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An Experimental Evaluation of the Relationship Between In-Vivo Stimuli and Attentional Bias to Smoking and Food Cues Among Female Smokers

John Bernard Correa
University of South Florida, jcorrea1@mail.usf.edu

An Experimental Evaluation of the Relationship Between In-Vivo Stimuli and Attentional Bias to Smoking and Food Cues Among Female Smokers

by

John B. Correa

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Department of Psychology
College of Arts and Sciences
University of South Florida

Major Professor: Thomas H. Brandon, Ph.D.
David J. Drobes, Ph.D.
J. Kevin Thompson, Ph.D.
Geoffrey F. Potts, Ph.D.

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DEDICATION

I would like to dedicate this thesis to my mother Eileen, my father John, and my brother Mark, for your unconditional support through both successful and trying times. I also would like to dedicate this thesis to all of my mentors, colleagues, and collaborators from Louisiana State University, Pennington Biomedical Research Center, University of South Florida, and the Tobacco Research and Intervention Program at H. Lee Moffitt Cancer Center. I have been very lucky to work in a plethora of productive, collegial environments, and I believe that this thesis represents a significant milestone and example of the outstanding training I've received thus far.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Background: Cross-sectional and experimental research has shown that female smokers more frequently report using cigarettes to control negative affect, manage dietary restraint, and suppress body image dissatisfaction. However, there has been little research to identify cognitive mechanisms that may underlie these effects. Cross-stimulus attentional bias is one such mechanism.

Aims and Hypotheses: We hypothesized that, when compared to neutral stimuli, in-vivo appetitive stimuli would enhance motivation to obtain a particular substance. More specifically, in-vivo smoking stimuli would increase attentional bias to smoking-related pictorial cues, whereas in-vivo food stimuli would increase attention to smoking-related and food-related pictorial cues. We also hypothesized that environmental tobacco smoke exposure history, negative affect, dietary restraint, body image dissatisfaction, and perceived appetite suppression of smoking would influence these attentional biases, such that higher levels of these characteristics would produce greater attentional biases.

Method: Thirty-five female smokers were exposed to visual stimuli containing two independent pictorial cues: smoking/neutral, smoking/food, neutral/food, or neutral/neutral. Twenty images were presented in 3 counter-balanced, within-subjects sets differentiated by smoking (cigarette pack), food (snack) and neutral (jewelry) in-vivo stimuli. Attentional bias was measured using eye-tracking technology. Dietary restraint, body image dissatisfaction, negative affect, and environmental tobacco smoke exposure were assessed with self-report measures before the manipulations.

Results: Effects counter to the hypotheses were observed, as in-vivo cigarettes and snack foods did not cause participants to differentially attend to pictorial smoking or food stimuli. Initial and maintained attention to smoking pictorial cues was greater than attention to food and neutral cues only when participants were administered a non-appetitive in-vivo stimulus. None of the theoretically hypothesized personality characteristics served as predictors or moderators of attentional bias.

Discussion: Findings with the neutral in-vivo stimulus replicate and extend previous research identifying attentional bias for smoking cues among smokers. Results also enhance understanding of how attentional bias may change when smokers encounter other types of appetitive stimuli. These findings encourage further theoretical and clinical exploration of how the relationship between motivation and attentional bias can be conceptualized and translated from the laboratory to the natural environment.

INTRODUCTION

Smoking remains a significant contributor to morbidity and mortality across the lifespan and is a risk factor for several negative health outcomes, including cardiovascular disease, several types of cancers, and respiratory disorders such as emphysema (U.S. Department of Health and Human Services, 2010). Prevalence of smoking in adult females is similar to that of adult males (CDC, 2012), and male and female smokers report similar intentions to quit smoking and similar prevalence of quit attempts (CDC, 2011). However, despite contrary population-based data (Fidler, Ferguson, Brown, Stapleton, & West, 2013; Jarvis, Cohen, Delnevo, & Giovino, 2013), several randomized controlled trials have found that cessation outcomes vary across gender, with women traditionally experiencing less success at quitting smoking than men (Piper et al., 2010; Scharf & Shiffman, 2004; Wetter et al., 1999). Given the inconsistencies regarding gender differences in smoking cessation, systematic research exploring potential pathways that may contribute to gender disparities in smoking motivation and cessation would provide valuable insight for gender-specific cessation strategies.

Negative Affect, Dietary Restraint, Body Image Dissatisfaction, and Smoking: Cross-Sectional and Longitudinal Findings

Survey and questionnaire research has identified several psychological factors and expectancies that represent potential motivators for women to continue smoking. Women are more likely than men to smoke cigarettes in response to stress (Fidler & West, 2009), and female smokers demonstrate stronger expectancies for cigarettes to relieve negative affect, or to improve negative mood, than male smokers (Brandon & Baker, 1991; Pang, Zvolensky, Schmidt, & Levanthal, 2015).

Dietary restraint, or attempting to exercise cognitive control over eating behaviors instead of relying on physiological indicators of hunger and satiety, is another psychological construct that has been traditionally associated with smoking. Dietary restraint is elevated in women when compared to men (Allison, Kalinsky, & Gorman, 1992) and in female smokers when compared to female non-smokers (Facchini, Rozensztejn, & Gonzalez, 2005). This elevation in female smokers corresponds to reduced reward from eating (Goldfield & Lumb, 2008) and elevated expectancies for smoking to control body weight (Copeland & Carney, 2003; Pomerleau, Ehrlich, Tate, Marks, Flessland, & Pomerleau, 1993).

A third potential motivator for smoking is body image dissatisfaction, or unhappiness with one's perceptions of physical appearance, weight status, and body shape. Body image dissatisfaction is consistently higher in females than males (Pingitore, Spring, & Garfield, 1997), with female smokers endorsing higher dissatisfaction than female non-smokers (King, Matacin, Marcus, Bock, & Tripolone, 2000; Pomerleau & Saules, 2007). Further, body image dissatisfaction is a potential cause of smoking initiation (Stice & Shaw, 2003) and can represent a barrier to successful cessation among female smokers (King, Matacin, White, & Marcus, 2005).

Negative Affect, Dietary Restraint, Body Image Dissatisfaction, and Smoking: Experimental Findings

Experimental evidence corroborates cross-sectional and survey research supporting relationships between smoking, negative affect, dietary restraint, and body image dissatisfaction. Internally valid laboratory studies possess advantages over survey-based research, allowing for more informed conceptions of these relationships while controlling for potential extraneous factors. Laboratory-based research involving negative affect shows that female smokers report elevated cravings to smoke (Perkins, Karelitz, Giedgowd, & Conklin, 2013) and demonstrate shorter latency to smoke than males smokers following acute negative affect induction (Weinberger & McKee, 2012), as well as greater sensitivity to withdrawal-related negative affect (Pang & Levanthal, 2013). Among female smokers who are also restrained eaters, increases in smoking behavior have been seen when they resist consuming a tempting snack food (Shmueli & Prochaska, 2009) and when they actually do consume a tempting snack food, the latter representing a restraint violation (Kovacs, Correa, & Brandon, 2014). Finally, studies in which body image dissatisfaction was experimentally induced in female smokers produced increased urges to smoke (Lopez, Drobes, Thompson, & Brandon, 2008) and endorsement of smoking as a form of weight control (McKee, Nhean, Hinson, & Mase, 2006), with significant mediators and moderators of these relationships being negative affect (Lopez Khoury, Litvin, & Brandon, 2009) and dietary restraint (McKee et al., 2006).

Taken together, these survey-based and experimental studies consistently support the assertion that negative affect, dietary restraint, and body image dissatisfaction function as powerful motivators to smoke among women. However, there have been significantly fewer studies describing how these motivators to smoke might influence cognitive processing of smoking-related cues in the natural environment, which have themselves been found to increase cigarette cravings (Wray, Gray, McClure, Carpenter, Tiffany, & Saladin, 2015). Given the extensive cross-sectional and behavioral evidence of the relationships between smoking, negative affect, dietary restraint, and body image dissatisfaction, it seems reasonable to assume that these relationships may manifest themselves via other cognitive mechanisms related to motivation to smoke.

