PSYCHOPHYSIOLOGICAL RESPONSES TO SMOKING AND CHOCOLATE CUES AMONG FEMALE SMOKERS

A Thesis

by

AGNES SUSABDA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2006

Major Subject: Psychology

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Approved by:

Chair of Committee,	Antonio Cepeda-Benito
Committee Members,	Paul Wellman
	Louis Tassinary
	Michael Ash
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ABSTRACT

Psychophysiological Responses to Smoking and Chocolate Cues

Among Female Smokers. (August 2006)

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Chair of Advisory Committee: Dr. Antonio Cepeda-Benito

Interest in female smoking behaviors has grown due to research that has highlighted gender differences in smoking cessation trends. Specifically, female smokers tend to lag behind men in their success in smoking cessation and are more likely to report weight gain concerns. The first goal of this project is to examine the effect of smoking deprivation on smoking and chocolate cravings. In examining smoking deprivation and cravings, the goal is to also determine the affective motivational system underlying craving. Female cigarette smokers (N = 42) were recruited and randomly assigned to either a 10-hour smoking abstinence group or a control group. We examined both self-reported cravings and startle-eye blink responses to visual smoking and chocolate cues. Our results indicated that smoking and chocolate cravings are appetitive for both abstinent and non-abstinent female smokers. Both the psychophysiological and self-report data also indicate that female smokers who abstain from smoking for a short duration seem to be less sensitive to positive reinforcing stimuli than those who continued to smoke. The implications of these findings are discussed.

To my family

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CHAPTER I

INTRODUCTION

Tobacco use is associated with more than $75 billion dollars of medical costs annually and is the leading preventable cause of death in the United States (National Center for Chronic Disease Prevention and Health Promotion, 2003). In the U.S., smoking prevalence has declined substantially since the 1970's, however this downward trend has been considerably slower in women than men (National Institute of Drug Abuse, 2002). It appears that women lag behind men in both decreases in smoking initiation among teenagers and increases in smoking cessation success (NIDA, 2002). This relative lack of progress in women is alarming as the hazards of smoking in women are severe, ranging from cancer and pulmonary disease to reproductive problems (Surgeon General's Report, 2001). Thus, it is pertinent to explore factors which have hindered the decrease of smoking prevalence in women with respect to men.

Researchers have proposed that men and women seek different types of reinforcement from smoking (Perkins, Donny, & Caggiula, 1999). This hypothesis is supported in part by the finding that women and men benefit equally from nicotine-replacement therapy (NRT) at short term, but women have more trouble than men in maintaining smoking cessation gains at long term follow up (Cepeda-Benito, Reynoso, Erath, 2004). In comparison to men, smoking-related cues may induce more craving in women, women may have increased enjoyment from olfactory/taste and hand-to-mouth sensations associated with smoking, and women have greater expectations that smoking

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will facilitate social interactions, reduce negative mood and prevent weight gain (Cepeda-Benito and Reig-Ferrer, 2000; Perkins *et al.*, 1999; Reynoso, Susabda, & Cepeda-Benito, 2005).

With the well documented risk of weight gain following smoking cessation and a greater likelihood of female smokers to gain weight upon cessation, weight gain concern is another pertinent factor to investigate among female smokers (e.g., Hill, Roe, Taren, Muramoto, Leischow, 2000). Most smokers will gain less than 10 pounds after quitting cigarettes, but approximately 10%, of women will gain as much as 30 pounds after quitting smoking (Froom, Melamed, & Benbassat, 1998; Williamson *et al.*, 1991). Often, these concerns about weight gain and fears of fat are motivators for smoking initiation and the continuance of smoking (e.g., Klesges, Meyers, Klesges, LaVasque, 1989). In turn, concerns of weight gain following smoking cessation are important obstacles towards the success of smoking abstinence (Jeffery, Hennrikus, Lando, Murray, & Liu, 2000) and are associated with a greater likelihood of smoking relapse (Borrelli & Mermelstein, 1998). Notably, female smokers are twice as likely as men to report that they expect to gain a large amount of weight upon smoking cessation, and following cessation, women are more likely than men to report weight gain and increased desire to eat (Pirie, Murray, & Luepker, 1991). These findings justify examining the relationship between smoking cessation and appetite-related phenomena.

A number of studies on the relationship between psychostimulant drug administration and food intake have found that consumption or deprivation of either one can affect the level of intake of the other. Researchers have shown that saccharin ingestion can reduce drug self-

administration in rhesus monkeys (Campbell & Carroll, 2000) and that food deprivation can increase the reinforcing value of a drug in rats (Carroll, France, & Meisch, 1981). In fact, both human and animal studies indicate that nicotine administration is accompanied by a decreased intake of food, particularly sweet-tasting, high-caloric foods (Grunberg, 1982). Despite a lack of statistical significance due to small sample size, Bulik and Brinded (1994) reported that female smokers worked more to obtain cigarettes and smoked more puffs in a food-deprived than in a nondeprived state. However, other studies examining the effect of restricted food intake and prolonged food deprivation have found no significant increases in cigarette consumption (Zacny & de Wit, 1990; Zacny & de Wit, 1992).

Another important question is whether smoking cessation increases the desire of food and food consumption. Perkins, Epstein, Sexton, & Pastor (1990) found that smoking cessation increased intake of alcohol and sweet, high-fat foods. This pattern of increased food intake has been observed also among abstinent alcoholics who appear to experience a 'craving shift' from alcohol to either coffee, cigarettes, chocolate, or other sweets, and that their desire and consumption of these substances correlated significantly with their desire for alcohol (Junghanns, Veltrup, & Wetterling, 2000). With regards to smoking, some studies report evidence of increased ad lib food consumption following smoking cessation (DiLorenzo, Walitzer, Sher, & Farha, 1991). However, there are also many studies reporting insignificant effects of smoking abstinence on craving for various types of food (Alsene, Chaverneff, & de Wit, 2003; DiLorenzo *et al.*, 1991). Discrepancies between investigations on the effects of smoking cessation on craving and consumption shifts are perhaps due in part to the fact that these investigations have relied almost exclusively on self-report and

retrospective accounts of craving and food consumption. That is, self-report may not be the sole index of craving (Tiffany, 1990) and retrospective accounts of cravings and food intake can be inaccurate (Zinser *et al.*, 1999; Geier, Mucha & Pauli, 2000; Robinson & Berridge, 1993).

For many years there has been continuing debate on the definition of craving and its underlying motivational and affective states (Kozlowski & Wilkinson, 1987; Robinson & Berridge, 1993; Baker, Brandon, & Chassin, 2004). There are numerous theories of craving, however, most current conceptualizations concede that cravings are strong desires for a substance which can be brought about by contextual cues that inevitably become paired with the consumed substance and its effects (Cepeda-Benito & Gleaves, 2001).

Incentive Sensitization Theory

The incentive sensitization theory proposes that the pursuit of food and drugs share common underlying mechanisms and motivational states. Robinson and Berridge (1993) posited that repeated drug use produced long-lasting neural adaptations in the brain, including the sensitization of the dopamine neural system or brain-pathway responsible for the processing of incentive motivation and reward. This neural sensitization translates into a sensitization towards the incentive value of the drug that results in increased wanting (craving) for the drug. In fact, the sensitization process can result in cue triggered wanting for a reward that may or may not be liked.

The theory also posits that drug related stimuli (or conditioned stimuli) have profound effects on the development and expression of this sensitization (Robinson & Berridge, 1993). Berridge (1995) cites studies where investigators found that although dopamine neurons were

activated initially only when food rewards were received and tasted, with repeated practice the activity in these areas of the brain began to precede the reward. Over time, maximal activity of the dopaminergic neurons was elicited by the conditioned stimuli that consistently predicted the reward.

According to Berridge (1995), people develop cravings for certain foods because these foods were past stimuli that were already salient incentives and which become more salient with the activation of the dopaminergic system. In other words, well liked foods may induce neural sensitization of the dopaminergic system. However, neutral stimuli, such as setting the table, become paired with the activation of the system and also can act as future excitors of the neural system themselves. Repeated intake of the food and its rewarding effects lead to the dopaminergic incentive system becoming hypersensitive to the incentive value of food and activation of the this system will result in enhanced responding for a reward, regardless of the extent to which the reward is liked or possesses a positive hedonic value (Berridge, 1995). With time, this response system becomes increasingly automatic and may function out of the individual's awareness.

Robinson and Berridge (2003) further hypothesized that sensitization from one drug or food can also increase the incentive value of other rewards and the conditioned stimuli for those rewards. Thus a hypothesis of the relationship between nicotine and food craving is that nicotine craving can increase cue-triggered urges for food and vice versa. For example, Wyvell and Berridge (2001) found that drug-free rats that had been subjected to a pre-regimen of amphetamine injections worked more for sucrose in response to food-predictive cues than control rats that had not been pre-sensitized with amphetamine. These results are

congruent with the hypothesis that smokers might be sensitized to food cues because of prior exposure to nicotine.

