ABSTRACT

Title of Document: GENDER, BEHAVIORAL ASSESSMENT OF NEGATIVE REINFORCEMENT DRIVEN RISK TAKING PROPENSITY, AND CIGARETTE SMOKING

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Cigarette smoking remains the leading preventable cause of death and disability in the United States and most often is initiated during adolescence. An emerging body of research suggests that a negative reinforcement model may explain factors that contribute to tobacco use during adolescence and that negative reinforcement processes may contribute to tobacco use to a greater extent among female adolescents than among male adolescents. However, the extant literature both on the relationship between negative reinforcement processes and adolescent tobacco use as well as on the relationship between gender, negative reinforcement processes, and adolescent tobacco use is limited by the sole reliance on self-report measures of negative reinforcement processes that may contribute to cigarette smoking. The current study aimed to further disentangle the relationships between negative reinforcement based risk taking, gender and tobacco use during older adolescence by utilizing a behavioral analogue measure of negative reinforcement based risk taking, the Maryland

Resource for the Behavioral Utilization of the Reinforcement of Negative Stimuli (MRBURNS). Specifically, we examined the relationship between pumps on the MRBURNS, an indicator of risk taking, and smoking status as well as the interaction between MRBURNS pumps and gender for predicting smoking status. Participants included 103 older adolescents (n=51 smokers, 50.5% female, Age (*M*(*SD*) = 19.41(1.06)) who all attended one experimental session during which they completed the MRBURNS as well as self-report measures of tobacco use, nicotine dependence, alcohol use, depression, and anxiety. We utilized binary logistic regressions to examine the relationship between MRBURNS pumps and smoking status as well as the interactive effect of MRBURNS pumps and gender for predicting smoking status. Controlling for relevant covariates, pumps on the MRBURNS did not significantly predict smoking status and the interaction between pumps on the MRBURNS and gender also did not significantly predict smoking status. These findings highlight the importance of future research examining various task modifications to the MRBURNS as well as the need for replications of this study with larger, more diverse samples.

GENDER, BEHAVIORAL ASSESSMENT OF NEGATIVE REINFORCEMENT DRIVEN RISK TAKING PROPENSITY, AND CIGARETTE SMOKING

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Chapter 1: Introduction

Cigarette Smoking

Cigarette smoking is the leading preventable cause of death and disability in the United States, estimated to kill 480,000 people annually (U.S. Department of Health and Human Services (USDHHS), 2014). Millions more currently live with tobacco-related illness as the combined costs of medical care and lost productivity associated with tobacco-related health conditions approach $300 billion annually (USDHHS, 2014). Despite the grave health consequences associated with tobacco use, approximately 22.1% of U.S. residents ages 12 and older currently smoke cigarettes (Substance Abuse and Mental Health Services Administration (SAMHSA), 2013). In light of the enormous public health impact of tobacco use in the U.S., understanding factors that contribute to tobacco use across the lifespan is vitally important.

Cigarette Smoking and Adolescence

Adolescence is a critical period for both smoking initiation as well as progression, with the vast majority of adult cigarette smokers reporting initiating cigarette smoking and beginning to smoke daily before age 18 (SAMHSA, 2013). Despite declines in use over time, approximately 10% of teens in grades 8 through 10 report smoking cigarettes in the last month (Johnston et al., 2014). Further, risk for smoking initiation continues following high school, as recent research suggests that a substantial number of smokers begin smoking during college (Costa, Jessor, & Turbin, 2007; Myers, Doran, Trinidad, Klonoff, & Wall, 2009).

A developmental perspective is useful for understanding the initiation, progression, and maintenance of tobacco use during adolescence. From a developmental perspective, the transition from childhood to adolescence is a critical period characterized by rapid changes in biological (Casey, Tottenham, Liston, & Durston, 2005; Crews, He, & Hodge, 2007), psychological (Costello, Copeland, & Angold, 2011; Costello, Mustillo, Erkanli, Keeler, & Angold, 2003), and social (Chassin, Presson, Sherman, Montello, & McGrew, 1986) processes and domains. Consequently, between childhood and adolescence, rates of internalizing and substance use disorders dramatically increase (Costello et al., 2011). This increase in psychopathology is coupled with a slowly developing neuroregulatory cognitive control system (Steinberg, 2007) as well as significant changes in school and peer relationships, which may be sources of stress for at risk youth (Windle et al., 2008).

As a result of these rapid developmental shifts, adolescence is a period of heightened risk taking, such that adolescents take more risks than any other developmental group (Steinberg, 2004, 2007), and, by extension, may be more vulnerable to tobacco initiation, escalation, and maintenance. Consistent with this developmental framework, smoking prevalence continues to increase throughout adolescence, such that 17.3% of college-aged older adolescents smoke cigarettes (Centers for Disease Control and Prevention (CDC), 2014). Further, during the transition from high school to college, older adolescents with histories of smoking cigarettes during high school are more likely to become heavy smokers (Patterson, Lerman, Kaufmann, Neuner, & Audrain-McGovern, 2004) and those who did not smoke during high school are at risk for experimenting with cigarette smoking and for becoming social smokers during college (Wetter et al., 2004).

The majority of these adolescents will continue to smoke into adulthood and, if these rates continue, 5.6 million Americans who are currently younger than 18 years of age are projected to die prematurely due to tobacco-related disease (USDHHS, 2014). Taken together, adolescence is an important period for the development of tobacco use. As such, examining factors that contribute to cigarette smoking during adolescence and throughout the course of adolescence is crucial.

Cigarette Smoking and Negative Reinforcement

In light of developmental shifts during adolescence, which can all lead to heightened negative affect as well as heightened sensitivity to negative affect (Spear, 2009), a negative reinforcement model of tobacco use during adolescence fits well. Negative reinforcement models suggest that the motivational basis of addictive drug use is the reduction or avoidance of aversive internal states (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Eissenberg, 2004). Indeed, across studies, negative reinforcement processes have been implicated in tobacco initiation as well as in escalation and maintenance of tobacco use over time (for a broad review of negative reinforcement processes and cigarette smoking, see Eissenberg, 2004). Below, in turn, we review the literature on negative reinforcement processes in adolescent cigarette smoking across initiation and escalation/maintenance.