Attentional Bias for Smoking and Food Stimuli

One cognitive process that reflects motivational state involves attentional bias, a process by which salient stimuli capture an individual's attention more quickly and more effectively than other stimuli in one's field of view. Attentional bias is often described as a consequence of incentive sensitization, a theory proposed by Robinson and Berridge (1993). This theory postulates that as substance use progresses, cues that are consistently paired with substance use become salient over time through classical conditioning. As salience for these cues increases, motivation to use substances also increases when in the presence of these cues. As a result of this increase in motivation, attention to such stimuli increases, reflecting an increased motivation to obtain and potentially consume a substance.

Attentional bias is typically assessed with implicit measures, such as dot-probe or Stroop tasks. Attentional bias may also be assessed more directly by using eye-tracking technology. All of these methodologies have been used to explore attentional bias to smoking cues, both in terms of initial and maintained attention. Smokers demonstrate increased attentional bias toward smoking-related cues over neutral cues (Waters, Shiffman, Bradley, & Mogg, 2003) that can be heightened when experiencing negative affect, whether from an acute mood induction (Bradley, Garner, Hudson, & Mogg, 2007) or in a state of nicotine withdrawal (Field, Mogg, & Bradley, 2004). Attentional bias to smoking cues has been associated with unsuccessful cessation outcomes and smoking relapse (Powell, Dawkins, West, Powell, & Pickering, 2010; Waters et al., 2003), and former smokers often direct attention away from smoking-related stimuli (Peuker & Bizarro, 2014).

In contrast to the literature on attentional bias among smokers, there are inconsistencies regarding the role that attentional bias might have for eating-related pathology such as dietary restraint and body image dissatisfaction. Some research suggests that females who are restrained eaters demonstrate attentional bias to food cues (Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010; Westenhoefer et al., 2013). However, other research found no such relationship (Freijy, Mullan, & Sharpe, 2014; Werthmann, Roefs, Nederkoorn, Mogg, Bradley, & Jansen, 2013). Further, although several studies describe an attentional bias for body-related stimuli among individuals with body image dissatisfaction (e.g., Gao, Deng, Yang, Liang, Liu, & Chen, 2014), there is virtually no research quantifying whether similar biases exist for food-related stimuli. These contradictory findings and lack of consistent evidence encourage further exploration into whether attentional biases exist among individuals with dietary restraint and body image dissatisfaction. One population that reports elevated restraint and dissatisfaction comprises female smokers. This leads to the question of whether, and how, food-related and smoking-related stimuli may influence attentional bias to environmental cues that, in turn, contribute to the motivation to smoke or eat.

Study Aims and Hypotheses

The general purpose of this study was to evaluate the impact of in-vivo smoking and food stimuli on attentional bias to smoking-related and food-related pictorial cues among adult female smokers, and to determine if biases were associated with negative affect, dietary restraint, or body image dissatisfaction. Female smokers are more sensitive to smoking cues in their environment (Perkins, 2001) and are more likely to use smoking as a form of appetite suppression than other populations of smokers (Brandon & Baker, 1991). Therefore, both smoking and food cues represent salient stimuli in this population that could influence attention.

Further, exploring how a range of in-vivo stimuli might influence attention may help identify other potential scenarios that would increase attention to smoking stimuli, thereby making an individual more motivated to smoke. Priming effects from in-vivo stimuli often activate cognitive processes related to addictive behaviors (Field, Mogg, & Bradley, 2005; de Wit, 1996), such that presentation of cues associated with substance use might trigger craving for, and subsequent consumption of, the substance being considered. These effects have been seen in attentional bias research with alcohol, such that exposure to in-vivo alcohol stimuli primes attentional bias for alcohol-related cues (Cox, Brown, & Rolands, 2003; Ramirez, Monti, & Colwell, 2014). However, to the author's knowledge, the influence of in-vivo smoking stimuli on attentional bias to smoking cues has never been empirically evaluated. It is also possible that alternative types of in-vivo stimuli (e.g., food cues) could produce attentional bias to smoking cues, which would further elucidate the observed relationships between smoking and eating.

Participants in this study were exposed to three types of in-vivo stimuli, one at a time: full packs of cigarettes, snack foods, and jewelry. The in-vivo jewelry were used as an active control or neutral condition, as these items are not typically associated with smoking or eating but still possess a sense of value to young adult females. After being presented with each group of in-vivo stimuli, participants were asked to select and hold onto an in-vivo stimulus of their choosing while being shown a series of images containing two of the three in-vivo stimulus categories (smoking, food, and jewelry cues) on a computer screen. Eye-tracking technology was used to quantify attentional bias toward pictorial stimuli in all three experimental conditions. This method, which involves following a participant's gaze during presentation of stimuli on a computer screen, is considered to be a direct measure of attention and has been used frequently to evaluate attentional bias to smoking cues (Kwak et al., 2007; Lochbuehler, Voogd, Scholte, &

Engels, 2011; Maynard et al. 2014) and food cues (Doolan, Breslin, Hanna, Murphy, & Gallagher, 2014; Werthmann et al., 2013). Outcome measures from the eye-tracker that were analyzed in this study include gaze duration (the amount of time spent looking at a particular type of cue) and number of initial fixations (the cue to which participants first directed their gaze). These outcomes are reflected in the following aims and hypotheses:

Specific Aim 1: To evaluate the effects of in-vivo smoking and food stimuli on attentional bias to consistent, same-category pictorial smoking and food cues.

Hypothesis 1a: In-vivo smoking stimuli will elicit greater attentional bias towards pictorial smoking cues (as measured via gaze duration and initial fixations) than in-vivo neutral stimuli.

Hypothesis 1b: In-vivo food stimuli will elicit greater attentional bias towards pictorial food cues (as measured via gaze duration and initial fixations) than in-vivo neutral stimuli.

Specific Aim 2: To evaluate the effects of in-vivo smoking and food stimuli on attentional bias to inconsistent, alternate-category pictorial smoking and food cues.

Hypothesis 2a: In-vivo food stimuli will elicit greater attentional bias towards pictorial smoking cues (as measured via gaze duration and initial fixations) than in-vivo neutral stimuli.

Research Question 2b: To determine whether exposure to in-vivo smoking stimuli would increase or decrease attention to food cues. It is possible that in-vivo smoking stimuli may increase attentional bias to pictorial food cues if individuals curb nicotine cravings by eating. It is also possible that in-vivo smoking stimuli may decrease attentional bias to food cues based on smoking’s association with appetite reduction. Therefore, this aim was explored without an a priori hypothesis.

Specific Aim 3: To evaluate theoretically-based predictors and moderators of attentional bias to food and smoking cues.

Hypothesis 3a: Based on previous research findings regarding the relationship between environmental smoke exposure and attentional bias (Oliver & Drobes, 2012), a history of environmental exposure to tobacco smoke will similarly predict attentional bias to smoking cues, and negative affect will predict attentional bias to both food and smoking cues.

Hypothesis 3b: Dietary restraint, smoking to mitigate body image dissatisfaction, and perceived appetite suppression by smoking will moderate attentional bias to both food and smoking cues, such that the effects described in Aims 1 and 2 will be stronger among participants who report higher levels of restraint, smoking to mitigate body image dissatisfaction, and smoking to suppress appetite.

Exploratory Aim: To explore how in-vivo stimuli affect attentional bias toward pictorial smoking and food cues when both are presented simultaneously, rather than individually paired with neutral cues.

METHOD

Participants

A sample of 35 female participants completed this study. Participants were administered phone screens prior to enrollment and were invited to participate after meeting the following inclusion criteria: 1) age 18-35 years; 2) regular smokers, defined as having smoked more than 100 cigarettes lifetime at least 5 cigarettes per day every day for the past 30 days; 3) not currently attempting to quit smoking with counseling or pharmacotherapy; 4) no lifetime history of eating disorders; 5) no current significant visual problems. Smoking status was verified in person via a breath carbon monoxide (CO) test (Vitalograph, Inc.) before each experimental session. A CO value of 6 parts per million (ppm) was used to classify participants as regular smokers (Middleton & Morice, 2000), and any participants whose CO value was less than 6 ppm were disqualified from participation.