Wack and Rodin (1982) also highlighted that smoking appears to improve information processing and performance in certain visual detection tasks. Commensurate with the incentive sensitization theory, the authors proposed that this heightened arousal of brain mechanisms caused by nicotine sensitized the brain to cues and increased "the probability that the smoker would eat if there were stimulating food cues in the environment" (Wack & Rodin, 1982, p. 371). In finding that glucose tablets can relieve smoking urges (craving), West *et al.* (1999) also proposed that the desire to smoke shared a common mechanism with appetite and a drive to seek out carbohydrates. Thus, satisfying one need would reduce motivation for the other. West *et al.* (1999) further suggested that nicotine's ability to relieve carbohydrate craving may contribute to the relationship between nicotine and food craving. This author postulated that because nicotine can reduce both nicotine craving and hunger in some people, cravings for food/hunger can often be interpreted as cravings for nicotine. Also, to the extent that nicotine reduces hunger and food intake (Bellinger *et al.*, 2005; Wellman *et al.*, 2005), it is also possible that, over time, low nicotine levels overlap and become paired with hunger-like states. This would result in hunger becoming a conditioned stimulus and craving for nicotine its conditioned response.

Dual Affect Model

The dual affect model, on the other hand, proposed that craving can be understood as either a positive or negative affective state. Similar to Lang's *et al.* (1998) conceptualization of affect, Baker *et al.* (1986) proposed that cravings are affect-related responses that are

processed by two mutually exclusive motivational systems in the brain that respond to either appetitive or aversive stimulation and which motivate approach and avoidance responses, respectively. This motivational system has information on affect (craving) related setting events, responses, and possible consequences of various response options. The particular information that is coded into the motive system will vary with drug, drug history variables, and types of cravings. In addition, the threshold of activation of the motive system is reduced as more information is gathered through the reoccurrence of drug exposure and usage. In theory, desires to use drugs or foods (cravings) can be governed by either the appetitive (positive-affect) or avoidance (negative-affect) systems.

Nonetheless, Baker *et al.* (2004) postulated that the negative-affect motivational system is the main but not necessarily the sole processing channel that promotes drug use. Baker *et al.* theorized that the negative-affect motive system codes information that includes withdrawal-associated physiological and behavioral responses, cues previously associated with withdrawal, expectations regarding withdrawal, the consequences of possible response options, and stimuli that signal drug unavailability. Drug withdrawal activates the negative-affect motivational system, and with repeated rehearsal of the withdrawal-drug use cycle, sensitization to exteroceptive and interoceptive cues of negative affect and drug-associated cues occurs. This rehearsal process sets the stage for negative-affect states becoming conditioned stimuli capable of activating the negative-affect motivational system and associated responses. In theory, seemingly drug-neutral cues such as aversive or disagreeable stimuli that are capable of activating negative affect can generate negative affect cravings.

An important feature of Baker's *et al.* (2004) motivational system is that activation of either the positive- or negative- affect systems makes the organism insensitive to stimuli that are incongruent with the system that is already activated. Thus, an organism in a positive-affect state would be less responsive to negative-affect stimuli, whereas an organism in a negative-affect state would be less responsive to stimuli associated with the positive-affect system. For example, similar to Lang's (1995) theory, the dual-affect theory of cravings hypothesizes that when the individual's emotional state is affectively unpleasant, the avoidance/aversive motivation system is activated and defensive reflexes such as startle would increase in amplitude. In contrast, when one's affect is pleasant, the appetitive/approach motivational state is activated and defensive reflexes such as the startle would be inhibited. That is, individuals startled while in a negative affect state will respond with more intensity than individuals startled while in a positive affect state.

The common idea proposed by the incentive salience and dual affect theories is that drug associated behavioral conditioning may reflect the involvement of learning mechanisms in the brain critical for survival (e.g., obtaining and consuming food). Schroeder *et al.* (2001) reported that nicotine cues not only activated similar brain regions (nucleus accumbens) as those activated by morphine associated cues but also regions (prefrontal cortex) that were activated by chocolate cues. Moreover, studies using food deprived rats have found that chocolate cues can significantly activate also the nucleus accumbens (Schroeder *et al.*, 2001).

The main goal of this study was to investigate the effect of smoking deprivation on smoking and food cravings as measured in self-reported cravings and autonomic psychophysiological responses (startle eye-blink) to affect-laden cues. A concomitant goal

of the investigation was to explore whether nicotine and chocolate cravings resemble either positive or negative affect. Due to aforementioned findings that nicotine administration or cessation does not seem to have a strong relationship to all types of food cravings, but specifically to sweet, high-fat foods (Grunberg, 1982; Perkins *et al.*, 1990), smoking cravings and chocolate cravings among women will be assessed concurrently. In particular, we investigated how smoking abstinence would affect smoking and chocolate craving in female smokers exposed to smoking- and chocolate-related pictures.

The first prediction of the study was that the response of female smokers to negative, positive, and neutral affect pictures would resemble those of previous investigations that have used Lang's (1994) emotional modulation of the startle response paradigm (i.e., potentiated blink startle response amplitudes in response to negative affect pictures and inhibited blink startle response amplitudes in response to positive affect pictures). Second, to the extent that smoking deprivation may activate negative affect, smokers deprived of smoking and presented with visual smoking cues would have greater cravings to smoke and would also respond with higher startle amplitudes than nondeprived smokers across all stimuli. However, if smoking deprivation does not induce negative affect, responses to aversive, pleasant, and neutral stimuli should not differ across our two groups.

Third, if Baker *et al.* (2004) are correct in that drug cravings triggered by negative-affect states/stimuli and are processed mainly as negative affect, we would expect that smoking deprivation would enhance negative affect and reactivity to smoking pictures in the form of potentiation of the startle response. That is, responses to smoking pictures would look more like responses to aversive than to pleasant pictures in smoking-deprived female

smokers. On the other hand, if the Incentive Sensitization theory is correct and approach motivation/positive affect phenomena is the basis of drug craving, startle responses to smoking pictures in our abstinent group should be more inhibited and should resemble responses to pleasant-related stimuli.

Fourth, given Robinson and Berridge's (1993) hypothesis that sensitization from one drug or food can also increase the incentive value of other rewards and the impact of conditioned stimuli for wanting those rewards, we hypothesized that increases in nicotine craving among our abstinent group would be accompanied by increases in chocolate cravings. Moreover, according to the incentive sensitization of craving hypothesis, responses to smoking and chocolate pictures among the smoking abstinent should be similar to each other and would reflect cue triggered activation of an approach/positive affect motivational system (Zinser *et al.*, 1999).

CHAPTER II

METHOD

Subjects

Female cigarette smokers ($N = 52$) were recruited through the use newspaper adds and fliers posted on public bulletin boards. Six women did not attend their second appointment and four subjects were excluded from analysis due to a general lack of startle response. The participants' age ranged from 18 to 52 years ($M = 25.9$, $SD = 10.1$) and smoked an average of 17.5 ($SD = 7.2$) cigarettes per day. Frequency of chocolate consumption ranged from less than once a week to daily (41.9% less than once a week, 27.9% once a week, 16.3% 2-3 days out of the week, 14% more than 3 days a week), with 90.9% of the participants eating 2 or less servings each time they consumed chocolate.

Individuals interested in participating were screened over the phone and those who met criteria were invited to participate in a study concerning emotional reactions to pictures. Eligibility criteria included smoking at least 10 cigarettes per day for at least the last 12 months prior to the experiment. Due to unknown but potentially confounding effects of medications, participants who reported taking prescription medications were excluded from the study. Likewise, individuals with diabetes or other sugar metabolism problems were also excluded.

Callers were informed that some participants would be asked to abstain from smoking for 10 hours and all participants were asked to fast for 3 hours prior to the data collection session. Participants were told they would earn a total of $30 for their participation.

Subjects who agreed to participate were assigned randomly to either a 10-hour smoking deprivation group or a no deprivation group.

Materials

Visual Stimuli. A collection of 60 colored pictures were presented on a 25-inch computer monitor (Barco Multidata OCM 3346) at a distance of 1.5 m from the subject. The content of the pictures varied across 5 categories with 12 pictures per category. Three of the categories corresponded to the neutral, pleasant, and unpleasant classification of the International Affective Picture System (IAPS; Lang, 1995). These pictures were chosen according to their valence and arousal ratings (high arousal pleasant and unpleasant pictures and low arousal neutral pictures) reported in the IAPS. The fourth picture category corresponded to images depicting cigarettes, smoking-related stimuli, and women holding or smoking a cigarette. These pictures were selected from a pool of pictures according to their craving-evoking properties rated from a sample of college student smokers. The fifth picture category depicted chocolate and chocolate consumption images that were chosen also from a pool of pictures rated on the dimension of chocolate craving by a sample of college students who identified themselves as chocolate cravers.

Self-report Measures

Bulimia Test-Revised (BULIT-R; *Thelen, Farmer, Wonderlich, & Smith, 1991)*. The BULIT-R is a 36-item questionnaire used to measure symptoms of bulimia. Only 28 of the items are scored based on responses to multiple choice questions presented in a 5-point, forced-choice format. High scores (104 or above) are indicative of a higher likelihood that the person may be diagnosed as bulimic in a clinical interview.