Initiation. Youth who report expectations of negative reinforcement from cigarette smoking are more likely to initiate smoking cigarettes than youth who do not report or who report lower levels of such expectations. For example, Wang and colleagues (1996) found that adolescents included in the Teenage Attitudes and Practices Survey (TAPS; Moss, Allen, Giovino, & Mills, 1992) were at twice the risk for experimental cigarette smoking if they endorsed “cigarette smoking helps people relax” and were at similar risk for experimental smoking if they endorsed “smoking helps people feel more comfortable at parties and in other situations.” Additionally, among a sample of approximately 700 high school students, Pallonen and colleagues (1998) found that adolescent never smokers were most likely to report a desire to try smoking cigarettes, which may serve as a precursor to smoking initiation, if they also endorsed the belief that cigarette smoking would help to reduce negative mood and increase positive mood. Further, Wills and colleagues (2006) found that among a sample of youth ages 11-17, self-reported emotion regulation was related to substance use including tobacco use such that youth who self-reported lower levels of emotion regulation were more likely to have used substances than youth reporting higher levels of emotion regulation.

Escalation/Maintenance. Beyond initiation, negative reinforcement processes also play a key role in the escalation and maintenance of tobacco use over time. Wetter and colleagues (2004) found that among a sample of 548 college students who were occasional smokers (defined as smoking “every few days”), smoking more cigarettes per smoking day was associated with endorsement of higher levels of negative reinforcement expectancies from cigarette smoking as well as with higher levels of expectancies of affective control from cigarette smoking. These students were followed longitudinally for four years. At the four-year follow-up, among students who were occasional smokers at baseline, both endorsement of negative reinforcement expectancies as well as endorsement of expectancies of affective control from cigarette smoking placed students at risk for continuing to smoke at the four-year follow-up (Wetter et al., 2004). Other studies have found that expectation of negative affect regulation as a result of cigarette smoking is related to both changes in negative and positive mood following smoking, such that adolescent smokers higher in negative affect regulation expectancies have greater reductions in negative affect and greater increases in positive affect following smoking (Colvin & Mermelstein, 2010; Kassel et al., 2007), which may promote the continuation of smoking over time among adolescents who expect that smoking will help to regulate negative affect.

Additionally, reinforcement smoking, defined as the tendency to smoke to regulate affect, appears to moderate the relationship between low positive affect and urge to smoke such that older adolescent smokers high in reinforcement smoking experience the greatest urge to smoke under conditions of low positive affect (Leventhal, 2010). This relationship may be most important among adolescents with depressive symptomatology who are at greater risk for heightened negative affect and low positive affect. Indeed, depressive symptoms across mid to late adolescence are predictive of subsequent increases in the smoking reward expectancies, which are in turn predictive of an increase in smoking over time (Audrain-McGovern, Rodriguez, Rodgers, et al., 2012)

Moving beyond self-report measurements of negative reinforcement smoking expectancies to measurements of negative mood and negative mood modulation as a result of smoking, Weinstein and colleagues (2008) found that, among a sample of 517 8th and 10th grade students who were followed over the course of a year using ecological momentary assessment methodology, negative mood variability at baseline differentiated those adolescents who escalated from smoking experimentation (smoking less than or equal to one cigarette per month) during the one-year period from those adolescents who did not progress beyond smoking experimentation during the course of the year. Among the adolescents who did escalate beyond smoking experimentation during the course of the year, as smoking levels increased, negative mood variability decreased. This suggests that variability in negative mood may be both a risk factor for smoking experimentation as well as for smoking escalation and that smoking may be maintained overtime due to the negative reinforcement process whereby smoking serves to stabilize negative mood. Additional support for this relationship has also been found. Audrain-McGovern and colleagues (2012) found that among a large sample of adolescents, low hedonic capacity, defined as the inability to experience pleasure, placed adolescents at heightened risk for having smoked a cigarette in the last month and was predictive of a 90% increase in smoking over the subsequent 18 months. This fits well with a negative reinforcement framework such that the inability to experience pleasure may be alleviated by cigarette smoking, which may promote the escalation and continuation of smoking over time.

Taken together, negative reinforcement processes play a crucial role both in the initiation of smoking as well as in differentiating those adolescents who will progress to regular smoking. Beyond escalation of smoking, tobacco use may be maintained over time such that negative affect and/or the expectation that cigarette smoking will help to modulate negative affect contributes to continued tobacco use and then subsequent decreases in negative affect and increases in positive affect following smoking reinforce cigarette smoking.

Gender Differences in Negative Reinforcement Processes Contributing to Smoking

Although support has been found for the role of negative reinforcement processes in tobacco initiation, escalation, and maintenance during adolescence, this relationship may be more nuanced. Across development, the relationship between negative reinforcement processes and cigarette smoking may vary by gender such that negative reinforcement processes may contribute to tobacco use to a greater extent for women than for men. Additionally, gender has also been found to play a role in the relationship between negative reinforcement processes and cessation.

Regarding gender differences in the relationship between negative reinforcement processes and stages of adolescent tobacco use, "emotional dependence" motives for smoking, which map on well to negative reinforcement expectations for smoking (e.g., "I need to smoke when I am stressed," "I need to smoke when I am sad or depressed"), are positively related to number of cigarettes smoked per smoking day for adolescent female smokers, but not for adolescent male smokers (Richardson, Memetovic, Ratner, & Johnson, 2011). Additionally, adolescent female smokers are more likely to have internalizing (depression, anxiety) symptoms than male smokers (Richardson, He, Curry, & Merikangas, 2012) and vulnerability to such internalizing symptoms is related to smoking status among older adolescent females, but not males (Morrell, Cohen, & McChargue, 2010). Teasing apart this unique relationship between female gender, internalizing symptomatology, and cigarette smoking, for female older adolescent smokers only, the relationship between depression vulnerability and smoking status is mediated by expectation of negative affect reduction such that depression vulnerability leads to expectation of negative affect reduction from smoking, which in turn contributes to smoking status (Morrell et al., 2010). In light of the above presented findings that depression places youth at risk for increases in tobacco use over time by increasing expectations of reward from smoking, adolescent females may be more at risk for escalation of smoking over time due to the unique risks associated with elevated depressive symptoms (Audrain-McGovern, Rodriguez, Rodgers, et al., 2012).

