

Distribution Statement

Distribution A: Public Release.

The views presented here are those of the author and are not to be construed as official or reflecting the views of the Uniformed Services University of the Health Sciences, the Department of Defense or the U.S. Government.

Assessment of Mood and Cognition in Perinatal Smokers Attempting to
Maintain Abstinence:
Two Pilot Ecological Momentary Assessment Studies

by

R. Gwen Gunter

Dissertation submitted to the Faculty of the
Medical and Clinical Psychology Graduate Program
Uniformed Services University of the Health Sciences
In partial fulfillment of the requirements for the degree of
[Doctor of Philosophy] [2021]



UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES

SCHOOL OF MEDICINE GRADUATE PROGRAMS

Graduate Education Office (A 1045), 4301 Jones Bridge Road, Bethesda, MD 20814



**APPROVAL OF THE DOCTORAL DISSERTATION IN THE DEPARTMENT OF
MEDICAL AND CLINICAL PSYCHOLOGY**

Title of Dissertation: "Assessment of Mood and Cognition in Perinatal Smokers Attempting to Maintain Abstinence: Two Pilot Ecological Momentary Assessment Studies"

Name of Candidate: Rebekah Gunter
Doctor of Philosophy Degree
September 11, 2020

DISSERTATION AND ABSTRACT APPROVED:

DATE:


10/09/20

Dr. Tracy Sbrocco
DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY
Committee Chairperson


10/09/20

Dr. Andrew J. Waters
DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY
Dissertation Advisor


10/09/20

Dr. Joshua Gray
DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY
Committee Member


10/09/20

Dr. Laura Juliano
AMERICAN UNIVERSITY
Committee Member

ACKNOWLEDGMENTS

I would like to acknowledge my research advisor, Andrew Waters, and my committee members, Tracy Sbrocco, Josh Gray, and Laura Juliano, for their help in preparing this thesis. I would also like to acknowledge my fellow LOCI lab members who also helped prepare this thesis. Lastly, I would like to acknowledge and dedicate this thesis to my parents and husband who have been an unwavering support throughout this process.

COPYRIGHT STATEMENT

The author hereby certifies that the use of any copyrighted material in the dissertation manuscript entitled: Assessment of Mood and Cognition in Perinatal Smokers Attempting to Maintain Abstinence: Two Pilot Ecological Momentary Assessment Studies is appropriately acknowledged and, beyond brief excerpts, is with the permission of the copyright owner.



Gwen Gunter

August 4, 2020

ABSTRACT

Assessment of Mood and Cognition in Perinatal Smokers Attempting to Maintain Abstinence: Two Pilot Ecological Momentary Assessment Studies

Gwen Gunter, 2019

Dissertation directed by: Andrew J. Waters, Professor, Department of Medical and
Clinical Psychology

Cigarette smoking is a leading cause of preventable death in United States. Even though most smokers report a desire to quit, the majority of quit attempts end in relapse, even when using treatment. The perinatal period provides a unique opportunity for intervention, as many smokers quit smoking during pregnancy but relapse postpartum. Novel relapse prevention interventions are required.

Research has identified cognitive processes as targets for intervention. One intervention that targets cognitive processes is attentional retraining (AR). While laboratory and field studies have demonstrated a reduction in attentional biases towards smoking-related stimuli following AR, the method has not been applied to perinatal women, and the effect of AR on craving and smoking is not clear.

Ecological Momentary Assessment (EMA) may be a useful method to examine relapse process in perinatal women attempting to remain abstinent, and to examine the effects of a mobile intervention. Perinatal women in particular may benefit from a mobile intervention.

This dissertation involves analysis of pre-existing data from two studies that examined the feasibility of mobile assessment and intervention implementing attentional bias measurements and AR among perinatal women. Study 1 examined postpartum smokers ($N=10$), and assessed parental stress, attentional bias, craving and smoking over a 2-week period postpartum. Specific Aim 1 examined the feasibility of using EMA in this population. Ninety per cent of the participants completed EMA, and participants completed about 64% of scheduled assessments. Study 2 was a pilot study of AR administered on mobile devices in perinatal former smokers ($N=17$) attempting to remain abstinent. AR (or Control Training) was administered for two weeks before and after delivery. Specific Aim 1 (Study 2) examined if AR delivered on a smartphone modified attentional bias to smoking-related stimuli. There was evidence that attentional bias was reduced in the AR group (vs Controls). Specific Aim 2 examined whether AR delivered on a smartphone modified craving for cigarettes. There was no evidence that craving was reduced in the AR group. In an exploratory aim, there was no evidence that AR reduced smoking during the study period. Further research using larger samples is required to evaluate the utility of mobile AR in perinatal smokers.

TABLE OF CONTENTS

LIST OF TABLES	x
CHAPTER 1: INTRODUCTION	3
Background on Cigarette Smoking	3
Smoking Prevalence.....	4
Health Effects of Cigarette Smoking	4
Treatment for Smoking	9
Pharmacological Treatments	10
Nicotine Replacement	11
Varenicline	11
Bupropion	12
Special Populations	13
Psychological Treatments	13
Individual and Group Counseling	14
Relapse Prevention Interventions	14
Smoking Cessation Among African Americans	17
Summary	19
CHAPTER 2: PSYCHOLOGICAL PROCESSES UNDERLYING RELAPSE	21
Hormonal Changes During Pregnancy	21
Affect, Stress, and Post-Partum Relapse.....	21
Intention to Quit and Relapse	24
Craving and Relapse	26
Summary	29
CHAPTER 3: COGNITIVE BIAS AS A TREATMENT TARGET	31
Attentional Bias	31
Assessment of Attentional Bias	33
Stroop.....	33
Visual Probe.....	35
Eye Tracking	36
Self-Report Measures.....	36
Cognitive Bias Modification.....	37
Ecological Momentary Assessment.....	39
EMA Assessment Schedules.....	41
EMA in the Perinatal Population	42
Attentional Retraining with EMA.....	44
Compliance During EMA	46
EMA Among African Americans	47
Feasibility vs. Pilot	48
Summary	49
CHAPTER 4: STUDY RATIONALE & SPECIFIC AIMS	51

Rationale	51
Study 1	52
Specific Aim 1	52
Exploratory Aim 1.	52
Study 2	52
Specific Aim 1	52
Specific Aim 2	53
Exploratory Aims.....	53
 CHAPTER 5: STUDY 1 METHODS & ANALYTIC PLAN	 54
Participants.....	54
Procedure	54
Self-Report Measures.....	59
Smoking Stroop Task.....	62
Data Analytic Plan (Study 1)	66
Exploratory Aim 1	67
Power Analysis	68
 CHAPTER 6: STUDY 1 RESULTS	 70
Descriptive Statistics (Lab).....	70
Descriptive Statistics (EMA)	70
Specific Aim 1: Feasibility	71
Exploratory Analyses.....	72
Supplementary Analyses.....	73
 CHAPTER 7: STUDY 1 DISCUSSION	 74
Feasibility.....	74
Association between Parental Stress and Craving	75
Association between Attentional Bias and Craving.....	76
Association between Craving and Smoking	78
Additional Observations	79
Limitations	81
Strengths	83
Future Research	84
 CHAPTER 8: STUDY 2 METHODS & ANALYTIC PLAN	 84
Participants.....	84
Procedure	85
Measures	89
 CHAPTER 9: STUDY 2 RESULTS	 96
Lab Descriptive Statistics	96
EMA Contributors vs. Non-Contributors	96
EMA Descriptive Statistics	97
Number of Trainings.....	98
Specific Aim 1: Effect of AR on Attentional Bias	99

Specific Aim 2: Effect of AR on Craving.....	100
Exploratory Aims.....	100
Effects of AR on Smoking.....	100
Effect of AR at Prepartum and Postpartum phases.....	101
Supplementary Analyses.....	102
Analysis of Lab Data	102
Analysis of Abstinent Subset.....	102
Additional Analysis of Attentional Bias Data	103
Analysis of Effect of Time on Craving.....	104
 CHAPTER 10: STUDY 2 DISCUSSION	 105
Effect of AR on Attentional Bias (Aim 1)	105
Effect of AR on Craving (Aim 2)	106
Effect of AR on Smoking (Exploratory Aim).....	107
Study Phase and Effect of AR (Exploratory Aim).....	108
Limitations	108
Strengths	110
Future Directions	110
 CHAPTER 11: GENERAL DISCUSSION	 112
Assessment.....	113
Intervention	114
 Appendix 1	 138
 REFERENCES	 139

LIST OF TABLES

Table 1. Study 1 Telephone/Lab Assessments	117
Table 2: Study 1 Baseline Measures	118
Table 3: Study 1 Summary Statistics Lab Assessments	119
Table 4: Study 1 EMA Summary Statistics	120
Table 5: Study 1 LMM Analyses	121
Table 6: Study 2 Telephone/Lab Assessments	122
Table 7: Study 2 Baseline Measures	123
Table 8: Study 2 Summary Statistics Lab Assessments	124
Table 9: Study 2 Analyses of Lab Data.....	125
Table 10: Study 2 EMA Summary Statistics.....	126
Table 11: Study 2 LMM Analyses.....	127

LIST OF FIGURES

Figure 1. Illustration of cognitive bias modification.	128
Figure 2. Flowchart of procedure for Study 1. Includes timeline of procedure from pre-visit telephone screen through the second lab visit. It also includes a breakdown of the 2-week EMA portion of the study. Overlaid is the timeline of the perinatal period.	129
Figure 3. Consort Chart for Study 1.	130
Figure 4. Stroop task on mobile device (Study 1). Smoking-related words and neutral words were presented in varying colors (i.e., blue, green, red). Attentional bias was measured through assessment of reaction times to identify the color of the font the word was printed in.	131
Figure 5. Compliance in Study 1.	132
Figure 6. Relationships between Mean parental stress/Deviation parental stress and Craving.	133
Figure 7. Flowchart of procedure for Study 2. Includes timeline of procedure from pre-visit telephone screening through two intervention phases and follow-up visits. Overlaid is the timeline of the perinatal period.	134
Figure 8. Consort Chart for Study 2.	135
Figure 9. Picture of VP task (Study 2). In the modified visual probe (VP) task, participants were tasked with focusing on the fixation cross in the center of the screen. The cross was then replaced by a series of picture pairs (smoking and neutral pair) that were presented for 500ms. The side of the screen that the picture was presented on was randomized. Following presentation of the picture pairs, a probe (i.e., the dot) appeared in the position of one of the pictures. Participants were asked to indicate whether the probe appears on the right (M key) or on the left side of the screen (C key).	136
Figure 10. Attentional Bias by Group.	137

CHAPTER 1: INTRODUCTION

Background on Cigarette Smoking

Cigarette smoking remains a prevalent, preventable health behavior that affects people globally. While the proportion of smokers worldwide has decreased, due to population growth the number of smokers worldwide continues to increase. Some populations are at particular risk from the negative health effects of cigarette smoking. One such population is perinatal women who smoke, as there are many health consequences to both the mother and fetus associated with smoking during gestation. Even when women are successful in maintaining abstinence throughout pregnancy, they are at high risk for relapse following delivery. Novel relapse prevention interventions are needed for this population.

The first part of this dissertation proposal is organized as follows. First, in this chapter a background on smoking prevalence and the health effects of smoking is provided. Additionally, included is a review of the cigarette smoking literature specifically among perinatal women to include a review of literature on the health effects of smoking, and interventions for smoking cessation. Second, in Chapter 2 there is a review of the literature on relapse process, with a particular focus on relapse to smoking among perinatal women. Third, in Chapter 3, a cognitive target for intervention, attentional bias to smoking cues, is introduced. In addition, research on attentional retraining (AR) will be described. Fourth, given ecological momentary assessment (EMA) was the methodology used in the current studies, a review of EMA methodology is provided in Chapter 3. Last, in Chapter 4, the Specific Aims and Hypotheses will be described.

Note that this dissertation involves analysis of pre-existing data from two studies that examined the feasibility of mobile assessment and intervention among perinatal women. Therefore, no new data was collected. USUHS IRB approval was obtained for conducting analyses on existing data.

Smoking Prevalence

Tobacco use is responsible for nearly six million deaths per year across the globe (209). A large portion of these deaths - 600,000 approximately - are caused by second-hand smoke. Additionally, as noted above, although the percentage of smokers across the world has decreased over time, the total number of smokers has *increased*, because of growth in the global population (Stewart & Tofield, 2014). Since 1980, the estimated number of daily smokers increased from 721 million to just under 1 billion smokers (127).

Health Effects of Cigarette Smoking

The first official public statement detailing the negative health consequences of cigarette smoking was reported by the United States Surgeon General in 1964 (134). It is now common knowledge cigarette smoking contributes to a number of serious health conditions including cancer, coronary heart disease, and emphysema (195). Despite the well-known negative health effects, cigarette smoking continues to lead the list of preventable causes of death in the United States.

Nicotine Addiction

Smoking cessation is difficult for many people due to the addictive nature of tobacco products. Cigarettes are an addictive product due to the presence of nicotine

(198). A detailed account of nicotine addiction will not be presented in this proposal, but a brief summary is provided below.

Nicotine is an alkaloid and acts as an agonist, binding to nicotinic acetylcholine receptors that are distributed throughout the body (32). Nicotine binds to receptors in the complex of neurons located in the Ventral Tegmental Area (VTA), which is located in the midbrain area related to motivational effects of drug use. Once nicotine binds to nicotinic receptors in the VTA, ascending neurons are activated, leading to the release of a number of neurotransmitters including dopamine. Dopamine is involved with a number of psychological processes, including pleasure, arousal, cognitive enhancement, and modulation of mood. Activation of nicotinic receptors also results in changes in other neurotransmitters, such as norepinephrine (also called noradrenaline) and acetylcholine. Subsequent elevation of these neurotransmitters contributes to the overall development of addiction to smoking (17).

Further, neurobiological differences may explain differences between sexes in motivation for smoking behavior (198). Pertinent to this dissertation, some longitudinal research findings suggest there are sex differences in smoking-cessation related outcomes (177). Specifically, women appear to have a lower success rate (31% lower odds) in quitting compared to men. Such differences highlight the need to tailor smoking cessation interventions to specific populations.

Smoking in the Perinatal Population

Perinatal women who smoke are a particularly vulnerable population. In light of the many negative health effects of smoking, it is unsurprising that smoking is particularly harmful to pregnant women. Smoking during pregnancy has direct impacts

on the risk of the pregnancy itself. Such risks include an increased risk of premature rupture of the membranes, placenta previa, placental abruption, preterm delivery, and fetal growth syndrome (196). It was estimated that 5.3%-7.7% of preterm deliveries, and 5.0%-7.3% of preterm-related deaths, were attributable to smoking during pregnancy (49). Preterm birth in itself is associated with various short- and long-term health problems such as neurological, developmental, and neurosensory morbidities, as well as increased incidence of metabolic, cardiovascular, and respiratory issues. While difficult to establish causality, there is also mounting evidence for an association between in-utero smoking and an increased risk for mental health-related morbidities, such as attention deficits, hyperactivity, and other behavioral disorders among children (104).

Research indicates there is a race differential in risks associated with smoking during pregnancy. More specifically, African American women who smoke during pregnancy are especially vulnerable to adverse birth outcomes, such as preterm delivery and infant mortality (4). In general, the African American population is more at risk for delivering preterm, as the risk for preterm delivery is twice as likely among African American women compared to Caucasian women (157). It is likely that both biological and socioeconomic factors contribute to this disparity. For example, recent research indicates recurring bacterial vaginosis (BV) may biologically interact with agents of smoking such that the risk for preterm delivery increases. In turn, recurring BV is far more common among African American women (4). Socioeconomic factors that may contribute to the disparity include neighborhood characteristics such as adverse neighborhood conditions and unemployment rates.

Despite the plethora of negative health outcomes associated with perinatal smoking, it remains prevalent in many countries. Globally, the prevalence of smoking during pregnancy is estimated to be 1.7%, with the majority of those smokers identifying as daily smokers (rather than occasional smokers). However, among U.S. women, in 2016, the prevalence of smoking during pregnancy was 7.2%, which is higher than the global rate (30). That is, of every 100 pregnant U.S. women, about 7 report smoking during pregnancy. One of the objectives of Healthy People 2020 is to significantly reduce the prevalence rate of smoking during pregnancy within the U.S. to a much lower proportion (1.4%) more comparable to the global rate (133).

Of women who identify as smokers at the onset of pregnancy, ~50% of those women quit smoking during pregnancy and the remainder continue to smoke, according to a 10 state survey conducted across six years (38). Moreover, within six months postpartum, over 50% of the women who quit smoking relapsed to smoking. One study found that mothers returned to smoking in an even shorter period of time, with a reported 40% of mothers returning to smoking at two weeks post-delivery (107). Most mothers report relapsing due to stress or the presence of another smoker (Letourneau et al., 2007).

Although prenatal smoking may be perceived as more harmful, postnatal smoking also has adverse effects on the mother and child. A susceptible period for tobacco smoke to affect the infant is during lactation and breastfeeding. When a woman smokes and breastfeeds, the inhaled nicotine remains readily available in the breast milk, thus directly further exposing the infant to the effects of nicotine (12). Evidence suggests maternal smoking during lactation increases the likelihood of neurobehavioral disorders, sudden infant death syndrome, and adverse metabolic and respiratory outcomes. Additionally,

infant sleep and wake patterns appear to be susceptible to disruption immediately after the mother smoked, potentially due to the stimulant effects of nicotine.

Prevention of smoking during pregnancy would not only improve health outcomes among mothers and infants, but would also significantly lower annual health expenditure for hospitals (i.e., approximately \$232 million across the United States) (49). Pregnancy presents a “window of opportunity” for women to achieve long-term abstinence from smoking. Currently, guidelines on prevention and management recommends all health-care providers provide advice and psychosocial interventions for tobacco cessation to all pregnant women who smoke (208). However, some women quit spontaneously and are referred to as “spontaneous quitters” because they quit upon finding out they are pregnant and before they receive advice or intervention from prenatal care providers (179).

Spontaneous quitters are typically highly motivated to protect their babies, and are knowledgeable about the health risks of smoking during pregnancy (48). Other predictors of spontaneous quitting include factors such as the belief that smoking during pregnancy will “greatly harm my baby,” as well as education attainment, stress ratings, age of smoking initiation, marital status, and quits during pregnancy (204). Additionally, spontaneous quitters who remain abstinent compared to those who relapse, tend to be older, have a higher education, and be on their first child (102).

The exact relationship between spontaneous quitting, health literacy, and education level is less clear. In general, health literacy is a factor that is associated with negative cessation outcomes, especially among low-SES racial/ethnic minority populations (187). More specifically, being African American is associated with poor

health literacy, a lower level of knowledge about smoking risks, and lower perceptions regarding the health risks of smoking. In contrast, another study found that while reading level is related to both knowledge and health-related concerns among pregnant women, reading level does not correlate with smoking prevalence (9). Additionally, educational attainment - more commonly assessed than reading level - is not necessarily indicative of poor health literacy. More specifically, in one study, perinatal patients with a particularly high proportion of individuals (42%) with a high-school degree or lower showed generally good knowledge of smoking-related risks to health. This suggests that lack of knowledge, at least in the perinatal population, may not be a major factor in continued smoking during pregnancy (34).

While guidelines exist on smoking prevention in perinatal women, sustained cessation success is limited. Observed differences in women who quit during pregnancy vs. are not able to quit suggest the use of tailored interventions. The following section will review current interventions and treatment for smoking cessation and relapse prevention.

Treatment for Smoking

Each year in the U.S., approximately 50% of smokers make an attempt to quit smoking (196). An even higher percentage of people - 75% - express a desire to quit. When smokers attempt to quit, the majority of smokers - somewhere between 50% and 66% - attempt to quit without using any form of assistance, psychological or pharmacological (33). This is known colloquially as quitting "cold turkey". However, the reported success rates of a single quit attempt are abysmal, with only 7.2% of male and 7.6% of female smokers successfully quitting (29). Note also that it is difficult to define

what a “successful” quit attempt is, and the U.S. Department of Commerce (193) found through a survey study that most people (~95%) cannot stay abstinent beyond six months of quitting.

A number of factors - biological and sociological - contribute to difficulty in quitting smoking and remaining abstinent. For example, lower educational attainment is highly associated with smoking among U.S. women in general. The prevalence of current smoking among those with less than a high-school education is 26.4%, 25.3% among those with a high-school education, 23.8% among those with some college, and 12.1% among college graduates (72).

The addictive nature of nicotine and the aversive effects of nicotine withdrawal are biological factors that thwart quit attempts. Physical effects, while not lethal, include an array of uncomfortable symptoms such as coughing, constipation, dizziness, poor sleep, and mouth ulcers (87). Individuals attempting to quit also report cognitive and mood-related symptoms including impaired memory, confusion, diminished concentration, and increases in negative affect (81). Moreover, irritability, frustration, anxiety, and depressive symptoms are associated with nicotine withdrawal (8). While most of these symptoms dissipate within two weeks, other symptoms such as increased weight, appetite, and craving can last for up to six months (88).

Despite the presence of numerous withdrawal symptoms, as noted above, many smokers who desire to quit choose to do so without the assistance of any treatment options. The following sections will briefly review existing treatments - including pharmacotherapy and psychotherapy - as well as the literature on their efficacy.

Pharmacological Treatments

Nicotine Replacement

Nicotine replacement therapies (NRTs) aid smokers in quitting by providing an alternative source of nicotine that reduces withdrawal symptoms and craving during cessation. They include several over-the-counter products such as gum, lozenges, patches, nasal spray and inhalers. Nicotine withdrawal can be a barrier to successful cessation due to the unpleasant nature of the symptoms. NRTs safely deliver nicotine to the bloodstream at a slower level than it is delivered through cigarettes, thus maintaining overall lower levels of nicotine in the bloodstream (184). Therefore, the goal of NRTs is to reduce the amount of nicotine delivered to the system at a more gradual rate by reducing the dose of the NRT while also maintaining abstinence. The initial dose of NRT is based on the average smoking rate per day and may gradually be decreased over time. Research demonstrates the efficacy of NRTs, with the odds of success roughly doubled in smokers using NRT compared to those smokers who did not use NRT (130; 174).

Varenicline

Varenicline is a prescription medication that acts as a partial agonist specifically on nicotinic $\alpha 4\beta 2$ receptors. Approved in 2006, this pharmacological treatment binds on $\alpha 4\beta 2$ nicotine receptors so that nicotine can no longer bind to them and subsequently when smokers have a cigarette they experience less pleasure. At the same time, it is thought that activation of $\alpha 4\beta 2$ receptors by nicotine reduces withdrawal symptoms and craving. In theory, Varenicline is meant to “teach” smokers to not associate smoking with the experience of pleasure, thus leading to extinction of smoking behavior. Research also demonstrates that reduced pleasure in smoking seems to also be associated with a reduction in craving and withdrawal symptoms during a quit attempt (36). The odds ratio

for a successful quit attempt while taking Varenicline (vs placebo) has been estimate to be ~2.50 (76).

Bupropion

Bupropion, also a prescription medication and alternatively known as Wellbutrin, was not originally developed as a smoking cessation treatment. It was first approved and labeled by the FDA as a medication used to treat depressive symptoms. However, following further research, it was later also approved for use as a smoking cessation aid. Since it was originally created as an antidepressant, researchers hypothesized it decreases cigarette withdrawal and craving through the mechanism of reduction in negative affect. It has comparable efficacy to NRT, with nearly double the odds of abstinence compared to smokers who do not use any smoking aid (54). Moreover, the odds ratio for cessation is ~2.07 (54).

Electronic Cigarettes

Electronic cigarettes or “e-cigarettes” could be viewed as a healthier alternative to smoking cigarettes and be recommended as a way to quit cigarettes, including to pregnant women. One study found that 64.27% of pregnant women view e-cigarettes as safer than tobacco cigarettes (200). The same study found 6.5% of pregnant women used e-cigarettes and 5.6% used regular cigarettes (8.54% of women used both tobacco and electronic cigarettes). In other words, women were more likely to use to report using e-cigarettes than regular cigarettes. However, recent research has cast doubt on whether e-cigarettes should be used as a method for cessation in pregnant women, and a recent review revealed that e-cigarettes expose pregnant users and their growing fetus to similar levels of nicotine - a known harmful substance for the fetus - as tobacco cigarettes (205).

Special Populations

While the U.S. Public Health Service recommends pharmacotherapy be used to augment psychotherapy, pharmacotherapy is not generally recommended for certain populations (67). For example, the efficacy and safety of drug treatments for perinatal women trying to quit smoking has not been widely examined or established. A few studies have evaluated the effects of NRT use among perinatal women and while results suggest a potential benefit, the amount of evidence is too limited to provide a compelling reason for perinatal women to use NRTs (175). Moreover, NRTs are considered a Category D medication for pregnant women, which means there is positive evidence for fetal risk (i.e., increased risk of cesarean delivery, increased blood pressure). It is not known whether the use of NRT or smoking during pregnancy is riskier. Furthermore, NRT is the only pharmacotherapy that has been investigated among perinatal women, so the efficacy and/or harm of other pharmacotherapies - bupropion and varenicline - is unknown (175). In sum, pharmacological treatment options that are considered first-line treatments for the general population of smokers cannot be considered in the same way for perinatal women.

Psychological Treatments

Most psychotherapy for smoking behavior often involves behavioral strategies and motivational interviewing techniques. The goal of psychotherapy in regards to assisting an individual quit smoking is to help the individual learn how to recognize and avoid situations where relapse is common. This form of treatment also involves collaborative identification and monitoring of actions the individual will take to remain abstinent. However, in comparison to pharmacological treatments, psychotherapy alone

has relatively modest success in promoting successful quit attempts as the odds ratio for smoking cessation has been estimated to be 1.44 (106).

Individual and Group Counseling

Psychotherapy may be delivered to those interested in quitting via an individual or group setting. Both forms of counseling target similar areas - motivation, cognition, and behavior - though the format is different. They are also both considered more effective than “control” interventions such as minimal contact, routine medical care, or self-help materials (106). In a group format there is an added opportunity for participants to learn from other group members and also practice the new skills (183; 202).

Relapse Prevention Interventions

Behavioral interventions and pharmacotherapy aid individuals who desire to quit smoking. Particularly relevant for the current dissertation, however, after achieving abstinence many individuals relapse to smoking, which is why development of relapse prevention interventions (RPIs) is important (3). RPIs are meant to explicitly reduce relapse upon completion of an acute treatment phase and may include interventions aimed at preventing initial relapse or preventing any lapses from developing into full relapse (114).

RPIs, overall, can span a broad spectrum of designs in order to reduce relapse at various points. For example, in the 2019 Cochrane review, the authors differentiated between studies based on design and other methodological characteristics (114). A key methodological differentiation was between studies that randomly assigned participants *before* smoking cessation and studies that randomly assigned participants *after* smoking cessation. Other methodological variables included whether or not the abstainers were

aided or unaided. Thirdly, the intensity of the intervention varied, if behavioral. More intense interventions were those that involved repeated face-to-face contact. Meanwhile, less-intensive interventions were communicated more often through written materials, telephone, or brief face-to-face sessions. Across studies that included unaided abstainers, it seems the majority of interventions described in studies were of relatively low intensity. Meanwhile, behavioral interventions for assisted abstainers seem to be of higher intensity.

The 2019 Cochrane review concluded there is, in general, limited evidence that behavioral methods of relapse prevention are effective. Additionally, the review concluded the best evidence on effectiveness of RPIs was gleaned from studies that randomized abstainers. More specifically, the review, covering 77 studies, found no clinically significant effect of current, existing behavioral RPIs (i.e., counseling, skills teaching, advice materials). Most important for the current study, with regard to postpartum women the efficacy of RPIs was similar, as the 18 studies reviewed did not show clinically significant effects of RPIs (Livingstone-Banks et al., 2019).

It may seem logical to recruit smokers before they have stopped smoking, due to the theoretical benefits of relapse prevention in the early stages of quitting. However, the combination of cessation and relapse prevention efforts muddles the effects of relapse prevention, thereby reducing the power to detect said effects. Therefore, randomly assigning smokers who have already achieved a successful quit attempt represents a stronger design. (This was the design used in Study 2 of the current dissertation, in that smokers who had reportedly achieved abstinence were randomly assigned to treatment conditions). Despite the strength of the design, this approach also had its limitations, as

abstainers varied considerably in the length of time they had abstained. This is further complicated by a lack of an operational definition concerning the differentiation between relapse and an initial failure to stop smoking. For example, it is unclear how much time must pass to consider re-engagement in smoking a relapse or an initial failure.

Psychological Interventions for Perinatal Women

Smoking cessation treatments specifically tailored for postpartum women are limited in terms of development and rate of success. In fact, systematic review of postpartum interventions reviewed three randomized control trials specifically examining relapse prevention, smoking cessation or smoking reduction interventions in the postpartum period (111; 112). They found no evidence for the efficacy of these behavioral and advice-based interventions. Additionally, motivational interviewing (MI) also seems to have limited benefits for pregnant and postpartum women, as demonstrated by comparable quit rates between a control group and MI group (149). They speculated this may be related to the motivation that many perinatal women already have regarding quitting. While a motivational and problem solving based intervention “r(MAPS)” helped temporarily increase the maintenance of postpartum smoking abstinence, relapse rates that increased over time demonstrate the diminishing effect of the treatment (149).

Contingency based therapy is another type of intervention that has been piloted among pregnant/postpartum women through multiple controlled trials (85). This form of intervention is a method of incentivizing (i.e., vouchers exchanged for abstinence) and promoting biochemically-verified smoking abstinence. In pilot studies it has been moderately efficacious, demonstrating improvement in birth outcomes related to newborn mortality and morbidity. While the smokers in the contingency group achieved a higher

rate of abstinence (34.1% vs. 7.4% at 12 weeks postpartum), the abstinence rates decreased across groups as time passed postpartum (85). Additionally, the use of vouchers or any monetary incentive limits the accessibility and ease of implementation of this intervention (e.g., in community settings).