Eating Attitudes Test (EAT-26; *Garner et al., 1982*). The EAT-26 is an abbreviated 26-item version of the EAT-40 and has been found to be a reliable, valid measure of the symptoms of anorexia nervosa (Garner *et al.*, 1982). Subjects rate each item using a 6-point scale ranging from 0 (*Never*) to 6 (*Always*). Full scale scores range from 0 to 156, with higher scores indicating a higher presence of disturbed eating patterns and eating disorder symptomatology.

Chocolate Craving Questionnaire-Trait (CCQ-T; *Rodriguez et al., 2005*). The CCQ-T (39 items) is an adaptation of the Food Craving Questionnaire-Trait (FCQ-T) to measure chocolate cravings (Rodriguez *et al.*, 2005). The FCQ-Trait measures the intensity of 9 trait dimensions of food craving by instructing participants to think about specific foods they tend to crave (Cepeda-Benito *et al.*, 2000). Thus, the CCQ-T instructs subjects how frequently each statement about chocolate would be generally true for them using a 6-point scale ranging from 1 ('Never' or 'Not Applicable') to 6 ('Always'). Full scale scores range from 39 to 234, with higher scores indicating higher levels of chocolate craving trait.

Chocolate Craving Questionnaire-State (CCQ-S; Cepeda-Benito et al., 2000). The 15-item CCQ-S is an adaptation of the Food Craving Questionnaire-State (FCQ-S). The CCQ-S measures 5 state dimensions of chocolate cravings by instructing participants to think about their current chocolate craving and indicating the extent to which they agree with each statement at that moment from "*strongly agree*" (1) to "*strongly disagree*" (5). Full scale scores range from 15 to 75, with higher scores indicating a higher state of chocolate craving.

Questionnaire of Smoking Urges (QSU; Tiffany & Drobes, 1991). The QSU is a 32-item questionnaire used to assess current craving for smoking (Tiffany & Drobes, 1991).

The QSU has 2 factors. The first factor (*F1)* reflects intention to smoke and the anticipation of pleasure from smoking. The second factor (*F2))* reflects the anticipation of relief from negative affect and smoking withdrawal. In our sample, Cronbach's alpha for *F1* was 0.79 and *F2* was 0.85.

Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Freckner & Fagerström, 1991). The FTND includes two multiple-choice items (0 to 3 scale) and four two-choice (0 to 1 scale) that are added to compute a total nicotine dependence score ranging from 0 to 10, with high scores indicating higher levels of dependence (Heatherton *et al.*, 1991).

The Hopkins Symptom Checklist-21(HSCL-21; Green, Walkey, McCormik, Ross, & Taylor, 1988). The HSCL-21 is a 21-item version of the 58-item Hopkins Symptom Checklist (Derogatis, Lipman, Rickels, Uhlenhuth & Covi, 1974) that is frequently used to assess symptoms of distress. The HSCL-21 asks subjects to endorse items on a 1 to 4 Likert scale to indicate how they have felt in the previous seven days. Total score scores range from 21 to 84.

Self-Assessment Manikin (SAM; Bradley & Lang, 1994). The SAM is a self-report rating form that consists of figures which represent the dimensions of valence (happy to sad affect), arousal (low to high activation), and dominance (feeling very small to feeling in control). We adapted this ratings form to also include a fourth dimension, craving. Each dimension has 5 figures which represent varying intensity level. Subjects are instructed to rate pictures by selecting the figure that best represents their state for each of the dimensions.

Demographic, Food, and Smoking History forms. These questionnaires collected information on age, race, 3-hour food/caffeine recall data, and smoking history.

Physiological Measure

Startle (eye blink) response was used as an index of affective responding to the visual stimuli. Startle responses to food and smoking pictures are conceptualized as reflecting craving and the motivational processes underlying responses to these cues (Geier, 2000; Drobes *et al*., 2001; Hawk Jr., Baschnagel, Ashare, & Epstein, 2004). The eyeblink response was assessed as EMG activity using the MP100 System (Biopac, Goleta, CA) data recorder. Two 4mm Biopac Ag-AgCl electrodes filled with electrode gel (Signa Gel) were secured on the orbicularis oculi region below the left eye. Impedance was checked using the UFI 1089 mk III Checktrode. The raw EMG signal was amplified, filtered (bandpass = 10-500Hz), and integrated using EMG100 and the AcqKnowledge 3.5 software (Biopac, Goleta, CA). The data were edited off-line to detect any clear movement artifact. Scoring of startle responses was accomplished by taking the peak amplitude of EMG integrated signal from 20ms until 120ms after probe onset.

Procedures

Participants who met the inclusion criteria and agreed to participate were scheduled for two appointment sessions. Upon arrival to the laboratory for their first session, participants were asked to complete a series of questionnaires (BULIT-R, EAT, CCQ-T, QSU, Fargerstrom, Hopkins Checklist-21, and the Smoking History form). Participants who scored in the clinical range in the BULIT-R (score >104) or the EAT (score > 24) were

excluded from participation. Participants who did not qualify or declined participation in the second part of the study were compensated with $10 for their time.

Qualified participants were randomly assigned to either a 10-hour smoking deprivation group or a no-deprivation group and asked to return the next day. All participants were asked to not eat and to drink their usual amounts of caffeine for 3 hours prior to the testing session. On the day of the second testing session, a blood sample was obtained to measure glucose level (Bayer Dex Meter Glucometer) and then a CO-level test was performed. Subjects assigned to the non-abstinent group were asked to smoke one of their own cigarettes shortly after their arrival to their second session; while subjects in the deprived group were asked to chew sugar-free mint gum for 5 minutes. After smoking the cigarette, or chewing the gum, all participants were then asked to fill out a food log form, the CCQ-S, and the QSU.

After the questionnaires were completed, all subjects were asked to rinse and dry their hands and sit in a comfortable recliner. Their face was then prepared for electrode placement and the electrodes were attached according to established guidelines (Blumenthal, *et al.*, 2005). The light in the room was dimmed, headphones were put in place, baseline physiological data were collected for 10 minutes while the participant relaxed, and then physiological reactivity (eye blink startle response) to neutral, positive, negative, chocolate and smoking pictures was monitored. Each subject were instructed to watch each picture for the entire time it was on the screen and to ignore the noises that could come from the headphones.

At the end of the visual presentation, the electrodes were removed and the participants were asked to fill out the CCQ-S and the QSU. The pictures were then shown again in groups of three, with all the pictures in each group corresponding to the same type of picture (i.e., aversive, pleasant, neutral, smoking, or chocolate). Participants were asked to rate all the pictures using the SAM figures. Each picture was shown for 6 seconds and, after each block presentation, participants had 15 seconds to rate each picture type along dimensions of valence, arousal, dominance, and craving. All participants were then debriefed and paid $30. The second testing session lasted approximately 1½ hours.

Stimuli Presentation

The pictures were presented in two pseudorandomised orders, where each picture was shown for 6 s, followed by a blank (white background) monitor for 10 seconds. The acoustic startle stimulus consisted of a 100dB (A) white noise burst presented for 50 ms. over Sennheiser EH2270 headphones. The noise was produced by Cool Edit 2002 (Syntrillium, Phoenix, AZ) with instantaneous rise time. To reduce anticipation of the startling noise, the noise was presented at three random intervals from 2.5 to 5 s after picture onset (2.5, 4, and 5) and only during nine of twelve pictures per picture category. Additionally, nine startle probes were presented randomly during inter-trial intervals (ITI). The presentation and timing of the pictures and startle probes was controlled by Superlab software (Cedrus Corporation, San Pedro, CA).

Data Reduction

Startle responses were scored off line by extracting the peak amplitude of startle responses for each trial (falling within a 21-120 ms window following the acoustic stimuli)

(Blumenthal, *et al.*, 2005). A difference score was then obtained for each startle response by subtracting the mean baseline EMG activity (1 second before picture onset) for that particular trial. Trials where the waveform suggested too much baseline activity or clear movement artifact in the startle response were considered a zero-response trial and not included in the analyses (zero-response trials < 7%). To correct for individual differences in startle response magnitudes, each startle response was converted to a *z* score (using the mean and sd of that particular subject's startle response), and then transformed to a *T* score ([*z* x 10] + 50) (Drobes *et al.*, 2001).

Statistical Analysis

All analyses were performed using the SPSS 13.0 statistical package. The subjective data were analyzed using either multivariate between group ANOVAs (Fagerstrom, CCQ-T, Hopkins, BULIT-R, EAT-26) or mixed between group with repeated measures ANOVAs (QSU, CCQ-S, SAM). Between group comparisons explored differences between abstinent and non-abstinent smokers on their responses to these measures.

In our assessment of whether female smokers presented modulation of startle in response to aversive, pleasant, and neutral stimuli, a repeated measures ANOVA compared blink startles in response to Positive, Negative, and Neutral pictures. This analysis was conducted to test whether we had replicated significant differences between Positive, Negative, and Neutral pictures, as found by other researchers (Vrana, Spence, & Lang, 1988; Lang *et al.*, 1993; Geier, Mucha, & Pauli, 2000, Drobes *et al.*, 2001). A mixed design ANOVA was performed using Startle Presentation Times (2.5, 4, 5) as the within subjects factors and Group as the between. Researchers have also reported that activation of

attentional processes during earlier parts of picture viewing may inhibit startle, and that affective modulation of the startle response is thus more likely to occur during the second half of a 6-second picture presentation (Bradley, Cuthbert, & Lang, 1999; Codispoti, Bradley, & Lang, 2001). Thus, repeated measures ANOVA's were conducted using time as the within subjects variable to test for differences in startle responses between startles introduced at 2.5 and 4 seconds, and between 4 and 5 seconds within each type of picture presentation.