In addition to gender differences in affective vulnerabilities for smoking initiation and escalation, recent research supports a unique relationship between gender, negative reinforcement driven tobacco use, and abstinence-induced negative affect, such that during tobacco abstinence, older adolescent female smokers have greater increases in abstinence-induced negative affect than male smokers (Leventhal et al., 2007; Pang & Leventhal, 2013). Considering that abstinence-induced negative affect is thought to contribute to the transition from intermittent to dependent smoking (Baker, Brandon, & Chassin, 2004), this suggests that female older adolescent smokers may be at greater risk as compared to their male counterparts for continuing to smoke over time. In sum, the extent to which negative reinforcement processes contribute to the initial stages of tobacco use and to escalation of tobacco use over time may be more pertinent for adolescent females than for males.

Moving beyond smoking initiation and progression to smoking cessation, a large body of research suggest that across the lifespan, female smokers are less motivated to quit smoking than are male smokers (Branstetter, Blosnich, Dino, Nolan, & Horn, 2012), are less likely to initiate a quit attempt (Haug, Schaub, & Schmid, 2014), and are less likely to successfully quit smoking (Amos, Greaves, Nichter, & Bloch, 2011). Additionally, while gender differences in abstinence-induced negative affect convey risk for smoking escalation among female smokers, this gender disparity may also place female smokers at heightened risk for relapse after initiating a cessation attempt as female smokers may experience more abstinence-induced negative affect than male smokers (Leventhal et al., 2007; Pang & Leventhal, 2013). Thus, a negative reinforcement pathway, whereby adolescent female tobacco use may be both initiated and perpetuated in order to regulate negative affect, may underlie gender differences in smoking cessation (Branstetter et al., 2012; Haug et al., 2014).

These gender differences in negative reinforcement processes contributing to tobacco use that emerge during adolescence continue into adulthood. Across studies, female adult smokers appear to be less sensitive than male smokers to the acute pharmacological effects of nicotine and more sensitive to non-pharmacological aspects of smoking, such as learned associations between cigarette smoking and reductions in negative affective states (for review, see Perkins, 1996). For example, Hogle & Curtin (2006) found that in response to a stressor, as compared to both male smokers and nicotine-satiated female smokers, nicotine-deprived female smokers had both significantly greater self-reported negative affect and salivary cortisol levels, a biological indicator of stress. Additionally, Perkins and colleagues (2006) found that among female smokers, knowledge of the nicotine dose of a cigarette being smoked significantly increased self-reported cigarette reward and reinforcement, whereas knowledge of the nicotine dose did not increase cigarette reward and reinforcement in male smokers. Further, Saladin and colleagues (2006) found that in response to negative affect induction cues, as compared to adult male smokers, adult female smokers reported significantly greater self-reported cigarette craving as well as greater subjective stress, arousal, and aversion. Thus, across both adolescent and adult samples, negative reinforcement processes may contribute to tobacco use to a greater extent for female smokers than for male smokers and, similar to the rationale presented for gender disparities in adolescent tobacco cessation, gender differences in negative affect may account for the continuation of gender disparities in tobacco cessation into adulthood (Amos et al., 2011; Hymowitz et al., 1997; Nides et al., 1995; although also see Jarvis, Cohen, Delnevo, & Giovino, 2013 for a discussion of sample issues in studies reporting gender differences in cessation rates).

Together, there is support for gender differences in the magnitude of the relationship between negative reinforcement processes and tobacco use across development. Thus, in addressing the need for additional research on mechanisms that contribute to adolescent tobacco use, particularly negative reinforcement mechanisms, gender may be a key factor that influences the relationship between negative reinforcement processes and tobacco use during adolescence and throughout development. Next, we turn to a discussion of limitations in the extant literature that addresses the relationship between negative reinforcement and cigarette smoking and follow with proposed next steps for addressing these limitations.

Limitations in the Extant Literature on Negative Reinforcement and Cigarette Smoking

Despite consistent relationships found across studies suggesting that negative reinforcement processes contribute to tobacco use and that gender affects the magnitude of this relationship, the extant literature on the relationship between negative reinforcement processes and cigarette smoking is limited by the sole use of self-report measures for assessing negative reinforcement constructs. In the studies outlined above, self-reports are used to measure expectancies of negative reinforcement from smoking, changes in negative affect as a result of smoking abstinence and smoking satiety, and psychopathology. The sole reliance on self-report measures for disentangling the relationships between negative reinforcement processes and smoking as well as between gender, negative reinforcement processes, and smoking is concerning for a number of reasons. First, the accuracy of reporting as well as the accuracy of observed relationships may be questionable due to lack of insight among adolescent smokers into motives for smoking (Cyders & Coskunpinar, 2011; Shiffman, 1993). Second, the validity of self-report measures may be limited due to the sensitive nature of risky behaviors such as cigarette smoking (Lejuez et al., 2002). Third, self-report measures are thought to assess trait levels of behavior; thus, the ability of such measures to predict state levels of behavior, such as in response to differing contextual factors (e.g., stress, the effect of peers), may be limited (Cyders & Coskunpinar, 2011). Fourth, the sole reliance on self-report measures to understand negative reinforcement processes underlying adolescent tobacco use limits the ability to be able to predict which adolescents may be at risk for tobacco initiation as constructs such as negative reinforcement expectancies may become more crystallized as an individual has more experience with cigarette smoking (Copeland et al., 2007). With these limitations in mind, there is a need to supplement and extend the extant literature regarding the role of negative reinforcement processes, gender, and adolescent tobacco use with assessments other than self-report measures.