While pregnancy-specific interventions for smoking cessation and relapse are limited, there are general clinical practice guidelines that are applicable to pregnant women (35). These guidelines are based on the 5 A's, a model often used in the primary care setting. The major steps consist of: 1) asking if the patient uses tobacco, 2) advising the patient to quit, 3) assessing willingness of the patient to make an attempt at quitting 4) assisting the patient in quitting if they are willing, 5) arranging follow-up contact to prevent relapse. While the "assist" step for the general population may include recommendation of medication, special considerations are acknowledged for populations where there is a lack of evidence for the use of medications (e.g., pregnant women, adolescents).

Smoking Cessation Among African Americans

A broader conceptualization of the variables that influence health behaviors is important to consider. The socio-ecological model provides a framework in which to examine health behaviors including smoking and smoking cessation (71). This model helps to inform this area of research by describing how a health behavior, like smoking, is related to interpersonal, organizational, community and social subsystems. Taking these subsystems into account helps to explain the complexities of health determinants and also disparities between various cultural groups.

The socio-ecological model can be applied to various populations, such as the Hispanic population and the so-called “Hispanic paradox” (118). This paradox refers to data indicating that Hispanics tend to have a more favorable health and mortality profile compared to non-Hispanic White populations, despite being at a lower socioeconomic status in general. Possible explanations for this paradox include strong ethnic identity and the centrality of family (i.e., social support), as protective factors. These observations serve as an illustration of how socio-ecological factors impact health outcomes in general.

Regarding smoking, it is difficult for smokers of any race to quit smoking. However, some populations find it more difficult to quit and/or maintain abstinence. Certain socioecological factors - low SES, less education, lack of access to care - contribute to the relationship between race and smoking cessation. Pertinent to the current dissertation, some data suggest that African Americans report lower long-term quitting success compared to non-Hispanic Whites (191). This is relevant to the current dissertation because a majority of the participants in this study self-identified as African-American. Specifically, the CDC (194) indicates the prevalence of cessation among African American smokers is 35.4% compared to 50.5% among Caucasian smokers. Additionally, the CDC’s most recent report on smoking cessation demonstrated evidence for a disparity between ethnic groups regarding cessation prevalence (29). In 2015, there was a prevalence of recent smoking cessation of 4.9% among Black, non-Hispanics compared to 7.1% among White, non-Hispanics. In the 2015 report, recent smoking cessation was defined as successfully quitting for ≥ 6 months in the past year. There are also significant ethnic differences regarding when people start smoking, as African

Americans initiate smoking at a later age compared to non-Hispanic Whites (190). The presence of these disparities demonstrate the need for prevention strategies specifically targeting these ethnic populations.

While it is difficult to determine why there are racial differences in smoking cessation, possible mechanisms include potential effects of menthol cigarettes and racial differences in nicotine metabolism. Evidence suggests the majority of African American smokers use menthol cigarettes (135). Meanwhile, comparatively fewer Caucasian smokers use menthol cigarettes, which are believed to result in greater nicotine consumption (75). Therefore, the use of menthol cigarettes may make it more difficult to quit. Menthol cigarettes do not single-handedly explain racial differences in smoking cessation, but differences in nicotine metabolism may contribute as well. More specifically, research suggests African Americans metabolize nicotine slower, prolonging the effect of nicotine in the brain and resulting in greater dependence (137). However, the relationship between nicotine metabolism and smoking cessation has not been definitively determined.

Summary

In summary, cigarette smoking remains a leading public health concern, as indicated by relatively high prevalence and associated health risks. While the proportion of cigarette smokers has decreased across the worldwide, the total number of cigarette smokers continues to increase, with a majority of these smokers expressing interest in quitting. Certain populations, such as perinatal women, however, provide unique opportunities for smoking cessation treatment and relapse prevention.

Challenges for treating perinatal women include the limitations in treatment options and unique stressors involved with pregnancy and delivery. Given the limitations in treatment options for perinatal women, alternative treatments are necessary. In order to develop more efficacious treatments, it is necessary to improve understanding of the psychological processes underlying relapse. The following chapter will review the psychological processes that underlie relapse both in the general population and among perinatal women in particular.

CHAPTER 2: PSYCHOLOGICAL PROCESSES UNDERLYING RELAPSE

In order to develop safe, efficacious, and convenient interventions for perinatal women, additional research must be done to examine key psychological processes underlying relapse to smoking. Perceived stress, in particular, may be a contributor to relapse among postpartum women. Additionally, craving also likely contributes to relapse among postpartum women. Exposure to smoking cues, and subsequent elevations in craving, may also precipitate relapse.

But first, although the focus of this chapter is on psychological processes underlying relapse, a brief discussion on pertinent biological processes is provided.

Hormonal Changes During Pregnancy

Although the focus on the chapter is on psychological processes, research has suggested that hormone changes during pregnancy may relate to cessation. Specifically, while estrogen may increase vulnerability to smoking, progesterone may be a protective factor (115). Preclinical animal studies demonstrate the importance of progesterone in nicotine's reinforcing effects and potentially decreasing these effects. Specifically, findings also suggest the increased levels of progesterone that occur during pregnancy may counter the biological vulnerability women have to nicotine and provide a "natural assist" to cessation during pregnancy. A study that specifically examined the effect of changing hormone levels among female smokers found an association between the naturally increasing levels of progesterone and a 23% increase in abstinence rate (158). Conversely, the precipitous decline in progesterone level postpartum may put women at risk for relapse, as nicotine becomes more rewarding.

Affect, Stress, and Post-Partum Relapse

Within this proposal, affective experience and “mood symptoms” will be referred to by a construct known as affect. Often, the words “mood”, “emotion”, and “affect”, are assumed to have the same meaning. Here, mood captures “diffuse, slow-moving feeling states that are weakly tied to specific objects or situations”, whereas emotions are considered to be quicker moving, situationally based reactions (156). Affect, described as shifting and external, parallels the definition of emotion more closely than it does mood. However, in this proposal, negative affect in general, as well as stress, were variables of interest due to research that demonstrates their roles as predictors of postpartum relapse (99).

In stress-coping and self-medication models of smoking, negative affect is highlighted as these models suggest people use drugs in order to regulate emotions (99). Moreover, reports of increased negative affect are shown to predict higher levels of craving as well as relapse (99). While not necessarily evidence or support of these conceptual models, many smokers do explain their smoking habits as a means, at least in part, to reduce various negative affective states (180). Many smokers hold a genuine expectation that smoking will reduce negative affect (40)

In addition to negative affect, psychosocial stressors and the experience of increased stress may influence smoking behavior at various stages, including initiation, maintenance, and cessation (176). A number of mechanisms may contribute to this relationship. Specifically, individuals may use smoking as a form of coping with acute or chronic stress. Moreover, chronic stress may reduce self-regulation and by extent the individual’s control over the urge to smoke, thus increasing the likelihood of smoking. Multiple observational studies support the link between chronic stressors (e.g., financial,

occupational, relational), smoking, and increased probability of relapse (11; 173; 185).

While stress seems to have a robust relationship with smoking, research suggests not all stressors influence smoking behavior in the same way (176). Their national cohort study found evidence that high financial and work stress may be associated with higher odds of cessation.

For many women, pregnancy and having a newborn child introduces a new stressor into their lives. This stress may be related to care-taking, financial burden, weight management, and other factors. According to one survey study, stress in general is the most frequently cited reason for relapsing at 1 month, 8 months, and 12 months post-partum (41). Compared to women who continue to smoke during pregnancy, those who quit report feeling less stressed during the pregnancy (27).

However, maintaining abstinence during the postpartum period is complicated by various factors, such as having a partner who smokes. A partner who smokes, in addition to the associated smoking paraphernalia, serves as a salient cue for craving and smoking. Additionally, depressive symptoms and stress have been shown to predict relapse following delivery among women who quit during pregnancy (136). For example, Park et al (136) found that women who relapse were more likely to have reported a history of depression in comparison to women who did not relapse. This is concerning as smokers in general are more likely to report depressive symptoms in comparison to those who have never smoked (213). Thus, a predictor of post-partum smoking relapse - history of depressive symptoms - is a characteristic that has higher prevalence among smokers in general. Additionally, while non-smokers report a decrease in stress post-partum over the course of 12 weeks, smokers experience an increase in perceived stress (136)

Another risk factor related to stress and mood changes is concern about shape and weight post-partum. Among women in general, weight concerns appear to affect smoking and cessation rates (138). Specifically, confidence levels in the ability to manage weight postpartum without smoking is associated with a decreased risk of post-partum relapse, at least in the first 6 months postpartum (110). Conversely, concerns about weight gain related to cessation, and viewing smoking as a tool to manage weight, increased the likelihood of relapse. Interestingly, Levine and colleagues (110) did not find a significant association between changes in perceived stress and postpartum relapse. However, they noted that perceived stress levels were in general high from late pregnancy to 24 weeks postpartum. Therefore, it is possible their measure was not sufficiently sensitive to changes in perceived stress to capture an increased vulnerability to relapse.

Stress during the postpartum period can also be caused by relationship strain or discord. In fact, relationship discord has been shown to be negatively associated with quitting smoking (82). Strained relationships introduce another layer of stress and suggests there is limited support in coping with other stressors related to quitting and rearing a new child. Additionally, research demonstrates that when the partner is a smoker too and does not quit as well, the perinatal woman's perception of support drops (120). Conversely, when the partner is also trying to quit, significantly more positive support is perceived by the perinatal woman. Taken together, these associations demonstrate the importance of support in quitting and in reducing stress post-partum.

Intention to Quit and Relapse

Given women are encouraged by others (i.e., doctors, family) to quit during the perinatal period, the perinatal woman's intention to quit and motivation to remain

abstinent are important variables to consider. Qualitative research has specifically examined intention to quit and salient beliefs shaping this intention among women who recently delivered and had remained abstinent through pregnancy (199). It seems that while many new mothers do not intend to return to smoking postpartum, they expressed doubt about their intention (e.g. “I think it’s going to be pretty hard to stay quit... Hopefully I don’t [smoke again], but it is pretty hard not to go back”). Expressions of doubt about their intention to quit spanned general doubt to more specific doubt (i.e., comments related to external motivation to quit during pregnancy to quit, and subsequent lower faith in themselves to remain abstinent). Other qualitative data encapsulated beliefs the mothers had regarding their ability to protect their infants from second-hand smoke and/or the effects of smoking should they resume smoking. Lastly, Von Kohorn and colleagues’ data described mothers’ belief in their control over smoking and even denial of a need for help to remain abstinent post-partum (199).

Other data support the relationship between intention to quit and relapse during the post-partum period. In comparing women who self-reported their likelihood to return to smoking as “somewhat likely” to “extremely likely” and women who reported “not at all” to “not very likely”, only 54% of the latter group returned to smoking, while 76% of the former relapsed (141). These data suggest intention to quit is associated with women’s likelihood of relapse.

Various factors influence intention to quit. Identifying these factors may make it possible to modify intention to quit and promote lower likelihood of returning to smoking post-partum. Five factors that are associated with probability of intention to quit include demographic factors, pregnancy factors, and psychosocial factors (142). For demographic

factors, non-White women and women with lower levels of education (high-school or less) were more likely to report an intention to return to smoking ($OR=1.5$ for both factors). Similarly, those who had an unwanted pregnancy and shorter duration of abstinence were also more likely to report an intent to return to smoking ($OR=2.;$ $OR=0.8$).

Among psychosocial factors there were three identified predictors, including lack of concern about negative health effects, attribution of cessation, and self-identification as a smoker. Specifically, women who were not concerned about the negative health effects of smoking reported being more likely to intend to return to smoking ($OR=1.6$, $95\% CI= 0.9-2.8$). Women who attributed their cessation as temporary rather than permanent were more likely to intend to return ($OR= 2.1$, $95\% CI= 1.2-3.6$). Lastly, women who self-identified as anything other than a “non-smoker” were more likely to intend to return to smoking post-partum ($OR= 8.8$, $95\% CI= 5.0-15.2$).

Craving and Relapse

During most attempts to quit, smokers experience nicotine cravings due to the nicotine dependence smokers develop (131). Craving is defined as a conscious desire individuals experience to use a drug, or for the content of this proposal, smoking (189). As noted earlier, craving is associated with both smoking and relapse to smoking. In particular, craving is induced or increased by cues for smoking that are proximal to the smoker. Thus, cue-induced craving is proposed to be a mediator between smoking cues and smoking behavior (128).

Craving is predictive of the success rate of smoking cessation and risk of relapse (166). Craving can be described by two separate categories - background and phasic (52).

Independent of situational cues, background craving relates to the steady, persistent level of craving an individual experience. However, feelings of craving that are influenced by situational cues, are called phasic cravings or cue-induced cravings as they are contingent on cues. Both types of craving may be linked to relapse, with stronger levels of background craving and episodic craving as more important in predicting cessation outcomes (166). These two craving types are targets for interventions for smoking cessation.

As noted earlier, research suggests craving is predictive of smoking cessation outcomes and relapse, thus making craving a target for intervention. There are numerous environmental and internal cues that can induce craving and thus complicate individuals' attempts to quit or remain abstinent. For example, being around other smokers is an environmental cue (e.g., the smell of smoke, seeing them smoke, a box of cigarettes), but one that can be difficult to modify or remove.

Results from a systematic review of studies that have tried to study the role of craving in addiction support the necessity of specificity when studying craving. The systematic review found there were a large number of studies reporting a relatively modest association between craving and smoking cessation outcome (210). However, a number of methodological factors may explain the relatively modest association. For example, one factor is related to the time of the craving assessment and, in particular, the interval between assessment of craving and assessment of outcome in smoking cessation.

While there are not many comparative studies between pregnant women and non-pregnant women, there is limited research that provides insight into the relationship between craving and smoking among perinatal women compared to non-pregnant

women. Withdrawal symptoms seem to be comparable, which suggest there are not any distinctive withdrawal symptoms among pregnant women (197). However, one study reported that general levels of craving appear to be higher among pregnant smokers (16). Moreover, the general craving score was largely driven by two factors - expectancy and emotionality - two of the four dimensions on the Tobacco Craving Questionnaire. These two factors of persistent craving are related to anticipation of relief from withdrawal as well as the anticipation of the positive benefits perceived to be related to smoking. Specifically, emotionality decreased less in pregnant smokers than it did in non-pregnant smokers. Additionally, expectancy remained relatively stable during smoking cessation among the pregnant smokers compared to non-pregnant smokers.

Although there is an association between craving and smoking, this does not of course mean that cue-induced craving inevitably leads to relapse. Cognitive processes, such as coping strategies, can be utilized by smokers to overcome the conscious experience of craving. Such coping strategies include urge surfing and relaxation training to surpass the craving (59). The ability to engage in these cognitive coping strategies may explain why there are mixed findings on the relationship between craving and smoking as there is likely variation in smokers' use and success of using these coping strategies to mitigate craving.

Executive Function and Addiction

According to Koob's model of addiction, an imbalance in neurobiological circuits lead to compromised executive functioning (103). Deficits in executive function impact inhibitory control and decision-making skills, which may play a role in an individual's ability to inhibit certain behaviors, such as smoking the first cigarette or taking another

drink. Thus, theoretically, addiction development is contributed to by an imbalance in key neurobiological circuits responsible for keeping impulsive and compulsive behaviors in check (182). Chronic drug users, drinkers, and smokers have deficits in executive functioning, which impair their ability to resist impulsive use of a drug, drink, or cigarette. In turn, in order to avoid withdrawal, individuals continue to compulsively use.

For perinatal smokers, deficits in executive function may be particularly relevant. For example, while it is evident that perinatal women experience significant changes in mood/stress, it is also possible cognitive changes occur. These cognitive changes, which have been noted anecdotally (“pregnancy brain”), may be reflective of changes in mood. Few studies have systematically studied attentional, memory, and concentration problems during the prenatal period (26) . It also seems likely that some women are sleep-deprived during the perinatal period. While studies have demonstrated deficits in psychomotor speed, verbal learning, and memory during the perinatal period, results are inconclusive regarding associations between mood, cognitive changes, and hormonal changes. However, deficits in executive function may be associated with poor outcomes in regards to smoking cessation and relapse (152). For example, deficits in executive function may make it less likely that women will engage in coping strategies when in a crisis situation when attempting to remain abstinent. Therefore, even if women quit during pregnancy, cognitive deficits postpartum may further put them at risk to relapse.

Summary

The perinatal period provides a unique opportunity to intervene and prevent continued use of cigarettes. This is especially important because smoking is detrimental for the health of the fetus as well as the mother. While a large number of women are able

to quit or “suspend smoking” during pregnancy, nearly 80% of this group relapse following delivery (48). Therefore, understanding the underlying psychological processes underlying relapse in this population is important for development of interventions to reduce risk of relapse. While the current chapter has focused on the role of affect, stress, and craving, as well as intention to quit, the following chapter focuses on a cognitive process, attentional bias to smoking cues, that is a target for intervention, and a central focus of this dissertation.

CHAPTER 3: COGNITIVE BIAS AS A TREATMENT TARGET

Recently, research has examined cognitive processes underlying smoking and relapse in hopes that cognitive targets for intervention can be identified. For example, much research has focused on assessment of “attentional bias” (or “attention bias”) to smoking cues, which can be defined as the tendency to automatically attend to smoking cues and maintain attention on smoking cues. As described in detail later, researchers have developed interventions that attempt to decrease attentional bias to smoking cues. First, some background on theory and assessment of attentional bias will be provided.

Attentional Bias

Many researchers believe that exposure to drug-related cues and subsequent cue-elicited craving play a large role in the maintenance of drug use, and promote the likelihood of relapse (128). The incentive-sensitization theory supports this line of reasoning. More specifically, the incentive-sensitization theory posits that brain circuitry is impacted by persistent drug use in such a way that, in certain individuals, excessive amounts of incentive salience are assigned to mental representations of drug cues, resulting in excessive “wanting” for drugs and drug cues (18). According to Robinson and Berridge (1993), an index of elevated incentive salience is attentional bias to drug cues, wherein a cue commands attention. As Berridge (2009) puts it:

“.... incentive salience transforms the mere sensory shape, smell or sound into an attractive and attention-riveting incentive. Once attributed, the incentive percept becomes difficult to avoid noticing, the eyes naturally move toward the incentive, it captures the gaze and becomes motivationally attractive, and the rest of the body may well follow to obtain it.”

Multiple studies have also suggested attentional bias to drug cues contributes to increases in craving (62; 70). Thus, according to theory, increases in attentional bias can give rise to (or cause) increases in craving, due to increases in attention towards drug cues (28). Thus, a smoker with high attentional bias is more likely to pay attention to smoking cues, which in turn may increase craving. In addition, effects of attentional bias may be greater in an individual who has compromised executive function, because they may be less able to use higher-order cognitions to prevent approach behaviors. This may be relevant for a perinatal population, who may experience deficits in executive function during pregnancy, and who may be sleep-deprived.

Attentional bias is part of a larger literature relating cognitive psychological theories to addiction. An important distinction in this literature is between automatic (“system 1”) and controlled (“system 2”) processes (Kahneman, 2003). As stated, attentional biases are automatic processes, part of the category of cognitive processes that are fast, parallel, and largely outside of one’s consciousness (62; 95; 96). Meanwhile, a different category of cognitive processes are those that are non-automatic, slower, reflexive cognitive processes, i.e., controlled processes ((96). However, targeting automatic processes like attentional bias have in recent years become a research interest of those attempting to develop new interventions for health behaviors like addictions.

Empirical research suggests that attentional bias may be associated with craving and use or relapse. A meta-analysis found an association across 45 studies between automatic cognitions such as measures of attentional bias and consumption of cigarettes (154). Another meta-analysis reported a significant association between attentional bias and craving (66). Studies also suggest an association between attentional bias and poor

short-term cessation outcomes in smokers (64; 202). Other studies also demonstrated that individuals also have a higher success rate in remaining abstinent in the short term when they have a lower attentional bias towards smoking cues (91; 144). Therefore, there is evidence that attentional bias is at least predictive of short-term abstinence. This suggests that interventions that reduce attentional bias may be useful for smoking cessation.

Assessment of Attentional Bias

Attentional bias can be assessed with a number of methods including eye movements, self-report measures, and reaction time tasks. Regarding reaction time tasks, attentional bias can be assessed with the smoking Stroop task (used in Study 1) and the visual probe task (used in Study 2). They are described in more detail below, and are a main focus of the current studies.

Stroop

The Stroop test consists of words presented in a different font color in the center of the screen, and participants are tasked with identifying the color of the font for each word that is presented as quickly and accurately as they can (44). Participants are told that they can ignore the meaning of the word, and just focus on the color. In the “classic Stroop task”, the task consists of a number of word categories including neutral trials (i.e., neutral words presented in different colors), congruent trials (i.e., color words written in colored font consistent with the word, e.g., RED written in red ink), and incongruent trials (i.e., color words written in colored font not consistent with the word, e.g., RED written in green ink). Typically, there are four keys on a keyboard that correspond with the four colors in which the words can be presented. A Stroop effect can be defined as the difference in reaction times to correctly identify colors of incongruent

versus congruent stimuli. People are typically slower at identifying the color of incongruent stimuli.

The “smoking Stroop” is a variant of the classic Stroop and the emotional Stroop task (44). In the emotional Stroop task, there are two categories—emotional and neutral words. In the smoking Stroop task, there are two categories—smoking and neutral words. As with the classic Stroop, the smoking Stroop also assesses accuracy and speed of response to correctly identify the color of the font of each word. The difference in reaction times to correctly identify the colors of smoking versus neutral words is termed the smoking Stroop effect. When participants are slower to identify colors of smoking-related words compared to neutral words, they have a positive smoking Stroop effect. Stated another way, they exhibit attentional bias to smoking cues.

For every Stroop task, the words are irrelevant to the “primary task”, which is identifying the colored font. The words can be described as being “task-irrelevant”. However, despite being irrelevant to the completion of the primary task (color identification), Stroop effects are often observed, because the semantics (meaning) of the words capture attention and lead to slower performance on the primary task. If a positive smoking Stroop effect is observed in smokers, one interpretation is the smoking-related words may automatically capture attention and take away resources from the primary task (color identification) and therefore slow performance (125).

The Stroop has also been modified for use with other drugs such as assessment of attentional bias to alcohol cues in heavy drinkers. In that modified Stroop test, stimuli consist of images (non-alcoholic or alcoholic beverages) or words (neutral or alcohol-related) presented on a colored background or written in color on the computer.

Participants are required to respond to the background color as quickly and accurately as possible while ignoring the picture or word (non-alcohol related or alcohol related).

Heavy drinkers will typically exhibit slower reaction times to identify colors of alcohol related stimuli compared to non-alcohol related stimuli (43).

Visual Probe

The visual probe (VP) task has been used in many studies of addiction and is used in Study 2. In the visual probe task, a picture (or word) pair is presented on the computer screen, with one picture of the pair located on the left and the other picture on the right. Additionally, one picture is salient for the participants (e.g., cigarettes for smokers) and the other is neutral. The picture pair is presented for a brief time period - typically 500 ms – and then the pair disappears and one of the pictures is replaced by a probe (i.e., a dot). The participant is then asked to make a decision regarding the dot, e.g., indicate the position of the dot (right or left) as quickly as they can by pressing a key (e.g., the F key for the left half of the screen and J for the right half of the screen) on the keyboard.

Basic research in attention has indicated that individuals will respond faster to a stimulus (e.g., a small dot) when that stimulus is presented in an attended part of a visual display (139). Therefore, faster responses to probes that replace the salient picture (compared to probes that replace the neutral picture) are interpreted as an “attentional bias” toward the salient picture. Stated another way, it is assumed that the salient stimulus has automatically captured attention, and attention shifts in space to the location of the salient picture, thereby facilitating response to the probe (because the individual is already attending to that region of space).

In many addiction studies that use the VP task, individuals have faster reaction times for probes that replace drug cues (123). The differences in response times are reflective of an attentional bias towards the drug cue. Therefore, in studies where the target population are smokers, the smokers tend to respond more quickly to the probes that replaces stimuli such as pictures of cigarettes. From these findings, researchers have inferred that there is an “attentional bias” to smoking stimuli in some individuals and contexts.

Eye Tracking

Another objective measure of attention to cues is eye movement. One of the first studies to apply eye movement methodology to attention and addiction examined cocaine dependent participants (155). The participants were assessed while looking at an image of a crack cocaine pipe and a neutral image (i.e., a flower) for 90 seconds each. The visual scanning path of the cocaine pipe closely followed the actual image, whereas the visual scanning paths of the flower were less precise. The accuracy of the visual scanning pathways demonstrated positive attentional bias among users and further differentiated light users from heavy users. Through tracking of eye movements, attentional bias to smoking cues has also been reported (124).

Self-Report Measures

Attentional bias to smoking cues can also be assessed using self-report items, such as “How often have you found yourself staring at cigarettes and cigarette smoke?”. Self-report measures do not provide detailed information on attentional processes such as those derived from computerized reaction time or eye tracking tasks. However, there may be a conscious “end product” of the automatic processes underlying attention capture that

can be assessed using self-report. Measures like the Subjective Attentional Bias Questionnaire (SABQ) have been shown to have favorable psychometric properties (108).

Cognitive Bias Modification

Given the role of cues in maintaining addictive behaviors such as smoking, attentional bias to smoking cues may be a target for intervention. Modifying the external environment to reduce exposure to cues (and therefore cue-induced craving) can be challenging. However, attentional bias can be modified or reduced through attentional retraining (AR). AR is an example of a type of intervention referred to as cognitive bias modification (CBM) (see Figure 1 for schematic of AR). AR is the most common form of CBM used for targeting addiction-related biases, but AR has also been used in studies as a treatment for other conditions, such as anxiety (77).

In CBM, cognitive tasks are used to train participants' attention away from salient stimuli. More specifically, the VP task is modified such that performance of the tasks is thought to *change* cognitive processes (rather than simply *assessing* these processes). This is done by consistently replacing the same type of stimuli with the probe so that eventually participants are trained to attend to that type of stimuli. Researchers can therefore train participants to attend toward or away from salient stimuli (117). Therefore, if researchers want participants to attend away from smoking stimuli they would set up the task so that the probe always replace neutral stimuli. Some researchers have suggested that, during training, participants learn an implicit production rule, which states that if smoking and neutral stimuli are both present in the current environment then attention should automatically shift to the neutral stimulus (119). The effect of the

modified VP on attention can be assessed through assessing performance on the standard version of the VP, described earlier.

AR has been applied to treatment of anxiety and drug addiction (64). For example, AR has been shown to reduce attentional bias and craving among heavy alcohol drinkers (65). Initial studies conducted using inpatients with alcohol-related problems provided preliminary evidence that AR could be useful to promoting abstinence (163).

In the largest CBM study ever conducted, involving 1405 inpatients who completed six CBM sessions over the course of two weeks, the researchers reported higher one-year treatment success rates in the active CBM group when compared to control groups (i.e., sham and no-training) (150). Of note, the effect of CBM was “comparable to the most effective of current medications used for alcohol use disorder, acamprosate”. Moreover, this CBM study demonstrated two types of CBM programs - AR and approach-avoidance training - were equally effective.

The literature examining the effect of AR in smokers has been reviewed in a number of papers (152). For the most part, studies examining the effect of AR on attentional bias have been performed in a laboratory setting. In this controlled setting, participants will complete an AR task for a certain amount of trials when they come to the lab, and the effect of AR on attentional bias and craving is assessed. Attwood and colleagues (10) were the first to demonstrate that attentional retraining can alter attentional biases in smokers. They recruited smokers and randomized them into conditions where they were trained to either attend towards smoking-related stimuli or to avoid the smoking-related stimuli (i.e., attend towards neutral stimuli). They found that retraining resulted in significant differences in bias scores, with the “avoid smoking”

group exhibiting significantly lower attentional bias than they did at baseline and the “attend smoking” group exhibiting significantly higher attentional bias scores than they did at baseline. They also reported that AR reduced cue-provoked craving, although only in males.

Research conducted in the field has also shown that AR can reduce attentional bias and craving (101). However, most studies performed in a laboratory study only support short-lasting effects of attentional retraining, showing that a single session of AR may not be sufficient to sustain lasting effects in real world (64). Not only may there be limited generalizability (i.e., from lab to field), but results of CBM studies in smokers have yielded inconsistent results (152). A recent meta-analysis of CBM studies in addiction further highlighted the infancy of this field of research and the need to further study its efficacy of CBM as an intervention (21). In response to these limitations, researchers began to investigate how cognitive bias procedures might be adapted for mobile devices.

Ecological Momentary Assessment

In the past two decades, mobile devices have been widely used for assessment in smoking research (170). This form of assessment is known as Ecological Momentary Assessment (EMA) (60). Unlike laboratory procedures, EMA requires collection of data in the participants’ natural environment (170). This allows researchers to collect datasets with higher external ecological validity. EMA also allows a wealth of data to be gathered for each individual, which permits researchers to conduct detailed investigations of predictors of relapse over the time scale of hours for each individual (171).

EMA datasets are multilevel datasets with subjects at “level 2” (the higher level) and assessments at “level 1” (the lower level) (145). EMA allows researchers to separate between-subject (e.g., do smokers who report generally higher levels of negative affect report generally higher levels of craving?) and within-subject associations (e.g., when an individual reports higher level of negative affect than their person-specific average, do they report higher levels of craving?) in the data. Importantly, between- and within-subject associations are not always the same. For example, one can observe a between-subjects effect but not a within-subjects effect and vice versa. Alternatively, between-subjects effect and within-subjects effect may have opposite signs.

The assumption that between- and within-subject effects are equal has been termed the “ecological fallacy” (68; 153). An example of this principle are voting trends in the United States (74). In this example, states are at level 2 and individuals are at level 1. Across states (level 2), on average wealthier states tend to vote for Democratic presidential candidates while less wealthy states tend to vote for Republican presidential candidates. On the other hand, within states (level 1), the probability of an individual person voting Republican increases as individual income increases whereas the probability of an individual person voting Democratic increases when individual income decreases (74). This is an example of where a positive between-state association is observed but in the presence of a negative within-state association.