Repeated measures ANOVAs were conducted to explore whether startle responses for smoking and chocolate pictures were significantly different than positive, neutral or negative startle responses. Furthermore, to determine a significant difference between Group 1 (abstainers) and Group 2 (non-abstinent) on their startle response to Chocolate and Smoking pictures, a mixed design ANOVA was conducted using Group as the between subjects factor and Picture Type as the repeated measures factor. This difference tested whether smoking abstinence can increase the motivation for chocolate and smoking. Lastly, we examined how abstinence influenced startle responding in the presence of smoking and chocolate cues after controlling for Smoking Addiction (Fagerstrom) and Trait Chocolate craving (CCQ-T).

To control for deviations from the sphericity assumption, the degrees of freedom associated with the within factor were adjusted using the Greenhouse-Geisser correction for all of our repeated measures analysis. Interaction effects were further explored using either repeated or univariate ANOVAs. Statistical significance was set at $\alpha = .05$, which was adjusted using the Bonferroni method for post hoc comparisons.

CHAPTER III

RESULTS

Subjective Variables

Table 1 summarizes the univariate analysis of variance (ANOVA) results that tested for baseline between group differences across theoretically relevant variables. Smokers in the abstinent and control groups reported similar levels of nicotine dependence (FTND), chocolate craving traits (CCQ-T), symptoms of eating disorders (BULIT-R and EAT-26), and levels of psychological distress (HSCL-21). That is, the randomization of smokers into the abstinent and control conditions created two comparable groups of participants. Compliance to study instructions was high as abstinent smokers had significantly lower CO level than the non-abstinent group, $F(1, 40) = 55.70$, $p<.001$.

To monitor smoking and chocolate cravings we conducted two repeated measures ANOVAs with time of assessment (baseline, pre-cue exposure, post-cue exposure) as the repeated measures factor and group (abstinent, control) as the between subjects factors. There are two main factors on the QSU, one which involves the anticipation of positive outcomes from smoking (F1) and another which highlights the anticipation of relief from nicotine withdrawal and/or negative affect associated with withdrawal (F2). From the F1 factor on the QSU (See Figure 1), the results yielded a significant within subjects effect, F (2, 70) = 88.20, $p < .001$, a significant group effect, F (1, 35) = 14.34, $p<.005$, and a time by group interaction effect, F (2, 70) = 13.34, $p < .001$. The time effect indicated that reports of cravings that anticipate positive reinforcement from smoking declined from baseline to the beginning of the second session (pre-cue exposure), F (1, 36) = 131.84, $p < .001$, and

increased from pre- to post-cue exposure, F (1, 37) = 60.69, $p < .001$. The interaction effect showed that the decrement in F1 craving report from baseline to pre-cue exposure was substantially greater in the control than in the abstinent group, F (1, 36) = 11.73, $p < .005$. The change in craving report following cue exposure was greater also in control than in abstinent smokers, F (1, 37) = 3.27, $p < .001$ (see Table 2).

Reports of cravings that anticipate relief from nicotine withdrawal and/or negative affect related to withdrawal (F2) had a different trend across time (see Figure 2). The results yielded a significant within subjects effect, F (2, 76) = 6.225, $p < .01$, a significant group effect, F (1, 38) = 15.27, $p < .001$, and a time by group interaction effect, F (2, 76) = 14.93, $p < .001$. The interaction effect indicated that reports of cravings that anticipate the negative reinforcement qualities of smoking declined from baseline to the beginning of the second session (pre-cue exposure) for the control group, F (1, 18) = 20.85, $p < .001$, but increased for the abstinent group, F (1, 20) = 24.66, $p < .001$. In comparing reports at pre-cue exposure and post-cue exposure, the results revealed a significant within subjects effect F (1, 39) = 6.06, $p < .05$, a significant group effect, F (1, 39) = 26.52, $p < .001$, but an insignificant time by group interaction effect. Thus, although the trend in F2 craving report on pre and post cue exposure were similar in both groups (both reported increased F2 craving at post-cue exposure), participants in the control group still reported significantly less F2 craving than abstinent smokers (See Table 2).

For chocolate cravings (CCQ-S), the results yielded a significant effect for time, F (1.79, 66.29) = 18.30, $p < .001$, a time by group interaction effect, F(1.79, 66.29)= 3.55, $p < .05$, but the between group effect was not statistically significant (see Figure 3). The time

effect indicated that chocolate cravings did not change from baseline to pre-cue exposure, $F < 1$, but increased significantly from pre- to post-cue exposure, F (1, 38) = 19.28, $p < .001$. To interpret the interaction, we conducted pre- to post-cue exposure changes within each group and found that the control group reported significantly higher chocolate cravings at post-cue vs. pre-cue exposure F (1, 17) = 18.66, $p < .001$, whereas the abstinent group showed no time effect.

Overall, the results suggest that the experimental manipulation, smoking abstinence vs. no abstinence, was effective in that abstinent smokers reported more cravings that involve the negative reinforcement properties of smoking than non-abstinent smokers. Conversely, chocolate craving remained unchanged from baseline to pre-cue exposure in both groups. The cue-exposure procedure increased smoking cravings related to positive reinforcement and chocolate cravings significantly more in the control group. This seems to suggest that the control group was more sensitive to positive reinforcing qualities of cues in their environment.

SAM Ratings

Each SAM variable (affective valence, arousal, dominance, and craving) was analyzed separately using a mixed, repeated measures ANOVA, with the five types of pictures sat the repeated factor and group as between subjects factor (see Table 3). For each ANOVA, we specified four a priori planned contrasts to compare the means of each picture type to the mean of the neutral picture category.

All analyses yielded a significant picture type effect, and most of the analyses did not result in significant effects for either the group or the group by picture interaction factors (see

Table 3). The significant repeated measures effects were as follows (see Figure 4,5,6,7). Participants reported greater arousal reactivity to negative, positive, chocolate, and smoking pictures than to neutral pictures. Here, we also found a significant between group difference in the smoking pictures, with the abstinent group reporting significantly higher arousal to these cues F (1, 40) = 4.92, $p < .05$. In terms of valence, subjects rated aversive pictures as negative in affect, and pleasant, chocolate and smoking pictures producing similar levels of positive affect. For dominance, there were statistically significant differences between neutral and both unpleasant and smoking pictures, with participants reporting less control in reaction to unpleasant and smoking pictures than in response to neutral pictures. In the abstinent group, craving for smoking was significantly greater than for chocolate F (1,21) = 9.28, $p < .01$, whereas the non-abstinent group did rated similar cravings to smoking and chocolate.

Physiological Cue Reactivity

In congruence with findings that attentional processes may inhibit startle during earlier parts of picture viewing (Bradley, Cuthbert, & Lang, 1999; Codispoti, Bradley, & Lang, 2001), separate repeated measures ANOVAS revealed that startle probes presented earlier in the trial (i.e. 2.5 seconds) resulted in startle amplitudes that were significantly different than those at 4 and 5 seconds (with startle to negative pictures being more inhibited than both positive and neutral at 2.5 seconds). Moreover, there were no significant differences in startle probes presented in the later part of the trial (at 4 and 5 seconds) within any of the picture types. Thus we assessed emotional modulation using the average of the startle response across the 4 and 5 second probes. A repeated measures mixed ANOVA, with

picture type as the repeated measure, and smoking status (deprived and nondeprived) as the between group factor, revealed an effect for picture type, (F (1.84,73.54) = 7.62, p<.005, partial eta squared = .160), but neither the group , $F(1,40) = 3.22$, $p > .05$), nor the picture by group interaction, $F(1.84, 73.54) = .052$, $p > .05$) were statistically significant. A priori planned comparisons comparing startles to positive and negative pictures showed that the startles to pleasant pictures were inhibited with respect to the startles to aversive pictures, $F(1, 40) = 4.12$, $p < .05$. Startles to neutral pictures were not different from the startles to pleasant pictures but inhibited with respect to negative pictures, $F(1, 40) = 13.8$, $p < .001$ (see Figure 8).

A mixed repeated measures ANOVA with aversive, pleasant, neutral and chocolate pictures as the repeated measures factor and group as between factor revealed a significant main effect for picture type $F(2.82, 112.69) = 5.62$, p <.01, partial eta squared = .123, but there were neither significant differences for the between group factor, $F(1,40) = 4.82$, $p > .05$, nor the group by picture type interaction, $F(2.82, 112.69) = 0.04$, p >.05. A priori planned comparisons revealed that chocolate pictures were inhibited with respect to aversive pictures, $F(1,40) = 7.492$, $p < .01$, but were not significantly different from either positive or neutral pictures. This seems to suggest that smokers, regardless of their level of craving, affectively respond to chocolate pictures in a way that was more similar to positive/neutral than to negative affect.