In an attempt to mask the aims of the study, advertisements and phone screens informed potential participants that the study was designed to measure visual perception and evaluate preferences for retail products designed for young adult females. Upon completion of the study, participants received cash compensation and were partially compensated if they disqualified during the experimental visit due to a CO value < 6 ppm. Participants provided informed consent prior to beginning the study and were informed of the true purpose of this study via debriefing following study completion.

Self-Report Measures

Participants completed self-report measures at two distinct time points. Questionnaires assessing trait characteristics were completed online by participants prior to their experimental session, and questionnaires evaluating state constructs were administered during the experimental session.

Online Questionnaires. The following trait-based characteristics were evaluated via the online survey: 1) demographics, including age, race, and marital status; 2) purchasing practices related to jewelry, vacation, automobiles, clothing, and food, which were assessed to sell the back story of the project being a marketing study; 3) how enjoyable participants considered cigarettes, snacks, jewelry, vacations, and automobiles to be, rated on 5-point Likert scales with 1 meaning "Not at all enjoyable" and 5 meaning "Extremely enjoyable"; 4) smoking behavior (Appendix A), including the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991); 5) the Restraint Scale (RS; Drewnowski, Riskey, & Desor, 1982; Appendix B), a 10-item measure that includes questions related to weight fluctuation and concern for dieting and is used to identify potential restrained eaters; 6) the Smoking-Related Weight and Eating Episodes Test (SWEET; Adams, Baillie, & Copeland, 2011; Appendix C), a 10-item measure of reasons to smoke that involve eating-related and weight-related concerns and include sub-scales evaluating smoking for appetite suppression and smoking to cope with body image dissatisfaction.

Experimental Session Questionnaires. The following state-based questionnaires were administered during the experimental session: 1) Positive and Negative Affect Schedule – state version (PANAS; Watson, Clark, & Tellegen, 1988; Appendix D), a 20-item measure comprised of two subscales assessing state positive and negative affect.; 2) Questionnaire on Smoking

Urges – Brief version (QSU-B; Cox, Tiffany, & Christen, 2001; Appendix E), a 10-item measure that includes a total score reflecting overall cigarette cravings as well as two subscales evaluating perceived reward from smoking and perceived relief of negative affect from smoking; 3) General Food Craving Questionnaire – State version (G-FCQ-S; Nijs, Franken, & Muris, 2007; Appendix F), a 15-item measure that produces a total score of general food cravings, as well as subscales assessing desire to eat, perceived positive reinforcement from eating, perceived negative reinforcement, obsessive preoccupation with food, and physiological aspects of food cravings.

In addition to these state measures, participants were also administered the Environmental Tobacco Smoke Exposure interview (ETSE; Cummings, Markello, Mahoney, & Marshall, 1989; Appendix G) before completing the eye-tracking experiments. This measure quantifies general passive exposure to cigarette smoke, as well as smoke exposure in 3 specific domains: childhood household, adult/current household, and workplace. Years and degree of severity of exposure to smoke in these environments were used to estimate smoke exposure via methods described in Oliver and Drobes (2012).

Eye-Tracking Data

Eye-tracking data were collected using a SmartEye Pro 5.8 dual camera infrared desktop system (Smart Eye AB; Göteburg, Sweden). The system employed in this study used a 60Hz sampling speed and did not require a head mounting apparatus to collect eye gaze data, instead relying on pupil detection, corneal reflection, and a profile creation feature that allowed the system to identify unique facial features to locate the eyes on the face. The eye-tracking task was created and administered with E-Prime® 2.0 (Psychology Software Tools, Inc., Sharpsburg, PA), and custom software allowed for communication between the SmartEye system and E-Prime® 2.0 during the experimental tasks. This software also allowed for the export of eye-tracking data into Microsoft Excel spreadsheets so that gaze data could be managed, summarized, and analyzed in other statistical software programs.

Image Manipulation

The eye-tracking task was composed of 20 test images and 5 washout images, and the same 25 images were used in all three experimental blocks. The order of image presentation within each block was randomized prior to study initiation and kept constant across sessions. Thus, each participant viewed images in the same order within experimental conditions. The 20 test images were classified into 4 groups, each containing 2 types of pictorial cues: smoking/food, smoking/neutral, food/neutral, and neutral/neutral. Images were displayed on the screen for 6000 milliseconds (ms), were preceded by a fixation cross displayed for 500 ms, and were followed by a blank screen for 1000 ms. Areas of interest reflecting the location of these stimuli on the screen were established within E-Prime® 2.0, which then allowed the system to identify when a participant's gaze was directed toward a particular test stimulus.

The 25 images included in the experimental task were a sub-sample of 157 images photographed under laboratory conditions by the experimenter. These images were collected by the experimenter in an effort to enhance external validity and to incorporate various types of smoking-related and food-related stimuli in various locations on the screen. These images were believed to present a better reflection of how participants might encounter these types of stimuli outside the laboratory. Pilot testing with female research assistants was conducted prior to study initiation to select the final experimental images. During this pilot testing, participants rated each image on three qualities: 1) likelihood to appear in a magazine; 2) clarity of the image; and 3) attention-grabbing nature (salience) of the image. Objective comparisons of the final test images confirmed that contrast and brightness did not significantly differ across images (p = .47). Examples of the images included in the final experiment are shown in Figure 1.

Figure 1. Sample images from the eye-tracking experiment used in this study.

**From left to right, images depict smoking/food, smoking/neutral, food/neutral, and neutral/neutral test images.*

In-Vivo Stimulus Manipulation

During each in-vivo stimulus condition, participants were asked to select one of five options that the participant considered to be most appealing or most preferable. Full packs of cigarettes were used as the in-vivo smoking stimuli, and participants selected from the following brands: Marlboro Ultra Lights, Camel Lights, Marlboro Reds, Newports, and Marlboro Lights. These brands were used because they were rated most popular by young adult smokers in the Substance and Mental Health Data Archive (O'Conner, 2005). The following snack foods were used as in-vivo food stimuli: Doritos potato chips, Little Debbie Zebra cakes, Reese's Peanut Butter Cup, Little Debbie brownie, and Hershey's Milk Chocolate Bar. These options reflected both sweets (chocolate, candy) and carbohydrates (potato chips, cakes) and were used because sweets are more preferred by and induce strong feelings of guilt in females (Wansink, Chaney, & Chan, 2003), while female smokers who are in nicotine withdrawal experience heightened reward sensitivity to carbohydrate snacks (Spring, Pagoto, McChargue, Hedeker, & Werth, 2003). Finally, the neutral in-vivo condition included five pieces of jewelry of varying colors and presentations: one ring, two necklaces, one bracelet, and one pair of earrings. These in-vivo stimuli were not used in any of the images displayed during the experimental task.

Procedure

An outline of experimental procedures is listed in Table 1. Once eligibility was confirmed, participants received an email reminder of their study appointment that included a link to the online trait-based questionnaires and instructions to refrain from smoking or eating for two hours prior to their session. Participants completed the online questionnaires prior to beginning their experimental session, which was held in the psychology department at the University of South Florida.

After providing informed consent and verbally confirming abstinence from smoking and eating, the participants completed state self-report measures and the ETSE interview. Next, the eye-tracking system was calibrated and prepared for gaze data collection via the profile creation feature described in Table 1. Next, participants completed the eye-tracking experiment three separate times: once holding a smoking in-vivo stimulus, once holding a food in-vivo stimulus, and once holding a neutral in-vivo stimulus. The order of in-vivo stimulus presentation was counterbalanced across participants, while the order of pictures presented within each eye-tracking task was kept constant for each participant, so each participant had the same experimental experience within each task even though the order of tasks differed between subjects. Following each experimental block, participants completed the QSU-B and G-FCQ-S, and at the conclusion of the experiment, participants were debriefed and provided compensation of $25 or $40. The compensation was increased after 21 participants had completed the study as an effort to improve recruitment.