Pleasant and unpleasant emotions have been investigated through EMA methodology. Using EMA researchers can examine subjective experiences and potential predictors of smoking. For example, Hedeker et al. (84) examined mood variation among adolescent smokers. This EMA study found adolescents’ self-reported mood varied as a

function of current smoking level, demonstrating a positive relationship. Through EMA, their data demonstrate an ecologically valid support for the development of tolerance. Furthermore, EMA facilitates the study of situational factors that may serve as predictors of smoking in real-time. EMA data can also capture how individuals are differentially affected by factors such as affect and craving. For example, Stennet et al. (186) reported that intermittent smokers who were previously daily smokers were more sensitive than other intermittent smokers to the influence of cravings.

EMA Assessment Schedules

An assessment schedule refers to either event-based assessments or time-based assessments (e.g., “random assessments”). When using EMA methodology, researchers may choose to use one or both types of assessment schedules, depending on the variables of interest (168). When an assessment is event-based, this requires the participant to self-initiate an assessment whenever they experience a pre-defined event (170). Such events could include experiences of temptation, exposure to drug cues, or actual use of a substance. This allows researchers to capture specific data such as location, social context, and other factors, occurring temporally close to an event of interest. In the current dissertation, an event-based assessment was used for temptation episodes in Study 1. This is described in detail later.

In contrast, time-based assessment schedules are typically set and programmed into the mobile device by the researcher. Time-based assessments can vary on frequency and interval but are either on a fixed-interval or random-interval schedule. If assessments are on a fixed-interval schedule, participants are prompted at a pre-determined interval (e.g., every four hours) during waking hours (170). Meanwhile, if the assessment

schedule is random-interval, participants are prompted at random times a number of times throughout the day. This type of schedule allows researchers to examine fluctuations in various psychological variables throughout the day and how they may be associated with behavior and other outcomes (e.g., smoking, drinking, etc.). In the current dissertation, random assessments were used for both studies.

EMA in the Perinatal Population

Mobile assessments and interventions have been used among perinatal women, as various health-related applications have been created with the intent of delivering efficacious tools to perinatal women. Studies have examined an array of topics, including EMA mood monitoring, overall physical activity, and other health-related outcomes. In general, mobile health strategies can equip perinatal women with quick and convenient tools to support a healthy lifestyle.

Specifically, mobile assessment has been used to examine risk factors for perinatal depression. With the wealth of data garnered through EMA methodology, researchers were able to identify various predictors and outcomes related to perinatal-depression (57). Factors that were accounted for in this study were radius of travel, mood, depressive symptoms, time-passed, and mobility. Overall, there were implications for enhancing the well-being of perinatal women, which is promising for other EMA studies examining health-related behaviors in perinatal women.

Recent research has also used EMA to examine post-traumatic stress symptoms as well as substance use among pregnant women (161). Given changes in risk and protective factors for substance use across time, researchers were interested in using mobile assessment to evaluate these factors and their associations in this high-risk population.

Participants ($N=33$) completed mobile assessments for 28 days, including assessments about PTSD symptomatology, drug use, and perinatal specific measures (i.e., prenatal bonding). Through collection of data over the course of nearly a month, data were used to assess compliance rates, as well as associations between PTSD symptoms, prenatal bonding, and substance use reported throughout the EMA portion of the study. The authors reported 74% compliance during EMA, which was considered good compliance by the researchers given SUD severity and social instability.

Sanjuan et al. (2019) were also particularly interested in the role prenatal bonding may play as a proximal protective factor for prenatal substance use. However, their results were mixed. Regarding risk factors, they did observe associations between PTSD symptoms and substance use in the prenatal population, which suggests PTSD symptoms are a risk factor for substance use in this population.

EMA has also been used to examine smoking-related symptomology among pregnant women (7). During this study, women completed EMA assessments post-partum after being randomized into either a placebo or exogenous progesterone group. The goal was to examine the role of exogenous progesterone as a modifier in relationships between various perinatal events (i.e., childbirth, termination of breastfeeding, and smoking relapse) and outcomes, such as mood. They noted a number of between- and within-subjects changes, which suggest childbirth, termination of breastfeeding, smoking relapse, and use of exogenous progesterone do affect mood and smoking-related symptomology. For example, they found that women in the exogenous progesterone treatment group did not experience significant increases in craving immediately after smoking relapse.

Mobile devices have also been used for intervention in perinatal women. A review of four randomized controlled trials demonstrates the heterogeneity of mobile interventions being developed for this population (46). The review reported wide variability in participant characteristics, intervention, and study outcomes measures. For example, though all four studies assessed “change in maternal behaviors by intervention goals”, each study used different outcome measures and interventions. Targets of intervention ranged from promotion of physical activity for pregnant women to nutritional counseling antenatal, though in general the interventions targeted healthier perinatal lifestyles. Additionally, none of these studies found a significant difference between intervention group and control group. Although there is a wealth of mobile applications available to perinatal women, currently it is difficult to assess the efficacy of these applications on maternal behavior and health outcomes.

An additional intervention investigated using a randomized control trial is a mobile health program called Quit4Baby (<https://quit4baby.com/>). This text-based program is based on Social Cognitive Theory, involving messages focusing on self-efficacy for quitting, expectation management, and teaching effective quitting strategies and coping skills. The randomized control trial found the majority of participants viewed this program positively and also interacted with the text messaging system (2).

In sum, EMA is a promising tool for examining predictors of substance use in this population. This in turn will help to develop interventions for perinatal women. As mobile technology becomes more popular, it is important for studies to examine and optimize the interventions that are provided.

Attentional Retraining with EMA

Utilizing EMA mobile technology makes it possible to deliver AR and other types of interventions in a naturalistic setting and at a greater frequency. As indicated by laboratory studies of AR, there seems to be limited generalizability from a single session of AR. However, AR delivered through mobile doses may lead to greater reductions in attentional biases and better outcomes overall.

Outside the addiction literature, mobile attentional retraining interventions and paradigms have been implemented on mobile devices. One of the most notable attention training paradigms is the “n-back memory task” developed for use on mobile devices. These types of tasks are not necessarily aimed at reducing a behavior or cognitive process such as attentional biases towards smoking-related cues. Instead, the well-known n-back memory task is purported to improve fluid intelligence (90).

Similar mobile training programs have been created and used for the treatment of anxiety disorders, spanning social anxiety and phobias. One study examined a game-like AR task administered on mobile devices in the context of decreasing anxiety and stress reactivity (47). This study, similar to other mobile training programs, used a variation of the VP task as described earlier. As expected, over time and with practice, the “concern-related” stimuli (e.g., a spider for spider phobia), garners less attention, as revealed by responses on the VP task. The reduction in attentional bias to concern-related stimuli correlated with a reduction in subjective and observed levels of anxiety (47).

There is also research on cognitive mobile interventions for addiction specifically. Cox and colleagues (43) created a computerized intervention they called the Alcohol Attention Control Training Program (AACTP), which they then modified it to be a game-like mobile version with the same underlying principles. In their field study of habitual,

heavy drinkers, they required participants to play the game for at least 12 minutes per week. However, findings demonstrated better than expected engagement as well as a reduction in reported alcohol consumption.

Field studies have also targeted smoking behavior. In one study (Kerst & Waters, 2014), smokers were randomized into either an AR group or control group, and then asked to complete the interventions and assessments when prompted throughout the day for one week. AR was successful in reducing attentional bias to smoking cues. Attentional bias declined over the course of the week in the AR group. There were also reductions in craving following exposure to compound stimuli containing smoking-related and neutral cues.

Kerst and Waters (2014) demonstrated the feasibility of AR administered on mobile devices for smokers not trying to quit. While there was no effect of AR on smoking in this study, researchers speculated it is possible their non-treatment seeking nature made it difficult to detect an effect of AR. Similarly, Robinson and colleagues (2017) found AR reduced attentional bias in a field study of African American smokers. They also found it reduced reported number of cigarettes smoked on the EMA item, but not as indicated by biological measures or entries in a smoking diary. Regardless, both studies demonstrated the feasibility of administering an AR intervention to smokers, including ethnic minority smokers. Data overall suggest a need to further investigate the clinical utility of AR in this format, as well as in specific populations.

Compliance During EMA

While there are various methodological advantages associated with EMA, there are also challenges involved with using EMA, such as compliance rates. Specifically, low

compliance rates or non-compliance can become an issue with any EMA protocol owing to various factors. These factors include a lesser amount of control compared to a laboratory setting, as well as the myriad complexities of everyday life (i.e., distractions). These issues are of particular interest among participants who may lead more unconventional lifestyles, such as substance users. In turn, low compliance has negative impacts on data analysis due to the negative effect it can have on statistical power and accuracy of inferences.

Although there is no “gold standard” for compliance, there are multiple studies that recommend 80% (92; 188). One study examining the feasibility of using EMA among substance users found that across substance types, a compliance rate of 80% or greater was typical (165). Moreover, tobacco users had higher compliance rates compared to the group rates for alcohol, cannabis, and opioids. However, of note, in this particular study, participants’ compliance was incentivized with payment, which is not always used in EMA studies. Meanwhile, it is evident from a meta-analysis of EMA studies that there is heterogeneity in observed compliance rates, perhaps highlighting the ambiguity of 80% and the need to better define standards for compliance (92). Lastly, although compliance is of concern for EMA methodology, response rates seem to be better for mobile technology formats as opposed to a paper-and-pencil format (14).

EMA Among African Americans

As noted earlier, the majority of participants in this dissertation study self-identified as African Americans. Of note, African Americans, in general, report higher medical mistrust than Caucasians (113). While medical mistrust may be attributed to incidents of medical malice or views of traditional masculinity, there are multiple

consequences to medical mistrust. These consequences include lower care satisfaction, utilization of healthcare services, and treatment adherence (79). In the context of an EMA study, heightened medical mistrust could also potentially contribute to under-reporting of symptoms among African Americans or compliance during EMA protocols.

To date, EMA studies among African Americans have been limited. However, in studies that have been conducted, African Americans reported generally positive experiences, relating to degree of technical challenges, as well as perceived burden and stress (93). In Jones et al. (2016), compliance was 68.9% over the course of this 7-day EMA study. Other studies demonstrated compliance rates of 80% or better among African Americans. For example, a study examining African American young adult smokers reported a median compliance rate of 86%, ranging from 50% to 99% across individuals (121). Another EMA study among African American men reported an overall compliance of 80.7% (211). Finally, as noted above, Robinson et al. (2017) conducted an AR study in an African American population and reported promising results in terms of perception and compliance.

Feasibility vs. Pilot

The current dissertation involves two studies. Study 1 is primarily a “feasibility study”. Few studies have used EMA in the period immediately following delivery of a child. Study 1, therefore sought to confirm whether mobile assessment could feasibly be used among perinatal women to assess smoking-related measures. In other words, the study sought to investigate whether this methodology could be useful in this specific population, perinatal women. Study 2 is a “pilot study”, wherein a small-scale mobile intervention will be examined. While the terms “feasibility” and “pilot” are often used

interchangeably, for this dissertation these two terms will be used in the manner articulated by Eldridge and colleagues (55). In line with their conceptual framework, Study 1 asks whether something (i.e., EMA) can be done. Study 2, the pilot study, expands upon Study 1's proof of feasibility, examining a similar question, yet by design tests the feasibility of a future study, in this case an intervention study, on a smaller scale.

Summary

Exposure to smoking cues and cue-induced craving seem to play a role in the maintenance of smoking behavior. Attentional bias means certain salient cues capture a person's attention more than other stimuli might, and individuals with higher levels of attentional bias may experience more exposure to smoking cues and therefore cue-provoked craving. Recently studies have investigated the utility of modifying these biases. The idea behind cognitive bias modification is the idea it is difficult to change the environment, but it may be possible to change the perception of the environment. Specifically, the conceptual model for Study 2 is as follows: Individuals who undergo attentional retraining may be less likely to attend to smoking cues in the environment which may lead to less cue-provoked craving and relapse when trying to maintain abstinence.

There has also been a growing interest in applying attentional bias measurements and attention retraining to mobile technology. The intent is to create mobile interventions that are convenient, frequent, and efficacious. In this dissertation, Study 1 will examine whether mobile assessment using EMA is feasible among perinatal women. It also seeks to understand how stress, attentional bias, and craving are associated with smoking behavior outcomes in period after delivery. Study 2 will examine a pilot study of

attentional retraining in this population. It will test whether attentional retraining can reduce attentional bias and craving before and after delivery.

CHAPTER 4: STUDY RATIONALE & SPECIFIC AIMS

Rationale

Cigarette smoking remains the leading preventable cause of death in the United States. Furthermore, although there are numerous efficacious smoking cessation treatments - psychological and pharmacological - the majority of people relapse following a quit attempt. Relapse is also a common outcome for perinatal women who have quit for the duration of their pregnancy but struggle to remain abstinent after birth. Novel smoking interventions are needed to address the needs of perinatal women attempting to remain abstinent.

Recently, research has examined how cognitive processes underlie smoking behavior in the hope that cognitive targets for intervention can be identified. Attentional bias and approach bias to smoking cues have been examined. Interventions that implement cognitive bias modification are being developed to target these cognitive processes. The majority of these cognitive bias modification interventions have been tested in a laboratory setting, and so the generalizability and duration of effects of attentional retraining have not been well studied.

EMA has been used administer assessments and interventions from various domains across populations. This includes assessment and interventions for various drug-users, including smokers. EMA may be useful to examine relapse process in perinatal women attempting to remain abstinent. In addition, perinatal women in particular may benefit from a mobile intervention, and may provide an interesting population for further research examining the feasibility and efficacy of these mobile interventions.

As noted below, Study 1 seeks to test the feasibility of using EMA in a postpartum population. Study 2 investigated if attentional retraining (AR), delivered on a smartphone, can reduce attentional bias to smoking-related stimuli, and craving for cigarettes. In Study 2, participants were randomized into an AR intervention condition or control condition for the duration of the EMA portions of the study.

Data from both Study 1 and Study 2 have already been collected, and so these studies are analyses of pre-existing data.

Specific Aims

The Specific Aims are as follows:

Study 1

Study 1 is a feasibility study relating to the use of EMA in post-partum former smokers attempting to remain abstinent.

Specific Aim 1: To examine the feasibility of using EMA for 2 weeks in post-partum former smokers attempting to remain abstinent.

Hypothesis 1: It will be feasible to use EMA in this population as determined by rate of attrition, compliance on EMA procedures, and duration of completed assessments.

Exploratory Aim 1: To examine associations between parental stress, attentional bias, craving, and smoking behavior during EMA.

Study 2

Study 2 is a pilot study of the effect of Attentional Retraining, administered on mobile devices, in perinatal former smokers attempting to remain abstinent.

Specific Aim 1: To examine whether attentional retraining (AR) delivered on a smartphone can modify attentional bias to smoking-related stimuli.

Hypothesis 1: Women randomized to AR, as compared to those in the Control group, will exhibit less attentional bias toward smoking-related stimuli

Specific Aim 2: To examine whether attentional (AR) delivered on a smartphone can modify craving for cigarettes.

Hypothesis 2: Women randomized to AR, as compared to those in the Control group, will report less craving for cigarettes.

Exploratory Aims: We will also examine the effect of AR (vs Control) on smoking during the study period. We will also examine whether study phase (pre-partum vs. post-partum) moderates the effect of AR on study outcomes.

CHAPTER 5: STUDY 1 METHODS & ANALYTIC PLAN

Participants

Participants ($N=10$) were recruited through the “Women’s Center” at Yale-New Haven Hospital (YNHH) at its affiliated Maternal Fetal Medicine High Risk obstetrical clinics. Participants self-identified race/ethnicity was: 7 black, non-Hispanic; 3 white, Hispanic. The inclusion criteria were: 1) Women with a history of smoking 5+ cigarettes per day that have achieved abstinence during pregnancy; 2) Aged 18 to 40 years; 3) Able to speak and write English; 4) Edinburgh Postnatal Depression Scale (EPDS) score <10 . The exclusion criteria were: 1) Current substance abuse (e.g., alcohol, benzodiazepines, marijuana); 2) Current major depressive disorder, minor depression or dysthymia, or history of any of these disorders in the last 6 months; 3) Presence of an Axis I psychotic disorder; 4) Plans to relocate out of the area; 5) Imminent incarceration; 6) Planned inpatient hospitalization during study period. The study was approved by the Institutional Review Boards of Yale University.

Data collection for EMA took place between August 2011 and November 2013.

Procedure

Figure 2 provides an overview of Study 1 procedures. Participants were screened by telephone (participants had previously provided written consent to be contacted for potential participation in research studies). This sensitive data was kept in a file separate from study assessments so as to protect confidentiality. This procedure was completed as part of a larger study that was taking place at the prenatal clinics at YNHH. Women provided written consent for this screening and to be contacted later for participation in

other research studies. During a telephone screen, the PI (Forray) asked about smoking history and subjects completed the Edinburgh Postnatal Depression Scale (EPDS).

If participants met preliminary eligibility (met criteria 1 and 4 above) they were asked to come in for an enrollment interview at the Center for Wellbeing of Women and Mothers, which occurred within four days of delivery. Respondents were given a detailed description of the study by the PI, given time to ask questions, and were invited to take part in the study. Respondents who agreed provided written informed consent. Participants then completed the baseline assessments (Table 1). Women who were not eligible were given the number for the CT “QUIT” line and educational materials to promote abstinence during the perinatal period (Forever Free for Baby and Me TM) which were adapted from the original Forever Free self-help materials (25). In total 42 participants were screened of whom 11 were eligible and 10 enrolled in the study (Figure 3).

Participants were trained in the use of the PDA and told to carry the PDA as they went about their daily lives for 2 weeks. The PDA prompted them at random times 4 times per day (between a subject-specific “wake-up” time and “bed-time” that can vary from day to day), and participants were required to complete assessments any time when beeped, for a maximum of 56 assessments in the two-week period. As is common in many EMA studies involving smokers attempting to quit (e.g., Shiffman and Waters, 2004) participants were also instructed to complete a participant-initiated assessment whenever they experienced a temptation to smoke, defined as “an acute increase in the urge to smoke or an occasion when they felt that they came to the brink of drinking without actually doing so” (temptation assessment; TA). At each assessment (RA or TA),

participants were required to respond to a series of questions assessing subjective states described below. They were also required to complete the smoking Stroop task.

If a participant missed an assessment they were prompted with a “missed alert” prompt so that they were cognizant of any missed assessments. To facilitate the completion of the protocol, participants were also able to prevent the PDA from presenting an assessment for up to 2 hours (“suspend” function); this function has worked well in previous studies (e.g., Waters & Li, 2008). Participants could also delay an RA in 5-minute increments (up to a maximum of a 20-minute delay). This function is important in cases where the participant could not complete the assessment immediately (e.g., if they were driving), but could do so after a few minutes. Participants could also select the wake-up and bed-times each day,

Upon completion of the 14-day EMA study, participants returned the PDA and completed additional assessments in the lab (Table 1). Participants were compensated as follows: \$20 at screening; \$30 at intake; \$2 for each PDA assessment they completed plus \$4 per week for completing all assessments for the week (up to \$120 for completing all 56 assessments); and \$50 at the completion of the study.

Measures

Telephone/Laboratory (Table 1)

The EPDS was used to assess depressive symptoms (Cox, Holden, & Sagovsky, 1987; Cox, Chapman, Murray, & Jones, 1996). It is designed specifically for use with pregnant and postpartum women. The scale is 10 items, has good internal consistency (Cronbach’s $\alpha = 0.87$) and has been used in multiple different languages and different cultures (42; 126).

The Mini-International Neuropsychiatric Inventory 5.0.0 Clinician-Rated (MINI-CR) was used to determine the presence of a mood, psychotic or substance use (abuse and dependence) diagnoses (167). The MINI-CR correlates highly with the SCID (0.43 to 0.90), and the Composite International Diagnostic Interview (CIDI) (0.36 to 0.82) but is shorter and easier to complete. It also has good inter-rater reliability, with kappa values greater than 0.90 across diagnoses.

The Fagerstrom Test for Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, Fagerstrom, 1991). It consists of six items that give a quantitative measure of the severity of nicotine dependence. The FTND is associated with biochemical indices (e.g., CO levels, plasma cotinine) of tobacco smoking (83). A review of studies that evaluated the reliability and validity of the FTND demonstrated it has moderate internal consistency, with Cronbach's alpha coefficients ranging from 0.55-0.74, a correlation of 0.39 with cotinine verified smoking, and good test-retest reliability (0.87) (122; 143). In the Study 1 sample in the current dissertation ($N=10$), Cronbach's alpha was 0.46. In the Study 2 sample, Cronbach's alpha was 0.71 ($N=17$), and 0.72 in the 13 women who identified as "Black Non-Hispanic" or "Black Hispanic".

The Modified Kendler Social Support Interview (MKSSI) is a 21-item scale that measures social support from family and friends (100). Modified from the original Kendler Social Support Index, the MKSSI had a Cronbach's coefficient alpha of 0.86, indicating high reliability. Additionally, the MKSSI was significantly correlated to decreased odds of depression in the first trimester of pregnancy, which demonstrates external validity of this interview (181). Principal components analyses conducted by the PI (Forray) found that there is a single dominant factor.

The Parenting Stress Index (PSI)-Short Form is an established measure of observed parent and child behaviors (1). The PSI is a valid and reliable instrument that can assess a wide range of parenting behaviors in a single instrument, including: participant's attachment to child, social isolation, sense of competence in the parenting role, relationship with spouse/parenting partner, role restrictions, and parental health. The PSI-SF has good test-retest reliability ($r=0.75$) and the correlation between the long and short form is also high ($r=0.87$) (80). Five items from the PSI were used in laboratory visits in the current study, which also showed good internal consistency.

The Minnesota Nicotine Withdrawal Scale (M-NWS) assessed DSM-IV symptoms of tobacco withdrawal such as craving for nicotine, irritability, anxiety, difficulty concentrating, restlessness, headaches, fatigue, increased appetite, weight gain and insomnia (89). The scale asks the participants to rate the presence of symptoms on a scale from "0" (not present) to "4" (severe). The MNWS has good validity and reliability as demonstrated by multiple studies showing it correlates as expected with health status, is predictive of withdrawal symptoms on subsequent cessation, and has internal reliability estimates above 0.70 (5; 94)

The Brief Questionnaire on Smoking Urges (BQSU) is a reliable 10-item scale that is sensitive to nicotine deprivation (Bell, Taylor, Singleton, Henningfield, & Heishman, 1999; Morgan, Davies, & Willner, 1999).

The Timeline Follow-Back (TLFB) assessed reported smoking for the prior week (178). This self-report assesses both the frequency and quantity of substance abuse using a visual calendar. While it used to assess use of various substances, it seems to produce valid estimates frequency and amount of tobacco smoking (37).

Participants' expired breath carbon monoxide (CO) level was determined with a Vitalograph Breath CO device. Breath CO levels are only sensitive to recent smoking because of the short half-life of CO (2 to 3 hours) (159). For smoking abstinence, a CO level of < 8 ppm will be used (a sensitivity analysis using a cut-off of CO $\leq$ 4 ppm was also considered).

Cotinine is a breakdown product of nicotine and can be assessed in blood, plasma, or urine samples (13; 78). The half-life of cotinine is ~16-20 hours, and the presence of cotinine reveals nicotine intake over the past couple of days. In the current study, urine cotinine levels were measured at screening with a semi-quantitative NicAlert ® assay (Krishnan-Sarin et al., 2008) which provides a "0" to "6" ordinal scale ("0" = 0 to 10 ng/mL; "6" = 1000+ ng/ml) with higher numbers corresponding to higher cotinine levels (3 and above can be used as a cut-off to indicate smoking). Semi-quantitative urine cotinine analyses take about 10 minutes and is highly correlated with the quantitative assay which takes longer.

Cotinine levels, along with breath CO levels, are used to confirm reports of abstinence.

The urine toxicology screen used an immunoassay for the qualitative detection of multiple drugs and drug metabolites in urine, testing for cocaine metabolites, cannabinoids (THC), and opiates (including oxycodone, but not methadone).

EMA

Self-Report Measures

During the two weeks that participants had the PDA, at each assessment (RA or TA) participants responded to the following items. Unless otherwise noted, participants

responded on a 7-point scale with the following anchors: (1 = Strongly Disagree, 7 = Strongly Agree) according to how they feel “right now”:

- 1) A single item for craving for cigarettes (“I am craving a cigarette”)
- 2) A single item on level of difficulty concentrating (“I feel spacey or have difficulty concentrating”) (169).
- 3) Seven affect items (happy, calm, bored, sad, tense, irritable, tired). An additional item assessed “overall mood” (“Overall my mood is good”)
- 4) Four items adapted from the Parenting Stress Index (“I feel I can't handle things”; “I feel trapped by parenting”; “I feel overwhelmed by trying to meet my baby's needs”; “Since the last assessment, my baby has been difficult to console”) were administered (1).
- 5) An adapted form of the six-item version of the Social Support Questionnaire (example item: “Do you feel you have someone you can really count on to distract you from your worries when you feel under stress?”) (Sarason, Sarason, Shearin, & Pierce, 1987).
- 6) Self-reported attention capture - three items were used to assess the subjective sense to which the participant feels that their attention has been captured by smoking stimuli (example item: “Since the last assessment, how often have you found yourself staring at cigarettes and cigarette smoke?”)
- 7) Two items assessed recent smoking (“Since the last assessment have you smoked a cigarette? (this includes a single puff)”; Response options: “Yes” or “No”; “If you smoked a cigarette, what time did you smoke it? (indicate which time best applies to

you)”; Response options: “I have not smoked”, “5-10 minutes ago”, “30 minutes ago”, “1 hour ago”; “2 or more hours ago”).

8) Two items assessed sleep: “Since the last assessment, how many hours of sleep did you get? (Response Options: “I have not slept”; “Less than 1 hour”; “1-2 hours”; “3-5 hours”; “6+ hours”); “Since the last assessment, how many times were you interrupted while you were sleeping?” (Response Options: “I have not slept”; “1 time”; “2 times”; “3 times”; “4+ times”).

9) Three items assessed general context (example item: “Where are you currently? (“Indicate which one applies to you”; Response Options: “At home or a friend's house”; “At work”; “Travelling”; “At a bar”; “At a restaurant”).

10) Two items assessed smoking context (“Right now, is anyone smoking around you? If so, who?”: Response Options: “No”; “Yes, spouse/significant other”; “Yes, family member/friend(s)”; “Yes, coworker(s)/others”; “If you smoked a cigarette, was anyone else smoking around you at the time? If so, who?” Response Options: “I have not smoked”; “No”; “Yes, spouse/significant other”; “Yes, family member/friend(s)”; “Yes, coworker(s)/others”).

11) Two items assessed the amount of alcohol/coffee drunk in the past two hours. (example item: “How many alcoholic drinks have you consumed in the last two hours?”, Response Options: “I have not smoked”; “No alcohol”; “1-2 alcoholic drinks”; “3-5 alcoholic drinks”; “6 or more alcoholic drinks”).

12) A single item assessed interruptions during the reaction time task: “When you were doing this task, on how many occasions were you interrupted, for example by the

telephone ringing or by somebody trying to talk to you?" Response options: "No times"; "1 time"; "2 times"; "3 times"; "4+ times").

As described later, the main focus in the current studies is on responses to the “parental stress”, “craving”, and “smoking” items.

For parental stress, Cronbach’s alpha computed for all assessments (ignoring hierarchical nature of data) was .77. Using the R program `multilevel.reliability`, multilevel reliability was computed for parental stress using generalizability theory. The between-subject reliability (Generalizability of between-subject differences averaged over time) was determined to be 0.92, and the within-subject reliability (Generalizability of within-subject variations averaged over items) was determined to be 0.73. Stated simply, these data indicate that the parental stress measure can reliably assess between-subject differences as well as within-subject variation. However, some caution should be applied to these estimates, given the small sample sizes and limited variation in one or more items.

Smoking Stroop Task

As discussed earlier, the smoking Stroop task was used to measure attentional bias towards smoking-related stimuli. At each assessment participants completed the smoking Stroop task as described in Waters & Li (2008) (Figure 4). For each task, the participants were told they would see words written in either blue, green, or red on the PDA screen. As each word was presented on the screen, the task for the participant was to identify the color in which the word was written and to respond as quickly and accurately as possible. The color identification task was carried out by pressing one of three response buttons on the PDA using a stylus. Participants were informed that they

could ignore the meaning of the word itself; the task involved just responding to the color. Prior to the real task, participants completed a practice block, consisting of a string of letters rather than words (e.g., MMMMM). The practice block was then followed by two test blocks of 33 trials each with one block consisting of neutral words and one block consisting of smoking words. All words were presented in capital letters. The word would remain on the screen until the participant responded or until 3 seconds elapsed.

The stimuli of the task were made up of 24 sequences or “lists” of words. Half the lists contained 11 smoking words and 11 neutral words from the category of “household objects” of similar length and frequency to the smoking words (201). Neutral words were: Sink, Iron, Sofa, Couch, Carpet, Lounge, Curtain, Hallway, Bookcase, Tidy, Furniture. Smoking words were: Nicotine, Pack, Cigarette, Smoke, Inhale, Drag, Urge, Ashtray, Tobacco, Puff, Craving.

The other lists contained classic Stroop words (e.g., “GREEN” written in red font) and a set of neutral words (e.g., “ROUND” written in red font). The focus in the dissertation is on performance on the smoking Stroop task. Nonetheless, descriptive statistics from the classic Stroop task will be presented to show the expected presence of classic Stroop effects.

At each assessment (RA or TA) a list was selected at random (from the 24 lists). For the smoking Stroop lists, on six lists the neutral words preceded the smoking words, while on the other six lists the smoking words preceded the neutral words. For the classic Stroop lists, on six lists the neutral words preceded the classic Stroop words, while on the other six lists the classic Stroop words preceded the neutral words. This was done in order to counterbalance order of presentation of word type (e.g., neutral vs smoking).