Both groups had startle responses to smoking pictures that were significantly inhibited with respect to responses to negative affect pictures, $F(1, 40) = 27.35$, $p < .001$) and significantly inhibited with respect to positive pictures, $F(1, 40) = 5.64$, $p < .05$. An analysis

of the startle responses to smoking and neutral pictures resulted in a significant interaction effect $F(1,40) = 4.74$, $p < .05$) (see Table 2). The data suggests that smoking pictures presented to Group 2 subjects (non-abstinent) resulted in further inhibition of startle responses when compared to neutral and positive affect pictures; while in Group 1 subjects the pattern was not observed. Furthermore, there was a significant group difference in the startle data, with more inhibition in startle responses to smoking pictures observed in Group 2 (non-abstinent) vs. Group 1 (abstinent) $F(1,40) = 4.68$, $p < 0.05$, Partial Eta Square = 0.105. With significantly less startle inhibition in Group 1, abstinent smokers may not respond to smoking cues as positively in affect as those who continue to smoke.

CHAPTER IV

SUMMARY AND DISCUSSION

In this investigation we examined the effect of smoking deprivation on affective modulation among female smokers, as well as the affective response underlying smoking and chocolate cravings. We found evidence that our smoking deprivation manipulation was effective in inducing greater smoking cravings in female smokers, and that, according to subjective self-report, smoking deprivation enhanced the anticipation of negative reinforcement effects from smoking more than the anticipation of positive effects from smoking. The significant decline in F1 (anticipation of positive reinforcement effects) smoking cravings before cue exposure found only in the non-abstinent group is probably due to the fact that these participants had just finished smoking a cigarette; while the significant increase in F2 (anticipation of negative reinforcement effects) smoking cravings at pre-cue exposure among the abstinent group may be reflective of greater deprivation. The cue-exposure procedure itself did not have an effect on smoking cravings in the deprived group but significantly increased the anticipation of positive effects from smoking in the non-deprived group.

Contrary to expectations, chocolate craving reports did not increase in parallel with smoking cravings in the smoking deprived group. Moreover, similar to what we observed for the effect of the cue reactivity procedures on smoking cravings, the non-deprived group showed an increase in chocolate craving report. The post-cue increases in chocolate cravings and F1 smoking cravings among the non-abstinent group may reflect their sensitivity to sources of positive reinforcement. The lack of increased chocolate craving report in the

abstinent group and their increase in F2 (negative reinforcement effects) smoking cravings are in line with the Baker *et al.* theory of the activation of negative affect during deprivation and indicative of an insensitivity to stimuli associated with the positive affect system.

Our analysis of the SAM ratings found valence effects across different picture types in the expected pattern, with negative pictures rated significantly lower in pleasure than neutral and positive pictures. Furthermore, both groups rated smoking and chocolate pictures as positive in affect. In terms of arousal, subjects rated negative, positive, chocolate and smoking pictures are high in arousal, with smoking pictures rated highest in arousal and neutral pictures rated lowest in arousal. We also found a significant between group difference in the smoking pictures, with the abstinent group reporting significantly higher arousal to these cues. There were also statistically significant differences in dominance ratings between neutral and both unpleasant and smoking pictures, with participants reporting less control in reaction to unpleasant and smoking pictures than in response to neutral pictures. The craving ratings indicated that while the Group 2 (non-abstinent) had similar cravings for smoking and chocolate, the abstinent group had rated their smoking as significantly higher than chocolate cravings.

The psychophysiological data revealed that, as suggested by other researchers (Bradley, Cuthbert, & Lang, 1999; Codispoti, Bradley, & Lang, 2001), emotional modulation of the blink response was restricted to the latter part of the 6-second picture presentation. That is, for pleasant, aversive and neutral picture types, we found that the startle responses elicited at the 2.5 second significantly differed from the startles produced at 4 and 5 seconds,

with modulation occurring at these latter times and no significant differences found between them.

In congruence with self-report, we found evidence of emotional modulation of the startle reflex in response to positive and negative pictures. That is, the startle to negative pictures was potentiated with respect to the startle to positive and neutral pictures. Although startle responses to neutral pictures were not different from startles during positive picture viewing, this may be due to our choice of positive IAPS pictures which were significantly higher in arousal than the neutral pictures. That is, some researchers have argued that emotional processing is arousal dependent and that viewing positive affect pictures high in arousal may lead to increased startle responses (Dillon & LaBar, 2005).

Overall, our psychophysiological data indicated that smokers, smoking deprived or not, tend to process smoking stimuli as positive affect. That is, startle responses to smoking pictures were significantly more inhibited than those of negative and positive pictures. As was found by other researchers (Geier, Mucha, Pauli, 2000; Mucha *et al.*, 1999), smoking cues were experienced by our subjects as pleasant; however, it was interesting to find in the startle data that our non-abstinent smokers found these cues to be more appetitive than abstinent smokers. This may suggest that although both groups experienced these cues to be pleasant, abstinent smokers experienced more ambivalence or a state of frustrative non-reward than our control group (Rodriguez *et al.*, 2005; Drobes *et al.*, 2001). The subjective data for smoking craving (QSU) at pre-cue exposure is commensurate with this in that the abstinent group not only reported higher cravings that were related to the anticipation of

positive outcomes from smoking than the control group, but they also reported significantly higher cravings that were related to the negative reinforcement properties of smoking.

When comparing data on startle responses to chocolate pictures to those of positive, neutral, and negative stimuli, the chocolate cues appeared to be appetitive for both groups. The subjective self-report from the FCCQ-S and the SAM ratings of the chocolate pictures were commensurate with the psychophysiological data in that both groups craved chocolate at a similar level on time 1 (Day 1) and time 2 (Day 2, pre-cue exposure) and rated chocolate pictures as pleasant. However, at time 3 (post cue exposure), the data on the FCCQ-S indicated that while chocolate craving (state) for the abstinent group remained the same at time 2 and time 3, the control group had a significant increase in chocolate cravings from pre to post-cue exposure. This seems to suggest that smokers who are abstinent for 10 hours may be less sensitive to other appetitive cues in their subjective self report.

In summary, our startle eye blink data is consistent with theories which posit that drug cues activate appetitive motivation. However, when comparing the psychophysiological data of the 2 smoke deprivation groups, we also found that in their startle response to smoking cues, the smoke deprived group did not experience these cues to be as appetitive as the control group and their startle was augmented. This finding seems to convey that drug cues can activate a state of ambivalence/frustrative non-reward and is in line with findings reported by Rodriguez *et al.* (2005) and Drobes *et al.* (2001). Furthermore, the chocolate cued response data did not convey that smoking deprivation increased chocolate craving among chocolate cravers. However, we did find that smokers who were non-abstinent subjectively reported higher chocolate cravings after the chocolate-

cue exposure. This implies that, based on self report, female smokers who continue to smoke find food cues to be appetitive and more so than those who are abstinent. This further suggests that craving among smoke deprived women is experienced not only as an appetitive state, but that the co-activation of a frustrative-nonreward state may also inhibit their report of craving for other appetitive rewards.

Future directions of this research need to include non-smokers in order to rule out the influence of nicotine administration on group differences in emotional responding to craving stimuli. Furthermore, an examination of the role of arousal in cue-elicited craving may provide a better understanding of deprivation effects on startle responses to smoking cues. By increasing the deprivation manipulation, recruiting female smokers which report higher chocolate craving, and including a measure of ad lib consumption, we will also be able to examine withdrawal based smoking/food craving which more closely resembles women who are attempting to quit smoking and further explore how chocolate craving traits may affect smoking cravings. Future research on female smoking and food craving may also benefit from exploring the role of female menstrual cycle.