Table 1. Outline of procedures.

Part I: Recruitment and Screening of Participants

- Individuals recruited via:
  - Fliers.
  - Classrooms.
  - Recruitment databases in lab.
  - Craigslist.
  - Face-to-face interactions with persons in smoking sections of campus.
- Interested individuals completed a phone screen during which eligibility was confirmed and study details were discussed.
- Sessions were scheduled and email reminders were sent to potential participants. Email reminders contained a link to the online questionnaires to be completed prior to the scheduled session.

Part II: Confirmed eligibility and informed consent (20 minutes)

- Two members of the research team greeted the participant, confirmed her identity, and ensured successful completion of online questionnaires and successful 2-hour abstinence from smoking and eating.
- Research staff reviewed the study's informed consent document and allowed the participant ample opportunity to ask questions or review the document themselves.

Part III: Baseline Measures completed by all participants (20 minutes)

- Exhaled Carbon Monoxide (CO); if participant produced a CO value < 6 ppm, the participant was excluded from completing the study and provided with partial compensation.
- Positive and Negative Affect Schedule – State version (PANAS).
- Questionnaire of Smoking Urges- Brief (QSU-B).
- General Food Craving Questionnaire – State version (G-FCQ-S).
- Environmental Tobacco Smoke Exposure interview (ETSE).

Part IV: Eye-Tracker Calibration (30 minutes)

- Aperture and focus were checked to ensure clarity of image collection by the eye-tracker.
- The eye-tracker cameras were calibrated to ensure that there was little error between cameras and that axis orientation was correct.
- A unique participant profile was created in the SmartEye system so that it could accommodate to each participant's unique facial features and more accurately identify the position of the eyes on the face, consequently improving the accuracy of gaze measurement.
- Gaze calibration and measurement was tested before beginning the experimental task to ensure proper communication between the SmartEye system and E-Prime 2.0.

Part V: Experimental Tasks (20 minutes)

- One member of the research team presented to the participant one of the three groups of five in-vivo stimuli (smoking, food, neutral). Participants were instructed to select the in-vivo stimulus that they most preferred. The remaining in-vivo stimuli were covered to reduce distraction.
- During in-vivo stimulus selection, the second member of the research team set up the eye-tracking experiment in a separate room and initiated the experiment. This member of the research team also monitored the eye-tracking system for continuous data collection.
- After the experiment was loaded and viewable in the experimental room, the participant was instructed by the first member of the research team to maintain focus on the computer screen while holding onto the in-vivo stimulus. The participant was then instructed to begin the task, and the first member of the research team remained in the experimental room to ensure compliance with instructions.
- Following the task, the first member of the research team collected the in-vivo stimuli and administered the QSU-B and G-FCQ-S, then prepared the in-vivo stimuli for the next experimental condition.
- These steps were completed a total of three times in a counter-balanced order for smoking in-vivo stimuli, food in-vivo stimuli, and neutral in-vivo stimuli.

Table 1 (Continued)

Part VI: Compensation and Debriefing (10 minutes)

- Participants were debriefed about the actual purpose of the experiment and given the option to have their data omitted from analysis due to the deception during the advertisement period.
- Participants received compensation and were allowed to depart the lab.
- Eye-tracking data were transferred to a password-protected thumb drive and loaded onto desktop computers at the Tobacco Research & Intervention Program (TRIP) at Moffitt Cancer Center. Paper-based materials were stored in locked file cabinets at TRIP.

Data Management and Analysis

Eye-tracking data were exported into a Microsoft Excel spreadsheet from E-Prime® 2.0 following each experimental task. Data were structured such that each row in the spreadsheet corresponded to one data collection point. Since the images were on the screen for 6 seconds, and the SmartEye 5.8 system possessed a 60 Hz collection rate, each image produced 360 rows of data that were considered for analysis. Any data collection points where the SmartEye 5.8 system did not collect gaze data, either because participants blinked, moved, or directed their gaze away from the screen, were identified in the Excel export and summarized to determine if amount of missing data differed across experimental conditions.

For each picture in an experimental task, trained research staff conducted manual counts of the number of data collection points where a participant's gaze was directed at one of the two areas of interest. These counts yielded a measure of gaze duration, which was summed within blocks to calculate total gaze duration towards the three categories of areas of interest (smoking, food, and neutral). Trained research staff also identified the area of interest that first attracted the participant's gaze for each individual image, which yielded a measure of initial fixation. The number of initial fixations for each area of interest was then summed within blocks in a similar manner as gaze duration. We considered it important to assess both initial and maintained attention during experimental tasks because these constructs may have conceptually different roles in influencing drug-seeking behavior (Hogarth, Dickinson, & Duka, 2009). Both gaze duration and initial fixation data were double-entered and reviewed for accuracy using procedures and formulas described in Elliott, Hynan, Reisch, and Smith (2007). Discrepancies were corrected, and the resulting gaze duration and initial fixation data were merged with online survey data (which was managed by Moffitt's Survey Core) and experimental survey data (which was double entered and reviewed via the same procedures used for eye-tracking data). All subsequent data analysis was done using IBM SPSS Statistics, Version 21.

To determine whether the type of in-vivo stimulus influenced attentional bias towards pictorial stimuli, a pair of 3 X 3, within-subjects analyses of variance (ANOVAs) were conducted, with one model using gaze duration as the dependent variable and the other using number of initial fixations as the dependent variable. In-vivo stimulus (cigarettes, food, jewelry) and area of interest in test images (smoking, food, neutral) were entered as independent variables in both models. Significant interactions were seen as indicators of differences in attentional bias and were explored with repeated measures ANOVAs that constituted pairwise post-hoc comparisons. These follow-up ANOVAs were used to address the individual hypotheses under the first two specific aims and to explore differences in gaze duration and number of initial fixations across experimental conditions. For all ANOVAs, violations of sphericity were addressed using Greenhouse-Geiser adjustments.

To evaluate predictors and moderators of attentional bias within each experimental condition, a series of bivariate correlations and the ModProbe SPSS macro function developed by Hayes and Mathes (2009) were used to address the third specific aim. Finally, a series of repeated measures ANOVAs were used to address the exploratory aim regarding attentional bias to smoking or food pictorial cues when both were presented simultaneously. These ANOVAs evaluated whether attention to these pictorial stimuli differed within each experimental condition.

RESULTS

Missing Data and Transformations

The 35 participants in this study completed a total of 105 experimental tasks. Fourteen of these tasks (13.3% of all blocks) were excluded from analysis because no eye-tracking data were collected during the task. This was primarily due to an inability to create a participant profile in the eye-tracking system or experimenter error, either by allowing participants to move during the block or by not confirming that the eye-tracking system was in fact identifying the location of the eyes on participants' faces. Six excluded tasks came from both the smoking and food in-vivo conditions, while two excluded tasks came from the neutral in-vivo condition.

After removing the 14 blocks without eye-tracking data, 91 blocks of eye-tracking data were used for analysis: 29 associated with a smoking in-vivo stimulus, 29 associated with a food in-vivo stimulus, and 33 associated with a neutral in-vivo stimulus. A one-way ANOVA confirmed that, of the blocks included in the analysis, percent missing data did not differ across the three experimental conditions, $F(2, 88) = 0.697$, $p = .501$. Therefore, missing data was not considered a significant confound.

Because several aims of this project involved analysis of variance, eye-tracking data considered for analysis was screened to verify that the dependent variables being analyzed met assumptions of normality. Raw data for 8 of the 18 eye-tracking measures (4 gaze duration measures, 4 initial fixation measures) demonstrated significant positive skew; therefore, all of the eye-tracking measures underwent square root transformations, and primary and secondary analyses were conducted on both raw and transformed data. No changes in interpretation emerged following analyses with transformed variables; therefore, the results reported here reflect analyses conducted with raw data.