Within each list, words were presented in a random order under the constraint that the same word or color was not repeated on the following trial.

If responses were incorrect, reaction times (RTs) were discarded, as were RTs < 100 ms. To reduce influence of RT outliers, the median RT for smoking words and for neutral words were computed for each block. The smoking Stroop effect was calculated as the median RT on smoking words minus median RT on neutral words. Greater attentional bias was indicated by higher (more positive) smoking Stroop scores, i.e., slower responses on the color identification task for smoking words than neutral words. The classic Stroop effect was computed as the median RT on classic Stroop words minus median RT on related neutral words.

To estimate reliability for the classic Stroop task presented in this context, two classic Stroop scores were computed at each assessment, one from “odd” trials, and the other from “even” trials. A split-half correlation coefficient computed using the Spearman-Brown formula ($2r/(1+r)$) for all assessments (ignoring hierarchical nature of data) was .77. Using multilevel.reliability, the between-subject reliability (Generalizability of between-subject differences averaged over time) was determined to be 0.89, and the within-subject reliability (Generalizability of within-subject variations averaged over items) was determined to be 0.72.

To estimate reliability for the smoking Stroop task, two smoking Stroop scores were computed at each assessment, one from “odd” trials, and the other from “even” trials. A split-half correlation coefficient computed using the Spearman-Brown formula for all assessments (ignoring hierarchical nature of data) was .64. Estimates from generalizability theory are not presented due to problems in estimation. A Pearson’s r

computed on subject means on odd and even trials (i.e., two separate means, one for odd trials and one for even trials) was .82.

General Analytic Strategy

Linear mixed models (LMM) were used for analyses of EMA data (22). SAS PROC MIXED was used for analysis of continuous outcomes (assuming a normal distribution in the underlying population, conditional on model covariates). For binary outcomes, SAS PROC GLIMMIX was used. LMMs take into account clustering of data by participants, and participants can have different numbers of assessments. A random (subject-specific) intercept and an autoregressive model of order 1 for the residuals within subjects was used. An autoregressive model of order 1 that assumes unequal intervals (164) was also tried, but models often failed to converge or other problems with estimation were apparent, perhaps due to the relatively small sample size. Therefore, the primary analyses report results using the autoregressive model of order 1, AR (1).

Effect sizes were indexed by unstandardized parameter estimates. In addition, for select findings, the standardized effect size measure Pearson's r (computed using the methods of (98) was presented. Note, however, that the effect size yielded by this method depends on the denominator degrees of freedom selected (in this case, the Satterthwaite degrees of freedom).

Day in study was included as a covariate in all models examining level 1 predictors; for analysis of intensive longitudinal data, Bolger and Laurenceau (22) recommended including a measure of time in study as a level 1 covariate. All analyses used the Satterthwaite option for the denominator degrees of freedom. Other covariates (level 1 and level 2) were considered for inclusion if they are associated with

“missingness” of data (e.g., (20) or are associated with study outcomes (Study 1 and 2) and/or Group (Study 2). In Study 2, baseline (pre-intervention) measures of the dependent variables were included, as appropriate. For all analyses alpha was set to .05 (2-tailed).

In addition, for each study separately, a false discovery rate (FDR) procedure was implemented to help identify findings (“discoveries”) that are likely to be more robust. Following procedures described in Howell (86) for the Benjamini and Hochberg Linear Step Up (LSU) procedure, uncorrected p values for primary tests reported were identified (for each study separately), sorted by magnitude, and compared against a p critical value derived from the term $.05*(i/k)$, where k = number of comparisons in a set, and i is the rank of the p value from smallest (closest to zero) to largest. These results were confirmed using GraphPad Prism Version 8.1.1 for Windows (GraphPad Software, San Diego, California USA, www.graphpad.com). According to the principles of FDR correction, 95% of the discoveries identified are “true positives” with the remaining 5% “false positives” (when using $Q = .05$).

Specific analyses pertaining to Study 1 are described below. In addition, Appendix 1 provides example code in SAS for one analysis in each study.

Data Analytic Plan (Study 1)

First, descriptive statistics such as mean, median, standard deviation, and range will be presented as appropriate for level 1 variables, such as parental stress, attentional bias, craving, and smoking. Statistics are provided regarding the number of subjects who reported lapsing during the study. As previously noted, where applicable (e.g., for multi-

item measures) we will compute two separate reliability indices for between-subjects differences and within-subjects using the R package `multilevel.reliability`.

Hypothesis 1: It will be feasible to use EMA in this population as determined by rate of attrition, compliance on EMA procedures, and duration of completed assessments.

Rate of attrition will be computed as the proportion of individuals who signed the informed consent, but failed to complete the EMA study. Compliance will be computed as the proportion of RAs that subjects had the opportunity to complete that were actually completed. Duration of completed assessments will be computed as the mean time to complete assessments.

Descriptive statistics such as mean, median, standard deviation, and range will be presented as appropriate, as well as confidence intervals. For EMA self-report items, descriptive statistics will focus on the primary items of interest.

Feasibility will be evaluated from the overall pattern of data. Note that, in a meta-analysis, compliance in EMA tobacco studies aggregated over all populations studied was reported to be 77.79% (95% CIs, 73.76–82.64) (92). One article suggested that a compliance rate of 80% was reasonable (188).

Exploratory Aim 1: To examine associations between parental stress, attentional bias, craving, and smoking behavior during EMA.

LMMs will examine associations between parental stress, attentional bias, craving, and smoking during EMA. Given that all these variables are level 1 variables (assessed at each assessment), analyses will separate out between- and within-subject associations. As described by Gunter (2019), an association between two level 1 variables (1→1 model) can reflect a between-subject effect and/or a within-subject effect (145).

For example, Attentional Bias and Craving may be associated because individuals who exhibit generally high levels of Attentional Bias report generally higher Craving ratings (a between-subject association) and/or because individuals tend to report higher Craving ratings when they report more Attentional Bias than usual (a within-subject association) (145).

Therefore, the primary independent variables in LMMs will be a *Mean* score (level 2 variable) and a *Deviation* score (level 1 variable), entered together in analyses. A *Deviation* score is the difference between an observed score and a participant's *Mean* score. A significant coefficient for a *Mean* score would indicate a between-subject association (i.e., individuals who had higher mean scores on the independent variable (IV) had generally higher scores on the dependent variable (DV)). A significant coefficient for the *Deviation* score would indicate a within-subject association (i.e., when individuals had higher scores than their subject-specific average on the IV they had higher scores on the DV) (84).

As noted above, an FDR procedure will be implemented to help identify significant findings that are more likely to be robust.

Power Analysis

As described in Gunter (2019), Field (61) has written that power analyses for mixed models are not easy to compute. Field (61) described methods reported in Twisk (192), which involve the use of “traditional” methods (i.e., methods used for single-level data), and adjusting the sample size to take into account clustering of data by subjects. This approach was taken in the current dissertation. Power analyses were calculated using G*Power 3.1 (58). All power analyses assumed 2-tailed tests (alpha= .05).

Power analyses for EMA data depend on the number of level 1 (assessments) and level 2 (subjects) units, subject attrition/compliance, as well as the *ICC* (intraclass correlation coefficient). Study 1 examines associations between a) a level 2 variable (e.g., *Mean* Attentional Bias) and a level 1 variable (e.g., Craving) ($2 \rightarrow 1$), and b) a level 1 variable (e.g., *Deviation* Attentional Bias) and a level 1 variable (e.g., Craving) ($1 \rightarrow 1$). For $2 \rightarrow 1$ associations, assuming 10 participants completed ~442 assessments (70% of presented RAs and 50 TAs), and an *ICC* of 0.1 (or 0.3), the study had power = .80 to detect a correlation in population, *rho*, of .30 (.47). If the *ICC* were greater (closer to 1) power would be lower. For $1 \rightarrow 1$ associations, assuming 10 participants completed ~442 assessments, the study had power = .78 to detect a mean correlation (between *Deviation* scores and the dependent variable) in the population of .3, assuming the *SD* of the correlation in the population = .3.

CHAPTER 6: STUDY 1 RESULTS

Descriptive Statistics (Lab)

Participants were on average 26.25 years old ($SD = 4.48$) and 60% identified as African American (Table 2). Participants reported that they had smoked an average of 8.2 cigarettes per day prior to attaining abstinence. Seven participants (70%) reported “Not working”, and available income data indicated low income. Summary statistics for other baseline measures are reported in Table 2, and summary statistics for other laboratory measures can be found in Table 3.

Descriptive Statistics (EMA)

During EMA, the 10 participants completed 390 assessments (297 RAs, 93 TAs). For assessments that occurred on the same day as the previous assessment ($n=268$ assessments), the average interval since the previous assessment was 2.72 hours ($SD=1.90$). For assessments that occurred on a different day as the previous assessment ($n=112$ assessments), the average interval since the previous assessment was 19.73 hours ($SD=11.76$). Across all assessments, 26.67% were completed between 4.00 AM and Noon, 57.44% were completed between Noon and 7.00 PM, and 15.90% were completed between 7.00 PM and 4.00 AM.

Nine participants completed at least 1 TA. Participants completed on average 29.70 RAs and 10.33 TAs. As expected, craving was higher at TAs ($M=2.70$, $SD=2.05$) than RAs ($M=1.54$, $SD=1.16$), and a LMM indicated that there was a significant within-subject association between Assessment Type and Craving, $F(1, 7.28) = 15.98$, $p = .004$.

Summary statistics for EMA measures are reported in Table 4. When computing means for each participant, across the 10 participants the average level of craving was

2.19 ($SD=1.50$), the average level of parenting stress was 1.27 ($SD=0.30$), and the average Smoking Stroop effect was 21.21 ms ($SD=96.51$ ms).

Seven participants (70%) reported smoking at least one cigarette during the study period. These participants reported smoking since the last assessment at 15 assessments (Table 4). Three participants reported no smoking during EMA, which was verified by biochemical measures at the final lab visit (i.e., CO levels < 8 ppm, cotinine levels < 3). (CO levels were also all < 4 ppm).

Specific Aim 1: Feasibility

Hypothesis 1 predicted it will be feasible to use EMA in this population as determined by rate of attrition, compliance on EMA procedures, and duration of completed assessments.

Of the 10 participants who completed at least 1 EMA assessment, 9 (90%) completed the EMA study. The participant who stopped completing EMA assessments did so due to relapse. However, she did attend the final lab visit and completed lab assessments.

Compliance can be defined as the proportion of RAs that were presented to the participants that were completed. The ten participants completed a median of 68.9% of RAs presented. The mean compliance across all 10 participants was 63.53% ($SD=23.82$; 95% $CI=46.49, 80.57$), a compliance rate that overlaps with 80% (Figure 5). As noted above, one participant withdrew and the compliance for the remaining nine participants was 70.10% ($SD=12.33$, 95% $CI=60.62, 79.58$). Compliance on RAs was not significantly associated with age ($p=.47$), number of children ($p=.47$), prior smoking rate ($p=.87$), FTND ($p=.78$), or EPDS score at baseline ($p=.32$).

The mean duration of assessments was 4.69 minutes ($SD = 1.50$).

Exploratory Analyses

Results of exploratory analyses are shown in Table 5. As can be seen, Table 5 reports that when Craving was the dependent variable and *Mean* Parental Stress was an independent variable, there was a significant positive association between *Mean* Parental Stress and Craving, corresponding to $r = .73$ when using the formula used by Kashdan & Steger (2006) (and the Satterthwaite degrees of freedom). As *Mean* Parental Stress increased by 1 unit, the predicted value of Craving increased by 2.68 units. Additionally, Table 5 reports that the association between *Deviation* Parental Stress and Craving was also significant, corresponding to $r = .85$ when using the formula used by Kashdan & Steger (2006). As *Deviation* Parental Stress increased by 1 unit, predicted values of Craving increase by 1.26 units (Figure 6).

Exploratory analyses also examined the relationship between Smoking Stroop scores (i.e., attentional bias) and Craving (Table 5). On assessments where "no craving" (i.e., craving = 1) was reported ($n=146$ assessments), the average Smoking Stroop effect was -11.90 ms ($SD=140.75$), and on assessments where reported craving levels were two or more ($n=49$ assessments) the average Smoking Stroop was 14.55 ms ($SD=114.17$) (not shown in Table 5). When Craving was a dependent variable and *Mean* Smoking Stroop was an independent variable, there was a significant positive association between *Mean* Smoking Stroop and Craving, corresponding to $r = .53$ when using the formula used by Kashdan & Steger (2006). As *Mean* Smoking Stroop increased by 10 ms, the predicted value of Craving increased by 0.11 units. The association between *Deviation* Smoking Stroop and Craving was not significant.

When Smoking (Smoking since the last assessment) was the dependent variable, there was no evidence for significant association between *Mean* Craving and Smoking, or between lagged *Deviation* Craving and Smoking (Table 5).

When the six *p* values reported in Table 5 were analyzed using the Benjamini & Hochberg LSU test, one *p* value (.005) was designated as a discovery.

Supplementary Analyses

Supplementary analyses were conducted to clarify the nature of the relationship (if any) between Craving and Smoking. On those assessments on which participants reported smoking since the last assessment ($n=15$ assessments), average Craving was 2.87 ($SD=2.03$). On assessments on which there was no reported smoking since the last assessment ($n=375$ assessments), average Craving was 1.77 ($SD=1.47$). A LMM demonstrated that when Craving was the dependent variable and *Mean* Smoking was an independent variable, there was a significant positive association between *Mean* Smoking and Craving, $F(1, 8.14) = 5.66, p = .04$. As *Mean* Smoking increased by 0.1 units, the predicted value of Craving increased by 0.92 units. Additionally, the association between *Deviation* Smoking and Craving was significant, $F(1, 328) = 6.08, p = .02$. As *Deviation* Smoking increased by 1 unit, the predicted value of Craving increased by 0.90 units.

An additional supplementary analysis also demonstrated that lagged *Deviation* Smoking was not associated with Smoking at the subsequent assessment ($p = .57$).

CHAPTER 7: STUDY 1 DISCUSSION

The main results of the study were as follows. First, in regards to feasibility, all participants who signed the informed consent form completed at least one EMA assessment, and the majority (90%) completed EMA. Compliance on RAs exceeded 60%, and the upper confidence interval was higher than 80%. Additionally, the mean duration of assessments was under 5 minutes. For the exploratory analyses, multiple significant associations were reported, including those between parental stress and craving. Last, 7 out of 10 subjects reported relapse, when defined as the report of one of more occasions of smoking. These results are discussed in further detail below.

Feasibility

When interpreting data on compliance, it is important to consider the compliance level in past EMA studies examining substance users. It seems the majority of EMA studies aim for a compliance rate of 80% or higher (Jones et al., 2019). Therefore, one might argue that a mean compliance of 64% falls below expectations. However, 80% was contained within the confidence intervals of the estimate. In addition, EMA studies examining substance users have historically demonstrated relatively poor compliance (165). A meta-analysis of EMA studies with samples of substance users demonstrate a large degree of heterogeneity and variability in compliance rates, with many falling outside what is considered an “acceptable” compliance rate (92)

In addition, other factors, such as perinatal status, may affect compliance rates, as suggested by an EMA study examining substance use and post-traumatic stress symptoms in pregnant women (160). In Sanjuan et al., 74% compliance on RAs was described as being “high”.

Therefore, given the population used in the current study, it seems fair to classify the compliance of the current study - 64% - as a positive indication of feasibility in this population. In addition, it is encouraging that all participants who signed the informed consent form provided EMA data, and the majority (90%) completed the EMA study. Taken together, data on attrition, compliance, and duration of assessments support the feasibility of EMA in a perinatal population.

Association between Parental Stress and Craving

In the current study, there were significant associations between parental stress and craving at both levels of EMA data, when using uncorrected p values. At the between-subjects level, participants who reported generally higher levels of parental stress reported generally more craving. At the within-subjects level, when participants reported generally higher levels of parental stress than their subject-specific average, they reported more craving than their subject-specific average. Note, however, these findings were not designated as discoveries using the FDR correction, and so these results should be treated with caution pending replication.

These results are consistent with literature demonstrating a relationship between parental stress and craving. Specifically, reports of increased negative affect have been shown to predict higher levels of craving as well as relapse (99). While research regarding negative affect may not seamlessly apply to parental stress, survey studies do indicate that parenting a newborn introduces a new stressor to parents' lives and is often a reason cited for relapse (41). Also, as suggested by a thematic review, it is also possible that for some, parental stress (i.e., mothering role) impacts upon smoking relapse, while

for others it is a preventative role, meaning that the role of parental stress could differ across individuals (132).

Although this study focused on parental stress, it is possible that other stressors are the major driver for craving (and possible relapse). While stress and stress dysregulation has been repeatedly implicated in addiction literature, it remains unclear whether parenting stress or more general stress is more important in the postpartum period. Some researchers posit that the parenting role may be particularly problematic for those with addictions to substances, such as cigarettes (151). Other research indicates specific stressors, such as financial concerns, relationship issues, and medical issues, contribute to the mothers' personal level of stress and temptation to return to smoking (203). Therefore, future research would benefit from further differentiating between parenting stress and other stressors (e.g., related to housing, low income, etc.). However, it is also important to recognize different types of stress may often be intertwined especially in lower-income, underserved communities.

Association between Attentional Bias and Craving

In common with Waters et al. (2014), there was evidence for a between-subject association between attentional bias and craving. That is, individuals who generally exhibited higher attentional bias generally reported more craving. There was no evidence for a within-subject association between attentional bias and craving. That is, when an individual exhibited higher attentional bias than their subject-specific average they did not experience higher craving (relative to their mean). Therefore, smokers who generally exhibit elevated attentional bias when abstinent may benefit from interventions that reduce attentional bias.

However, a particularly elevated attentional bias may not acutely precipitate craving. This statement is made with caution given that a within-subject association is expected from theory. Waters et al. (2014) noted that measurement error in assessment of attentional bias may complicate interpretation of associations between attentional bias and variables such as craving. Additionally, the use of a single-item to assess craving of unknown reliability may be a limitation.

It was interesting that there was not a significant overall Smoking Stroop effect. Participants were not slower to respond to colors of smoking vs neutral words. This is slightly unexpected, given smokers tend to exhibit attentional bias towards stimuli - in this case words - that are cues for smoking (125). Note that, in regards to the overall classic Stroop effect, results indicated the expected pattern of data in that participants were much slower to respond to colors of words that did not match the word (e.g. the word “blue” in red font). However, the sample in the current study consisted of former smokers attempting to remain abstinent postpartum, so it is possible there is a less robust effect of the smoking Stroop effect in this population. It is possible that individuals who have been abstinent for an extended period of time, may have lower attentional bias towards smoking cues (Munafò et al., 2003). However, other research has demonstrated no significant difference in attentional bias between smokers and former smokers (148). In general, research comparing attentional bias of smokers and former smoker has resulted in variable results and has also used different attentional bias measures as well as differing operational definitions of “former” or “ex” smokers, though some research supports the idea of an enduring incentive sensitization (Rehme et al., 2018).

Other factors may contribute to relatively low attentional bias scores. For example, practice effects may affect the attentional bias scores since participants completed multiple assessments (i.e., smoking Stroop tasks) per day. They also completed the classic Stroop task repeatedly as the classic Stroop task was presented at every other assessment. It is possible that repeated completion of the classic Stroop could change the performance on the smoking Stroop. This could occur due to participants developing strategies to help minimize the distracting effect of incongruent words (e.g., focusing on individual letters rather than the entire word) (23).

Association between Craving and Smoking

Exploratory analyses also examined the association between craving and smoking. In prospective analyses, craving did not prospectively predict smoking before the next assessment, nor did smoking predict craving at the next assessment. However, in a contemporaneous analysis, there was a significant between- and within-subject association between smoking and craving. The latter indicated that when subjects smoked more than their subject-specific average (i.e., reported smoking), reported craving was higher at that assessment. While it is possible that craving was already elevated before the participant smoked, it is possible that smoking prior to an assessment provoked higher craving. Although EMA facilitates analyses of data at a granular level, it can be difficult to discriminate which event occurred first at the timescales analyzed here. This is especially true because participants were not completing assessments every time they relapsed (i.e., there were no “lapse” assessments of the type used by Shiffman et al., 1996), so it is difficult to tell if craving became elevated before or after smoking. Lastly,

it is also possible that when participants reported smoking at an assessment, the cognitive processes associated with making this report elevates level of craving.

Additional Observations

As noted earlier, 7 out of 10 participants reported smoking at least one cigarette during the study period, indicating relapse was experienced by 70% of participants.

Although this rate may seem high, one should note that the small sample size means that the 95% confidence intervals (for the true relapse rate in the population) are wide (Lower Confidence Interval=39.7%, Upper Confidence Interval=89.2%). Moreover, as noted in the introduction, the literature demonstrates a high postpartum relapse rate of women who quit smoking during pregnancy. Past literature indicates that approximately 70-80% of women relapse within one year postpartum, with rates of relapse increasing as time passes postpartum (149).

It is difficult to estimate the expected relapse rate at around 2 to 2.5 weeks postpartum, as few studies have included follow-ups with women so quickly after giving birth. However, an RCT addressing postpartum smoking relapse among low-income women did demonstrate comparable relapse rates within 6 months postpartum (6). More specifically, the relapse rates among intervention participants and control participants were 63.4% and 87.7%, respectively. Research also demonstrates that relapse rates gradually increase as time progresses, as demonstrated by relapse rates of 62%, 67%, and 76% recorded at 12 weeks, 24 weeks, and 52 weeks postpartum (109). Similarly, in an RCT, Reitzel and colleagues found at relapse rates at 2 months were 72.2% (Usual Care group) and 58.1% (Treatment group), which increased to 83.5% and 77.2% respectively.

While all of the studies described above verified abstinence/relapse via biochemical measurement, studies varied on how relapse was defined. For example, one study defined relapse as “the self-report of 7 consecutive days of smoking, a carbon monoxide level exceeding 8 ppm or a cotinine level exceeding 15 µg/L” (109). Meanwhile, another study defined relapse as either self-reported smoking of at least one cigarette in the last week or a CO breath sample ≥ 6 ppm (6). The third study defined relapse as expired CO levels ≥ 10 ppm without specification of including self-reports in the absence of CO levels ≥ 10 ppm (149). Therefore, when examining expected rates of relapse, it is important to be sensitive to the fact that studies define relapse in different ways.

Additionally, biochemical measures indicated that many participants in the current study had not smoked recently, which suggests the relapsers were not smoking at a high frequency. More specifically, out of 390 total assessments, 15 assessments included reports of smoking since the last assessment, while the remaining 375 indicated no smoking. Furthermore, no relapser had an elevated CO levels (> 8 ppm) at the final lab visit, and only three relapsers had cotinine levels > 3 at the final lab visit. Therefore, the statistic of 70% participants relapsing should be tempered by the fact that both self-report and biochemical measures indicated that those who relapsed were for the most part smoking at low rates. This is in line with literature that demonstrates while women may continue to smoke during pregnancy and postpartum, some may engage in “harm-reduction” strategies (e.g., reduced smoking frequency compared to pre-pregnancy; only smoking when not around the baby) (129).

These points notwithstanding, one should also bear in mind that some research has reported that any level of “relapse” = even 1 cigarette - is predictive of resuming the former pattern of smoking subsequently (73). A similar pattern was found in perinatal women, such that on average women returned to more than half their preconception smoking by 9 months postpartum (i.e., > half of ~11 cigs/day on average), even when they reduced smoking significantly during pregnancy (172). The extent to which these findings generalize to perinatal former smokers is, however, not known.

While no specific hypotheses were made in regard to any of the laboratory measures, it is worth noting that parental stress levels were relatively low on both the lab and EMA measures (Mean of 1.2 on a 1-7 scale for EMA; Mean of ~7 on a 5-25 scale for Lab). This is counterintuitive given that the sample encapsulated lower income, underserved women. However, in the context of related literature, other factors may contribute more to parenting stress than ethnicity and/or income. For example, past research has indicated that ethnicity has no effect on parenting stress trajectories. Such research also indicates that certain communities may consider early childbearing normative (31). Given the mean age (M=26.25), most participants were well past “young motherhood”, it is possible that in a community where early childbearing is more normative, having a child at a later age was perceived as less stressful. Other research also indicates that factors such as self-efficacy and family circumstances are more powerful predictors of parenting stress than income alone or even social support (147).

Limitations

This study had a number of limitations. First, in common with many feasibility studies, the sample size was small, which reduces the precision of estimates of feasibility as well as power of analyses.

Second, in common with other EMA studies, missing data have the potential to cause biased parameter estimates in mixed models (if “missingness” is not predictable from study covariates). The potential for bias increases as the proportion of missing data increases. This is important to bear in mind given the compliance rate reported in this study.

Third, the study had limitations related to assessments. More specifically, no information was collected as to whether or not subjects had plans to breastfeed postpartum, and there was no information on whether or not subjects actually breastfed. This information is relevant given breastfeeding is thought to aid in preventing or delaying postpartum relapse to smoking in the broader context of promoting child health (50). Research also suggests breast-feeding, among other factors, influence mood and negative affect. A second assessment-related limitation was the absence of information on partner status (e.g., marital status, whether the partner was a smoker, etc.). This information would be useful to know for future studies especially in regards to how it may affect stress levels in general, as well as craving. For example, having a partner who smokes may influence levels of reported craving, even if the subject isn’t around the partner when they are smoking (39). Additionally, partner/spousal stress may contribute to increased levels of reported stress postpartum. A third assessment-related limitation of Study 1 was the use of an abbreviated Parenting Stress Index (i.e., only 5 questions were used in lab and during EMA). While the PSI and PSI-SF are well-validated measures, the

use of 5 questions may limit the reliability and validity of the parental stress assessment. Furthermore, with the data gathered, as mentioned above it is not possible to differentiate between the influence of parental stress and non-parental stress.

One could also argue that the use of a single-item for Craving was a limitation. Single-item scales have limitations in the area of assessing reliability and validity, since internal reliability cannot be directly assessed and it will likely have lower validity than measures consisting of multiple-item scales. However, multiple researchers have argued that single-item craving measures specifically have adequate reliability and predictive validity may be adequate (15; 16; 51). Furthermore, if researchers were to use multiple-item scales, it is possible multiple items would induce reactivity (Sayette et al., 2000). Additionally, a measure of craving that takes an extended period of time to complete may not truly and validly capture the psychological state of craving as it is one that fluctuates over time (162)

A fourth limitation was the use of temptation assessments, as this can be criticized (Lammers, 2018). For example, different participants may initiate TAs based on different thresholds. However, assessment type (comparing RAs to TAs was not a focus of the current study).

Last, the use of PDAs, rather than a smartphone, could be considered a limitation of the study. For example, participants may be more willing to become fully engaged in a study that uses more contemporary technology.

Strengths

The main strength of this study is that it one of a few EMA studies to study relapse process in postpartum women. Again, perinatal women present as a unique

opportunity for smoking cessation intervention and it is thus important to develop effective interventions tailored to this population. Another strength was the recruitment of an underserved minority population who are at risk of relapse and lifelong smoking. In addition, good retention of low-income African American women in an inner city setting was also a notable strength of this study.

Future Research

Future research can build off the results of this study. For example, the focus of this study was feasibility, but also included exploratory analyses of a limited number of variables. In particular, a number of measures were not included in analyses. For example, measures of sleep as well as social support could potentially provide insight on the experience of perinatal women attempting to maintain abstinence. Social support, especially, would facilitate further examination of factors contributing to relapse, for example, as a moderator variable. Potential future research direction are discussed in greater depth in the final chapter.

In addition, and most relevant for this dissertation, this study supports the feasibility of use of EMA in a perinatal population, and suggests that this methodology can be used in an intervention study. This is the focus of Study 2.

CHAPTER 8: STUDY 2 METHODS & ANALYTIC PLAN

Participants

Participants ($N=17$) in this intervention pilot study were recruited through the “Women’s Center” at Yale-New Haven Hospital (YNHH) at its affiliated Maternal Fetal Medicine High Risk obstetrical clinics. Participants self-identified their race/ethnicity as: 9 black, non-Hispanic; 4 black, Hispanic; 2 white, Hispanic; 1 white, non-Hispanic, 1

other (West Indian). The inclusion criteria were: 1) Women with a history of smoking 5+ cigarettes per day that have achieved abstinence during pregnancy by 32 weeks' gestation; 2) Aged 18 to 40 years; 3) Able to speak and write English; 4) Edinburgh Postnatal Depression Scale (EPDS) score <10. The exclusion criteria included: 1) Current substance abuse (e.g., alcohol, benzodiazepines, marijuana); 2) Current major depressive disorder, minor depression or dysthymia, or history of any of these disorders in the last 6 months; 3) Presence of an Axis I psychotic disorder; 4) Planned to relocate out of the area; 5) Imminent incarceration; 6) Planned inpatient hospitalization during study period.

Data collection for EMA took place between May 2014 and February 2015.

Procedure

Figure 7 provides an overview of Study 2 procedures. Research staff approached pregnant women in the reproductive health clinics at Yale New Haven Hospital. The pregnant women awaiting a routine visit were invited to complete a screening survey to determine provisional eligibility after providing screening consent. Provisionally eligible women were then invited to take part in the study. Forty-one women were screened, 20 women were eligible, and of this number, 17 were enrolled in the study (Figure 8). Women who were not eligible were given the number for the CT "QUIT" line and educational material (Forever Free for Baby and Me™) which as noted earlier was adapted from booklets prompting relapse prevention (24). At the time of recruitment women completed assessments as indicated in Table 6.

After screening, eligible women <32 weeks' gestation at the time of the screening were followed in order to determine if they were still eligible for randomization. The period of time they were followed for was variable depending on when in pregnancy they

were screened, e.g. a woman screened at 22 weeks was followed for about 2 months until they reached 32 wks gestation. Women who were eligible for randomization completed an intake interview that included a review of study procedures and consent, computer administered intake assessments (Table 2, Visit 1), collection of urine for toxicology and cotinine analysis, and breath sample for carbon monoxide analysis. All enrolled women were also provided with educational materials (Forever Free for Baby and Me TM) to help them maintain abstinence from smoking.