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APPENDIX

FIGURES AND TABLES

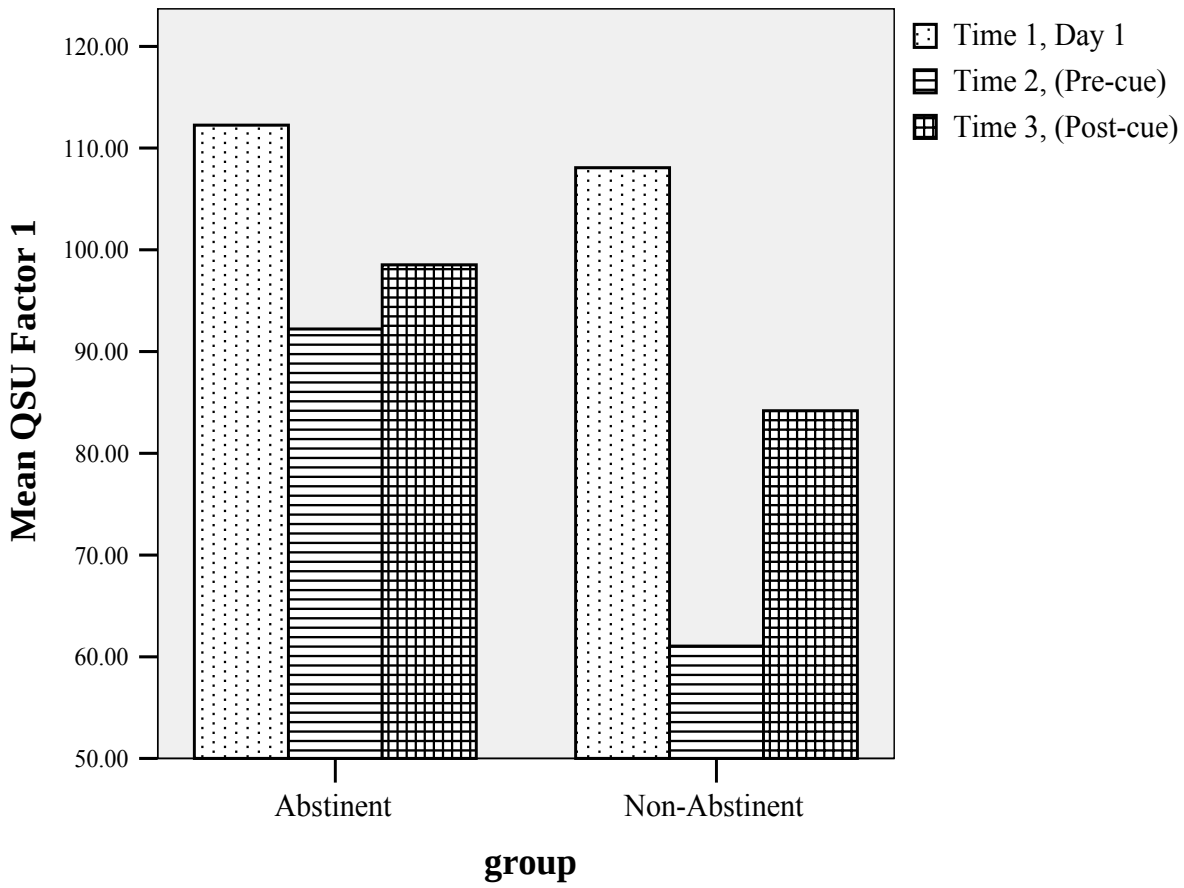

Figure 1. QSU Factor 1 cravings (positive reinforcement effects) as measured between group and across time

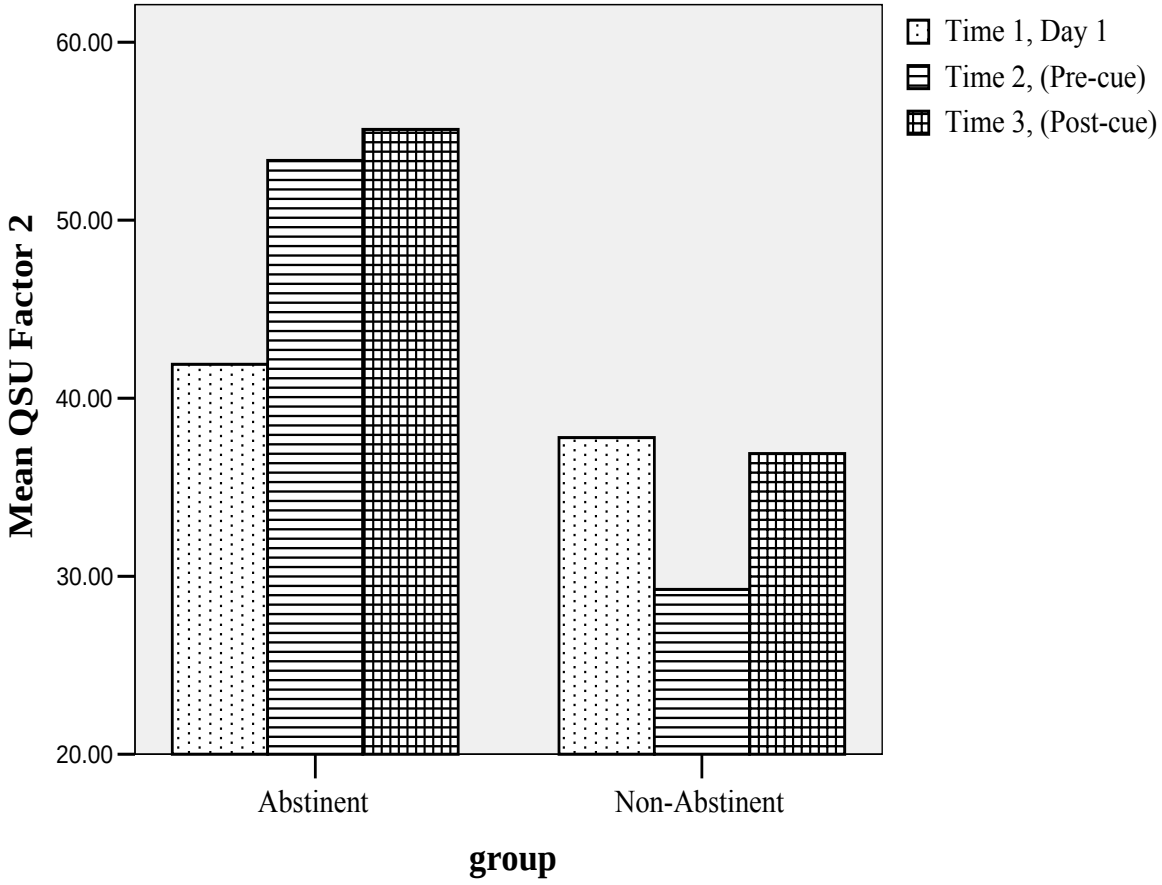

Figure 2. QSU F2 cravings (negative reinforcement effects) as measured between group and across time