Behavioral Assessment of Negative Reinforcement

Behavioral assessment of negative reinforcement processes can provide a complement to the sole use of self-report measures to examine the relationship between negative reinforcement processes and adolescent tobacco use. As discussed above, cigarette smoking can be conceptualized as a risk taking behavior. Further, the propensity to take risks exists on a continuum, such that some risk taking may be adaptive, but more extreme levels of risk taking, which may be more predictive of youth susceptibility to tobacco use, may be maladaptive (e.g., Lejuez, Aklin, Jones, et al., 2003; Lejuez et al., 2002). As such, a behavioral assessment of negative reinforcement driven risk taking would be the best fit for understanding the relationship between negative reinforcement processes and tobacco use among adolescents.

Similar behavioral assessments have been used to examine the role of positive reinforcement based, or appetitive, risk taking in youth tobacco use across stages of smoking. Utilizing the Balloon Analogue Risk Task (BART), a behavioral analogue task that assesses appetitive risk taking, Lejuez and colleagues (2005) found that among inner city adolescents, BART risk taking discriminated between ever (smoking at least one puff) and never smokers such that riskier behavior on the BART was associated with increased odds of ever smoking. Among high school students, BART risk taking is also related to smoking status (smoking at least five cigarettes per day), such that smokers are riskier than nonsmokers on the BART (Schepis, McFetridge, Chaplin, Sinha, & Krishnan-Sarin, 2011). This relationship appears to extend into older adolescence, with Lejuez and colleagues (2003) finding that among older adolescent college students, risk taking on the BART was related to smoking status (smoking was defined as smoking at least one cigarette per day over the past six months), such that riskier behavior on the BART was associated with increased odds of being a cigarette smoker. Although these studies all support a positive relationship between appetitive risk taking and cigarette smoking, Ryan and colleagues (2013) found a negative relationship between BART risk taking and nicotine dependence, such that greater BART risk taking was associated with lower levels of nicotine dependence among a sample of college student smokers. Thus, the relationship between BART risk taking and smoking status may be different from the relationship between BART risk taking and nicotine dependence.

Whereas a number of behavioral measures exist for assessing the positive reinforcement component of risk taking (e.g., Figner, Mackinlay, Wilkening, & Weber, 2009; Lejuez et al., 2002; Pleskac, Wallsten, Wang, & Lejuez, 2008; Slovic, 1966), considerably fewer measures exist that offer a behavioral assessment of negative reinforcement based risk taking. One newly developed behavioral analogue task specifically designed to assess negative reinforcement processes that contribute to risk taking is The Maryland Resource for the Behavioral Utilization of the Reinforcement of Negative Stimuli (MRBURNS). The MRBURNS was designed as a complement to the Balloon Analogue Risk Task (BART; Lejuez et al., 2002), which has been extensively used to assess appetitive risk taking (e.g., Cazzell, Li, Lin, Patel,

& Liu, 2012; Lejuez, Aklin, Jones, et al., 2003; Lejuez, Aklin, Zvolensky, & Pedulla, 2003; Rao, Korczykowski, Pluta, Hoang, & Detre, 2008; White, Lejuez, & de Wit, 2008).

The MRBURNS is a computerized measure of negative reinforcement based risk taking behavior (MacPherson et al., 2012) and is the only currently available behavioral measure of negative reinforcement based risk taking, making it a prime candidate as an assessment measure for examining the role of negative reinforcement based risk taking in adolescent tobacco use. Preliminary work to validate the MRBURNS found that the task evidences sound experimental properties and internal consistency reliability across trials. Further, the MRBURNS evidences convergent and discriminant validity with theoretically-related and distinct constructs of interest. Specifically, risk taking on the MRBURNS is significantly positively related to negative urgency, emotion regulation difficulties, symptoms of depression, symptoms of anxiety, alcohol-related problems, and negative reinforcement based drinking motives and is unrelated to performance on the BART and self-reported sensation seeking and impulsivity. Risk taking on the MRBURNS is moderately stable over time as the task evidences adequate test-retest reliability over a one-year period (Dahne et al., 2015). Taken together, there are clear limitations to only using self-report measures to assess negative reinforcement constructs as they relate to adolescent tobacco use. Use of the MRBURNS, a behavioral analogue task that assesses negative reinforcement based risk taking, could be useful for filling this gap in the literature.

Summary and Significance

Cigarette smoking is a prevalent, deadly, and costly behavior that is most often initiated during adolescence. An emerging body of research suggests that a negative reinforcement model may explain factors that contribute to the initiation, progression, and maintenance of tobacco use during adolescence. Specifically, youth who are vulnerable to heightened negative affect and/or who endorse negative reinforcement/negative affect regulation expectancies for smoking, may be at greatest risk for tobacco initiation. Over time, tobacco use may be maintained as a tool to reduce or cope with negative affect. Further, although the literature on gender differences in negative reinforcement processes as they contribute to adolescent tobacco use is comparatively more limited, negative reinforcement processes may contribute to tobacco use to a greater extent among female adolescents than among male adolescents. However, the extant literature both on the relationship between negative reinforcement processes and adolescent tobacco use as well as on the relationship between gender, negative reinforcement processes, and adolescent tobacco use is limited by the sole reliance on self-report measures of negative reinforcement processes that may contribute to cigarette smoking. The sole use of self-report measures is concerning as the accuracy of self-reports may be questionable due to limited insight among adolescent smokers into motives for smoking as well as possibly limited validity of such self-reports due to the sensitive nature of cigarette smoking. As such, in order to further disentangle the relationships between gender, negative reinforcement processes, and adolescent tobacco use, it is necessary to supplement the extant literature by using a behavioral measure of negative reinforcement based risk taking, such as the MRBURNS. Considering the long-term consequences of cigarette smoking, it is important to get a clear understanding of processes that contribute to tobacco use during adolescence in order to create and improve targeted preventative and cessation programs in the future for at risk youth.

