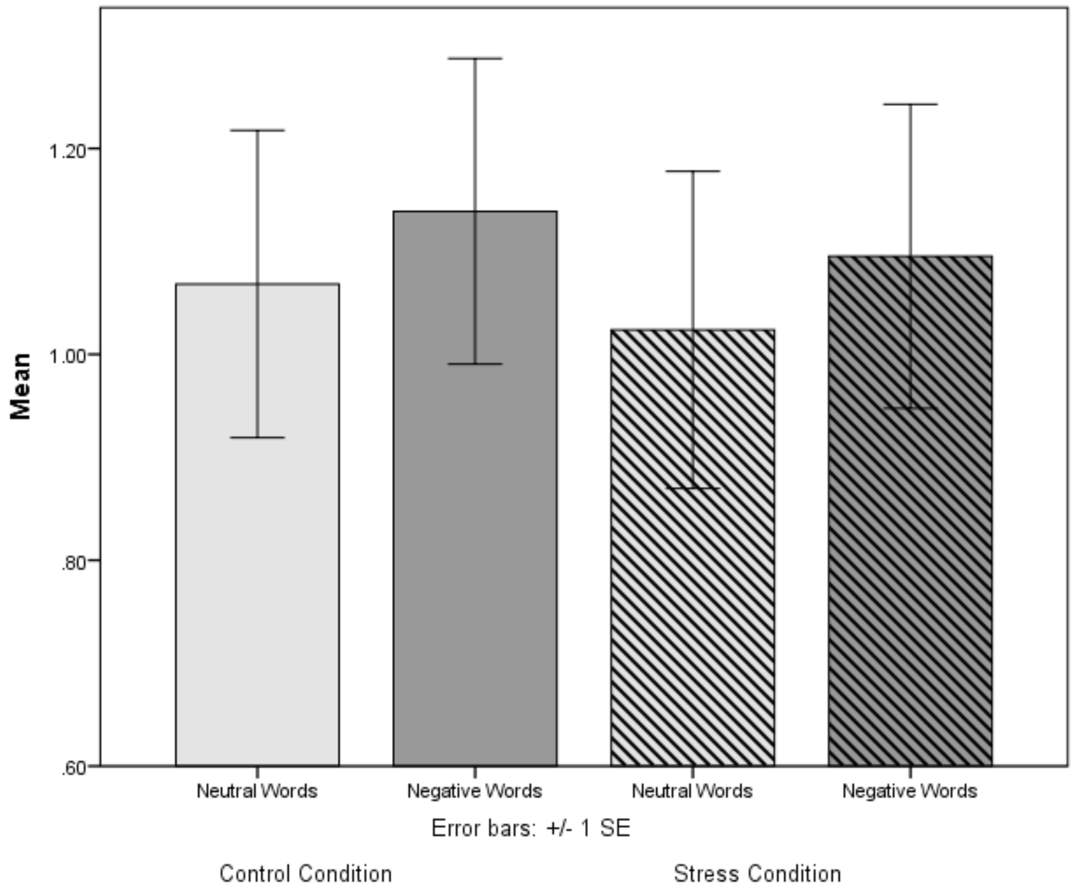


Figure 7. Mean self-reported distress on the WSWS after neutral and negative words as a function of stress and control conditions.



Appendix A:
Fagerström Test of Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerström, 1991)

1. How soon after you wake up do you smoke**?**

- ☐ Within 5 minutes
- ☐ 6-30 minutes
- ☐ 31-60 minutes
- ☐ After 60 minutes

2. Do you find it difficult to refrain from smoking in places where it is forbidden, e.g., in church, at the library, in a cinema, etc.

q Yes q No

3. Which cigarettes would you hate most to give up?

q First one in the morning q All others

4. Do you smoke more frequently during the first hours after waking than during the rest of the day?

q Yes q No

5. Do you smoke when you are so ill that you are in bed most of the day?

q Yes q No

6. How many cigarettes a day do you smoke?

- ☐ 10 or less
- ☐ 11-20
- ☐ 21-30
- ☐ 30 or more

Appendix B:
Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988)

	Very Slightly or Not At All	A Little	Moderately	Quite A Bit	Extremely
Interested	1	2	3	4	5
Distressed	1	2	3	4	5
Excited	1	2	3	4	5
Upset	1	2	3	4	5
Strong	1	2	3	4	5
Guilty	1	2	3	4	5
Scared	1	2	3	4	5
Hostile	1	2	3	4	5
Enthusiastic	1	2	3	4	5
Proud	1	2	3	4	5
Irritable	1	2	3	4	5
Alert	1	2	3	4	5
Ashamed	1	2	3	4	5
Inspired	1	2	3	4	5
Nervous	1	2	3	4	5
Determined	1	2	3	4	5
Attentive	1	2	3	4	5
Jittery	1	2	3	4	5
Active	1	2	3	4	5
Afraid	1	2	3	4	5

Appendix C:
Wisconsin Survey of Withdrawal Symptoms (WSWS) (Welsch et al., 1999)

	Strongly Disagree	Disagree	Feel Neutral	Agree	Strongly Agree
I have been tense or anxious.	0	1	2	3	4
I have felt sad or depressed.	0	1	2	3	4
It is hard to pay attention to things.	0	1	2	3	4
I am impatient.	0	1	2	3	4
I am bothered by anger/ irritability.	0	1	2	3	4
I am frustrated.	0	1	2	3	4

Appendix D:
Brief Questionnaire on Smoking Urges (QSU-Brief) (Cox, Tiffany, & Christen, 2001)

1 Strongly Agree	2	3	4	5	6	7 Strongly Disagree

I have a desire for a cigarette right now.	1	2	3	4	5	6	7
Nothing would be better than smoking a cigarette right now.	1	2	3	4	5	6	7
If it were possible, I probably would smoke now.	1	2	3	4	5	6	7
I could control things better right now if I could smoke.	1	2	3	4	5	6	7
All I want right now is a cigarette.	1	2	3	4	5	6	7
I have an urge for a cigarette.	1	2	3	4	5	6	7
A cigarette would taste good now.	1	2	3	4	5	6	7
I would do almost anything for a cigarette now.	1	2	3	4	5	6	7
Smoking would make me less depressed.	1	2	3	4	5	6	7
I am going to smoke as soon as possible.	1	2	3	4	5	6	7