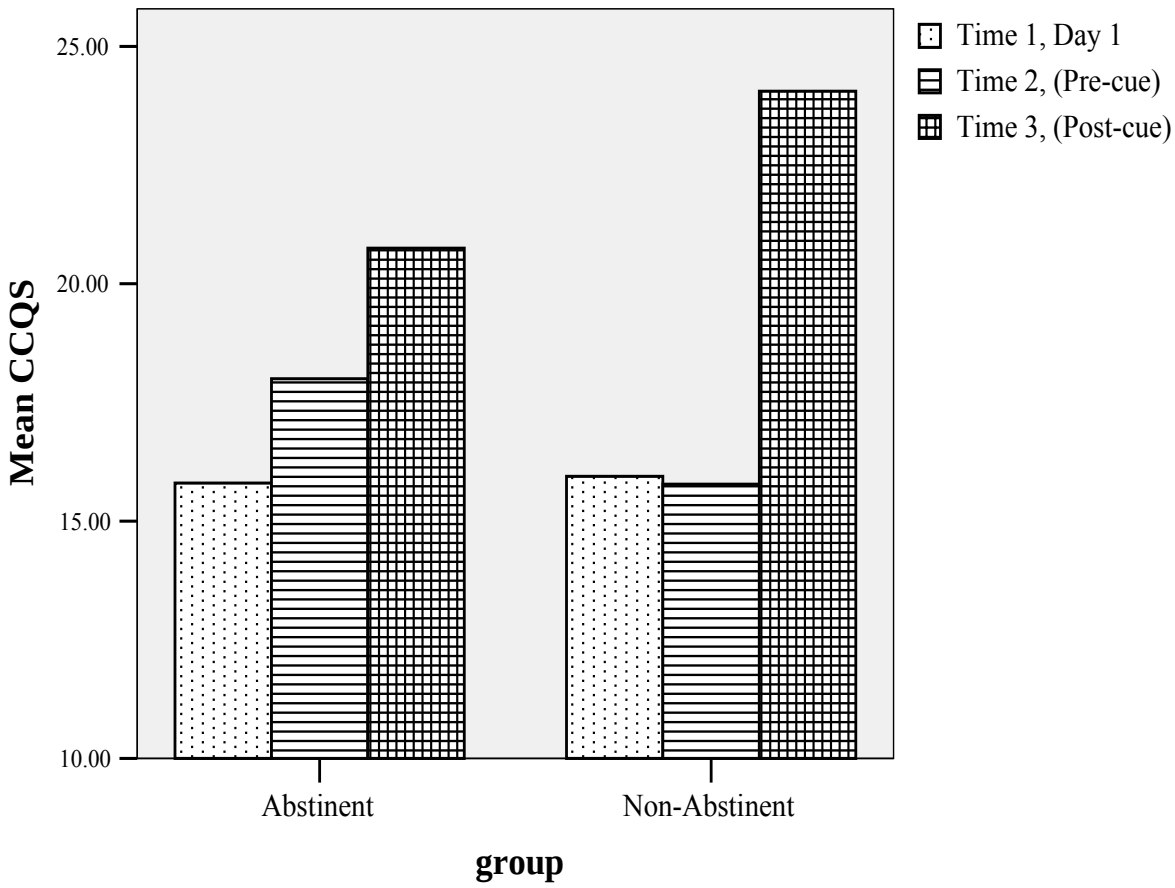

Figure 3. CCQ-S report as measured between group and across time

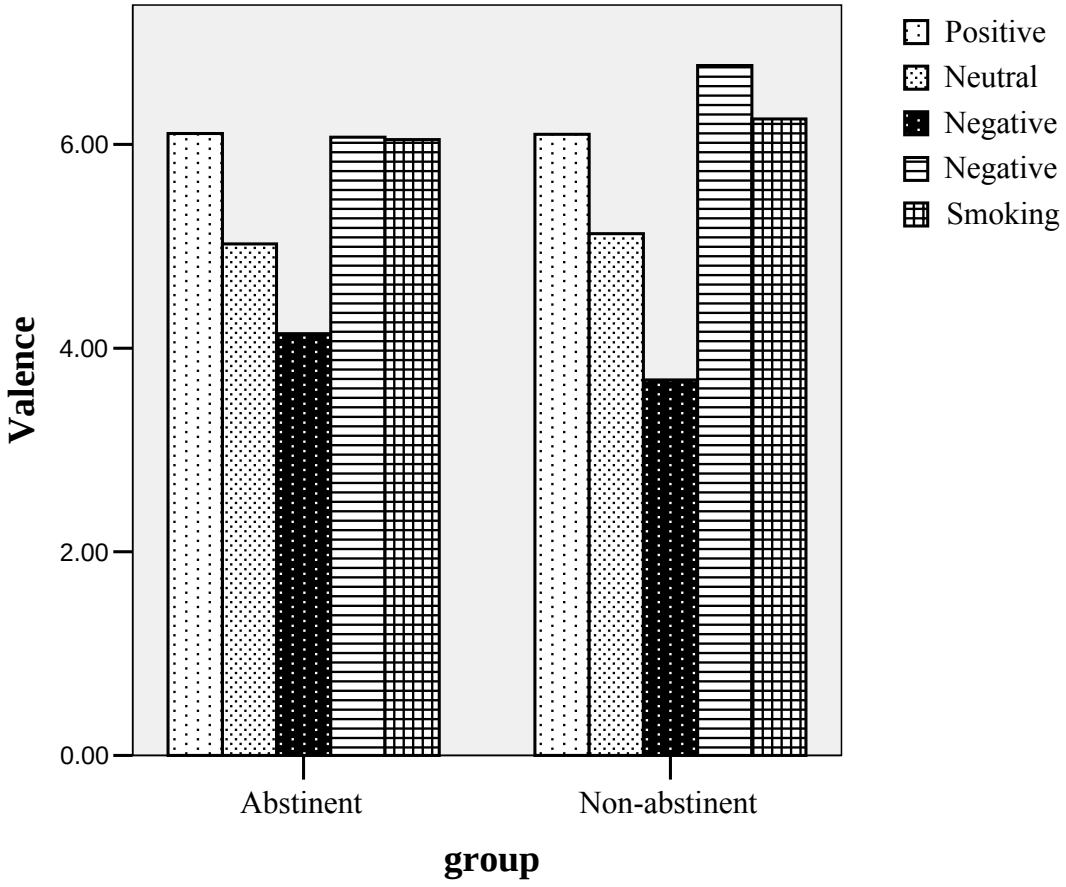

Figure 4. SAM valence ratings

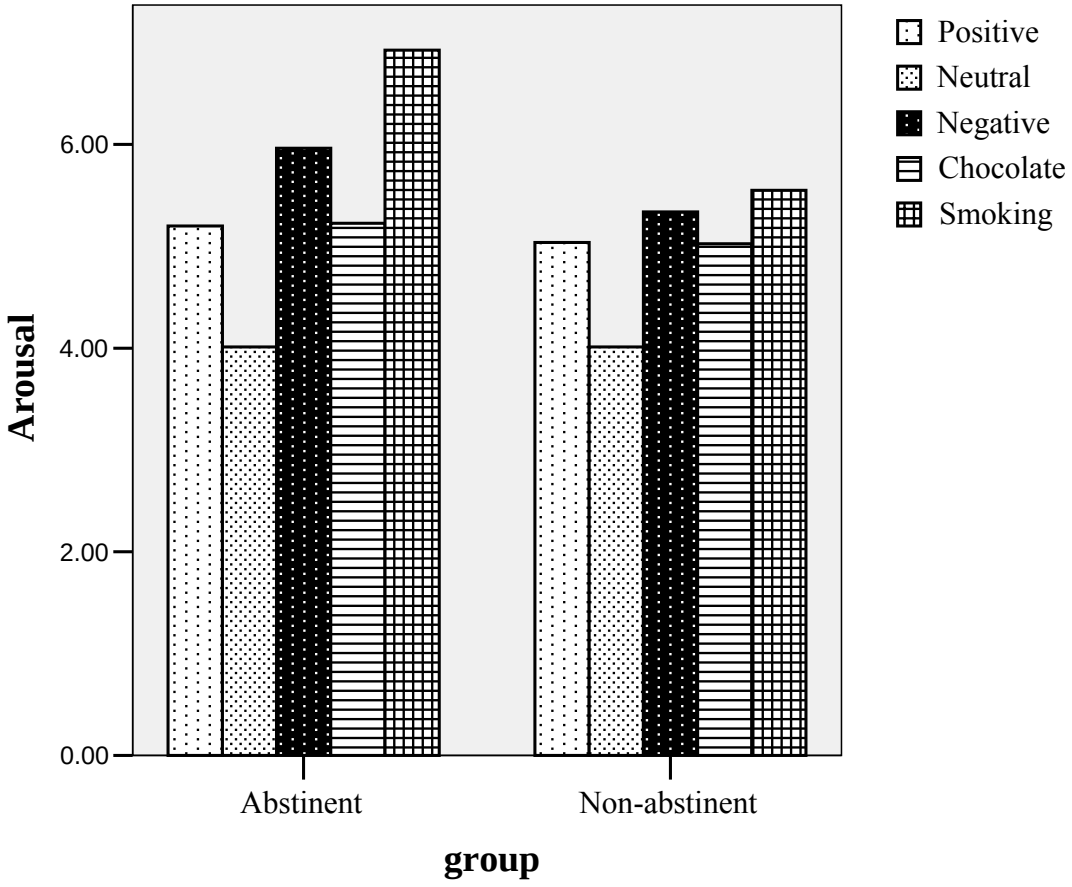

Figure 5. SAM arousal ratings

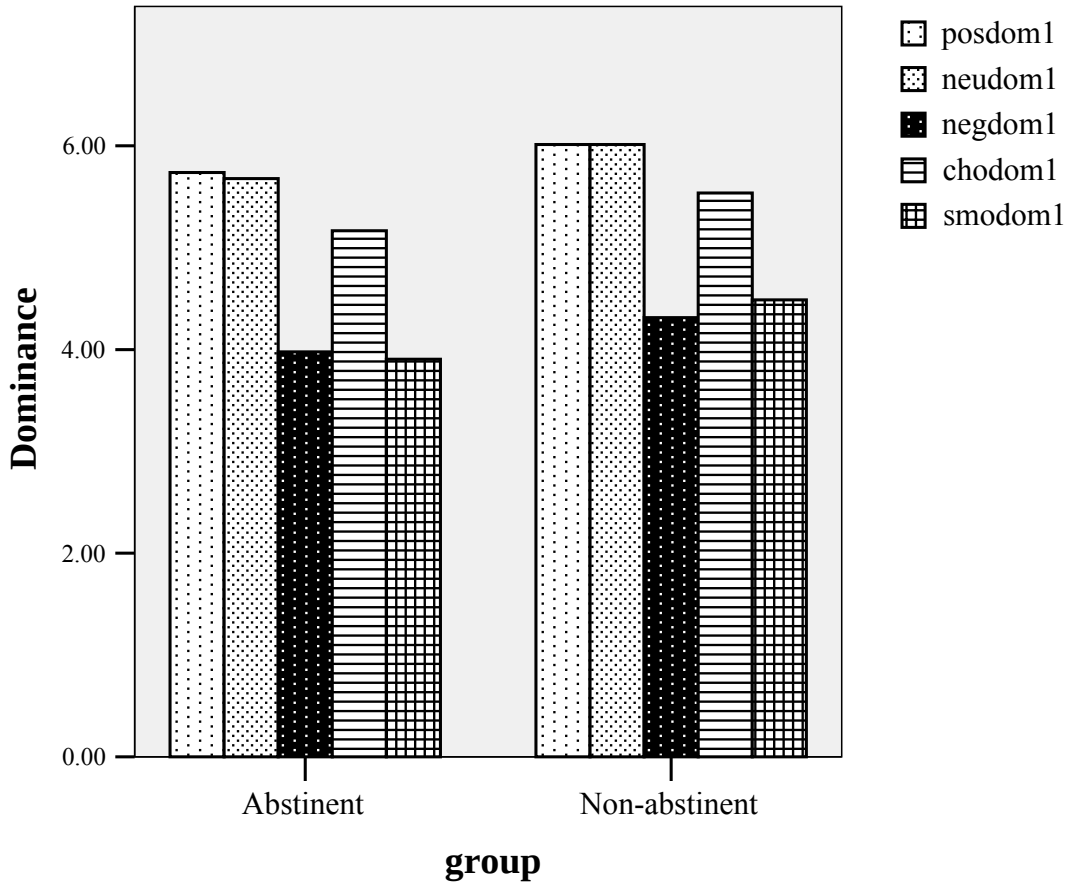

Figure 6. SAM dominance ratings

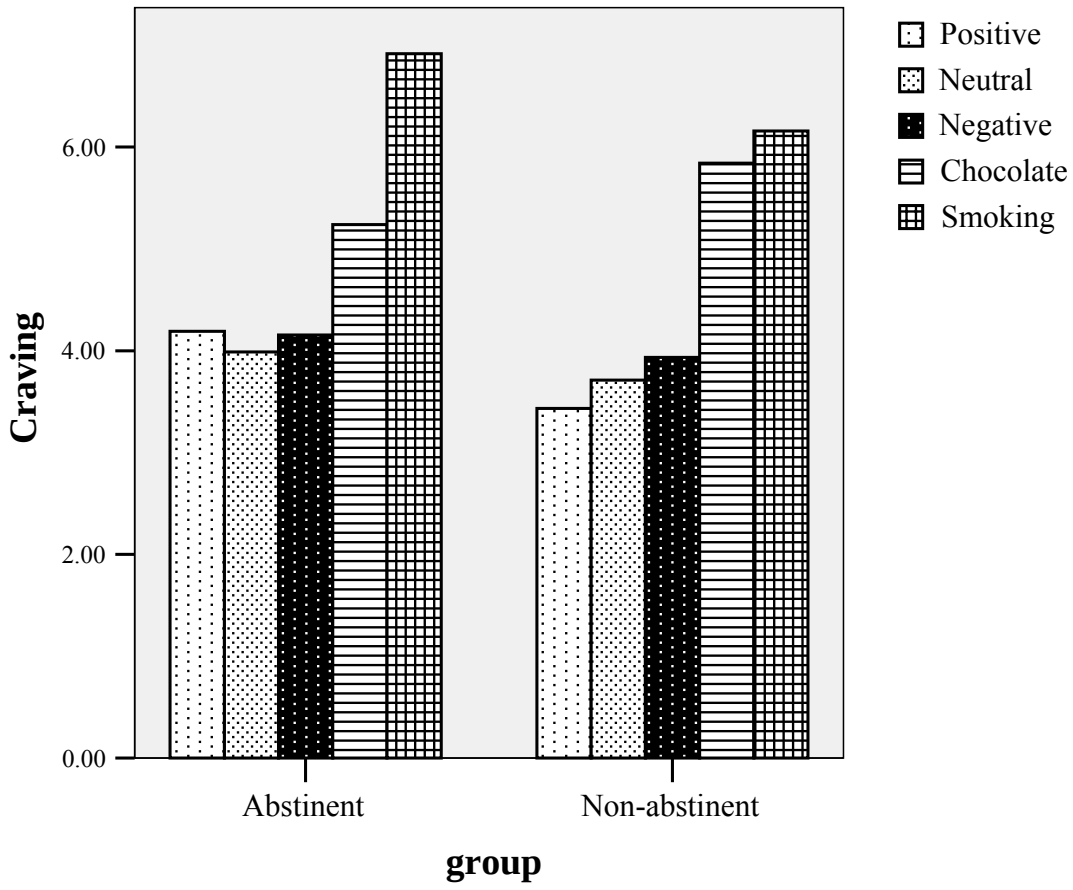

Figure 7. SAM craving ratings

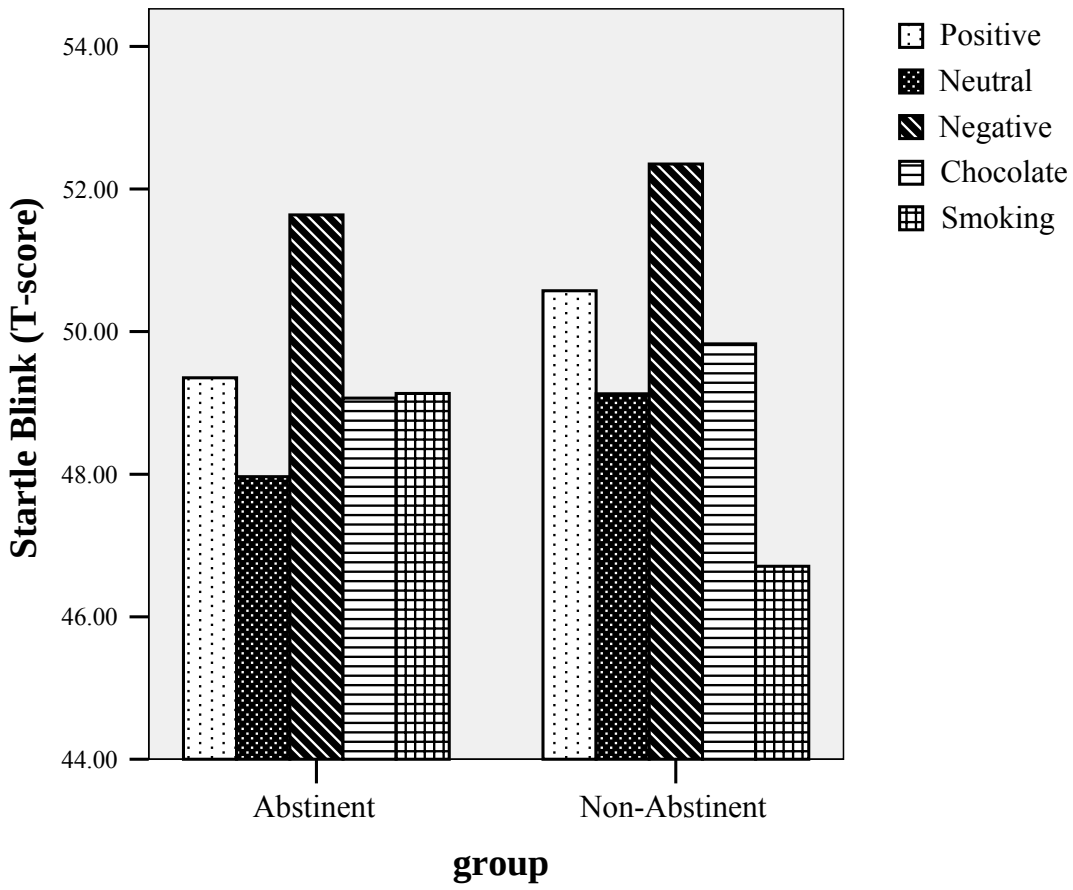

Figure 8. Startle blink responses between group and across 5 picture types

Table 1. Measures on Day 1

Measure	Group 1 (abstinent Day 2)	Group 2 (non-abstinent Day 2)
FTND	13.8 (1.61)	13.7 (1.31)
CCQ-T	94.07 (36.51)	94.06 (28.68)
BULIT-R	60.53 (15.15)	55.88 (18.65)
EAT-26	7.67 (6.65)	6.35 (5.04)
HSCL-21	38.87 (8.20)	38.71 (11.86)

Means and (standard deviations)

Table 2. Measures of Smoking and Chocolate Craving as a Function of Cue Exposure and Deprivation

Measure		Group 1	Group 2
QSU F1	time 1	113.10 (20.51)	108.06 (17.38)
	time 2	92.25 (7.82)	61.06 (21.86) **
	time 3	98.85 (8.11)	84.18 (17.54) *
QSU F2	time 1	41.81 (15.73)	37.79 (10.82)
	time 2	53.67 (13.31)	29.26 (11.52) **
	time 3	55.81 (16.86)	36.89 (17.51) *
CCQ-S	time 1	16.05 (6.03)	16.50 (7.88)
	time 2	18.45 (7.56)	16.21 (6.42)