Present Study

The primary aims of the current study were two-fold: 1) To extend research with alcohol and provide the first explicit examination of the relationship between negative reinforcement based risk taking and smoking status (smoker, non-smoker) and 2) To examine gender as a moderator of the relationship between negative reinforcement based risk taking and smoking status (smoker, non-smoker) among a sample of older adolescent college students. To address these aims, participants were recruited based on cigarette smoking history and age and were categorized into either one of two groups: 1) smoker or 2) non-smoker. All participants attended one experimental session during which they completed a behavioral assessment of negative reinforcement based risk taking, the MRBURNS, as well as supplemental measures of smoking history, current smoking patterns, and related psychopathology. To our knowledge, this is the first study to examine the relationship between negative reinforcement based risk taking, gender, and smoking status using a behavioral assessment of negative reinforcement based risk taking. Study Aims:

Primary Aim: To examine the relationship between negative reinforcement based risk taking and smoking status (smoker, non-smoker) among a sample of older adolescents.

Hypothesis: Regular cigarette smokers will be significantly riskier on the MRBURNS as evidenced by a greater average number of average pumps on the task as compared to non-smokers.

Secondary Aim: To examine gender as a moderator of the relationship between negative reinforcement based risk taking and smoking status.

Hypothesis: The relationship between negative reinforcement based risk taking and smoking status will vary as a function of gender. Specifically, the association between negative reinforcement based risk taking and smoking status among females will be significantly stronger than the association between negative reinforcement based risk taking and smoking status among males.

Chapter 2: Research Design and Method

Participants

Participants were recruited from the University of Maryland, College Park campus using flyers and postings on internet message boards (e.g., campus listservs). Half of the recruitment materials announced a study for cigarette smokers, while the other half of recruitment materials simply advertised a study for individuals between the ages of 18 and 21. Interested individuals were advised to contact the study by phone or e-mail to complete an online screening to determine eligibility.

During the online screening, which took approximately five minutes, participants were asked demographic and psychiatric questions to determine their eligibility for the study. Fifty one participants were current regular smokers between the ages of 18 and 21 meeting the following inclusion criteria: (1) smoked at least 1 cigarette per day for the past 6 months and (2) smoked 20 or more days out of the last 30 days. Fifty two participants were nonsmokers, defined as never having smoked an entire cigarette, also between the ages of 18 and 21. Participants were yoked on gender and age and, as such, half of each group was female and half was male (see power analysis below for information regarding the decision to recruit approximately 50 smokers and 50 non-smokers as well as the decision to recruit an equal number of males and females in each smoking group).

Measures

1. *Timeline Followback (Brown et al., 1998).* Timeline Followback (TLFB) procedures were used to index number of cigarettes smoked and number of

standard alcoholic drinks consumed. The TLFB procedure has been established with adult alcoholics (Sobell & Sobell, 1996) and has good reliability and validity with adolescent (Lewis-Esquerre et al., 2005) and adult smokers (Brown et al., 1998). TLFB information was collected for the past 90 days. Alcohol use was examined as a potential covariate.

2. *NCI Smoking History and Current Status Indices (Shumaker & Grunberg, 1986).* Smoking history was assessed using the smoking history and current status indices agreed upon by a NCI consensus panel (1986) including: rate, brand, nicotine content, previous quit attempts and duration, household smokers, and onset age.

3. *Modified Fagerstrom Tolerance Questionnaire (mFTQ) (Prokhorov et al., 2000).* The mFTQ is a seven-item measure of nicotine dependence and was designed to assess degrees of tobacco dependence in adolescents (Prokhorov et al., 2000). The mFTQ has shown good internal consistency as well as positive relations with key smoking variables. The mFTQ was used to assess nicotine dependence of the smokers included in the study.

4. *The Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977).* The CES-D was originally constructed as a measure of depressive severity for community adults (Radloff, 1977). The items primarily measure affective and somatic aspects of depression. Considering gender differences in rates of depression among older adolescents, CES-D score was examined as a potential covariate.

5. *State-Trait Anxiety Inventory (STAI) (Spielberger, 1996).* The STAI consists of two 20-item subscales designed to measure state and trait anxiety. Internal reliability, test-retest reliability, and convergent and discriminant validity have been demonstrated for the state and trait scales in both younger (Spielberger, Gorsuch, Lushene, & Vagg, 1983) and older adults (Kabacoff, Segal, Hersen, & Van Hasselt, 1997). Both subscales of the STAI were used in the current study. Similar to the CES-D, the STAI subscales were examined as potential covariates.

6. *Maryland Resource for the Behavioral Utilization of the Reinforcement of Negative Stimuli (MRBURNS, MacPherson et al., 2011)*. The MRBURNS involves inflating balloons to reduce the aversiveness of noise with negative reinforcement indexed as greater reduction in the aversiveness of the noise based on increased balloon pumps. The MRBURNS consists of 30 trials, comprising three distinct phases. In phase 1, the automatic pump selection phase, participants are informed of the lottery amount for that trial and select the number of pumps they would like to apply to an uninflated balloon (0-128 pumps). In phase 2, the aversive noise phase, participants are exposed to aversive noise (85 decibels white noise delivered through headphones with an intermittent boat horn sound to limit habituation). The number of pumps is chosen at the outset of the trial and determines the duration of exposure; each pump reduces the duration by 0.15 seconds. Throughout the 19.2 s exposure phase, a visual display indicates the remaining amount of time the participant will be exposed to the aversive

noise. In phase 3, the consequence and lottery phase, an animated balloon is displayed. The balloon is incrementally inflated according to the number of pumps selected at trial outset. During this phase, the balloon is either safe or pops at the end of inflation. On each trial, the participant receives a winning lottery ball if the balloon is safe and a losing lottery ball if the balloon pops. Following the completion of all 30 trials, each participant uses their accumulated lottery balls in a lottery. The task begins with a guaranteed lottery win and each subsequent explosion reduces the likelihood of winning the lottery. The lottery is divided into six drawings with each successive five trials constituting one drawing. Lottery values are $1, $3, or $9. The lottery order is: $1, $9, $3, $9, $1, $3 for the six drawings. The primary index of risk-taking on the MRBURNS is average number of pumps (see MacPherson et al., 2012). For a schematic of the phases of the MRBURNS, see Figure 1.