Participant Characteristics

Demographic and descriptive statistics for the participants who completed online questionnaires are reported in Table 2. Online questionnaire data for four of the 35 participants who completed the experiment were not collected, either due to participants failing to complete the questionnaires prior to their experimental session or due to data exporting issues. A relatively diverse sample of participants was recruited, and on average, participants demonstrated moderate nicotine dependence and fairly elevated levels of dietary restraint.

Attentional Bias to Smoking and Food Cues – Consistent Stimuli

Hypotheses 1a and 1b addressed whether attentional bias for smoking and food pictorial cues emerged when the in-vivo stimulus was consistent with the pictorial area of interest. To test these hypotheses, two 3X3 within-subjects ANOVAs, one for total gaze duration and one for number of initial fixations, were conducted. If interactions between in-vivo stimulus and area of interest were significant, follow-up repeated measures ANOVAs with post-hoc pairwise comparisons were used to identify between-block differences in attention. Results for these analyses are displayed in Figure 2, with panel A showing results for gaze duration and panel B showing results for number of initial fixations.

Both models showed significant main effects for in-vivo condition: 1) gaze duration, $F(1.168, 29.118) = 76.375$, $p < .001$; 2) number of initial fixations, $F(2, 50) = 12.816$, $p < .001$.

Table 2. Descriptive statistics obtained from online questionnaires.

	Participants Who Completed Online Questionnaires (*n* = 31)
<u>Demographic Variables</u>	
Race (n, %)	
White/Caucasian	16 (51.6)
Asian	1 (3.2)
African-American	14 (45.2)
Marital Status (n, %)	
Single	27 (87.1)
Married	3 (9.7)
Divorced	1 (3.2)
Age (M, SD)	27.35 (4.72)
FTND (M, SD)	4.17 (2.02)
Cigarettes per day (M, SD)	12.7 (6.60)
SWEET Total Score (M, SD)	27.06 (10.26)
Cope with Body Image Dissatisfaction	4.74 (2.53)
Suppress Appetite	7.65 (3.17)
Prevent Overeating	8.48 (3.68)
Relieve Withdrawal-Related Appetite	6.19 (2.55)
RS Total Score (M, SD)	23.45 (6.40)
5-Point Ratings of Enjoyment (M, SD)	
Snack Foods	4.26 (1.09)
Cigarettes	4.29 (1.01)
Jewelry	3.74 (1.34)

**FTND = Fagerström Test for Nicotine Dependence, SWEET = Smoking-Related Weight and Eating Episodes Test, RS = Restraint Scale.*

Both models also demonstrated significant main effects for pictorial stimulus condition: 1) gaze duration, $F(2, 50) = 35.303$, $p < .001$; 2) number of initial fixations, $F(2, 50) = 30.737$, $p < .001$.

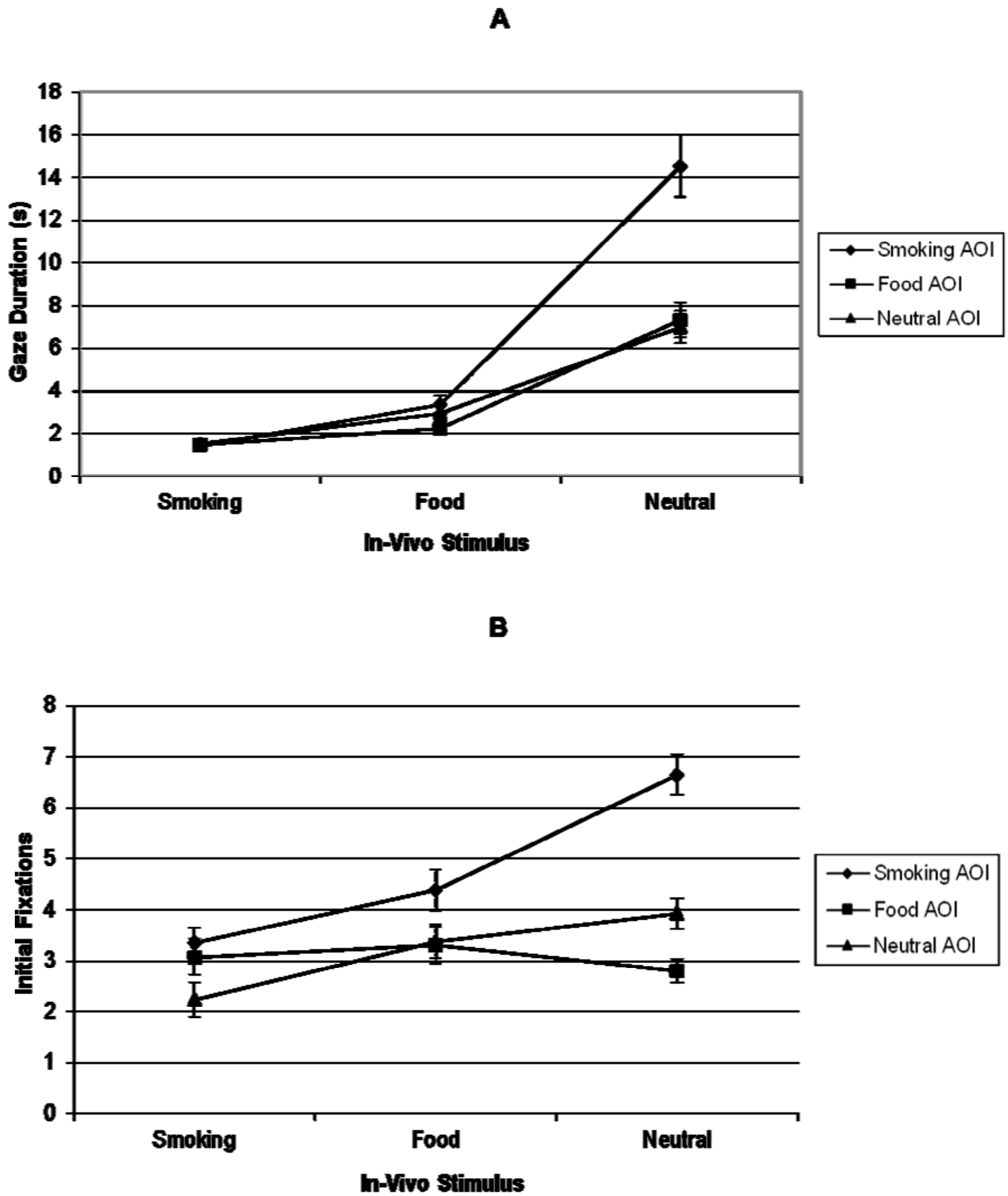

Figure 2. 3 X 3 ANOVAs evaluating gaze duration and number of initial fixations across experimental conditions.

**AOI = area of interest, s = seconds. Error bars indicate standard error of the mean.*

Finally, both models showed significant interaction effects between in-vivo condition and AOI: gaze duration, $F(2.393, 59.824) = 26.820$, $p < .001$; 2) number of initial fixations, $F(4, 100) = 9.474$, $p < .001$. Thus, follow-up repeated measures ANOVAs were conducted to address specific aims 1 and 2.

Hypothesis 1a stated that in-vivo smoking stimuli would elicit greater attentional bias towards pictorial smoking cues. Repeated measures ANOVAs produced observed effects that were opposite from the expected effects for both gaze duration and initial fixation. Total gaze duration towards smoking stimuli differed significantly across experimental conditions, $F(1.123, 28.083) = 71.939$, $p < .001$. Pairwise comparisons showed that participants looked at smoking stimuli for shorter total duration when administered a smoking in-vivo cue (1.41 $\pm$ 1.42 seconds) than when administered a neutral in-vivo cue (14.52 $\pm$ 7.22 seconds), $F(1, 28) = 93.156$, $p < .001$. Significant differences across conditions also emerged for number of initial fixations across experiments, $F(2, 50) = 20.992$, $p < .001$. Pairwise comparisons revealed significant differences in the number of initial fixations to smoking stimuli between the neutral in-vivo stimulus condition (6.76 $\pm$ 1.51 images) and the smoking in-vivo stimulus condition (3.31 $\pm$ 1.98 images), $F(1, 28) = 43.655$, $p < .001$.