Once enrolled, each woman was assigned to one of the two study conditions through randomization. Randomization was conducted by researchers at USUHS. Conditions were given code names (colors) to disguise allocation. An enrollment table was created that specified the coded intervention for each participant in order of enrollment (e.g., participant 1 = “red” group, participant 2 = “green” group). The order of conditions was randomized with the constraint that equal numbers were assigned to each group. A list of conditions was generated (e.g., “red”, “red”, “red”, “green”, “green”, “green”, etc.) and a random number generation program (random.org) was used to put the conditions in random order (e.g. “red”, “red”, “green”, “green”, “red”, “green”). The list of conditions in random order was matched with the list of participant ID numbers in order of enrollment (P1=“ red”, P2=“red”, P3=“green”, P4=“green”, P5=“red”, P6=“green”,). The researchers at Yale did not know which color corresponded to which condition (AR vs. control).

Both participant and investigators at Yale were blinded as to study condition, i.e., the study was a double-blind study.

After enrollment and randomization, women were instructed to carry a smartphone as they went about their daily lives for the next 2 weeks. Specifically, an LG Fathom phone was provided to each participant for conducting EMA procedures in this study. Participants were locked out of all functions other than the program. Participants were told they could email or call the project staff if they experienced any difficulties with the smartphone. The participants were told they were to complete four random assessments (RAs) per day. Note that, in contrast to Study 1, participants were *not* required to enter temptation assessments (TAs). Random assessments were comprised of questions assessing subjective states and a VP Training Task or Assessment (described later).

To encourage compliance there were three different functions the women could use if there was an issue of the timing of the AR task: “delay”, “suspend”, and “make-up” options. A woman could use the “delay” feature if she needed to delay the task by 5 minutes (up to four times in total). The “suspend” option could be used when a participant needed to prevent the phone from presenting assessments for a specific time period. Women could also “make-up” a training/assessment if they missed one or experienced technical difficulties (i.e., program failing to present RAs).

Women then returned to the research clinic after two weeks (Visit 2) at which they handed back the smartphone to the research staff.

Four days following delivery, women completed Visit 3 assessments (Table 6). They were given a smartphone and then instructed to repeat the same procedures as in Phase 1, i.e., complete 4 random assessments per day every day for 2 weeks. At the end

of 2 weeks they returned to the research clinic and completed Visit 4 assessments (Table 6).

AR & Control Training Conditions

Women randomized to AR were scheduled to complete 3 AR tasks (as well as 1 VP assessment) per day. On the AR tasks, the VP task was modified so the dot always replaces the neutral picture (see Figure 9). Based on pilot data, the mean duration of AR (and control) task was expected to be 5-7 minutes. For the AR intervention 15 picture sets consisting of 20 picture pairs (one smoking-related and one neutral) each were used. One picture set was administered on each study day (days 0-14 in pregnancy and days 0-14 postpartum). To facilitate compliance, as noted above a “make-up” option allowed women to complete assessments (in lieu of an RA) if they miss an AR or had technical difficulties (e.g., the program crashed and prevented random assessment from being presented). The program was operational independent of internet connectivity, as it ran directly on the smartphone. Data were stored on the phone but also transmitted wirelessly and backed-up on a server.

The Control condition was identical to the AR task in terms of the number of tasks per day and number of trials per task (160 trials per task). The only detail that differed between the Control and AR task was that in the Control condition the dot was equally likely to replace the smoking stimuli and the neutral stimuli. This was intended to ensure there is no correlation between the picture type and dot location, and therefore no training of attention is expected. This type of control condition has been used in previous AR studies and ensures that the duration of AR and Control training should not differ, that AR and Control participants receive equal practice on the motor aspects of the VP

tasks; and that the same smoking and neutral stimuli are presented to AR and Control participants (63). Apart from the number of trials, the control task (160 trials) was the same as the standard VP task (80 trials).

Self-Help Materials

As noted above, participants received self-help materials to assist their attempt to remain abstinent. The 10-booklet version of Forever Free® was adapted for pregnant and postpartum women, and is based on previous research and interviews with women. It also includes a booklet for the woman's partner. The booklet topics are: An Overview; Partner Support; Smoking Urges; Smoking and Health; A Time of Change; What if You Have a Cigarette?; Smoking, Stress, and Mood; Lifestyle Balance; Smoking and Weight; Life Without Cigarettes (see <https://moffitt.org/research-science/research-teams/tobacco-research-and-intervention-program-trip/trip-research/forever-free-self-help/>)

Measures

Telephone/Laboratory (Table 6)

The measures used were the same as those used in the Study 1 (please refer to Measures section for Study 1). The only exception was that the standard VP task was administered at lab visits on the smartphone (described below).

EMA

The EMA battery of Study 2 consisted of the same self-report assessments used in Study 1 (please refer to description of EMA items in Study 1) with one exception. For the craving, the item assessed craving in response to a “compound” smoking picture (cued craving item). A picture with both smoking and nonsmoking (neutral) features was presented on the PDA in landscape mode for 1 second. Participants subsequently reported

their craving for cigarettes on the smartphone on a 1–7 scale (1 = strongly disagree, 7 = strongly agree). The rationale for including this additional craving item was as follows. If AR causes attention to be drawn to neutral components of the picture (as is expected), then “exposure” to the smoking content should be reduced (because the participant is attending to neutral content) and therefore there should be reduced cue-provoked craving.

However, in contrast to Study 1, in Study 2 participants did not complete a smoking Stroop task. Rather, at each assessment (RA or make-up), participants completed a VP task, either a training task (AR or Control) (75% of RAs/make-ups), or a “standard” VP task (assessment of attentional bias) (25% of RAs/make-ups).

As noted earlier, in a standard VP task a pair of pictures (e.g. one smoking-related and one neutral) is briefly presented (for 500 ms) simultaneously side by side on a computer screen. When the pictures disappear, a probe stimulus (e.g., a small dot) is presented in the location that had been occupied by one of the pictures (either on the left or the right), and participants are required to press a key as quickly as possible in response to the probe. In the current study they were required to identify the location of the probe (left side or right side). Attentional bias for smoking-related cues is revealed by a faster response to a probe that replaces a smoking-related stimulus (vs. a neutral stimulus), since attention will have been allocated to that area of visual display (i.e., the location where the smoking picture had been). Note that the standard VP task assesses attentional bias, and should not change in any way.

The standard VP task was scored using typical procedures. Reaction times for incorrect responses were discarded, and RTs < 100 ms were also discarded. To reduce the influence of RT outliers, the median RT for probes that replace neutral and smoking

pictures was computed. For each standard VP task, attentional bias was computed as the median RT on probes that replace neutral pictures minus median RT on probes that replace smoking pictures. Greater attentional bias is indicated by faster response times on probes that replace smoking stimuli than probes that replace neutral stimuli. One extreme bias score was excluded (>5 SDs from overall mean). Average error rates on assessments were low ($M=4.45\%$ errors, $SD=10.54$), but there were some assessments with high error rates, perhaps suggesting inattention. Bias scores on assessments with $>40\%$ errors were discarded (4% of assessments) for primary analyses as this performance was not better than chance performance.

To summarize, during the modified VP task (AR condition), the dot always replaces the neutral picture. During the Control training, as noted earlier, the dot is equally likely to replace the neutral or smoking picture. On 3 of the 4 RAs scheduled each day, participants were scheduled to complete a training task (AR or Control), each of 160 trials. On 1 of the 4 RA scheduled each day, participants were scheduled to complete the standard VP task (for assessment of attentional bias), each of 80 trials. During the standard VP task, as noted earlier the dot is equally likely to replace the neutral or smoking picture. The standard VP task was scored using typical procedures.

Stimuli

The pictures for the AR/Control tasks and the standard VP task were selected from pictures stored on Flickr and pictures created by a former member of the Laboratory of Cognitive Interventions (Robinson). The procedures by which the pictures involving African Americans were generated are described elsewhere (Robinson et al., 2017). Briefly, because there was a lack of pictures of African American smokers on

Flicker, many of the photographs were created by Robinson. In total, 1,141 pictures were selected from Flickr or produced by Robinson. Pictures were selected from this pool by evaluating valence, noticeability of smoking stimulus (if present), and suitability of the pictures for an AR study involving similar procedures. Two independent raters (graduate students and research staff) who were knowledgeable of the study design rated each picture using a scale of 1 to 7. Items were: “How negative/positive is this picture to you?” (1= “extremely negative”; 4 = “neither positive nor negative”; 7 = “extremely positive”); “How noticeable is the smoking content in this picture” (1=“Not noticeable at all”, 7=“Highly noticeable”); “Overall, based on your knowledge of the study, how suitable is this picture for the study” (1=“The picture does not work for the study”, 7=“The picture should work very well for the study”). Responses on global suitability item were dichotomized into “7” vs. “not 7” (1-6). There was fair agreement between raters (Agreement: 66.4% - 73.7%; Kappas = .28 - .38). Pictures were selected if they had a “7” (maximum score) on the noticeability and suitability questions (both raters), and a non-extreme score (“4”) on the valence question.

Similar procedures were used to generate pictures for other racial/ethnic groups. The final pool of pictures included Caucasians, African Americans, and other races/ethnicities. Smoking objects generated for African American stimuli emphasized brands that African Americans smoke (Newport, Kools), whereas those for Caucasians emphasized other brands (e.g., Marlboro). Note that the pictures were not tailored to perinatal women in any way. That is, they were not generated from images that are representative of environments of perinatal (former) smokers.

From this final pool of pictures, “smoking object”, “neutral object”, “smoking

human”, and “neutral human” pictures were selected for use in Study 2. That is, each smoking picture was either a picture of a smoking object (such as a cigarette or pack of cigarettes) or a picture of a human (male or female) who was smoking. Correspondingly, each neutral picture was either a picture of a neutral object (such as a stapler) or a picture of a human (male or female) who was *not* smoking. Therefore, the pictures tended to be “simple”, which seemed appropriate given their small size on the smartphone screen.

From the resulting picture pairs, a number of picture lists were generated, each containing 20 pictures: 5 “smoking object”; 5 “neutral object”; 5 “smoking human”; 5 “neutral human”. The “smoking object” and “neutral object” pictures were randomly paired together. Likewise, the “smoking human” and “neutral human” pictures were randomly paired together. The ten picture pairs were organized so that half the time the smoking picture (object or human) would appear on the left side of the screen, and half the time it would appear on the right. The picture pairs were used to create 160 trials for AR/Control trainings and 80 trials for the standard VP assessments.

Data Analytic Plan (Study 2)

First, descriptive statistics for level 1 variables will be presented, broken down by Group (AR vs. Control).

Analyses of individual hypotheses follow.

Hypothesis 1: A LMM was utilized to compare attentional bias to smoking cues in the AR (vs. Control) group. For analysis of EMA data, Group (AR vs. Control), Phase (Pre- vs. Post-Partum), Day (within Phase) and the Group x Day interaction will be included in models. The primary analyses tested the main effect of Group and the Group x Day interaction.

Hypothesis 2: We utilized a LMM to compare craving in the AR (vs. Control) group. For analysis of EMA data, Group (AR vs. Control), Phase (Pre- vs. Post-Partum), Day (within Phase) and the Group x Day interaction will be included in models. The primary analyses will test the main effect of Group and the Group x Day interaction.

Exploratory Aims: Separate analyses from each phase will be presented as appropriate.

Analyses will explore if there is any evidence for Group differences in smoking.

Power

Study 2 examines the effect of a manipulated level 2 variable (Group) on level 1 variables (e.g., Attentional Bias, Craving). This is therefore a $2 \rightarrow 1$ design. Assuming the same approach to the a priori power analysis that was used in Study 1, and assuming 17 participants were randomized to treatment conditions and completed ~1008 trainings/assessments (which assumes 16 participants provide EMA data for an average of 3 weeks, with an average of 3 trainings/assessments per day), and an *ICC* of 0.1 (or

0.3), the study had power = .80 to detect a main effect of Group in the population, d , of 0.48 (0.80) for craving (which was recorded at every assessment). Power for attentional bias would be lower, as it was only assessed at every fourth EMA assessment. If the *ICC* were greater (closer to 1) power would be lower. The power to detect interactions (e.g., Group x Day) is more complex to estimate, and is not presented here.

CHAPTER 9: STUDY 2 RESULTS

Lab Descriptive Statistics

Seventeen subjects signed the informed consent form and enrolled in the study. All seventeen subjects attended the final laboratory visit and reported completing at least some training (AR vs Control). Fourteen subjects contributed EMA data. One subject returned the phone with the memory card removed (resulting in loss of EMA data). EMA data from two other subjects could not be retrieved due to technical problems.

The mean age of participants was 27.88 years, and a high percentage of participants self-identified as Black (76.5%). There were no significant Group (AR vs Control) differences on age or race (Table 7). There were also no significant Group differences on the PSI, EPDS, MNWS, QSU-Brief, or CO (Table 7).

Summary statistics on lab measures by Group and Time are presented in Table 8 (see also supplementary analyses section and Table 9).

EMA Contributors vs. Non-Contributors

As noted above, of the 17 participants who enrolled in the study 14 participants (82.4%) contributed EMA data to the study, and 3 participants (17.6%) did not contribute EMA data. Two Non-Contributors were in the AR group (22.2% of AR group), while 1 Non-Contributor was in the Control group (12.5% of Control group). The EMA Contributors self-identified as 78.5% Black, 7.1% Puerto Rican, and 14.3% White, Hispanic, and the Non-Contributors self-identified as 66.7% Black and 33.3% White, Non-Hispanic. For EMA Contributors and Non-Contributors respectively, the mean age was 27.86 ($SD=5.33$) and 28.00 ($SD=3.00$). The mean level of education was 11.57 years ($SD=1.65$) and 12.33 years ($SD=0.58$) respectively. EMA Contributors smoked an

average of 11.36 per day ($SD=11.78$) with a mean FTND score of 3.57 ($SD=2.85$), whereas Non-Contributors smoked an average of 9.33 cigarettes per day ($SD=6.03$) with a mean FTND score of 0.67 ($SD=1.15$). EMA Contributors reported a mean number of 4.21 pregnancies ($SD= 2.58$), and Non-Contributors reported a mean number of 3.00 pregnancies ($SD= 0.00$).

EMA Descriptive Statistics

Across the fourteen participants who provided EMA data, participants provided at least one data point from 575 trainings/assessments in total, with 290 from participants in the AR group and 285 from participants in the Control group. In the Control group, 164 of the trainings/assessments were RAs and 121 were subject-initiated. In the AR group, 93 of the trainings/assessments were RAs and 197 were subject-initiated. In total, there were 257 RAs and 318 subject-initiated trainings/assessments.

The average interval between trainings/assessments for those that occurred on the same day as the previous assessment ($n=388$ assessments) was 2.59 hours ($SD=2.76$). In the AR group ($n=198$ assessments), the mean interval was 2.30 hours ($SD=3.05$) and in the control group ($n=190$ assessments), the mean interval was 2.90 hours ($SD=2.40$).

Regarding time of day, 22.6% of trainings/assessments were completed between 4.00 AM and Noon (“AM”), 45.7% completed between Noon and 7.00 PM (“PM”), and 31.7% were completed between 7.00 PM and 4.00 AM (“night”). Similar proportions occurred across groups. More specifically, in the AR group 22.8% were completed in the AM, 43.4% were completed in the PM, and 33.8% were completed at night. In the Control group 22.5% were completed in the AM, 48.1% were completed in the PM, and 29.5% were completed at night.

On days on which participants completed at least one training or assessment, participants completed (either by an RA or subject-initiated assessment) a median of 73.86% of the expected number of trainings/assessments. Completion rate was not significantly associated with age ($p=.40$), number of children ($p=.70$), prior smoking rate ($p=.77$), FTND ($p=.38$), or EPDS score at baseline ($p=.62$).

Number of Trainings

Across both prepartum and postpartum EMA phases, participants in the AR condition ($n=7$) completed a mean of 28.29 ($SD=13.47$) AR trainings, and Control participants ($n=7$) completed a mean of 23.71 ($SD=12.63$) Control trainings. The two groups did not differ in the number of trainings completed, $t(12) = 0.65, p=.52$. Across phases, participants in the AR condition ($n=7$) completed a mean of 8.14 ($SD=4.26$) VP assessments, and Control participants ($n=7$) completed a mean of 8.00 ($SD=4.58$) VP assessments. The two groups did not differ in the number of VP assessments completed, $t(12) = 0.06, p=.95$.

For the AR group the mean duration of completed AR trainings was 8.98 minutes ($SD = 3.94$). For the Control group the mean duration of completed Control trainings was 8.74 minutes ($SD= 2.23$). For the AR group the mean duration of completed assessments that included the VP assessment was 5.49 minutes ($SD = 2.84$). For the Control group the mean duration of completed assessments (with the VP assessment) was 6.60 minutes ($SD= 2.77$). Note that trainings were longer than the assessments because they contain more trials.

Regarding Phase (prepartum vs postpartum), thirteen participants (6 AR, 7 Control) contributed data (396 trainings/assessments; 170 from AR participants and 226

from Control participants) from the prepartum phase, 11 (7 AR, 4 Control) contributed data from the postpartum phase (179 trainings/assessments; 120 from AR participants and 59 from Control participants), and 10 participants (6 AR, 4 Control) contributed data from both phases.

Summary statistics on dependent variables by Group and Phase are presented in Table 10.

Specific Aim 1: Effect of AR on Attentional Bias

Hypothesis 1 predicted that women randomized to AR, as compared to those in the Control group, will exhibit less attentional bias to smoking-related stimuli.

As shown in Table 11, AR significantly reduced attentional bias. Attentional bias was about 49 ms lower in the AR group (vs Controls), corresponding to an effect size $r = .66$ when using the formula used by Kashdan & Steger (2006). Therefore, Hypothesis 1 was supported.

Phase was not significant in the model ($p = .69$), meaning there was no evidence that attentional bias changed across phases.

To examine whether attentional bias declined more over time in the AR group (vs Control) within Phases, a Group x Day interaction term was tested. Day within Phase, and the Group x Day interaction term, were included in a model that also included Group and Phase. When coefficients for Day were treated as fixed, the Group x Day interaction was significant ($PE = -13.68$, $SE = 5.36$, $t = -2.60$, $p = .01$), indicating that attentional bias declined more over time in the AR group than Controls. When coefficients for Day were treated as random (i.e., allowed to vary over participants), the Group x Day interaction was not significant ($PE = -22.63$, $SE = 13.00$, $t = -1.74$, $p = .11$). Figure 10

presents summary data for attentional bias as function of Group (AR vs Controls) and days within phase (days 1-7, 8-14).

Specific Aim 2: Effect of AR on Craving

Hypothesis 2 predicted that women randomized to AR, as compared to those in the Control group, will report less craving for cigarettes.

There was a non-significant main effect of AR on the EMA measure of craving (Table 11). Therefore, Hypothesis 2 was not supported. Visual inspection of Table 10 indicates that, across all assessments, craving ratings were actually (non-significantly) higher in the AR group (vs. Control).

Phase was not significant in the model ($p=.26$), meaning there was no evidence that craving changed across phases.

To examine whether Craving declined more over time in the AR group (vs Control) within Phases by testing a Group x Day interaction term. Day within Phase, and the Group x Day interaction term, were included in a model that also included Group and Phase. When coefficients for Day were treated as fixed ($PE = 0.05$, $SE = 0.05$, $t = 1.00$, $p = .32$), or random ($PE = 0.11$, $SE = 0.11$, $t = 1.03$, $p = .34$), the Group x Day interaction was not significant.

When the four p values corresponding to the main effect of Group on Bias, the effect of the Group x Day interaction on Bias, the main effect of Group on Craving, and effect of the Group x Day interaction on Craving, were tested using the Benjamini & Hochberg LSU procedure, none were designated as a discovery.

Exploratory Aims

Effects of AR on Smoking

This aim examined whether or not there was a main effect of AR on smoking behavior. There was no evidence for a significant main effect of AR on smoking. (See Table 11). Phase was not significant in the model ($p=.65$), meaning there was no evidence that levels of smoking changed across phases.

Regarding assessment of relapse, defined as any self-reported smoking during the study period, 3 participants (21.4% of 14 participants) reported no smoking during the study period, which was confirmed with biochemical assessments. Eleven participants (78.6%) reported relapse. Two abstinent participants were in the AR group (28.6% of AR group) and 1 abstinent participant was in the Control group (14.3% of Control group).

Effect of AR at Prepartum and Postpartum phases

A second exploratory aim for this study was to examine whether study phase (prepartum vs. post-partum) moderated the effect of AR on study outcomes. In order to examine whether there were differences in the effect of Group in the two phases, analyses were conducted for each phase separately.

The prepartum phase was examined first. When craving was entered as the DV, there was a non-significant main effect of Group, $F(1, 8.57) = 0.19, p=.67$. When smoking was entered as the DV, there was also a non-significant effect of Group, $F(1, 8.69) = 0.14, p=.72$. Lastly, when attentional bias was entered as a DV, there was also a non-significant effect of Group, $F(1, 7.93) = 3.32, p=.11$. The results for the postpartum phase were as follows. When craving was entered as the DV, there was a non-significant main effect of Group, $F(1, 8.28) = 0.42, p=.54$. When smoking was entered as the DV, there was also a non-significant effect of Group, $F(1, 8.68) = 0.14, p=.72$. Lastly, when attentional bias was entered as a DV, there was also a non-significant effect of Group, F

(1, 7.13) = 0.01, $p = .93$. In sum, analyses indicate there was no evidence that the effect of Group was different in the two phases. A formal moderation analysis was not conducted due to the complexity of multilevel moderation analyses involving a level 1 variable (Phase) that differed across subjects (e.g., some subjects only had data from a single Phase), and the small sample size.

Supplementary Analyses

Analysis of Lab Data

As shown in Table 9, using ANOVA or ANCOVA, there were no significant effects of Group on post-treatment measures, including measures of craving (QSU-brief) and smoking (expired CO in breath).

Analysis of Abstinent Subset

Examination of descriptive statistics revealed that 5 women (3 AR, 2 Controls) had cotinine levels above the threshold pre-treatment (at enrollment), indicating the presence of recent smoking prior to data collection. Therefore, additional analyses were performed on the 12 participants (11 who provided EMA data) with no evidence of recent smoking so as to more clearly examine data relevant to relapse prevention.

When craving was entered as the DV, the effect of Group was not significant, $F(1, 8.53) = 1.57, p = .24$. When smoking was entered as the DV, the effect of Group was not significant, $F(1, 7.58) = 0.09, p = .78$. When attentional bias was entered as a DV, there was also a non-significant main effect of Group, $F(1, 54.6) = 0.43, p = .51$.

Analysis Controlling for Baseline Measures

Additional analyses were conducted controlling for baseline measures of dependent variables. This was not possible for attentional bias, as no assessment of

attentional bias was taken at baseline. For Craving, in a model containing baseline BQSU, Phase, and Group, the main effect of Group was not significant ($PE = 0.02$, $SE = 0.50$, $t = 0.05$, $p = .96$). For Smoking, in a model containing baseline FTND, Phase, and Group, the main effect of Group was not significant ($PE = 0.34$, $SE = 0.61$, $t = 0.55$, $p = .60$).

Additional Analysis of Attentional Bias Data

The analysis of attentional used all available data from which an attentional bias score can be computed. For the AR group, an attentional bias score can only be computed from the VP assessment. For the Control group, an attentional bias score be computed from the VP assessment and from Control trainings (which have the same structure as trainings but have more trials). For the Control group, attentional bias assessed in the Control trainings and the VP assessment were of similar magnitude ($M=-2.34$ ms, $SD=122.48$ and $M=0.79$ ms, $SD=65.23$ respectively, $F(1, 214) = 0.03$, $p = .87$). However, if the effect of AR on attentional bias was restricted to VP assessments, then the effect of Group was no longer significant, $PE=-43.17$, $SE=36.81$, $F(1, 2.8) = 1.38$, $p = .26$. Note, however, that the parameter estimate, an unstandardized measure of effect size, is of comparable magnitude to the parameter estimate presented in Table 11.

As indicated in Table 10, there was no evidence that the Control group exhibited significant attentional bias. For example, when computing a mean attentional bias score for each Control subject ($n=7$) and then computing a mean of these subject means, the mean attentional bias was 1.47 ms ($SD=10.03$), which was not significantly different from 0 using a 1-sample t-test, $t(6) = 0.39$, $p = .71$. The mean of the subject means in the AR group ($n=7$) was -41.32 ms ($SD = 61.02$), $t(6) = -1.79$, $p = .12$.

Analysis of Effect of Time on Craving

The author examined whether Craving ratings declined over time, given findings from other studies indicating that craving and other self-report outcomes decline over time in both AR and Control groups (56). To be consistent with a previous study (Robinson et al., 2017), analyses were conducted on the first two weeks of data collection (in this case, prepartum data). The effect of Day was significant for Craving, $F(1, 8.06) = 5.92, p = .04$, indicating that Craving declined over time. This model included Group and Day (Day was a level 1 numeric variable and coefficients for Day were treated as random). Additionally, when the Group by Day interaction was added to the model it was not significant, $F(1, 7.62) = 0.21, p = .66$. This means that the declines in Craving over time were not significantly different between the AR and Control groups.

Sensitivity Analysis

One outlier was noted with respect to Craving (e.g., *Mean Craving* = 6.25). This was the participant who stopped completing EMA assessments but returned to complete lab visits at the end of study, when this participant was excluded from analysis, the association between *Mean Parental Stress* and Craving was no longer significant ($p = .30$). The association between *Deviation Parental Stress* and Craving remained significant ($p = .03$). When this participant was excluded from analysis involving the association between Attentional Bias and Craving, the association between *Mean Attentional Bias* and Craving was no longer significant ($p = .37$). The association between *Deviation Attentional Bias* and Craving remained non-significant ($p = .29$).

CHAPTER 10: STUDY 2 DISCUSSION

The main results of the study were as follows. First, in regards to Specific Aim 1, there was some evidence that AR reduced attentional bias in perinatal women. Second, for Specific Aim 2, women in the AR group did not report significant less craving than women in the Control group, meaning that Hypothesis 2 was not supported. Results from exploratory aims demonstrated that women in the AR group did not report a significantly lower rate of smoking than women in the Control group. Additional separate analyses by phase demonstrated that there was no evidence the effect of AR on study outcomes was different in the two phases. The results are discussed in further detail below.

Effect of AR on Attentional Bias (Aim 1)

Compared to Control training, there was evidence that AR reduced attentional bias, as assessed by the visual probe task. Attentional bias was reduced about 50 ms in the AR compared to the Control group. This finding is consistent with other data suggesting that AR administered by the modified VP task can reduce attentional bias as assessed by VP task (e.g., Robinson et al., 2017). This suggests that AR can modify attentional bias in perinatal smokers when administered on a smartphone.

Although a significant effect of AR was observed, the following caveats should be noted. First, as noted earlier, the effect of Group was significant when all participants who provided EMA data ($n=14$) were included in analyses (“intent-to-treat” analysis). However, the effect of Group was not significant in analyses restricted to individuals who were abstinent at baseline and who provided EMA data ($n=11$). Therefore, more research is required to examine if the effect of AR in abstinent perinatal smokers is robust. Second, when restricting analyses to data from the VP assessment, the effect of Group

was no longer significant (although the parameter estimate was of comparable magnitude). Last, the main effect of Group was not designated as a discovery when using the FDR correction.

It was interesting that participants in the Control group did not exhibit significant attentional bias. This is in contrast to data from participants who received Control training in previous studies (Kerst & Waters, 2014; Robinson et al., 2017). However, one should bear in mind that the sample size in the Control group in the current study ($n=7$) is much smaller than sample sizes in other studies.

Effect of AR on Craving (Aim 2)

Compared to Control training, there was no evidence that AR reduced craving. This finding was true for craving assessed in the lab and field. This finding was contrary to hypothesis and differed from previous findings (Kerst & Waters, 2014). However, a null effect of AR on craving has also been reported in past research (Robinson et al., 2017). More specifically, Robinson et al. did not find a significant effect of AR on cued craving. She speculated this may be due to the pictures not eliciting craving, thus compromising the ability of AR to reduce cued craving. Additionally, there is no way to verify via EMA whether participants actually looked at the pictures during the craving assessment. It is possible that in a natural, real-world environment, participants can become distracted and miss seeing the pictures, as the cues were presented for only one second.

Results demonstrated that reported craving during EMA trended downward during the prepartum phase (i.e., a significant effect of Day was observed). Since there was no significant difference between the effect of Day in the two groups (AR and

Control), this suggests a similar decline in craving in the two groups. Other researchers have reported that both AR and Control training can yield positive outcomes. For example, Pettit and colleagues demonstrated similar findings in an RCT of AR in treating pediatric anxiety in that beneficial changes were observed in both the AR and Control group (140). Pettit et al. speculated that both AR and attentional control training can reduce anxiety and that they share a similar mechanism.

More specifically, Pettit et al. suggested that both groups, through repeated practice focusing, sustaining, and shifting attention, were able to improve on their regulatory abilities. This in turn may have helped youth in this study to modulate their emotional experiences. This suggests a different type of mechanism related to training flexible deployment of attention rather than a mechanism of change involving automatic attention allocation. These findings emphasize the need for further research regarding whether multiple cognitive mechanisms are affected during attentional retraining. However, one should also note that, given the absence of a no-treatment control group, these results should be treated with caution. That is, in the current study, declines in craving may have been observed even in the absence of AR or Control training.

Effect of AR on Smoking (Exploratory Aim)

There was no significant effect of AR on smoking assessed on the smartphone, or on a biological measure of smoking assessed at the lab. It must be noted that a low percentage of reported smoking (9.3% of assessments) was reported. However, the AR group appeared to report (non-significantly) more smoking than the Control group.