Assessment Procedures

The study consisted of one session held at the Center for Addictions, Personality and Emotion Research (CAPER) at the University of Maryland, College Park. Participants completed consent procedures at the beginning of their session. Following consent, participants completed interviewer-administered, self-report, and computerized measures in a separate room. Participants first completed the TLFB for cigarettes smoked and number of alcoholic drinks consumed in the past month. Participants then completed self-report measures including: demographics questionnaire, smoking history questionnaire, mFTQ, CES-D, and STAI. Following self-report measure completion, participants completed the computerized MRBURNS. Self-report measures and the MRBURNS were counterbalanced to prevent order effects. Non-smokers did not complete the mFTQ. To account for time differences in measure completion between groups, non-smokers completed a self-report measure of activities they might enjoy doing. At the end of the session, participants were debriefed and compensated for participation. Participants who were smokers were also provided with information on local smoking cessation resources. Each experimental session lasted between 60 and 90 minutes. Participants received $10 for the experimental session and had the opportunity to earn up to an additional $30 based on their performance on the MRBURNS for a possible total of $40.

Data Analytic Plan

To address the primary study aim that negative reinforcement based risk taking on the MRBURNS will be predictive of smoking status, a binary logistic regression was used with smoking status (0=non-smoker, 1=smoker) as the dependent variable and average pumps on the MRBURNS as the independent variable. Demographic variables, depression, and anxiety were examined as potential covariates.

To examine the secondary study aim of gender as a moderator of the relationship between negative reinforcement based risk taking on the MRBURNS and smoking status, we followed the procedures outlined by Baron and Kenny (1986). Specifically, we utilized a hierarchical logistic regression and entered the main effects of MRBURNS risk taking and gender in the first step of the regression and the interaction between MRBURNS risk taking and gender in the second step of the regression. Significant moderator effects would be indicated by a significant interactive effect of MRBURNS risk taking and gender on smoking status when controlling for MRBURNS risk taking and gender.

Sample Size Considerations

For the proposed moderator of gender, some literature suggests a medium effect of approximately .50 to .60 (Morrell et al., 2010; Richardson et al., 2012). Assuming an effect size of .50 for the gender moderator, a total sample of 126 (63 in each gender group) would be required to achieve a power of .80 and an alpha of .05 using a two-tailed test, whereas assuming an effect size of .60, a total sample of 90 (45 in each gender group) would be required to achieve a power of .80 and an alpha of .05 using a two-tailed test. With this power analysis in mind, we recruited 51 males and 52 females. Half of the sample was smokers and half of the sample was non-smokers.

Chapter 3: Results

Descriptive Findings

Participants. One hundred three participants (n=51 smokers, 50.5% female, Age (*M*(*SD*) = 19.41(1.06)) screened eligible for the study and attended the experimental session. See Table 1 for demographic characteristics of the full sample. For smokers, average cigarettes per smoking day (CPSD) was obtained via the TLFB by dividing the total number of cigarettes smoked in the last month by the total number of days on which the participant smoked in the last month. Average CPSD for smokers was *M(SD)*=5.49(3.34). On average, participants first smoked at age 15.54(2.42) and began smoking regularly at age 17.52(1.62). Regarding nicotine dependence, levels were relatively low with *M* score for the mFTQ = 2.84(1.32; see Table 2).

MRBURNS Risk Taking. Risk taking on the MRBURNS was examined as average pumps per balloon across all 30 trials as well as average pumps within each lottery among ($1, $3, $9). On average across all trials, participant balloon inflation was 30.56 (23.81) pumps. Pumps decreased as a function of escalating risk such that participants pumped more for the $1 lottery trials than for the $3 trials $t(102) = 4.45$, $p < 0.001$ and pumped more for the $3 trials than for the $9 trials $t(102) = 8.78$, $p < 0.001$. ANOVA analyses were used to examine pumps on the MRBURNS as a function of smoking status as well as a function of gender. When examining MRBURNS pumps as a function of smoking status, there was not a significant main effect of smoking status on MRBURNS average pumps ($F(1, 101) = 1.17$, $p = 0.28$) or average pumps at the $1 ($F(1, 101) = 1.43$, $p = 0.23$), $3 ($F(1, 101) = 0.54$, $p =$

0.47), or \$9 ($F(1, 101) = 0.61$, $p = 0.44$) lottery amounts. When examining MRBURNS pumps as a function of gender, there was a significant main effect of gender on MRBURNS average pumps ($F(1, 101) = 7.17$, $p = 0.01$), average pumps at the \$3 lottery amount ($F(1, 101) = 9.31$, $p = 0.003$), and average pumps at the \$9 lottery amount ($F(1, 101) = 9.98$, $p = 0.002$), such that women evidenced more pumps than men. There was not a significant main effect of gender on MRBURNS average risk taking at the \$1 lottery amount ($F(1, 101) = 2.27$, $p = 0.14$).

We also examined number of balloon explosions across the entire MRBURNS task as well as separately within each lottery amount as an additional dependent variable. In general, patterns of explosions by gender and smoking status were similar to patterns observed when examining average pumps. On average, across all trials, participants exploded 6.71 (5.32) balloons. Number of balloon explosions decreased as a function of increasing lottery amount such that participants exploded significantly fewer balloons for the \$3 trials than for the \$1 trials $t(102) = 3.59$, $p = 0.001$ and significantly fewer balloons for the \$9 trials than for the \$3 trials $t(102) = 8.51$, $p < 0.001$. When examining the effect of smoking status on explosions, there was not a significant main effect of smoking status on explosions on the MRBURNS ($F(1, 101) = 2.68$, $p=0.11$) or explosions within the \$1 ($F(1, 101) = 2.39$, $p = 0.13$), \$3 ($F(1, 101) = 1.69$, $p = 0.20$), or \$9 ($F(1, 101) = 1.22$, $p = 0.27$) trials. When examining the effect of gender on explosions, there was a significant main effect of gender on MRBURNS explosions ($F (1, 101) = 6.11$, $p = 0.02$), and explosions at the \$3 ($F(1, 101) = 7.59$, $p = 0.01$) and \$9 ($F(1, 101) = 5.66$, $p = 0.02$) lottery amounts such that women exploded significantly more balloons than men. There was not a significant main effect of gender on MRBURNS explosions ($F(1, 101) = 1.93$, $p = 0.17$) at the $1 lottery amount.