Hypothesis 1b stated that in-vivo food stimuli would elicit greater attentional bias towards pictorial food cues. As with hypothesis 1a, the observed effect for gaze duration was in contrast to what was hypothesized. Repeated measures ANOVA produced significant differences across experimental conditions for gaze duration to food stimuli, $F(1.259, 31.471) = 40.758$, $p < .001$. Pairwise comparisons confirmed that participants maintained gaze towards pictorial food stimuli significantly less often in the presence of a food in-vivo cue (2.35 $\pm$ 1.70 seconds) than a neutral in-vivo cue (7.01 $\pm$ 4.22 seconds), $F(1, 27) = 33.536$, $p < .001$. The second repeated measures ANOVA for this particular hypothesis did not reveal significant differences in number of initial fixations to pictorial food stimuli across conditions, $F(2, 50) = 0.595$, $p = .555$.

Attentional Bias to Smoking and Food Cues – Inconsistent Stimuli

Hypothesis 2a and research question 2b were designed to assess whether appetitive in-vivo stimuli that were not consistent with pictorial cues produced attentional bias to smoking or food pictorial cues. Four additional post-hoc pairwise LSD comparisons from the previously reported repeated measures ANOVA were used to test these aims. As with the hypotheses 1a and 1b, results for this set of analyses can be seen in Figure 2.

Hypothesis 2a proposed that in-vivo food stimuli would elicit greater attentional bias towards pictorial smoking cues than in-vivo neutral stimuli. As with both hypothesis 1a, the observed effect was in the opposite direction of the expected effect for both gaze duration and initial fixation. Post-hoc pairwise comparisons confirmed that participants maintained gaze toward pictorial smoking stimuli significantly less often when administered a food in-vivo cue (3.45 seconds) than when administered a neutral in-vivo cue (13.84 seconds), $F(1, 27) = 51.881$, $p < .001$. Similar results emerged for initial fixations, as post-hoc pairwise comparisons showed that significantly more initial fixations to smoking stimuli occurred in the presence of a neutral in-vivo stimulus (6.39 ± 2.23 images) than in the presence of a food in-vivo stimulus (4.36 ± 2.04 images), $F(1, 27) = 13.804$, $p = .001$.

Research question 2b was designed to determine whether exposure to in-vivo smoking stimuli would increase or decrease attention to food cues when compared to in-vivo neutral stimuli. Post-hoc pairwise comparisons from the previously reported 3 X 3 within-subjects ANOVA confirmed attentional bias to pictorial food cues seemed to decrease when participants held an in-vivo smoking stimulus. Participants maintained gaze toward pictorial food stimuli significantly less often when administered a smoking in-vivo cue (1.57 ± 1.19 seconds) than when administered a neutral in-vivo cue (7.63 ± 4.45 seconds), $F(1, 28) = 47.675$, $p < .001$. However, there was no significant difference in the number of initial fixations to pictorial food stimuli between the smoking in-vivo condition (3.24 ± 1.75 images) and the neutral in-vivo condition (2.76 ± 1.18 images), $F(1, 28) = 1.219$, $p = .279$.

Attentional Bias Within Neutral In-Vivo Condition

While not a direct aim of this study, it should be mentioned that additional repeated measures ANOVAs were conducted to determine if attentional bias existed in the absence of an appetitive in-vivo stimulus (i.e., in the neutral in-vivo condition). These ANOVAs found that, within the neutral in-vivo stimulus condition, participants demonstrated longer gaze duration (13.71 ± 7.47 seconds vs. 6.53 ± 3.90 seconds) toward pictorial smoking stimuli than pictorial neutral stimuli, $F(1, 32) = 60.217$, $p < .001$, as well as a greater number of initial fixations (6.45 ± 2.14 images vs. 3.82 ± 1.69 images) toward pictorial smoking stimuli than pictorial neutral stimuli, $F(1, 32) = 41.789$, $p < .001$. Thus, participants demonstrated both initial and maintained attentional bias to smoking stimuli while in the neutral experimental condition.

However, participants did not demonstrate a similar attentional bias to pictorial food stimuli in the neutral in-vivo condition. Gaze duration (7.31 ± 4.68 seconds) for pictorial food stimuli was not significantly different from gaze duration for pictorial neutral stimuli (6.53 ± 3.90 seconds), $F(1, 32) = 1.275$, $p = .267$. Further, participants actually demonstrated significantly more initial fixations towards neutral pictorial stimuli (3.82 ± 1.69 images) than food pictorial stimuli (2.70 ± 1.21 images), $F(1, 32) = 13.613$, $p = .001$.

The attentional bias seen for pictorial smoking cues in this condition was seen not only when compared to pictorial neutral stimuli, but also when compared to pictorial food stimuli.

Participants demonstrated significantly higher gaze duration towards pictorial smoking stimuli (13.71 $\pm$ 7.47 seconds) than towards pictorial food stimuli (7.31 $\pm$ 4.68 seconds), $F(1, 32) = 55.834$, $p < .001$. Participants also initially fixated on significantly more pictorial smoking stimuli (6.45 $\pm$ 2.14 images) than pictorial food stimuli (2.70 $\pm$ 1.21 images), $F(1, 32) = 124.188$, $p < .001$.

Predictors and Moderators of Attentional Bias to Smoking and Food Cues

Hypothesis 3a posited that environmental exposure to tobacco smoke would predict attentional bias to smoking stimuli, and negative affect was hypothesized to predict attentional bias to both smoking and food stimuli. To test these hypotheses, a series of bivariate correlations was conducted. ETSE results are reported in Table 3, and PANAS results are reported in Table 4. After employing Bonferroni corrections for multiple comparisons, neither the ETSE measures nor the negative affect subscale of the PANAS predicted gaze duration or number of initial fixations to pictorial smoking stimuli, regardless of the in-vivo stimulus condition. The negative affect sub-scale of the PANAS also did not predict gaze duration or number of initial fixations to pictorial food stimuli in any experimental condition.

Hypothesis 3b proposed that elevated dietary restraint, higher tendencies to smoke to mitigate body image dissatisfaction, and greater perceived appetite suppression by smoking would moderate attentional bias to pictorial and smoking food cues. That is, participants exhibiting these trait characteristics would endorse greater gaze duration and initial fixations to pictorial smoking and food cues when administered the smoking and food in-vivo stimuli. Participants were categorized as having high or low scores on these constructs according to median splits for three measures: the total score on the Restraint Scale, the coping with body dissatisfaction factor of the SWEET questionnaire, and the appetite suppression factor of the SWEET scale.

Table 3. Correlations between environmental tobacco smoke exposure and attentional bias to pictorial smoking cues.

	ETSE Childhood		**ETSE Adult**		**ETSE Workplace**		**ETSE Total**	
	r	***p***	**r**	***p***	**r**	***p***	**r**	***p***
Gaze Duration								
Smoking In-Vivo Stimulus	0.11	.56	-0.22	.26	-0.15	.43	-0.05	.79
Food In-Vivo Stimulus	0.07	.71	-0.32	.09	-0.09	.63	-0.10	.59
Neutral In-Vivo Stimulus	0.13	.47	-0.12	.51	0.21	.24	0.10	.59
Initial Fixations								
Smoking In-Vivo Stimulus	-0.17	.38	-0.14	.47	-0.37	.05	-0.27	.16
Food In-Vivo Stimulus	0.02	.93	0.00	1.00	-0.03	.86	0.00	.99
Neutral In-Vivo Stimulus	-0.06	.74	0.03	.87	0.07	.70	-0.01	.96

**ETSE = Environmental Tobacco Smoke Exposure interview.*

Table 4. Correlations between state negative affect and attentional bias to pictorial smoking and food cues.