One factor to consider is the level of motivation of the participants in Study 2 to remain abstinent. Wiers and colleagues have argued that the effects of CBM on drinking

outcomes are more robust in clinical populations, who are generally strongly motivated to maintain abstinence, than in student samples or samples recruited online (Wiers, Boffo, & Field, 2018). Although the sample recruited in Study 2 were recruited in a clinical context, and had made an attempt to abstain from smoking during pregnancy, there is still uncertainty regarding the level of motivation to remain abstinent. For example, there was evidence that five of the participants had recently smoked prior to randomization, and, of course, the relapse rate was high. Given the perspective of Wiers and colleagues, it is possible that AR may only be effective in a selected sample of perinatal former smokers who are highly motivated to quit.

Study Phase and Effect of AR (Exploratory Aim)

An exploratory aim investigated whether study phase moderated the effect of AR on study outcome measures. Given there was no effect of AR for smoking, craving, or attentional bias in any phase, there was no evidence that phase moderated the effect of AR on study outcomes.

Limitations

This study had a number of limitations. First, the sample size was small, which reduced power of analyses. The sample size was further reduced by loss of data due to technical difficulties. Technical limitations contributed to loss of EMA data from two participants who signed the informed consent.

Second, due to participants' extensive use of make-up assessments (rather than RAs) data from the study is likely less "random" than data from a study solely using random assessments. Use of make-up assessments reduces the generalizability of study findings and can potentially lead to bias in parameter estimates.

Third, there were limitations regarding the assessment of attentional bias. There was no baseline assessment of attentional bias, meaning that it was not possible to determine whether the two groups differed at baseline. The study did not assess whether the effect of AR on attention generalized to different stimuli type (e.g., words) or to performance on a different attention bias task. For AR to be effective in the real world, any effect of AR on attention has to be observed not only on the VP assessment task but also on other assessments of attention. A central challenge of research on cognitive interventions is to show that the effects of training on cognition generalize beyond the training task to other tasks, including real world tasks. Another assessment-related limitation was the lack of objective measures of attention to smoking cues, such as assessment of eye movements.

Fourth, in common with Study 1 there were other limitations related to assessments. The use of a single item for craving of unknown reliability could be considered a limitation. Participants' plans to breastfeed were not assessed, nor was actual breastfeeding assessed (see also Study 1). Participants' intention to remain quit or their motivation to quit was not assessed. Many mothers quit during the pregnancy for the health of the baby, but are not motivated specifically for their own health. Therefore, their level of motivation to remain quit after giving birth may greatly diminish, depending on where this motivation originated.

Last, the main focus of the study was to examine whether AR can reduce attentional bias and craving in abstinent perinatal former smokers who had achieved abstinence. There was evidence that a minority of participants ($n=5$) had smoked prior to randomization. This reduced the sample size of abstinent individuals. Moreover, results

should be interpreted in light of the fact that both abstinent and non-abstinent individuals were included in the intent-to-treat sample.

Strengths

The study also had strengths. First, and most importantly, this was the first study to develop and administer an AR intervention for perinatal former smokers, a group at high risk of relapse. Second, and similar to Study 1, another strength was the recruitment of an underserved minority population who are at risk of relapse and lifelong smoking.

Future Directions

Future research can build off the results of this study. It is possible that the effect of AR on outcomes is diluted by the presence of assessments administered in the field. Assessments were similar to Control trainings, and so future studies might manipulate the proportion of assessments to AR trainings in order to examine whether changes in proportion influence the effect of AR.

In this study, AR was used to train participants away from smoking cues. However, as noted in the introduction, AR can be easily modified and has been modified for various health conditions and behaviors, such as healthier eating (i.e., train away from unhealthy food) and anxiety (i.e., train away from a perceived threat) (47; 97). These studies suggest similar modifications can be made for smoking paradigms. For example, future research could examine the efficacy of training participants towards healthier behaviors or stress coping mechanisms.

As stated in the limitations section there were a number of assessments that were not included in this study. Therefore, future research would benefit from incorporating these measures and examining how they are associated with outcome variables. These

include measurements about plans to breastfeed, whether or not the woman breastfed, intention to quit, motivation to quit, and an objective measure of attention. Breastfeeding, while not assessed in this study, is thought to aid in preventing or delaying postpartum relapse to smoking in the broader context of promoting child health (Disantis, Collins, McCoy, 2010). Theoretically then, breastfeeding may moderate the effect of AR on various outcome variables. In regards to an objective measure of attention, future research may consider using technology such as Google glasses. Geo-location could also potentially be used to track participants' exposure in real-time to cues, such as advertisements in tobacco retail outlets.

Results from this study provide evidence that perinatal women tolerate several days of training. This doctoral research suggests another step in this line of research is to investigate the effect of AR in a sample of treatment-seeking smokers. Examining the combined effect of AR with commonly used cessation treatments (i.e., NRT, CBT) is necessary to determine how much of an incremental effect AR can truly have in the real world.

CHAPTER 11: GENERAL DISCUSSION

Both studies discussed in this dissertation help inform further research and development of mobile smoking assessment and intervention in perinatal women. A couple of cross-study observations are worth noting. Taken together, the studies discussed highlight the relapse rates in perinatal women. It was striking that relapse, when defined as any smoking during the period of the study, was relatively high (i.e., 70% in Study 1 and ~78% in Study 2). As discussed in Chapter 7, this must be qualified by the observation that smoking frequency was relatively low. Another cross-study theme was that there was no evidence of significant attentional bias in Study 1 or in the Control group in Study 2. This might reflect the fact that attentional bias is generally low in this population. Moreover, the sample sizes in both studies were small. However, we should not assume that perinatal women who are former smokers generally have a selective attentional bias towards smoking cues. Although attentional bias may be elevated in some contexts, there still may be benefit from training attention away from smoking cues. Interestingly, a recent meta-analytical study of baseline attentional bias data in the anxiety literature suggests attentional bias towards salient information (i.e., threats for anxious individuals), should not necessarily be an assumed characteristic among individuals with anxiety (105).

Overall, both of the studies discussed in this manuscript inform how future research may incorporate other technologies in the development of assessments and interventions for smoking in perinatal women. Furthermore, these technologies may be integrated into the combination of EMA/CBM research in this population. Regarding assessment, this area of research may benefit from the use of wearables, digital

phenotyping, and machine learning algorithms. Regarding intervention, this area of research may be informed by recent empirical and theoretical developments in CBM research. Each of these topics is briefly discussed.

Assessment

The addition of non-invasive wearable tools could increase the validity of measurements taken during EMA in perinatal women. Wearable tools include actigraphy, light sensors, accelerometers, and sleep trackers. Future research may also incorporate global positioning systems (GPS) in order to provide information on the participant's environment (19). As mentioned previously, there are concerns about how accurate self-report data is, even for EMA. Wearable technology would facilitate collection of precise, unbiased data including time-stamps and geographical location, enhancing the analysis of mood and behavior (Bertz, Epstein, & Preston, 2018).

A second form of technology that could supplement this area of research is digital phenotyping. Digital phenotyping has multiple nuanced definitions, but one definition describes it as the distinct measurements that accrue from a pattern of actions on a smartphone (i.e., how people interact with our smartphones at an individual level) (45). Digital phenotyping is currently being studied in relation to cognitive functioning, development of psychopathologies, and brain activity. This form of data may help reduce concerns about privacy and security, given its collection is not intrusive and is associated with ubiquitous interactions. If a study collected part of its data this way it would also reduce the level of burden on the participants, which is a recurring concern in EMA research, and particularly relevant for a perinatal population.

A third form of technology that future research in this area may further exploit is the use of machine learning algorithms. While research in the area of machine learning and addiction is still in its infancy, particularly in perinatal populations, past research has utilized classification tree approaches to predict adverse birth outcomes (e.g., preterm birth) and substance abuse during pregnancy (146; 212). This type of approach may be extended in the future with EMA data. Specifically, the use of level 2 and level 1 predictors would facilitate the prediction of not only “who” is at risk of relapse, but “when” they are at risk. With the use of algorithms tailored for multilevel data, such as “glmertree”, theoretically, mobile interventions could work in tandem to assess, and when prudent, provide interventions for identified at-risk subjects at at-risk moments (“ecological momentary interventions”) (69).

Intervention

As just noted, EMIs are a potential intervention strategy, and might include other types of cognitive interventions, such as working memory training and approach bias retraining. EMI might also include SMS messages, behavioral change promotion, psychoeducation information, motivational messages, and real-time coping strategies, all focused on changing the target behavior (i.e., smoking and/or relapse).

As CBM research progresses, future studies could examine the effect of CBM in conjunction with other interventions. As described by MacLeod et al (116), CBM is not meant to replace current interventions or serve as an alternative. Instead, it could supplement traditional interventions and thereby be an adjunct treatment for relapse and cessation. More traditional interventions, include CBT and even pharmacological treatments. Furthermore, Wiers et al (206) argue that it would be useful “to integrate the

cognitive-motivational part of CBT” with CBM, at least for treatment of alcohol use disorder.

Future research on CBM in perinatal women should also be informed by theoretical advances in CBM research. For example, Wiers et al (2007) have recently proposed that a simple “change automatic associations” account of CBM may not be sufficient to explain the mechanism of action. In the context of approach bias modification, they note that CBM works “through changes in propositional representations containing information about how concepts are causally related. Specifically, CBM (e.g., alcohol avoidance training) invokes propositions about the contingencies between stimuli (e.g., alcohol), responses (e.g., avoidance), and outcomes (e.g., positive effects) that translate into behavior.” Wiers et al (2007) describe a new training approach (ABC-training) which is informed by these theoretical developments.

CBM research in perinatal women should also consider moderators of treatment effects. Since the majority of Study 2’s sample consisted of minority (i.e., Black) women, another avenue for future research is to examine treatment effects across different populations. A number of other moderators may also potentially influence the effect of AR, such as age and pre-treatment cognitive bias (53). On the other hand, using a Bayesian meta-analysis of individual subject data, Boffo et al. (2019) reported that there was limited evidence of robust moderators of the effects of CBM. Future research should examine potential moderators using large sample sizes.

Finally, research accounting for the unique challenges of minority women and other underserved communities could greatly contribute to positive outcomes in minority women. For example, future research may explore additional assessments regarding the

unique experiences of minority women face (e.g., micro-aggressions). Data on these experiences may provide valuable insight into developing and tailoring efficacious treatments.

Table 1. Study 1 Telephone/Lab Assessments

Assessment	Screening	Enrollment	Study Completion
Screening form	X		
MINI International Diagnostic Interview		X	
FTND		X	
Urine toxicology		X	
Kendler Social Support Inventory			X
PSI			X
EPDS	X		X
Breath CO		X	X
Urine cotinine		X	X
TLFB		X	X
MNWS		X	X
QSU-brief		X	X

Table Note: MINI = Mini-International Neuropsychiatric Inventory; FTND = Fagerstrom Test for Nicotine Dependence; PSI = Parenting Stress Index; EPDS = Edinburgh Postnatal Depression Scale; CO = Carbon Monoxide; TLFB = Timeline Follow-Back; MNWS = Minnesota Nicotine Withdrawal Scale; QSU-brief = Brief Questionnaire for Smoking Urges

Table 2: Study 1 Baseline Measures

Baseline Assessment ↓					
	<i>n (%)</i>	<i>Mean</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
Age		26.25	4.48	19.03	32.65
Race					
Black Non-Hispanic	6 (60%)				
White Hispanic	3 (30%)				
Black Hispanic	1 (10%)				
Education (years)		11.80	1.93	7	14
Employment					
Full-Time	2 (20%)				
Part-Time	1 (10%)				
Not Working	7 (70%)				
Average Cigarettes Smoked/Day		8.20	6.49	3	20
Age Smoking Initiation		16.40	3.24	11	21
Most Cigarettes Smoked per Day		13.00	10.29	5	40
FTND		4.70	2.63	1	9
Number of Pregnancies		3.80	1.55	1	6
Number of Births		2.50	1.43	0	5
Number of Children		3.00	1.16	1	5

Table Note: Unless otherwise stated, $N = 10$ subjects. FTND = Fagerstrom Test for Nicotine Dependence. Income data were available for 2 subjects (\$9 per hour, \$8.75 per hour).

Table 3: Study 1 Summary Statistics Lab Assessments

Lab Assessment ↓	Range ↓	Screening	Enrollment	Study Completion
		Phone	Lab	Lab
		<i>Prepartum</i>	<i>Postpartum</i>	<i>Postpartum</i>
PSI	5-25			7.10 (<i>SD</i> =5.34)
EPDS	0-30	8.40 (<i>SD</i> =8.44)		7.60 (<i>SD</i> =8.63)
MNWS	0-28		5.80 (<i>SD</i> =5.16)	6.40 (<i>SD</i> =5.85)
QSU-brief	10-70		25.10 (<i>SD</i> =16.56)	23.40 (<i>SD</i> =22.24)
TLFB	Number			7.00 (<i>SD</i> =17.78)
Breath CO	ppm		0.10 (<i>SD</i> =0.32)	0.90 (<i>SD</i> =2.23)
Urine cotinine	0-6		1.10 (<i>SD</i> =0.74)	2.00 (<i>SD</i> =1.76)
Urine cotinine (“positive”*)	<i>n</i> (%)		0 (0%)	3 (30%)

Table Note: Data are *Mean* (*SD*). Unless otherwise stated, *N* = 10 subjects; *Score of 3 or higher. PSI = Items from Parental Stress Index; MNWS = Minnesota Nicotine Withdrawal Scale. EPDS= Edinburgh Postnatal Depression Scale. QSU-Brief = Questionnaire for Smoking Urges. TLFB = Reported Number of Cigarettes on Timeline Followback. CO = Carbon Monoxide.

Table 4: Study 1 EMA Summary Statistics

EMA Assessment ↓	<i>n</i>	<i>n (%)</i>	<i>Mean</i>	<i>SD</i>
Craving (1-7 scale)	390		1.82	1.51
Parental Stress (1-7 scale)	390		1.20	0.61
Smoked since last assessment (<i>n (%)</i> Yes)	390	15 (3.85%)		
Smoking Stroop Effect (ms)	195		-5.25	134.77
Classic Stroop Effect (ms)	195		91.40	159.00

Table Note: Data derive from 390 EMA assessments from 10 subjects. *n* = number of assessments

Table 5: Study 1 LMM Analyses

DVs →		Craving					Smoking				
IVs ↓	Component ↓	<i>df</i>	<i>PE</i>	<i>SE</i>	<i>F</i>	<i>p</i>	<i>df</i>	<i>PE</i>	<i>SE</i>	<i>F</i>	<i>p</i>
Parental Stress	<i>Mean</i>	1, 5.72	2.68	1.04	6.68	.04	.	.	.	.	.
	<i>Deviation</i>	1, 4.88	1.26	0.38	11.20	.02	.	.	.	.	.
Smoking Stroop	<i>Mean</i>	1, 24.6	0.01	0.004	9.30	.005	.	.	.	.	.
	<i>Deviation</i>	1, 53.2	0.0009	0.0008	1.54	.22	.	.	.	.	.
Craving	<i>Mean</i>	.	.	.	.	.	1, 15.17	0.58	0.36	2.65	.12
	<i>Lagged Deviation</i>	.	.	.	.	.	1, 342.4	0.00	0.20	0.00	.99

Table Note: Data are results from mixed models for exploratory analyses in Study 1. Data for Craving reflect results from LMMs. Data for Smoking reflect results for GLMM with a binary outcome variable. Smoking = Smoking since last assessment (Yes/No). *PE* = Parameter Estimate, *SE* = Standard Error. *Mean* = Mean scores; *Deviation* = Deviation scores (see text for details).
 . = Not Applicable

Table 6: Study 2 Telephone/Lab Assessments

		Phase 1: Pregnancy		Phase 2: Postpartum	
Measure	Screening	Visit 1	Visit 2	Visit 3	Visit 4
	≤32 wks	32 wks	End Phase 1	Start Phase 2	End Phase 2
Screening form	x				
MINI International Diagnostic Interview		x			x
FTND		x			
MKSSI		x			x
Urine toxicology		x			x
TLFB		x			x
Breath CO		x			x
Urine cotinine		x			x
EPDS	x				x
PSI					x
MNWS		x			x
QSU-brief		x			x

Table Note: MINI = Mini-International Neuropsychiatric Inventory; FTND = Fagerstrom Test for Nicotine Dependence; MKSSI = Modified Kendler Social Support Inventory; PSI = Parenting Stress Index; EPDS = Edinburgh Postnatal Depression Scale; CO = Carbon Monoxide; TLFB = Timeline Follow-Back; MNWS = Minnesota Nicotine Withdrawal Scale; QSU-brief = Brief Questionnaire for Smoking Urges. As shown, no assessments pertinent to the Study 2 were assessed at Visit 2 or Visit 3.

Table 7: Study 2 Baseline Measures

Assessment ↓	All	AR	Control			
	N=17	n=9	n=8			
	<i>Mean (SD) or n (%)</i>	<i>Mean (SD) or n (%)</i>	<i>Mean (SD) or n (%)</i>	<i>t/Chi Square</i>	<i>df</i>	<i>p</i>
Age	27.88 (SD=4.92)	26.33 (SD=4.18)	29.63 (SD=5.37)	-1.42	15	.18
Race/Ethnicity				4.78	2	.31
Black	13 (76.5%)	8 (88.9%)	5 (62.5%)			
Puerto Rican	1 (5.9%)	0 (0.0%)	1 (12.5%)			
White	3 (17.7%)	1 (11.1%)	2 (25%)			
Hispanic Heritage				3.29	2	.19
Puerto Rican and Dominican	1 (5.9%)	0 (0.0%)	1 (12.5%)			
Puerto Rican	4 (23.5%)	1 (11.1%)	3 (37.5%)			
None	12 (70.6%)	8 (88.9%)	4 (50.0%)			
Education (years)	11.71 (SD=1.53)	11.11 (SD= 1.69)	12.38 (SD=1.06)	-1.82	15	.09
Employment				4.39	2	.11
Full-Time	7 (41.2%)	4 (44.4%)	3 (37.5%)			
Part-Time	3 (17.6%)	0 (0.0%)	3 (37.5%)			
Not Working	7 (41.2%)	5 (55.6%)	2 (25%)			
Average Cigarettes Smoked/Day	11.00 (SD=10.86)	9.78 (SD=9.86)	12.38 (SD=12.42)	-0.48	15	.64
Age Smoking Initiation	15.65 (SD=3.35)	16.44 (SD=3.61)	14.75 (SD=3.01)	1.04	15	.31
Most Cigarettes Smoked per Day	17.18 (SD=16.44)	12.22 (SD=11.29)	22.75 (SD=20.12)	-1.35	15	.20
FTND	3.06 (SD=2.84)	2.67 (SD=3.16)	3.50 (SD=2.56)	-0.59	15	.56
Number of Pregnancies	4.00 (SD=2.37)	4.33 (SD=2.60)	3.63 (SD=2.20)	.60	15	.98
Number of Births	1.88 (SD=1.17)	1.89 (SD=0.60)	1.88 (SD=1.64)	.02	15	.98
Number of Children	1.47 (SD=0.94)	1.67 (SD=0.50)	1.25 (SD=1.28)	.90	15	.38

Table Note: Chi Square statistics reflect Pearson Chi Square statistics. Similar results are obtained using Fisher's Exact Test

Table 8: Study 2 Summary Statistics Lab Assessments

Group ↓	Assessment ↓	Screening	Enrollment	Study Completion
			Visit 1	Visit 4
		Phone	Lab	Lab
		Pre-Treatment	Pre-Treatment	Post-Treatment
		<i>Prepartum</i>	<i>Prepartum</i>	<i>Postpartum</i>
AR (n=9)				
	PSI			7.44 (<i>SD</i> =5.46)
	EPDS	3.44 (<i>SD</i> =3.54)		5.33 (<i>SD</i> =5.46)
	MNWS		9.33 (<i>SD</i> =9.46)	9.33 (<i>SD</i> =9.46)
	QSU-brief		24.67 (<i>SD</i> =22.78)	20.22 (<i>SD</i> =18.66)
	TLFB			3.63 (<i>SD</i> =16.80)
	Breath CO		4.50 (<i>SD</i> =7.84)	2.25 (<i>SD</i> =2.71)
	Urine cotinine		33.33% Positive	33.33% Positive
Control (n=8)				
	PSI			4.37 (<i>SD</i> =1.51)
	EPDS	2.75 (<i>SD</i> =3.41)		2.50 (<i>SD</i> =2.45)
	MNWS		8.75 (<i>SD</i> =6.92)	4.25 (<i>SD</i> =4.27)
	QSU-brief		25.50 (<i>SD</i> =28.04)	11.75 (<i>SD</i> =3.41)
	TLFB			9.00 (<i>SD</i> =16.81)
	Breath CO		1.88 (<i>SD</i> =4.55)	2.43 (<i>SD</i> =4.79)
	Urine cotinine		25.00% Positive	25.00% Positive

Table Note: Descriptive statistics for laboratory data. Unless otherwise noted, n=9 (AR group) or n=8 (Control). Breath CO Visit 1: (AR: n=8; Control n=8); Breath CO Visit 2: (AR: n=8; Control n=7); TLFB: (AR: n=8; Control n=7). PSI = Items from Parental Stress Index; MNWS = Minnesota Nicotine Withdrawal Scale. EPDS= Edinburgh Postnatal Depression Scale. QSU-Brief = Questionnaire for Smoking Urges. TLFB = Reported Number (Sum) of Cigarettes on Timeline Followback. CO = Carbon Monoxide

Table 9: Study 2 Analyses of Lab Data

IV↓	DV ↓	Covariate	<i>n</i>	<i>df</i>	<i>F</i>	<i>p</i>
Group (AR vs Control)	PSI	(None)	17	1, 15	2.36	.15
Group (AR vs Control)	Post-treatment EPDS	Pre-treatment EPDS	16	1, 14	1.18	.30
Group (AR vs Control)	Post-treatment MNWS	Pre-treatment MNWS	16	1, 14	0.69	.42
Group (AR vs Control)	Post-treatment QSU	Pre-treatment QSU	16	1, 14	2.65	.13
Group (AR vs Control)	Post-treatment CO	Pre-treatment CO	14	1, 12	0.32	.58

Table Note: Data are results from ANOVA (No covariate) or ANCOVA. *n* =number of subjects (*ns* differ across analyses due to missing data). *F* values reflect tests of between-group (AR vs. Control) differences in lab measures assessed post-treatment (Study Completion) controlling for pre-treatment (Enrollment or Screening) data where possible

Table 10: Study 2 EMA Summary Statistics

Group ↓	Assessment ↓	All Assessments <i>N</i> =575	Prepartum <i>n</i> =396	Postpartum <i>n</i> =179
AR				
	Craving (1-7)	2.08 (<i>SD</i> =2.14)	1.25 (<i>SD</i> =1.13)	3.24 (<i>SD</i> =2.64)
	Parental Stress (1-7)	1.87 (<i>SD</i> =1.38)	1.10 (<i>SD</i> =0.35)	1.90 (<i>SD</i> =2.01)
	Smoked since last assessment (% Yes)	12.8%	5.5%	23.1%
	Attentional Bias (ms)	-47.53 (<i>SD</i> =141.83)	-52.78 (<i>SD</i> =143.81)	-37.89 (<i>SD</i> =141.70)
Control				
	Craving (1-7)	1.42 (<i>SD</i> =1.30)	1.44 (<i>SD</i> =1.32)	1.34 (<i>SD</i> =1.23)
	Parental Stress (1-7)	1.20 (<i>SD</i> =0.63)	1.16 (<i>SD</i> =0.63)	1.34 (<i>SD</i> =0.61)
	Smoked since last assessment (% Yes)	6.7%	6.2%	8.6%
	Attentional Bias (ms)	-0.01 (<i>SD</i> =83.28)	+0.50 (<i>SD</i> =86.11)	-2.81 (<i>SD</i> =66.74)

Table Note: 7 AR subjects and 7 Control subjects contributed EMA data. 6 AR subjects and 7 Control subjects contributed EMA data to the prepartum phase and 7 AR subjects and 4 Control subjects contributed EMA data to the postpartum phase. *n*=number of assessments. *ns* for each group for Craving: AR prepartum (*n*=170), AR postpartum (*n*=120). Control prepartum (*n*=226), Control postpartum (*n*=59); *ns* for each group for Parental Stress: AR prepartum (*n*=166), AR postpartum (*n*=118). Control prepartum (*n*=226), Control postpartum (*n*=58); *ns* for each group for Smoked since last assessment: AR prepartum (*n*=164), AR postpartum (*n*=117). Control prepartum (*n*=226), Control postpartum (*n*=58); *ns* for each group for Attentional Bias: AR prepartum (*n*=33), AR postpartum (*n*=18). Control prepartum (*n*=186), Control postpartum (*n*=34). *ns* for Control group are larger for attentional because bias scores can be computed on Control trainings and the VP assessment. In the Control group, attentional bias assessed in the Control trainings and VP assessment were of similar magnitude (*M*=-2.34 ms, *SD*=122.48 and *M*=0.79 ms, *SD*=65.23 respectively).

Table 11: Study 2 LMM Analyses

			Continuous DV					Binary DV				
IV↓	DVs ↓	<i>n</i>	<i>df</i>	<i>PE</i>	<i>SE</i>	<i>F</i>	<i>p</i>	<i>df</i>	<i>PE</i>	<i>SE</i>	<i>F</i>	<i>p</i>
Group (AR vs Control)	Bias	271	1, 7.16	-48.54	20.52	5.59	.04	.	.	.	.	.
Group (AR vs Control)	Craving	575	1, 10.70	0.46	0.92	0.25	.63	.	.	.	.	.
Group (AR vs Control)	Smoking	565	.	.	.	.	.	1, 9.74	0.26	0.96	.08	.79

Table Note: Data are results from LMMs (continuous outcomes) and GLMM (binary outcome). 7 AR subjects and 7 Control subjects contributed data to analyses. *n* =number of assessments. All models include Phase (parameter estimates for Phase not shown). *df*= Satterthwaite degrees of freedom, *PE* = parameter estimate, *SE* = standard error. Group coded as 0=Control, 1=AR.

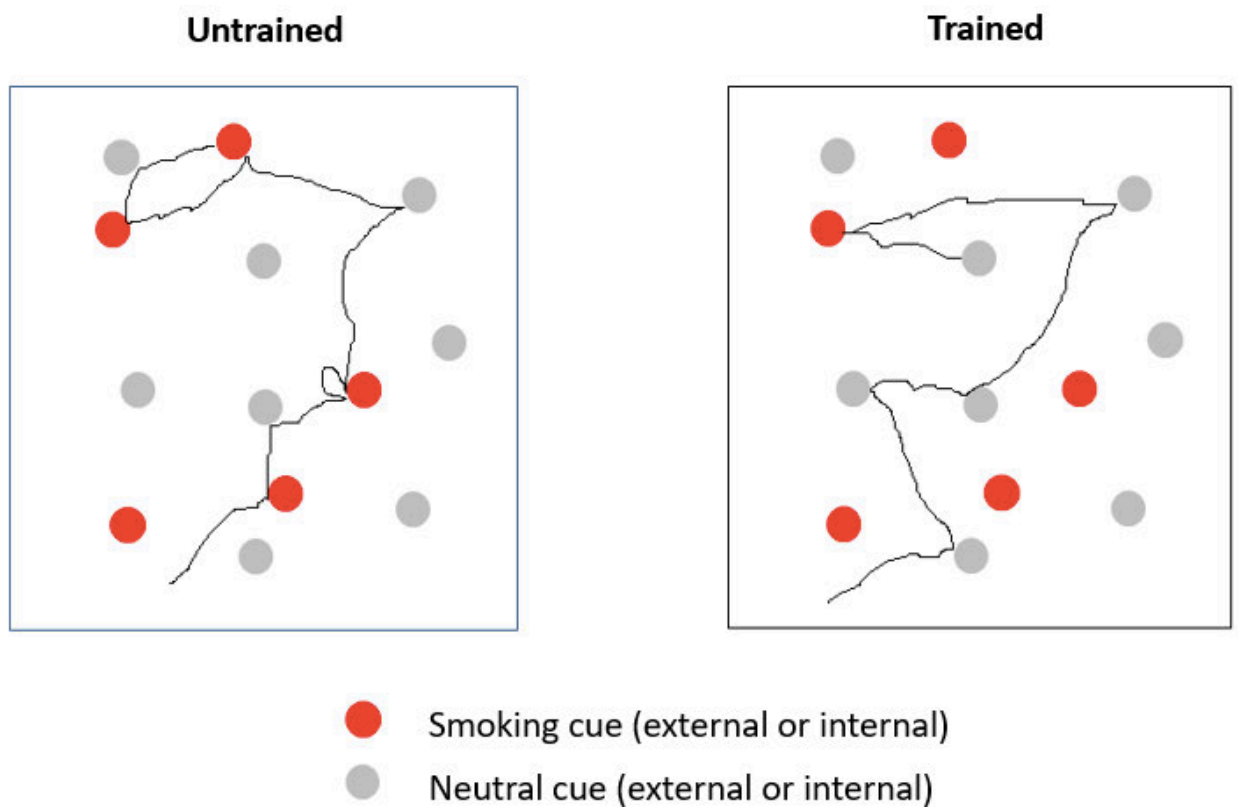


Figure 1. Illustration of cognitive bias modification.