	time 3	20.55 (10.24)	24.47 (10.58)

Means and (standard deviations)
* $p < .01$; ** $p < .001$

Table 3. SAM Ratings of 5 Picture Types Across 4 Dimensions

Picture		Valence [b]	Arousal [a, b]	Dominance [b]	Craving [b]
Positive	G1	5.94 (1.91)	5.07 (1.92)	5.73 (1.86)	na
	G2	6.10 (2.27)	5.04 (2.06)	6.01 (1.29)	na
Neutral	G1	4.90 (1.16)	3.92 (1.84)	5.72 (1.94)	na
	G2	5.12 (1.46)	4.01 (1.82)	6.01 (1.78)	na
Negative	G1	4.07 (2.41)	5.92 (1.55)	4.02 (1.34)	na
	G2	3.69 (2.12)	5.34 (1.90)	4.31 (1.96)	na
Chocolate	G1	5.91 (1.92)	5.10 (2.17)	5.18 (1.92)	5.39 (2.44)
	G2	6.78 (1.36)	5.03 (1.78)	5.54 (1.84)	5.84 (1.61)
Smoking	G1	5.89 (1.89)	6.74 (1.68)	3.98 (1.69)	7.01 (1.82)
	G2	6.25 (1.26)	5.55 (1.95)	4.49 (1.61)	6.16 (2.17)

Means and (standard deviations)
* $p < .01$; ** $p < .001$
a: Between Group Difference
b: Within Picture Type Difference

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1. Cepeda-Benito, A., Reynoso, J. T., Davis, K. W., Susabda, A., Mendez, I.A., & Harraid, J. H. (2005). Inter-dose interval effects on the development of contextual tolerance to nicotine's analgesic effects in rats. *Experimental and Clinical Psychopharmacology*, (in press).

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