	PANAS - Negative Affect	
	r	***p***
Gaze Duration – Smoking Cues		
Smoking In-Vivo Stimulus	0.16	.42
Food In-Vivo Stimulus	0.27	.16
Neutral In-Vivo Stimulus	0.20	.26
Gaze Duration – Food Cues		
Smoking In-Vivo Stimulus	-0.08	.67
Food In-Vivo Stimulus	-0.07	.71
Neutral In-Vivo Stimulus	0.31	.08
Initial Fixations – Smoking Cues		
Smoking In-Vivo Stimulus	-0.22	.25
Food In-Vivo Stimulus	0.01	.96
Neutral In-Vivo Stimulus	0.10	.57
Initial Fixations – Food Cues		
Smoking In-Vivo Stimulus	-0.09	.65
Food In-Vivo Stimulus	0.00	1.00
Neutral In-Vivo Stimulus	0.16	.38

** PANAS = Positive and Negative Affect Schedule - Moment.*

The interaction between these median splits and experimental condition were calculated and evaluated using the ModProbe SPSS macro function (Hayes & Mathes, 2009). Results from these moderator analyses are reported in Table 5. No moderation analyses were significant for gaze duration or initial fixation, as all interaction terms with experimental condition showed p-values $\geq$ .21.

Table 5. Results evaluating dietary restraint, smoking to mitigate body image dissatisfaction, and perceived appetite suppression from smoking as moderators of attentional bias to smoking and food stimuli.

Criterion Variable	**RS Total X Condition**			**SWEET Body Dissatisfaction X Condition**			**SWEET Appetite Suppression X Condition**		
	β	**SE**	***p***	**β**	**SE**	***p***	**β**	**SE**	***p***
Gaze Duration – Smoking Cues	-78.470	81.655	.34	-0.296	83.477	1.00	89.193	80.125	.27
Gaze Duration – Food Cues	49.974	54.804	.37	-68.956	54.963	.21	42.800	54.403	.43
Initial Fixations – Smoking Cues	0.473	0.559	.40	0.371	0.569	.52	0.523	0.555	.35
Initial Fixations – Food Cues	0.178	0.408	.66	-0.246	0.420	.56	0.266	0.408	.52

**RS = Restraint Scale, SWEET = Smoking-Related Weight and Eating Episodes Test.*

Exploratory Aim – Simultaneous Smoking/Food Pictorial Cues

The exploratory aim evaluated attention to smoking and food pictorial stimuli when both were presented simultaneously. A series of six repeated measures ANOVAs were conducted to identify within-condition differences in attention to smoking and food areas of interest. The smoking in-vivo stimulus and food in-vivo stimulus did not produce significant differences in gaze duration or number of initial fixations for these smoking/food images (p's > .16). However, in the neutral in-vivo condition, participants demonstrated attentional bias to smoking stimuli over food stimuli when both were on the screen at the same time. This was true for gaze duration (smoking area of interest = 6.18 ± 3.83seconds; food area of interest = 2.57 ± 1.85 seconds; $F(1, 32) = 35.272$, $p < .001$) and for number of initial fixations (smoking area of interest = 3.58 ± 1.32 initial fixations; food area of interest = 0.73 ± 0.57 initial fixations; $F(1, 32) = 118.604$, $p < .001$).

DISCUSSION

This project was designed to explore the impact that multiple types of appetitive in-vivo stimuli might have on attentional bias in young adult female smokers. Hypotheses for these relationships were derived from previous self-report and behavioral laboratory research, as in-vivo smoking and food stimuli were expected to enhance attentional bias to pictorial smoking and food cues over a neutral in-vivo stimulus. Several personality characteristics were hypothesized to be associated with these in-vivo/pictorial relationships, including environmental exposure to tobacco smoke, negative affect, dietary restraint, and expectancies for smoking to suppress appetite. Findings from this study produced essentially opposite effects from those that were hypothesized, as in-vivo cigarettes and snack foods did not produce attentional bias to pictorial smoking or food stimuli. Rather, initial and maintained attention was greatest when participants were administered a non-appetitive in-vivo stimulus, and none of the theoretically hypothesized personality characteristics served as predictors or moderators of attentional bias.

Theoretical Implications for Attentional Bias and Smoking

In the neutral in-vivo stimulus condition, both initial and maintained attention for smoking pictorial stimuli was higher than attention for non-smoking pictorial stimuli, regardless of whether the comparison pictorial stimuli were food-related or neutral. These findings replicate previous research with both implicit and explicit measures of attention where, in the absence of an appetitive in-vivo stimulus, smokers demonstrated attentional bias to smoking cues over those not associated with smoking (Bonitz & Gordon, 2008; Ehrman, Robbins, Bromwell, Lankford, Monterosso, & O'Brien, 2002; Kwak et al., 2007; Waters et al., 2003). This study also supports previous eye-tracking research demonstrating that smokers possess both an initial and maintained attentional bias to smoking-related stimuli over neutral stimuli (Lochbuehler, Voogd, Scholte, & Engels, 2011). However, it is important to note that these types of bias were not present for food-related stimuli, suggesting that this sample may be more motivated to consume cigarettes than food and may consequently view cigarettes as more reinforcing and more appetitive. This conclusion is also supported by the direct comparisons when participants were simultaneously shown smoking and food stimuli in the neutral in vivo condition, in which participants showed greater initial fixation and gaze duration to smoking stimuli. Indeed, unlike most previous attentional bias research, this study identified bias to smoking cues over two active control cues, namely food and jewelry. This study not only extends previous research by demonstrating that attentional biases for multiple types of stimuli can be evaluated within one experiment, but also by showing that these biases can be manipulated by the presence of in-vivo stimuli that smokers find appetitive, regardless of whether the stimulus is related directly or indirectly to smoking.

There are several potential explanations as to why the in-vivo smoking and food conditions may have attenuated attention to pictorial smoking stimuli. First, attentional bias in addictive behaviors is traditionally conceptualized as an index of motivation to obtain a particular substance (Field & Cox, 2008) and as a potential mediator of increased substance-seeking behavior (Franken, 2003). Because participants were physically holding cigarettes during the in-vivo smoking condition, it is possible that motivation to obtain cigarettes was reduced, thereby reducing attention allocation to other smoking stimuli. Secondly, in-vivo stimuli that are related to smoking seem to be particularly salient for female smokers, who experience elevations in cue reactivity and cravings in the laboratory (Saladin, Gray, Carpenter, LaRowe, DeSantis, & Upadhyaya, 2012) that may be resistant to attention retraining procedures (Attwood, O'Sullivan, Leonards, Mackintosh, & Munafò, 2008). Thus, in-vivo stimuli may possess greater attention-grabbing properties than pictorial stimuli, which would result in less attentional bias to smoking-related cues during computerized experimental tasks where in-vivo stimuli are present.

Both of these possibilities suggest that in-vivo smoking stimuli might act in competition and not in concert with other external stimuli, either by reducing motivation to obtain cigarettes or by monopolizing both initial and maintained attention. For this particular study, total time spent focusing on the computer screen did not differ across conditions, meaning that the in-vivo smoking stimuli did not cause participants to differentially attend away from the computer screen. Thus, our results partially support the theory that characteristics of smoking not associated with nicotine intake are particularly salient to female smokers (Perkins, 2001), including the presence of appetitive cues that do not directly reinforce the consumption of cigarettes (in this case, food).

Future research should explore whether the mere presence of such in-vivo stimuli may reduce attention to smoking stimuli, and consequently motivation to smoke, or if these reductions are specifically associated with anticipation of actual reinforcement from smoking or eating. In this particular study, participants were not instructed that they would be allowed to smoke or eat during the experimental session. However, it is unclear if the participants anticipated consumption of cigarettes or food despite the absence of instructions. The sample included in this study was asked to refrain from smoking and eating for two hours before an experimental session, meaning that they were likely experiencing nicotine withdrawal at session initiation (Hendricks, Ditre, Drobes, & Brandon, 2006). Food deprivation and nicotine deprivation work synergistically to make resisting smoking more difficult (Leeman, O'Malley, White, & McKee, 2010), and nicotine withdrawal promotes attentional bias to both smoking-related cues (Field, Bradley, & Mogg, 2004) and other cues associated with reward, particularly when anticipating an opportunity to smoke (McCarthy, Gloria, & Curtin, 2009). Future research could utilize expectancy paradigms like the one used by Juliano and Brandon (2002) to determine if the in-vivo nature of a reward stimulus is enough to satisfy motivation to obtain a substance, or if anticipation of using the reward stimulus is necessary for in-vivo stimuli to influence attention. Indeed, anticipation of smoking has been shown to influence other cognitive factors related to motivation to smoke (Ross & Juliano, 2015), and attentional bias is a logical outcome variable that would extend this research area.