Determining Covariates to Include in Subsequent Analyses

Demographic variables (age, race), depressive symptoms, anxiety symptoms, and alcohol use were examined as potential covariates to be included in subsequent analyses. There were significant group differences between smokers and non-smokers on the CES-D ($F(1, 101) = 10.41$, $p = 0.002$), STAI-T ($F(1, 101) = 9.73$, $p = 0.002$), STAI-S ($F(1, 101) = 8.04$, $p = 0.006$), and number of drinks per drinking day (DPDD; $F(1, 101) = 18.12$, $p < 0.001$). Specifically, as compared to non-smokers, smokers reported higher levels of current depressive symptoms, higher levels of trait and state aniety, and drinking more drinks per drinking day. As such, depressive symptoms, trait anxiety, state anxiety, and alcohol use were included as covariates in subsequent analyses.

MRBURNS Risk Taking as a Predictor of Smoking Status

We utilized four separate hierarchical logistic regressions in order to address the primary study aim to examine the relationship between negative reinforcement based risk taking and smoking status (smoker, non-smoker) among a sample of older adolescents (Tables 4-7). We utilized separate logistic regressions in order to examine the predictive utility of average pumps across the MRBURNS as well as average pumps within each lottery amount ($1, $3, $9) for predicting smoking status controlling for relevant covariates. For each of the four models, depressive symptoms, trait anxiety, state anxiety, and DPDD were entered in the first steps of the regressions and MRBURNS risk taking was entered in the second step of each regression. Across models, DPDD emerged as the only significant predictor of smoking status such that individuals who reported drinking more drinks per drinking day were more likely to be smokers. MRBURNS average pumps across all trials, pumps across the $1 lottery trials, pumps across the $3 lottery trials, and pumps across the $9 lottery trials were not significant predictors of smoking status (all p's > 0.20).

Gender as a Moderator of the Relationship between MRBURNS Risk Taking and Smoking Status

To address the secondary study aim to examine gender as a moderator of the relationship between negative reinforcement based risk taking and smoking status we again utilized four separate hierarchical logistic regressions in order to examine the interaction between MRBURNS pumps and gender for predicting smoking status. Four separate models were used in order to separately examine the interactions between gender and MRBURNS average pumps as well as MRBURNS average pumps within each lottery amount (Tables 8-11). Covariates including depressive symptoms, trait anxiety, state anxiety, and DPDD were entered in the first step of each model, gender and MRBURNS pumps were entered in the second step of each model, and the interaction between gender and MRBURNS pumps was entered in the third step of each model. In order to increase interpretability of interaction terms, MRBURNS pumps variables were grand mean centered. Gender was coded dichotomously with 0 = female and 1 = male. Results indicated that, across models, the interaction between gender and MRBURNS pumps was not a significant predictor of smoking status (all p's > 0.40), suggesting that the relationship between negative reinforcement based risk taking on the MRBURNS and smoking status did not vary as a function of gender.

Exploratory Analyses

There was not a significant interaction between gender and smoking status for predicting MRBURNS pumps, which would allow for probing of main effects within each smoking and gender group. However, we conducted several follow-up analyses to provide guidance for future studies. Specifically, we conducted additional exploratory analyses in order to examine the relationships between smoking status, gender, and MRBURNS pumps and explosions within each smoking and gender group. Within nonsmokers, women pumped significantly more than men ($F(1, 50) = 5.10$, $p = 0.03$) and exploded significantly more balloons ($F(1, 101) = 5.78$, $p = 0.02$) on average across all trials and on average across the $3 lottery balloons (Pumps: $F(1, 50) = 11.23$, $p = 0.002$; Explosions: $F(1,101) = 14.05$, $p < 0.001$). Within nonsmokers, there were no significant gender differences in MRBURNS pumps or explosions on the $1 and $9 lottery balloons. Within smokers, women pumped significantly more than men on average across the $9 lottery balloons ($F(1, 49) = 9.01$, $p = 0.004$) and exploded significantly more balloons than men across the $9 lottery trials ($F(1,101) = 6.00$, $p = 0.02$), whereas there were no significant differences by gender on average across all trials or within the $1 and $3 lottery amounts (all p's > 0.10) for pumps or explosions. Within women, there was not a significant effect of smoking status on pumps or explosions on average across all trials or within any of the lottery amounts (all p's > 0.10). Within men, there was a significant effect of smoking status on explosions within the $3 lottery trials (F(1,

101) = 4.12, $p = 0.05$) such that smokers exploded more balloons than nonsmokers, whereas there was not a significant effect of smoking status on average pumps on average across all trials or within any of the lottery amounts or on explosions across the entire task or within the $1 and $9 lottery amounts (all *p*'s > 0.10).

Chapter 4: Discussion

Tobacco use is responsible for 1 in 10 adult deaths worldwide and, as such, it is critical to understand processes that contribute to tobacco use across the lifespan. Tobacco use during adolescence and older adolescence is particularly problematic as 90% of current adult smokers report that they began smoking cigarettes before the age of 18 (Johnston et al., 2014). Despite dramatic decreases in rates of cigarette smoking among U.S. adolescents over the last 20 years, one in three high school seniors reports ever having smoked a cigarette and one in fifteen are regular, daily smokers (Johnston et al., 2014). Negative reinforcement processes have been implicated across stages of tobacco use such that tobacco use may be initiated and maintained in order to reduce or avoid negative aversive internal states (Baker et al., 2004; Eissenberg, 2004). Moreover, gender differences have been found across negative reinforcement constructs during adolescence suggesting that the relationship between negative reinforcement processes and tobacco use may vary as a function of gender. The present study sought to examine the relationship between negative reinforcement based risk taking using a behavioral analogue assessment of negative reinforcement based risk taking, the MRBURNS, and smoking status among a sample of older adolescents. A secondary aim of the present study was to examine gender as a moderator of the relationship between negative reinforcement based risk taking on the MRBURNS and smoking status. Below, in turn, we review and interpret the results of the study, followed by a discussion of the implications of these results as well as future directions.