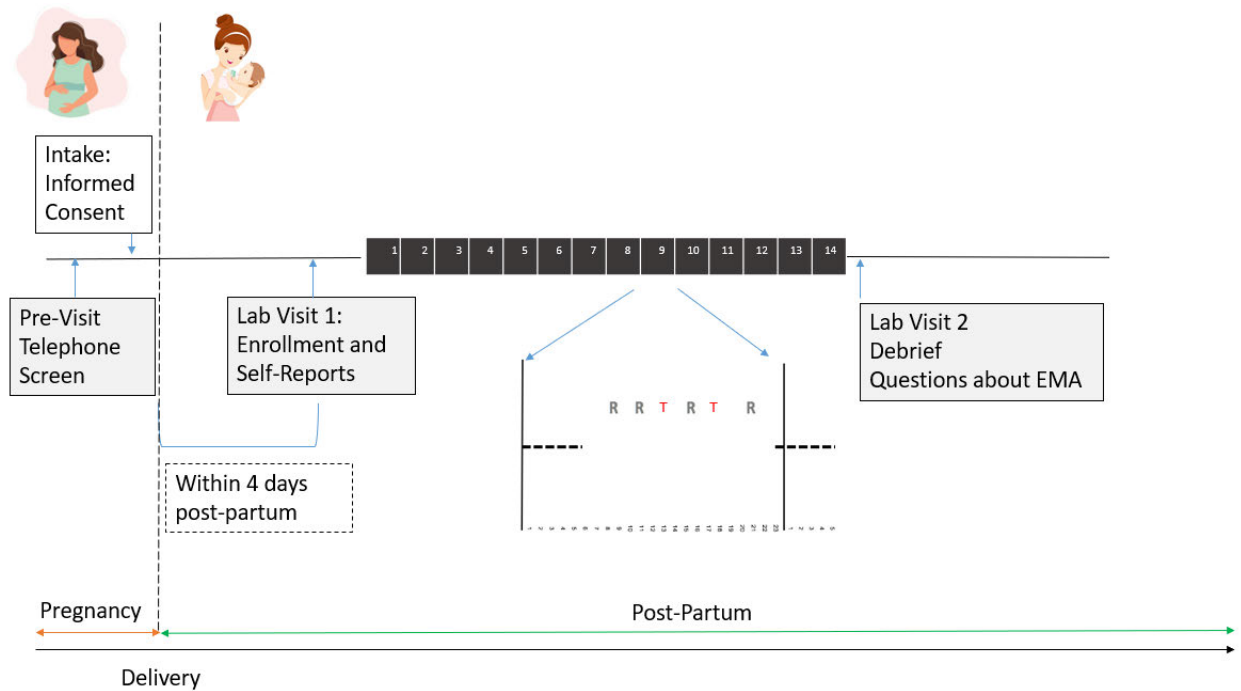
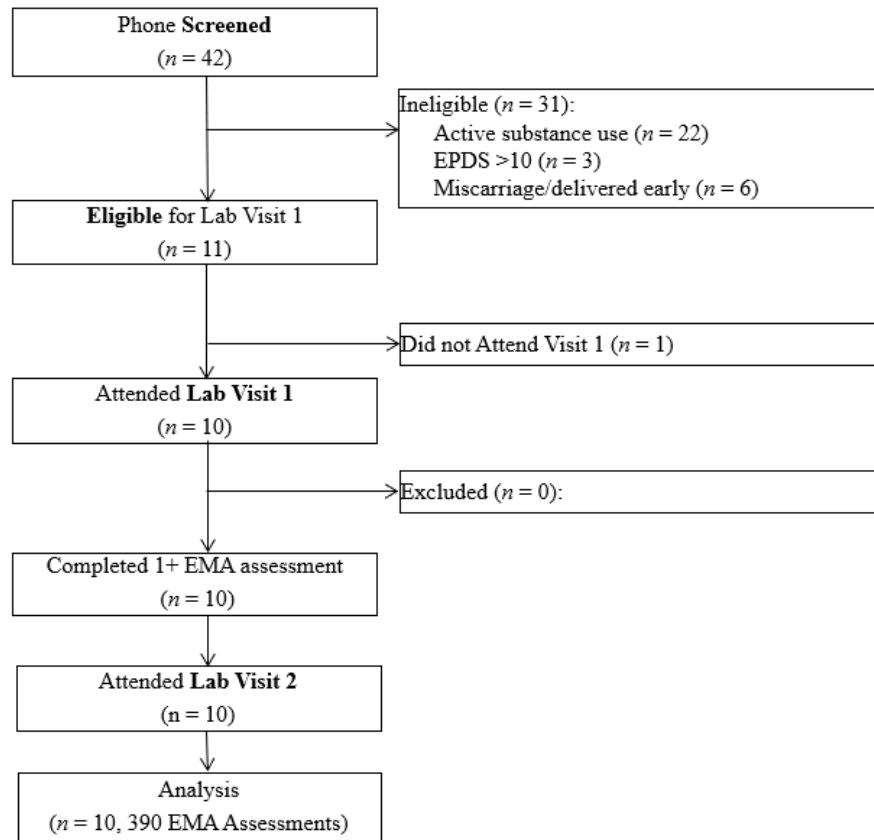


Figure 2. Flowchart of procedure for Study 1. Includes timeline of procedure from pre-visit telephone screen through the second lab visit. It also includes a breakdown of the 2-week EMA portion of the study. Overlaid is the timeline of the perinatal period.

Figure 3. Consort Chart for Study 1.



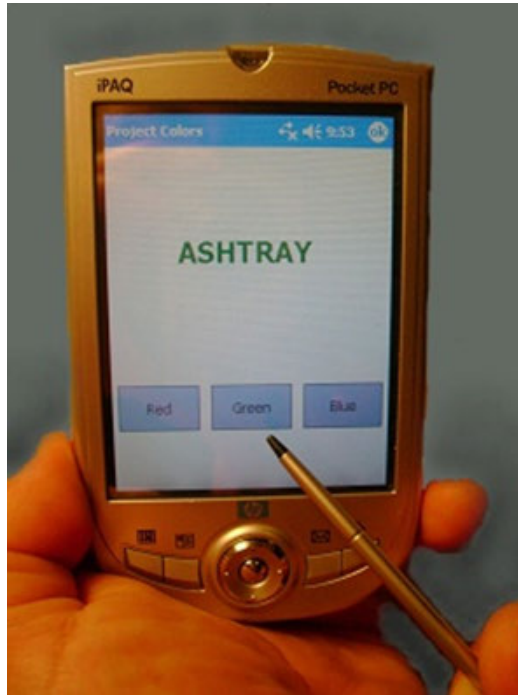


Figure 4. Stroop task on mobile device (Study 1). Smoking-related words and neutral words were presented in varying colors (i.e., blue, green, red). Attentional bias was measured through assessment of reaction times to identify the color of the font the word was printed in.

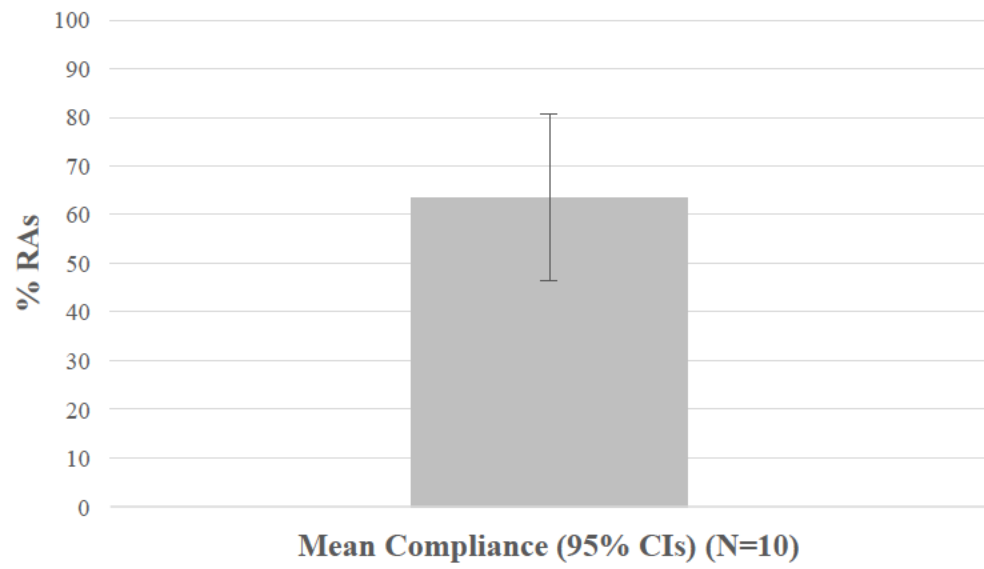


Figure 5. Compliance in Study 1.

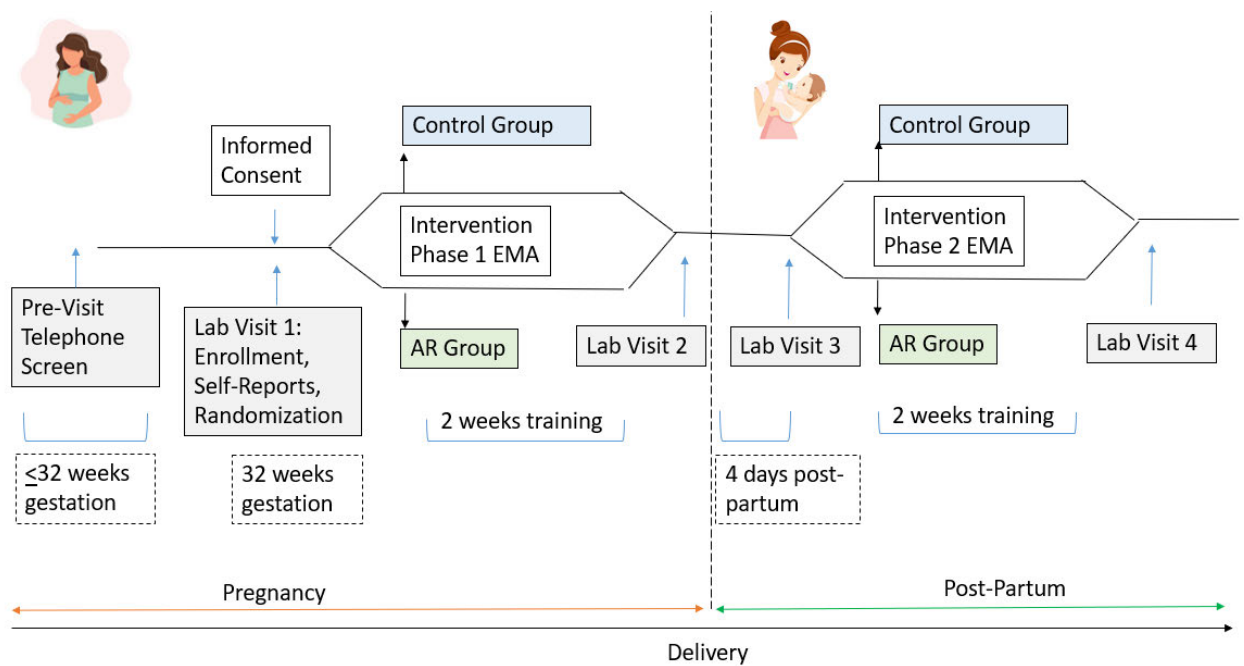


Figure 7. Flowchart of procedure for Study 2. Includes timeline of procedure from pre-visit telephone screening through two intervention phases and follow-up visits. Overlaid is the timeline of the perinatal period.

Figure 8. Consort Chart for Study 2

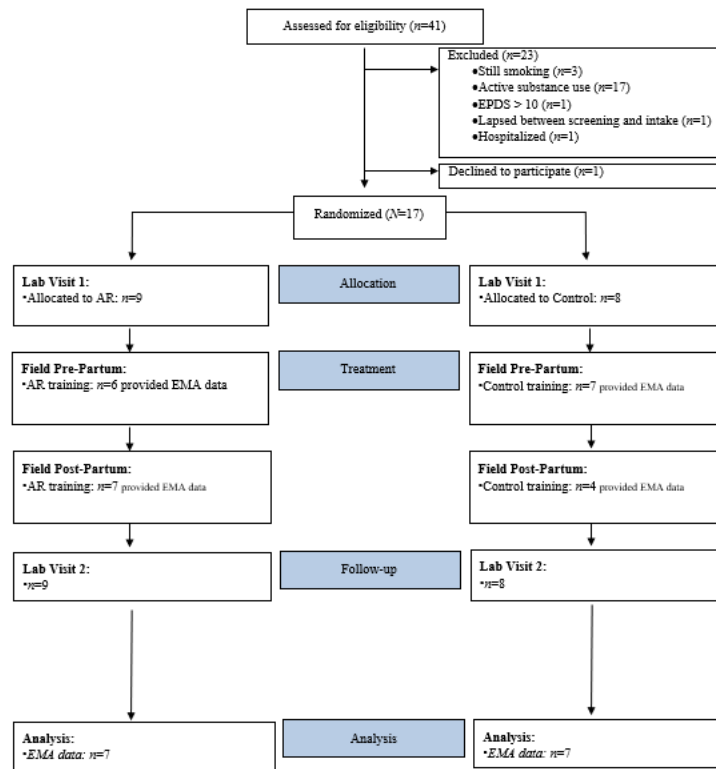




Figure 9. Picture of VP task (Study 2). In the modified visual probe (VP) task, participants were tasked with focusing on the fixation cross in the center of the screen. The cross was then replaced by a series of picture pairs (smoking and neutral pair) that were presented for 500ms. The side of the screen that the picture was presented on was randomized. Following presentation of the picture pairs, a probe (i.e., the dot) appeared in the position of one of the pictures. Participants were asked to indicate whether the probe appears on the right (M key) or on the left side of the screen (C key).

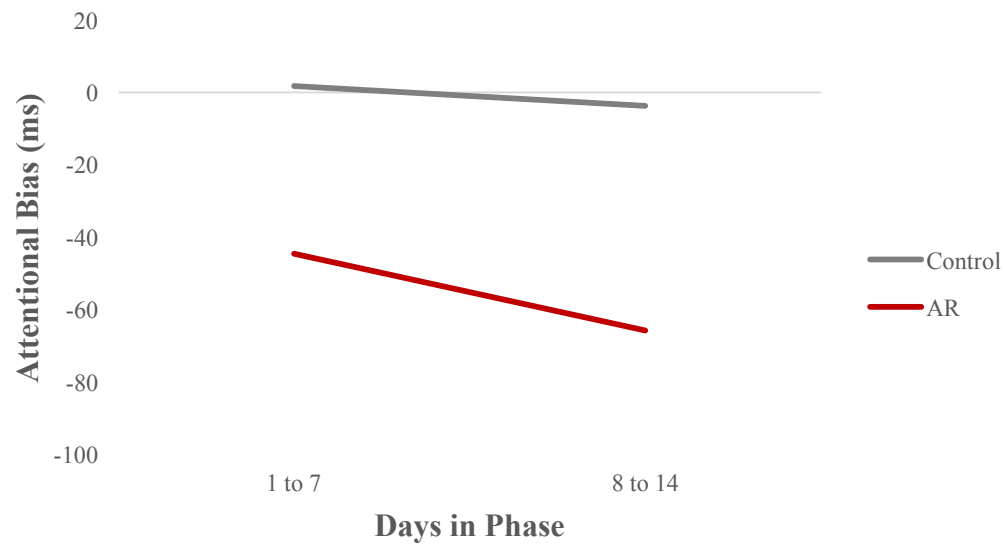


Figure 10. Attentional Bias by Group

Appendix 1

Study 1: Example Code

- Testing association between parental stress and craving

```
proc mixed data=gunters1 covtest;  
class Subject assessmentnum2 ;  
model cigarette = day parenting_s dev_parenting / solution ddfm=satterthwaite;  
random int dev_parenting / subject = Subject type=un gcorr;  
repeated assessmentnum2 / type = ar(1) subject = Subject r rcorr;  
run;
```

Note: cigarette = craving (DV); day = day of study; parenting_s = average parental stress for each subject (level 2 variable); dev_parenting (level 1 variable) = deviation score between observed parental stress and parenting_s; assessmentnum2 = assessment number. The code above tests the between- and within-subject associations between parental stress and craving, using parenting_s and dev_parenting respectively. The model provides fixed effects (B values in the B vector corresponding to the mixed model equation $Y = XB + Zu + e$) for predictors on the right hand side of the equation. The analysis tests the null hypothesis that the B value in the population for each predictor is equal to zero (conditional on model covariates). Coefficients for dev_parenting were treated as random (Bolger & Laurenceau, 2013). Consistent with past practice (Schwartz and Stone, 2007), an unstructured G matrix (type=un) allows for random intercepts and random slopes, and for covariance between intercepts and slopes. In the repeated statement, type=AR (1) allows for first-order autocorrelation between residuals.

Study 2: Example Code

- Testing Effect of AR (vs. Control) on attentional bias (Hypothesis 1)

```
proc mixed data=gunters2 covtest;  
class subject phase group;  
model bias = phase group / solution ddfm=satterthwaite;  
random int / subject = subject type=un gcorr;  
repeated / type = ar(1) subject = subject r rcorr;  
run;
```

Note: bias = attentional bias (DV); group = AR group (AR vs. Control) (level 2 variable); phase = phase of study (prepartum vs. postpartum) (level 1 variable). The primary analysis will test the main effect of AR group; the Group x Day interaction was also tested in a separate model (Day = Day Within Phase).

REFERENCES

1. Abidin R, Lutz FL. 1995. *Parenting Stress Index: Professional Manual*
2. Abroms LC, Johnson PR, Heminger CL, Van Alstyne JM, Leavitt LE, et al. 2015. Quit4baby: Results from a pilot test of a mobile smoking cessation program for pregnant women. *Journal of Medical Internet Research Mhealth Uhealth* 3:e10
3. Agboola S, McNeill A, Coleman T, Leonardi Bee J. 2010. A systematic review of the effectiveness of smoking relapse prevention interventions for abstinent smokers. *Addiction* 105:1362-80
4. Ahern J, Pickett KE, Selvin S, Abrams B. 2003. Preterm birth among African American and white women: A multilevel analysis of socioeconomic characteristics and cigarette smoking. *Journal of Epidemiology & Community Health* 57:606-11
5. Al-Mrayat YD, Okoli CTC, Studts CR, Rayens MK, Hahn EJ. 2019. The psychometric properties of the minnesota tobacco withdrawal scale among patients with mental illness. *Biological Research for Nursing* 22:247-55
6. Alaniz K, Christiansen B, Sullivan T, Khalil L, Fiore MC. 2019. Addressing postpartum smoking relapse among low-income women: A randomized control trial. *Journal of Patient-Centered Research and Reviews* 6:233-42
7. Allen A, Tosun N, Carlson S, Allen S. 2018. Allen, S. (2018). Postpartum changes in mood and smoking-related symptomatology: An ecological momentary assessment investigation. *Nicotine & Tobacco Research* 20:681-9
8. American Psychiatric Association. 2013. *Diagnostic and Statistic Manual of Mental Disorders DSM5* American Psychiatric Pub
9. Arnold CL, Davis TC, Berkel HJ, Jackson RH, Nandy I, London S. 2001. Smoking status, reading level, and knowledge of tobacco effects among low-income pregnant women. *Preventive Medicine* 32:313-20
10. Attwood AS, O'Sullivan H, Leonards U, Mackintosh B, Munafo MR. 2008. Attentional bias training and cue reactivity in cigarette smokers. *Addiction* 103:1875-82
11. Ayyagari P, Sindelar JL. 2010. The impact of job stress on smoking and quitting: Evidence from the HRS. *B.E. Journal of Economic Analysis Policy* 10
12. Banderali G, Martelli A, Landi M, Moretti F, Betti F, et al. 2015. Short and long term health effects of parental tobacco smoking during pregnancy and lactation: A descriptive review. *Journal of Translational Medicine* 13:327
13. Benowitz NL. 1983. The use of biologic fluid samples in assessing tobacco smoke consumption. *NIDA Research Monograph* 48:6-26
14. Berkman ET, Giuliani NR, Pruitt AK. 2014. Comparison of text messaging and paper-and-pencil for ecological momentary assessment of food craving and intake. *Appetite* 81:131-7
15. Berlin I, Singleton EG, Heishman SJ. 2013. Predicting smoking relapse with a multidimensional versus a single-item tobacco craving measure. *Drug and Alcohol Dependence* 132:513-20

16. Berlin I, Singleton EG, Heishman SJ. 2016. Craving and Withdrawal Symptoms During Smoking Cessation: Comparison of Pregnant and Non-Pregnant Smokers. *Journal of Substance Abuse and Treatment* 63:18-24
17. Berrendero F, Robledo P, Trigo JM, Martin-Garcia E, Maldonado R. 2010. Neurobiological mechanisms involved in nicotine dependence and reward: participation of the endogenous opioid system. *Neuroscience and Biobehavioral Review* 35:220-31
18. Berridge KC, Robinson TE. 2016. Liking, wanting, and the incentive-sensitization theory of addiction. *Journal of American Psychology* 71:670-9
19. Bertz JW, Epstein DH, Preston KL. 2018. Combining ecological momentary assessment with objective, ambulatory measures of behavior and physiology in substance-use research. *Addictive Behaviors* 83:5-17
20. Black AC, Cooney NL, Sartor CE, Arias AJ, Rosen MI. 2018. Impulsivity interacts with momentary PTSD symptom worsening to predict alcohol use in male veterans. *American Journal of Drug and Alcohol Abuse*
21. Boffo M, Zerhouni O, Gronau QF, van Beek RJJ, Nikolaou K, et al. 2019. Cognitive bias modification for behavior change in alcohol and smoking addiction: Bayesian meta-analysis of individual participant data. *Neuropsychological Review* 29:52-78
22. Bolger N, Laurenceau JP. 2013. *Intensive longitudinal methods: An introduction to diary and experience sampling research*. Guilford Press
23. Bollinger JW, Beadling C, Waters AJ. 2020. Effect of hypnotic suggestion on cognition and craving in smokers. *Addictive Behavior Reports* 11
24. Brandon TH, Collins BN, Juliano LM, Lazev AB. 2000. Preventing relapse among former smokers: a comparison of minimal interventions through telephone and mail. *Journal of Consulting and Clinical Psychology* 68:103
25. Brandon TH, Collins BN, Juliano LM, Lazev AB. 2000. Preventing relapse among former smokers: a comparison of minimal interventions through telephone and mail. *Journal of Consulting and Clinical Psychology* 68:103-13
26. Buckwalter JG, Buckwalter DK, Bluestein BW, Stanczyk FZ. 2001. Pregnancy and postpartum: Changes in cognition and mood. *Progress in Brain Research* 133:303-19
27. Bullock LF, Mears JL, Woodcock C, Record R. 2001. Retrospective study of the association of stress and smoking during pregnancy in rural women. *Addictive Behaviors* 26:405-13
28. Carter BL, Tiffany ST. 1999. Meta-analysis of cue-reactivity in addiction research. *Addiction* 94:327-40
29. Center for Disease Control and Prevention. 2017. Quitting smoking among adults— United States, 2000-2015. *Morbidity and Mortality Weekly Report* 65
30. Center for Disease Control and Prevention. 2018. *Cigarette Smoking During Pregnancy: United States, 2016*.
31. Chang Y, Fine MA. 2007. Modeling parenting stress trajectories among low-income young mothers across the child's second and third years: Factors accounting for stability and change. *Journal of Family Psychology* 21:584
32. Changeux JP, Taly A. 2008. Nicotinic receptors, allosteric proteins and medicine. *Trends in Molecular Medicine* 14:93-102

33. Chapman S, MacKenzie R. 2010. The global research neglect of unassisted smoking cessation: Causes and consequences. *PLoS Med* 7:e1000216
34. Chisolm MS, Brigham EP, Lookatch SJ, Tuten M, Strain EC, Jones HE. 2010. Cigarette smoking knowledge, attitudes, and practices of patients and staff at a perinatal substance abuse treatment center. *Journal of Substance Abuse Treatment* 39:296-305
35. Clinical Practice Guideline Treating Tobacco Use and Dependence 2008 Update Panel L, and Staff, . 2008. A clinical practice guideline for treating tobacco use and dependence: 2008 update. A U.S. Public Health Service report. *American Journal of Preventive Medicine* 36:158-76
36. Coe JW, Brooks PR, Vetelino MG, Wirtz MC, Arnold EP, et al. 2005. Varenicline: An alpha4beta2 nicotinic receptor partial agonist for smoking cessation. *Journal of Medicine and Chemistry* 48:3474-7
37. Collins SE, Eck S, Torchalla I, Schröter M, Batra A. 2009. Validity of the timeline followback among treatment-seeking smokers in Germany. *Drug and Alcohol Dependence* 164-7
38. Colman GJ, Joyce T. 2003. Trends in smoking before, during, and after pregnancy in ten states. *American Journal of Preventive Medicine* 24:29-35
39. Conklin CA, Salkeld RP, Perkins KA, Robin N. 2013. Do people serve as cues to smoke? *Nicotine & Tobacco Research* 15:2081-7
40. Copeland AL, Brandon TH, Quinn EP. 1995. The Smoking Consequences Questionnaire—Adult: Measurement of smoking outcome expectancies of experienced smokers. *Psychological Assessment* 7:484-94
41. Correa JB, Simmons VN, Sutton SK, Meltzer LR, Brandon TH. 2015. A content analysis of attributions for resuming smoking or maintaining abstinence in the post-partum period. *Maternity and Child Health* 19:664-74
42. Cox JL, Chapman G, Murray D, Jones P. 1996. Validation of the Edinburgh Postnatal Depression Scale (EPDS) in non-postnatal women. *Journal of Affective Disorders* 39:185-9
43. Cox WM, Fadardi JS, Intriligator JM, Klinger E. 2014. Attentional bias modification for addictive behaviors: Clinical implications. *CNS Spectrums* 19:215-24
44. Cox WM, Fadardi JS, Pothos EM. 2006. The addiction-Stroop test: Theoretical considerations and procedural recommendations. *Psychological Bulletin* 132:443-76
45. Dagum P. 2018. Digital biomarkers of cognitive function. *Digital Medicine* 1:1-3
46. Daly LM, Horey D, Middleton PF, Boyle FM, Flenady V. 2018. The Effect of Mobile App Interventions on Influencing Healthy Maternal Behavior and Improving Perinatal Health Outcomes: Systematic Review. *Journal of Medical Internet Research Mhealth Uhealth* 6:10012
47. Dennis TA, O'Toole L. 2014. Mental Health on the Go: Effects of a Gamified Attention Bias Modification Mobile Application in Trait Anxious Adults. *Clinical and Psychological Science* 2:576-90
48. DiClemente CC, Dolan-Mullen P, Windsor RA. 2000. The process of pregnancy smoking cessation: Implications for interventions. *Tobacco Control* 9 III16-21

49. Dietz PM, England LJ, Shapiro-Mendoza CK, Tong VT, Farr SL, Callaghan WM. 2010. Infant morbidity and mortality attributable to prenatal smoking in the U.S. *American Journal of Preventive Medicine* 39:45-52
50. Disantis KI, Collins BN, McCoy AS. 2010. Associations among breastfeeding, smoking relapse, and prenatal factors in a brief postpartum smoking intervention. *Acta Obstetricia Et Gynecologica* 89:582-6
51. Drobos DJ, Thomas SE. 1999. Assessing craving for alcohol. *Journal of the National Institute on Alcohol Abuse and Alcoholism* 23:179-86
52. Dunbar MS, Shiffman S, Kirchner TR, Tindle HA, Scholl SM. 2014. Nicotine dependence, "background" and cue-induced craving and smoking in the laboratory. *Drug and Alcohol Dependence* 142:197-203
53. Eberl C, Wiers RW, Pawelczack S, Rinck M, Becker ES, Lindenmeyer J. 2013. Approach bias modification in alcohol dependence: Do clinical effects replicate and for whom does it work best? *Developmental Cognitive Neuroscience*:38-51
54. Eisenberg MJ, Filion KB, Yavin D, Belisle P, Mottillo S, et al. 2008. Pharmacotherapies for smoking cessation: a meta-analysis of randomized controlled trials. *Canadian Medical Association Journal* 179:135-44
55. Eldridge SM, Lancaster GA, Campbell MJ, Thabane L, Hopewell S, et al. 2016. Defining feasibility and pilot studies in preparation for randomised controlled trials: Development of a conceptual framework. *PLoS One* 11:e0150205
56. Enock PM, Hofmann SG, McNally RJ. 2014. Attention bias modification training via smartphone to reduce social anxiety: A randomized, controlled multi-session experiment. *Cognitive Therapy and Research* 38:200-16
57. Faherty LJ, Hantsoo L, Appleby D, Sammel MD, Bennett IM, Wiebe DJ. 2017. Movement patterns in women at risk for perinatal depression: Use of a mood-monitoring mobile application in pregnancy. *Journal of the American Medical Informatics Association* 24:746-53
58. Faul F, Erdfelder E, Lang AG, Buchner A. 2007. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior research methods* 39:175-91
59. Ferguson SG, Shiffman S. 2009. The relevance and treatment of cue-induced cravings in tobacco dependence. *Journal of Substance Abuse and Treatment* 36:235-43
60. Ferguson SG, Shiffman S. 2011. Using the methods of ecological momentary assessment in substance dependence research--smoking cessation as a case study. *Substance Use & Misuse* 46:87-95
61. Field A. 2017. *Discovering Statistics Using IBM SPSS Statistics*. SAGE Publications.
62. Field M, Cox WM. 2008. Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence* 97:1-20
63. Field M, Duka T, Eastwood B, Child R, Santarcangelo M, Gayton M. 2007. Experimental manipulation of attentional biases in heavy drinkers: Do the effects generalise? *Psychopharmacology* 192:593-608.
64. Field M, Duka T, Tyler E, Schoenmakers T. 2009. Attentional bias modification in tobacco smokers. *Nicotine and Tobacco Research* 11:812-22