Clinical Implications

Given extensive evidence supporting the relationship between attentional bias and problematic behaviors across multiple domains of psychopathology, attentional bias modification interventions have been developed to reduce attentional bias for cues associated with such behaviors, with the clinical goal of reducing the behavior itself. Attentional bias modification, also known as cognitive bias modification and attentional retraining, involves re-training automatic cognitive processing by having participants learn to allocate more attention to stimuli not associated with the problematic behavior, with the idea that doing so will reduce motivation to engage in the problematic behavior.

This concept has been successfully translated into potential interventions for mood disorders (Yang, Ding, Dai, Peng, & Zhang, 2014) and anxiety disorders (Hakamata et al., 2010), and such training has been shown to reduce problematic substance use (Fadardi & Cox, 2009) and problematic eating (Kakoschke, Kemps, & Tiggemann, 2014). However, attempts to translate this approach into an efficacious intervention for smoking cessation have been largely unsuccessful (Field, Duka, Tyler, & Schoenmakers, 2009; Lopes, Pires, & Bizarro, 2014). One potential explanation for the lack of translation that is supported by these results is that in-vivo cues are more vulnerable to attentional bias than pictorial cues. Thus, interventions attempting to modify attentional bias to pictorial stimuli are not necessarily addressing more salient, sensory-involved stimuli that individuals could encounter outside the laboratory. Indeed, handling in-vivo smoking stimuli produces increased neural cue reactivity over static images (Yalachkov, Kaiser, Gorres, Seehaus, & Naumer, 2013), and smokers demonstrate attentional bias to in-vivo cues outside of traditional laboratory settings (Baschnagel, 2013). Thus, finding ways to continue to integrate in-vivo stimuli into attentional bias modification programs might enhance the efficacy of these interventions.

Limitations and Conclusions

Results from this project should be interpreted in the context of its limitations. First, power analyses conducted prior to study initiation called for 63 participants to enroll in the study due to the small effect sizes found in the attentional bias literature (Field, Munafo, & Franken, 2009). Because of difficulty accessing this population of smokers, recruitment was terminated before the target sample size was reached. Reduced power could contribute to the failure to support the predictor and moderator hypotheses, although most of the p values were highly elevated and not close to being statistically significant. Second, a head mount apparatus may have reduced the amount of missing data in this study, but we believed that the absence of such restraints would improve the external validity of the tasks. Third, the absence of a comparison group (e.g., male smokers) does not allow for further evaluation of how gender may influence the magnitude of attentional bias to smoking-related and food-related stimuli. Male and female smokers demonstrate different types of bias to smoking cues (Perlato, Santandrea, Libera, & Chelazzi, 2014), so interpretations on the role of gender on attentional allocation should be attenuated. Fourth, a control condition of non-smokers was not recruited for this study; therefore, we cannot conclude that the attentional bias to smoking cues seen in the neutral in-vivo condition is unique to smokers. Finally, several physiological factors may influence motivation to obtain food and cigarettes, including weight status and menstrual cycle phase. It is possible that these may have reduced the experiment effects in this particular study, given that they were not experimentally or statistically measured or controlled.

Nevertheless, this study successfully replicated the presence of attentional bias to smoking stimuli among regular smokers, while also providing preliminary evidence for alternative appetitive reinforcers that might impact this bias in attention. This study also suggests that individuals tend to allocate attention away from stimuli that might motivate them to obtain and use a substance when these rewarding reinforcers are present, regardless of whether they are directly or indirectly related to smoking.

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APPENDIX A:

MOFFITT SRC APPROVAL LETTER

MOFFITT CANCER CENTER

December 17, 2012

John Correa
Moffitt Cancer Center
12902 Magnolia Drive
Tampa, FL 33612

Dear Mr. Correa:

The Behavioral Subcommittee of the Scientific Review Committee (SRC) has approved your research protocol version dated 12/06/2012 entitled, **"The Effect of Priming with Food and Smoking Cues on Attentional Bias among Female Smokers: The Perception & Marketing Study "** (**MCC 17314**). The protocol is approved as written for use at the Moffitt Cancer Center pending approval of the Institutional Review Board (IRB) and satisfaction of institutional operational and financial review requirements.

Please be aware that after you receive IRB approval, you must request study activation before you commence any study activities. Please contact PSO mailbox at PSOmailbox@moffitt.org to request study activation. That office will ensure that all applicable institutional reviews have been completed. You will then be issued an automated activation notification by email.

It is your responsibility to ensure that all Moffitt staff (nursing, pharmacy, data management, etc.) are informed and aware of the details of the project. The committee encourages the use of in-services for those projects that are complex or require special attention.

All changes made to protocols approved by the SRC must be submitted to the Protocol Review and Monitoring System office. Changes made to the protocol document require SRC review and approval. Minor changes (i.e. changes to personnel, non-scientific changes, changes that do not affect patient participation) will be expedited through the SRC review process.

If this project is not being managed by the Clinical Trials Office or Clinical Research Unit, then it is your responsibility to follow through with all requirements for submission to the IRB. All IRB approvals are required to be documented in Oncore, and all associated regulatory documentation (signed applications, IRB approval letters and IRB approved consent forms, etc.) are to be saved in the appropriate study folder in the e-binders directory at J:\ebinders.

12902 Magnolia Drive Tampa, FL 33612-9416 1-888-MOFFITT MOFFITT.org H. Lee Moffitt Cancer Center & Research Institute An NCI Designated Comprehensive Cancer Center

Appendix A (Continued)

Oncore is the Cancer Center's mechanism for submission and review of materials requiring Scientific Review (SRC) and Protocol Monitoring (PMC). If you need access to Oncore, please contact Jeryl Madden, Oncore Administrator, at 745-6964 for assistance.

Sincerely,

David Drobes, PhD.
Chair, Behavioral Sub-Committee
Scientific Review Committee

12902 Magnolia Drive Tampa, FL 33612-9416 1-888-MOFFITT MOFFITT.org H. Lee Moffitt Cancer Center & Research Institute An NCI Designated Comprehensive Cancer Center

APPENDIX B:

USF IRB APPROVAL LETTER

USF
UNIVERSITY OF SOUTH FLORIDA

DIVISION OF RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-5618

January 14, 2013

John Correa
Psychology
15437 Plantation Oaks Dr., Apt. 10
Tampa, FL 33647

RE: **Expedited Approval** for Initial Review
IRB#: Pro00010828
Title: The Effect of Priming with Food and Smoking Cues on Attentional Bias among Female Smokers: The Perception & Marketing Study

Dear Mr. Correa:

On 1/13/2013 the Institutional Review Board (IRB) reviewed and **APPROVED** the above referenced protocol. Please note that your approval for this study will expire on 1/13/2014.

Approved Items:
Protocol Document:
17314_2012.12.06_OP_SRCApproved

Consent Document:
Informed Consent - Long Form.pdf
Please use only the official, IRB- stamped consent document(s) found under the "Attachment Tab" in the recruitment of participants. Please note that these documents are only valid during the approval period indicated on the stamped document.

Your study qualifies for a waiver of the requirements for the documentation of informed consent, for the online survey, as outlined in the federal regulations at 45CFR46.117 (c) which states that an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects if it finds either: (1) that the only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern; or (2) that the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context.

Appendix B (Continued)

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review categories:

(4) Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing.

(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

John A. Schinka, Ph.D.

John A. Schinka, Ph.D., Chairperson
USF Institutional Review Board