65. Field M, Eastwood B. 2005. Experimental manipulation of attentional bias increases the motivation to drink alcohol. *Psychopharmacology* 183:350-7
66. Field M, Munafò MR, Franken IH. 2009. A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin* 135:589
67. Fiore MC, Bailey WC, Cohen SJ, Dorfman SF, Goldstein MG, et al. 2000. *Treating tobacco use and dependence: Clinical practice guideline*. Rockville, MD: U.S. Department of Health and Human Services
68. Fisher AJ, Medaglia JD, Jeronimus BF. 2018. Lack of group-to-individual generalizability is a threat to human subjects research. *Proceedings of the National Academy of Sciences* 115:E6106-E15.
69. Fokkema M, Smits N, Zeileis A, Hothorn T, Kelderman H. 2018. Detecting treatment-subgroup interactions in clustered data with generalized linear mixed-effects model trees. *Behavior Research Methods* 50:2016-34
70. Franken IH. 2003. Drug craving and addiction: integrating psychological and neuropsychopharmacological approaches. *Progress in Neuropsychopharmacology and Biological Psychiatry* 27:563-79
71. Franzini L, Ribble F, Keddie A. 2001. Understanding the Hispanic paradox. *Ethnic Disparities* 11:496-518
72. Garrett BE, Dube SR, Trosclair A, Caraballo RS, Pechacek TF, (CDC) CfDcAP. 2011. Cigarette smoking—United States, 1965–2008. *Morbidity and Mortality Weekly Report* 60:109-13
73. Garvey AJ, Bliss RE, Hitchcock JL, Heinold JW, Rosner B. 1992. Predictors of smoking relapse among self-quitters: A report from the Normative Aging Study. *Addictive Behaviors* 17:367-77
74. Gelman A, Shor B, Bafumi J, Park DJ. 2007. Rich state, poor state, red state, blue state: What's the matter with Connecticut? *Quarterly Review and Journal of Political Science* 2:345-67
75. Giovino GA, Sidney S, Gfroerer JC, O'Malley PM, Allen JA, et al. 2004. Epidemiology of menthol cigarette use. *Tobacco Research* 6:67-81
76. Gonzales D, Rennard SI, Nides M, Oncken C, Azoulay S, et al. 2006. Varenicline, an alpha4beta2 nicotinic acetylcholine receptor partial agonist, vs sustained-release bupropion and placebo for smoking cessation: A randomized controlled trial. *Journal of the American Medical Association* 296:47-55
77. Hakamata Y, Lissek S, Bar-Haim Y, Britton JC, Fox NA, et al. 2010. Attention bias modification treatment: A meta-analysis toward the establishment of novel treatment for anxiety. *Biological Psychiatry* 68:982-90
78. Haley NJ, Axelrad CM, Tilton KA. 1983. Validation of self-reported smoking behavior: Biochemical analyses of cotinine and thiocyanate. *American Journal of Public Health* 73:1204-7
79. Hammond WP. 2010. Psychosocial correlates of medical mistrust among African American men. *American Journal of Community Psychology* 45:87-106
80. Haskett M, Ahern L, Ward C, Allaire J. 2017. Factor structure and validity of the Parenting Stress Index-Short Form *Journal of Clinical Child and Adolescent Psychology* 46:170

81. Hatsukami DK, Hughes JR, Pickens RW, Svikis D. 1984. Tobacco withdrawal symptoms: An experimental analysis. *Psychopharmacology* 84:231-6
82. Hauge LJ, Torgersen L, Vollrath M. 2012. Associations between maternal stress and smoking: Findings from a population-based prospective cohort study. *Addiction* 107:1168-73
83. Heatherton TF, Kozlowski LT, Frecker RC, Fagerström KO. 1991. The Fagerström Test for Nicotine Dependence: A revision of the Fagerström Tolerance Questionnaire. *British Journal of Addiction* 86:1119-27
84. Hedeker D, Mermelstein RJ, Berbaum ML, Campbell RT. 2009. Modeling mood variation associated with smoking: An application of a heterogeneous mixed-effects model for analysis of ecological momentary assessment (EMA) data. *Addiction* 104:297-307
85. Higgins ST, Bernstein IM, Washio Y, Heil SH, Badger GJ, et al. 2010. Effects of smoking cessation with voucher-based contingency management on birth outcomes. *Addiction* 105:2023-30
86. Howell DC. 2012. *Statistical methods for psychology*. Cengage Learning.
87. Hughes JR. 2007. Effects of abstinence from tobacco: Valid symptoms and time course. *Nicotine and Tobacco Research* 9:315-27
88. Hughes JR, Gust SW, Skoog K, Keenan RM, Fenwick JW. 1991. Symptoms of tobacco withdrawal: A replication and extension. *Archives of General Psychiatry* 48:52-9
89. Hughes JR, Hatsukami D. 1986. Signs and symptoms of tobacco withdrawal. *Archives of General Psychiatry* 43:289-94
90. Jaeggi SM, Buschkuhl M, Jonides J, Perrig WJ. 2008. Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences* 105:6829-33
91. Janes AC, Pizzagalli DA, Richardt S, de BFB, Chuzi S, et al. 2010. Brain reactivity to smoking cues prior to smoking cessation predicts ability to maintain tobacco abstinence. *Biological Psychiatry* 67:722-9
92. Jones A, Remmerswaal D, Verveer I, Robinson E, Franken IH, et al. 2019. Compliance with ecological momentary assessment protocols in substance users: A meta-analysis. *Addiction* 114:609-19
93. Jones KK, Zenk SN, McDonald A, Corte C. 2016. Experiences of African-American women with smartphone-based ecological momentary assessment. *Public Health Nursing* 33:371-80
94. Joseph C, Bushmakin A, Baker C, Merikle E, Olufade A, Gilbert D. 2005. Revealing the multidimensional framework of the Minnesota Nicotine Withdrawal Scale. *Current Medical Research and Opinion* 21:749-60
95. Kahneman D. 2003. Experiences of collaborative research. *American Psychology* 58:723-30
96. Kahneman D. 2003. Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review* 93:1449-75
97. Kakoschke N, Kamps E, Tiggemann M. 2014. Attentional bias modification encourages healthy eating. *Eating Behaviors* 15:120-4

98. Kashdan TB, Steger MF. 2006. Expanding the topography of social anxiety: An experience-sampling assessment of positive emotions, positive events, and emotion suppression. *Psychological Science* 17:120-8
99. Kassel JD, Stroud LR, Paronis CA. 2003. Smoking, stress, and negative affect: Correlation, causation, and context across stages of smoking. *Psychological Bulletin* 129:270-304
100. Kendler KS, Myers J, Prescott CA. 2005. Sex differences in the relationship between social support and risk for major depression: A longitudinal study of opposite-sex twin pairs. *The American Journal of Psychiatry* 162:250-6
101. Kerst WF, Waters AJ. 2014. Attentional retraining administered in the field reduces smokers' attentional bias and craving. *Health Psychology* 33:1232-40
102. Kondracki AJ. 2019. Prevalence and patterns of cigarette smoking before and during early and late pregnancy according to maternal characteristics: The first national data based on the 2003 birth certificate revision, United States, 2016 *Reproductive Health* 16:142
103. Koob GF, Volkow ND. 2016. Neurobiology of addiction: A neurocircuitry analysis. *The Lancet Psychiatry* 3:760-73
104. Kovess V, Keyes KM, Hamilton A, Pez O, Bitfoi A, et al. 2015. Maternal smoking and offspring inattention and hyperactivity: Results from a cross-national European survey. *European Child and Adolescent Psychiatry* 24:919-29
105. Kruijt AW, Parsons S, Fox E. 2019. A meta-analysis of bias at baseline in RCTs of attention bias modification: No evidence for dot-probe bias towards threat in clinical anxiety and PTSD. *Journal of Abnormal Psychology* 128:563
106. Lancaster T, Stead LF. 2005. Individual behavioural counselling for smoking cessation. *Cochrane Database of Systematic Reviews*:CD001292
107. Letourneau AR, Sonja B, Mazure CM, O'Malley SS, James D, Colson ER. 2007. Timing and predictors of postpartum return to smoking in a group of inner-city women: An exploratory pilot study. *Birth* 34:245-52
108. Leventhal AM, Waters AJ, Moolchan ET, Heishman SJ, Pickworth WB. 2010. A quantitative analysis of subjective, cognitive, and physiological manifestations of the acute tobacco abstinence syndrome. *Addictive Behaviors* 35:1120-30
109. Levine MD, Cheng Y, Marcus MD, Kalarchian MA, Emery RL. 2016. Preventing postpartum smoking relapse: A randomized clinical trial. *JAMA Internal Medicine* 176:443-52
110. Levine MD, Marcus MD, Kalarchian MA, Houck PR, Cheng Y. 2010. Weight concerns, mood, and postpartum smoking relapse. *American Journal of Preventive Medicine* 39:345-51
111. Levitt A. C., Shaw A. E., Wong A. S., J. KA. 2007. Systematic review of the literature on postpartum care: effectiveness of interventions for smoking relapse prevention, cessation, and reduction in postpartum women. *Birth* 34:341-247
112. Levitt C, Shaw E, Wong S, Kaczorowski J. 2007. Systematic review of the literature on postpartum care: Effectiveness of interventions for smoking relapse prevention, cessation, and reduction in postpartum women. *Birth* 34:341-7
113. Lillie-Blanton M, Brodie M, Rowland D, Altman D, McIntosh M. 2000. Race, ethnicity, and the health care system: Public perceptions and experiences. *Medical Care Research and Review* 57 Suppl 1:218-35

114. Livingstone-Banks J, Norris E, Hartmann-Boyce J, West R, Jarvis M, Hajek P. 2019. Relapse prevention interventions for smoking cessation. *Cochrane Database of Systematic Reviews* 2:3999
115. Lynch WJ, Sofuoglu M. 2010. Role of progesterone in nicotine addiction: Evidence from initiation to relapse. *Experimental and Clinical Psychopharmacology* 18:451-61
116. MacLeod C, Koster EW, Fox E. 2009. Whither cognitive bias modification research? Commentary on the special section articles. *Journal of Abnormal Psychology* 118:89-99
117. MacLeod C, Rutherford E, Campbell L, Ebsworthy G, Holker L. 2002. Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology* 111:107-23
118. Markides KS, Eschbach K. 2005. Aging, migration, and mortality: Current status of research on the Hispanic paradox. *The Journals of Gerontology* 60:68-75
119. Mathews A, MacLeod C. 2002. Induced processing biases have causal effects on anxiety. *Cognition & Emotion* 16:331-54
120. McBride CM, Curry SJ, Grothaus LC, Nelson JC, Lando H, Pirie PL. 1998. Partner smoking status and pregnant smoker's perceptions of support for and likelihood of smoking cessation. *Health Psychology* 17:63-9
121. Mead EL, Chen JC, Kirchner TR, Butler III J, Feldman RH. 2018. An ecological momentary assessment of cigarette and cigar dual use among African American young adults. *Nicotine and Tobacco Research* 20:S12-S21
122. Meneses-Gaya IC, Zuardi AW, Loureiro SR, Crippa JA. 2009. Psychometric properties of the Fagerstrom Test for Nicotine Dependence. *Jornal Brasileiro de Pneumologia* 35:73-82
123. Mogg K, Bradley B. 1998. A cognitive-motivational analysis of anxiety. *Behavior Research and Therapy* 36:809-48
124. Mogg K, Bradley BP, Field M, De Houwer J. 2003. Eye movements to smoking-related pictures in smokers: Relationship between attentional biases and implicit and explicit measures of stimulus valence. *Addiction* 98:825-36
125. Munafò M, Mogg K, Roberts S, Bradley BP, Murphy M. 2003. Selective processing of smoking-related cues in current smokers, ex-smokers and never-smokers on the modified Stroop task. *Journal of Psychopharmacology* 17:310-6
126. Murray D, Cox JL. 1990. Screening for depression during pregnancy with the Edinburgh Depression Scale. *Journal of Reproductive and Infant Psychology* 8:99-107
127. Ng M, Freeman MK, Fleming TD, Robinson M, Dwyer-Lindgren L, et al. 2014. Smoking prevalence and cigarette consumption in 187 countries, 1980-2012. *Journal of the American Medical Association* 311:183-92
128. Niaura RS, Rohsenow DJ, Binkoff JA, Monti PM, Pedraza M, Abrams DB. 1988. Relevance of cue reactivity to understanding alcohol and smoking relapse. *Journal of Abnormal Psychology* 97:133-52
129. Nichter M, Nichter M, Adrian S, Goldade K, Tesler L, Muramoto M. 2008. Smoking and harm-reduction efforts among postpartum women. *Qualitative Health Research* 18:1184-94

130. Nides M. 2008. Update on pharmacologic options for smoking cessation treatment. *American Journal of Medicine* 121:S20-31
131. Nosen E, Woody SR. 2014. Acceptance of cravings: How smoking cessation experiences affect craving beliefs. *Behaviour Research and Therapy* 59:71-81
132. Notley C, Blyth A, Craig J, Edwards A, Holland R. 2015. Postpartum smoking relapse—a thematic synthesis of qualitative studies. *Addiction* 110:1712-23
133. Office of Disease Prevention and Health Promotion. 2019. *Maternal, Infant, and Child Health*.
134. Office of the Surgeon General. 2014. The Health Consequences of Smoking—50 Years of Progress.
135. Okuyemi KS, Ahluwalia JS, Banks R, Harris KJ, Mosier MC, et al. 2003. Differences in smoking and quitting experiences by levels of smoking among African Americans. *Ethnicity & Disease* 14:127-33
136. Park R, Chang Y, Quinn V, Regan S, Cohen L, et al. 2009. The association of depressive, anxiety, and stress symptoms and postpartum relapse to smoking: A longitudinal study. *Nicotine & Tobacco Research* 11:707-14
137. Pérez-Stable EJ, Herrera B, Jacob P, Benowitz NL. 1998. Nicotine metabolism and intake in African American and Caucasian smokers. *Journal of the American Medical Association* 280:152-6
138. Perkins KA, Levine MD, Marcus MD, Shiffman S. 1997. Addressing women's concerns about weight gain due to smoking cessation. *Journal of Substance Abuse Treatment* 14:173-82
139. Petersen SE, Posner MI. 2012. The attention system of the human brain: 20 years after. *Annual Review of Neuroscience* 35:73-89
140. Pettit JW, Bechor M, Rey Y, Vasey MW, Abend R, et al. 2020. A randomized controlled trial of attention bias modification treatment in youth with treatment-resistant anxiety disorders. *Journal of the American Academy of Child & Adolescent Psychiatry* 59:157-65
141. Pollak KI, Fish LJ, Lyna P, Peterson BL, Myers ER, et al. 2016. Efficacy of a Nurse-Delivered Intervention to Prevent and Delay Postpartum Return to Smoking: The Quit for Two Trial. *Nicotine and Tobacco Research* 18:1960-6
142. Pollak KI, Fish LJ, Lyna P, Peterson BL, Swamy GK, Levine MD. 2015. Predictors of pregnant quitters' intention to return to smoking postpartum. *Nicotine and Tobacco Research* 17:742-5
143. Pomerleau CS, Carton SM, Lutzke ML, Flessland KA, Pomerleau OF. 1994. Reliability of the Fagerstrom Tolerance Questionnaire and the Fagerstrom Test for Nicotine Dependence. *Addictive Behavior Reports* 19:33-9
144. Powell J, Dawkins L, West R, Powell J, Pickering A. 2010. Relapse to smoking during unaided cessation: Clinical, cognitive and motivational predictors. *Psychopharmacology* 212:537-49
145. Preacher KJ, Zyphur MJ, Zhang Z. 2010. A general multilevel SEM framework for assessing multilevel mediation. *Psychological Methods* 15:209-33
146. Quesada O, Gotman N, Howell HB, Funai EF, Rounsaville BJ, Yonkers KA. 2012. Prenatal hazardous substance use and adverse birth outcomes. *The Journal of Maternal-Fetal & Neonatal Medicine* 25:1222-7

147. Raikes HA, Thompson RA. 2005. Efficacy and social support as predictors of parenting stress among families in poverty. *Infant Mental Health Journal* 26
148. Rehme AK, Bey K, Frommann I, Mogg K, Bradley BP, et al. 2018. Selective attention to smoking cues in former smokers. *European Neuropsychopharmacology* 28:276-84
149. Reitzel LR, Vidrine JI, Businelle MS, Kendzor DE, Costello TC, et al. 2010. Preventing postpartum smoking relapse among diverse low-income women: A randomized clinical trial. *Nicotine Tobacco Research* 12:326-35
150. Rinck M, Wiers RW, Becker ES, Lindenmeyer J. 2018. Relapse prevention in abstinent alcoholics by cognitive bias modification: Clinical effects of combining approach bias modification and attention bias modification. *Journal of Consulting and Clinical Psychology* 86:1005-16
151. Ripley-Moffitt CE, Goldstein AO, Fang WL, Butzen AY, Walker S, Lohr JA. 2008. Safe babies: A qualitative analysis of the determinants of postpartum smoke-free and relapse states. *Nicotine & Tobacco Research* 10:1355-64
152. Robinson CD, Waters AJ, Kang N, Sofuoglu M. 2017. Neurocognitive function as a treatment target for Tobacco Use Disorder. *Current Behavioral Neuroscience Reports* 4:10-20
153. Robinson WS. 1950. Ecological correlations and the behavior of individuals. *American Sociological Review* 15:251-7
154. Rooke SE, Hine DW, Thorsteinsson EB. 2008. Implicit cognition and substance use: A meta-analysis. *Addictive Behaviors* 33:1314-28
155. Rosse RB, Miller MW, Hess AL, Alim TN, Deutsch SI. 1993. Measures of visual scanning as a predictor of cocaine cravings and urges. *Biological Psychiatry* 33:554-6
156. Rottenberg J. 2005. Mood and emotion in major depression. *Current Directions in Psychological Science* 14:167-70
157. Rowley DL, Hogue CJ, Blackmore CA, Ferre CD, Hatfield-Timajchy K, et al. 1993. Preterm delivery among African-American women: A research strategy. *American Journal of Preventive Medicine* 9:1-6
158. Saladin ME, McClure EA, Baker NL, Carpenter MJ, Ramakrishnan V, et al. 2015. Increasing progesterone levels are associated with smoking abstinence among free-cycling women smokers who receive brief pharmacotherapy. *Nicotine & Tobacco Research* 17: 398-406
159. Sandberg A, Skold C, Grunewald J, Eklund A, Wheelock A. 2011. Assessing recent smoking status by measuring exhaled carbon monoxide levels. *Plos One* 6
160. Sanjuan PM, Pearson MR, Poremba C, Amaro HDLA, Leeman L. 2019. An ecological momentary assessment study examining posttraumatic stress disorder symptoms, prenatal bonding, and substance use among pregnant women. *Drug and Alcohol Dependence* 195,:33-9.
161. Sanjuan PM, Pearson MR, Poremba C, Amaro HDLA, Leeman L. 2019 An ecological momentary assessment study examining posttraumatic stress disorder symptoms, prenatal bonding, and substance use among pregnant women. *Drug and Alcohol Dependence* 195:33-9.
162. Sayette MA, Shiffman S, Tiffany ST, Niaura RS, Martin CS, Schadel WG. 2000. The measurement of drug craving. *Addiction* 95:189-210

163. Schoenmakers T, Wiers RW, Jones BT, Bruce G, Jansen ATM. 2007. Attentional re-training decreases attentional bias in heavy drinkers without generalization. *Addiction* 102:399-405
164. Schwartz JE, Stone AA. 2007. The analysis of real-time momentary data: A practical guide. *Self-reports in Health Research*:76-113
165. Serre F, Fatseas M, Debrabant R, Alexandre JM, Auriacombe M, Swendsen J. 2012. Ecological momentary assessment in alcohol, tobacco, cannabis and opiate dependence: A comparison of feasibility and validity. *Drug and Alcohol Dependence* 126:118-23
166. Shadel WG, Martino SC, Setodji C, Cervone D, Witkiewitz K, et al. 2011. Lapse-induced surges in craving influence relapse in adult smokers: An experimental investigation. *Health Psychology* 30:588-96
167. Sheehan M, Sheehan D, Lecrubier Y, Harnett Sheehan K, Janavs J, et al. 1997. The validity of the mini international neuropsychiatric interview (MINI) according to the SCID-P and its reliability. *European Psychiatry* 12:232-41
168. Shiffman S. 2009. Ecological momentary assessment (EMA) in studies of substance use. *Psychological Assessment* 21:486-97
169. Shiffman S, Paty JA, Gnys M, Kassel JA, Hickcox M. 1996. First lapses to smoking: Within-subjects analysis of real-time reports. *Journal of Consulting and Clinical Psychology* 64:366-79
170. Shiffman S, Stone AA, Hufford MR. 2008. Ecological momentary assessment. *Annual Review of Clinical Psychology* 4:1-32
171. Shiffman S, Waters AJ. 2004. Negative affect and smoking lapses: A prospective analysis. *Journal of Consulting and Clinical Psychology* 72:192-201
172. Shisler S, Homish GG, Molnar DS, Schuetze P, Colder CR, Eiden RD. 2016. Predictors of changes in smoking from third trimester to 9 months postpartum. *Nicotine & Tobacco Research* 18:84-7
173. Siahpush M, Carlin JB. 2006. Financial stress, smoking cessation and relapse: Results from a prospective study of an Australian national sample. *Addiction* 101:121-7
174. Silagy C, Lancaster T, Stead L, Mant D, Fowler G. 2004. Nicotine replacement therapy for smoking cessation. *Cochrane Database of Systematic Reviews*:CD000146
175. Siu AL. 2015. Behavioral and Pharmacotherapy Interventions for Tobacco Smoking Cessation in Adults, Including Pregnant Women: U.S. Preventive Services Task Force Recommendation Statement. *Annals of Internal Medicine* 163:622-34
176. Slopen N, Kontos EZ, Ryff CD, Ayanian JZ, Albert MA, Williams DR. 2013. Psychosocial stress and cigarette smoking persistence, cessation, and relapse over 9-10 years: A prospective study of middle-aged adults in the United States. *Cancer Causes Control* 24:1849-63
177. Smith PH, Kasza KA, Hyland A, Fong GT, Borland R, et al. 2015. Gender differences in medication use and cigarette smoking cessation: Results from the International Tobacco Control Four Country Survey. *Nicotine & Tobacco Research* 17:463-72

178. Sobell LC, Sobell MB. 1992. *Timeline Follow-back: A technique for assessing self-reported alcohol consumption*. New Jersey: Humana Press
179. Solomon L, Quinn V. 2004. Spontaneous quitting: Self-initiated smoking cessation in early pregnancy. *Nicotine and Tobacco Research* 6 Suppl 2:S203-16
180. Spielberger CD, In RD, Lexington MA. 1986. *Psychological determinants of smoking behavior*. pp 89-134. 89-134
- SRC - BaiduScholar pp.
181. Spoozak L, Gotman N, Smith MV, Belanger K, Yonkers KA. 2008. Evaluation of a social support measure that may indicate risk of depression during pregnancy. *Journal of Affective Disorders* 114:216-23
182. Stahl SM. 2013. *Stahl's Essential Psychopharmacology: Neuroscientific Basis and Practical Applications*, . Cambridge, UK: Cambridge University Press.
183. Stead JD, Jeffreys AJ. 2002. Structural analysis of insulin minisatellite alleles reveals unusually large differences in diversity between Africans and non-Africans. *American Journal of Human Genetics* 71:1273-84
184. Stead LF, Perera R, Bullen C, Mant D, Hartmann-Boyce J, et al. 2012. Nicotine replacement therapy for smoking cessation. *Cochrane Database of Systematic Reviews* 11:CD000146
185. Stein RJ, Pyle SA, Haddock CK, Poston WSC, Bray R, Williams J. 2008. Reported stress and its relationship to tobacco use among U.S. military personnel. *Military medicine* 173:271-7
186. Stennett A, Krebs NM, Liao J, Richie JP, Jr., Muscat JE. 2018. Ecological momentary assessment of smoking behaviors in native and converted intermittent smokers. *American Journal of Addiction* 27:131-8
187. Stewart DW, Adams CE, Cano MA, Correa-Fernández V, Li, Y., , Waters AJ, Vidrine JJ. 2013. Associations between health literacy and established predictors of smoking cessation. *American Journal of Public Health* 103
188. Stone AA, Shiffman S. 2002. Capturing momentary, self-report data: A proposal for reporting guidelines. *Annals of Behavioral Medicine* 24:236-43
189. Tiffany ST, Drobes DJ. 1991. The development and initial validation of a questionnaire on smoking urges. *British Journal of Addiction* 86:1467-76
190. Trinidad DR, Gilpin EA, Lee L, Pierce JP. 2004. Do the majority of Asian-American and African-American smokers start as adults. *American Journal of Preventive Medicine* 26:156-8
191. Trinidad DR, Perez-Stable EJ, White MM, Emery SL, Messer K. 2011. A nationwide analysis of US racial/ethnic disparities in smoking behaviors, smoking cessation, and cessation-related factors. *American Journal of Public Health* 101:699-706
192. Twisk JW. 2006. *Applied multilevel analysis: A practical guide for medical researchers*. . Cambridge university press.
193. U.S. Department of Commerce. 2012. National Cancer Institute-sponsored Tobacco Use Supplement to the Current Population Survey (2010-2011). *Commerce Bureau*:2010-1

194. U.S. Department of Health and Human Services. 1998. Tobacco Use Among U.S. Racial/Ethnic Minority Groups— African Americans, American Indians, and Alaska Natives, Asian Americans and Pacific Islanders, and Hispanics
195. U.S. Department of Health and Human Services. 2006. The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General. . Atlanta, GA
196. U.S. Health and Human Services. 2014. The health consequences of smoking — 50 years of progress a report of the Surgeon General
197. Ussher M, Etter JF, Giatras N, Coleman T. 2012. Tobacco withdrawal symptoms and urges to smoke in pregnant versus non-pregnant smokers. *Addictive Behavior* 37:1353-7
198. Verplaetse TL, Moore KE, Pittman BP, Roberts W, Oberleitner LM, et al. 2018. Intersection of stress and gender in association with transitions in past year DSM-5 substance use disorder diagnoses in the United States. *Chronic Stress*
199. Von Kohorn I, Nguyen SN, Schulman-Green D, Colson ER. 2012. A qualitative study of postpartum mothers' intention to smoke. *Birth* 39:65-9
200. Wagner NJ, Camerota M, Propper C. 2017. Prevalence and perceptions of electronic cigarette use during pregnancy. *Maternal and Child Health Journal* 21:1655-61
201. Waters AJ, Li Y. 2008. Evaluating the utility of administering a reaction time task in an ecological momentary assessment study. *Psychopharmacology* 197:25-35
202. Waters AJ, Shiffman S, Sayette MA, Paty JA, Gwaltney CJ, Balabanis MH. 2003. Attentional bias predicts outcome in smoking cessation. *Health Psychology* 22:378-87
203. Wen KY, Miller SM, Roussi P, Belton TD, Baman J, et al. 2015. A content analysis of self-reported barriers and facilitators to preventing postpartum smoking relapse among a sample of current and former smokers in an underserved population. *Health Education Research* 30:140-51
204. White TJ, Redner R, Skelly JM, Higgins ST. 2014. Examining educational attainment, prepregnancy smoking rate, and delay discounting as predictors of spontaneous quitting among pregnant smokers. *Experimental and Clinical Psychopharmacology* 22:384-91
205. Whittington JR, Simmons PM, Phillips AM, Gammill SK, Cen R, et al. 2018. The use of electronic cigarettes in pregnancy: A review of the literature. *Obstetrical & Gynecological Survey* 73:544-9
206. Wiers RW, Boffo M, Field M. 2018. What's in a trial? On the importance of distinguishing between experimental lab studies and randomized controlled trials: The case of cognitive bias modification and alcohol use disorders. *Journal of Studies on Alcohol and Drugs* 79:333-43
207. Wiers RW, Van Dessel P, Kopetz C. 2020. ABC Training: A new theory-based form of cognitive bias modification to foster automatization of alternative choices in the treatment of addiction and related disorders. *Current Directions in Psychological Science*
208. World Health Organization. 2013. *WHO recommendations for the prevention and management of tobacco use and second-hand smoke exposure in pregnancy.*
209. World Health Organization. 2017. *Prevalence of tobacco smoking.*

- 210. Wray JM, Gass JC, Tiffany ST. 2013. A systematic review of the relationships between craving and smoking cessation. *Nicotine & Tobacco Research* 15:1167-82
- 211. Yang C, Linas B, Kirk G, Bollinger R, Chang L, et al. 2015. Feasibility and acceptability of smartphone-based ecological momentary assessment of alcohol use among African American men who have sex with men in Baltimore. *Journal of Medical Internet Research* 3:67
- 212. Yonkers KA, Gotman N, Kershaw T, Forray A, Howell HB, Rounsaville BJ. 2010. Screening for prenatal substance use: Development of the Substance Use Risk Profile-Pregnancy scale. *Obstetrical & Gynecological Survey* 116:827
- 213. Zhu SH, Valbo A. 2002. Depression and smoking during pregnancy. *Addictive Behaviors* 27:649-58



UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES

SCHOOL OF MEDICINE GRADUATE PROGRAMS

Graduate Education Office (A 1045), 4301 Jones Bridge Road, Bethesda, MD 20814



FINAL EXAMINATION/PRIVATE DEFENSE FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE DEPARTMENT OF MEDICAL AND CLINICAL PSYCHOLOGY

Name of Student: Rebekah Gunter

Date of Examination: September 11, 2020

Time: 9:00 AM

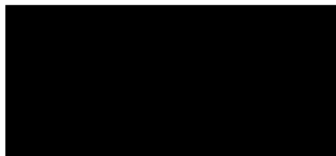
DECISION OF EXAMINATION COMMITTEE MEMBERS:

PASS FAIL



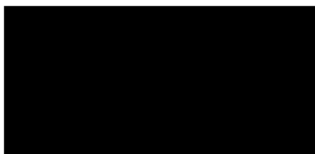
X

Dr. Tracy Sbrocco
DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY
Committee Chairperson



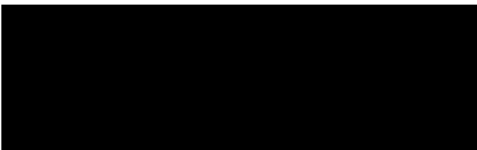
X

Dr. Andrew J. Waters
DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY
Dissertation Advisor



X

Dr. Joshua Gray
DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY
Committee Member



X

Dr. Laura Juliano
AMERICAN UNIVERSITY
Committee Member