Review of Results for Main Study Aims

The primary aim of the present study was to examine the relationship between negative reinforcement based risk taking and smoking status (smoker, non-smoker) among a sample of older adolescents. We hypothesized that smokers, as compared to non-smokers, would be significantly riskier on the MRBURNS as evidenced by a higher number of average pumps. This hypothesis was not supported. Specifically, when controlling for relevant covariates including alcohol use, depressive symptoms, trait anxiety, and state anxiety, smokers and non-smokers did not significantly differ on average number of pumps across the entire task or within any individual lottery amount (e.g., $1, $3, $9).

The secondary aim of the present study was to examine gender as a moderator of the relationship between negative reinforcement based risk taking and smoking status. We hypothesized that the relationship between MRBURNS negative reinforcement based risk taking and smoking status would vary as a function of gender such that the association between negative reinforcement based risk taking and smoking status among females would be significantly stronger than the association between negative reinforcement based risk taking and smoking status among males. This hypothesis was also not supported. Specifically, when controlling for covariates, the interaction between MRBURNS pumps across the entire task and within each monetary amount and gender was not a significant predictor of smoking status.

Considering these null results, this study suggests that negative reinforcement based risk taking on the MRBURNS is not predictive of smoking status as well as the fact that gender and MRBURNS risk taking similarly do not interact to predict smoking status. If taken at face value, the findings can be taken to indicate that behaviorally assessed negative reinforcement based risk taking does not discriminate between older adolescent smokers and non-smokers. Along these lines, one could conclude that the MRBURNS may not be an appropriate screening tool for determining risk for tobacco use and also may not be an appropriate assessment measure for understanding the mechanisms through which tobacco prevention and cessation interventions exert their effects. Similarly, in light of the findings of MacPherson et al. (2012), who found that negative reinforcement based risk taking on the MRBURNS was predictive of alcohol-related problems, results of the present study suggest that processes contributing to older adolescent cigarette smoking may be different from the processes that contribute to older adolescent problematic alcohol use. Taken together, in light of these null results, there may be a discrepancy in the literature between self-report measures of negative reinforcement constructs and behavioral assessment of negative reinforcement based risk taking. Although we included self-report assessments of depression and anxiety symptomatology in the current study, future studies should consider including additional self-report measures of negative reinforcement constructs. For example, negative reinforcement expectancies and negative mood regulation expectancies both previously have been related to smoking status. Including such measures may help to tease apart the relative contributions of self-reported and behaviorally assessed negative reinforcement based risk taking to smoking status.

While an explanation of no meaningful relationship between gender, smoking status, and MRBURNS negative reinforcement based risk taking provides the most parsimonious explanation of the results from the current study, there are other alternative explanations that should also be considered. First, null results in the current study may be due to a lack of power to detect a main effect of MRBURNS risk taking on smoking status as well as an interactive effect between MRBURNS risk taking and gender for predicting smoking status. Although we conducted a power analysis prior to the study that suggested that a sample size of 100 would be appropriate for our proposed moderator of gender, because there was a substantive amount of between-subjects variability in MRBURNS risk taking, it is possible that we were under powered particularly if the effects are more modest. When examining average pumps by gender and smoking status, average pump values did follow the general patterns that we hypothesized such that smokers were on average pumped more than nonsmokers and female smokers pumped the most overall. However, the effect size for MRBURNS pumps on smoking status was small across analyses. Thus, it is possible that the effect of MRBURNS pumps on smoking status and that the interactive effect between MRBURNS pumps and gender on smoking status were non-significant due to the substantial error associated with MRBURNS pumps and, had a larger sample been recruited, the study hypotheses would have been supported. The large between subjects variability in MRBURNS pumps may be inherent to the task as similar large error terms were found in the original MRBURNS study by MacPherson and colleagues (2012). Because of the small effect size of MRBURNS pumps on smoking status in the current study, future studies utilizing the MRBURNS should consider recruiting samples that are sufficiently large to find a significant effect with a small effect size.

A second factor that may have contributed to null results involves the inclusion criteria for smokers. We defined smokers as smoking at least one cigarette per day on 20 or more days out of the last 30 days. As such, we recruited a group of relatively novice smokers who, by extension, had low levels of nicotine dependence. It is possible that, although negative reinforcement based risk taking did not discriminate between non-smokers and novice smokers in the present study, negative reinforcement based risk taking would discriminate between nonsmokers and heavier, more dependent smokers. Thus, it is possible that had we recruited heavier, more dependent smokers, that study hypotheses would have been supported. Similarly, in light of longitudinal research on negative reinforcement mechanisms that predict changes in smoking over time (e.g., Weinstein, Mermelstein, Shiffman, & Flay, 2008; Wetter et al., 2004) there is also reason to believe that MRBURNS risk taking may have predictive utility for discriminating between smokers who will escalate in smoking levels over time and who will not. As we discuss in the future directions section below, future research should consider utilizing a longitudinal research design in order to evaluate the contribution of negative reinforcement based risk taking assessed via the MRBURNS to smoking trajectories over time. Furthermore, in order to determine whether the MRBURNS may distinguish between heavier, more dependent, older smokers and non-smokers, replication of the current study with a group of more hardened smokers should be considered.

A third factor that may have contributed to null results relates to the lottery amounts utilized in the MRBURNS. Differences between groups were magnified at the $1 lottery amount, where there was an 8.65 pump difference between smokers and non-smokers on average. Thus, it is possible that if the task incorporated lower monetary amount lottery values, then larger differences in pumping would have been observed between groups and study hypotheses would have been supported. This suggests that future studies utilizing the MRBURNS as an assessment of negative reinforcement based risk taking should consider incorporating additional lower value lottery amounts, a topic which we discuss further below.

Review of Exploratory Results

MRBURNS basic task properties

The present study is the second study to utilize the MRBURNS as an assessment of negative reinforcement based risk taking. Thus, for future utilization of the MRBURNS as a behavioral analogue assessment of negative reinforcement based risk taking, it is important to compare task characteristics from the present study to task characteristics from MacPherson et al.'s (2012) original validation study of the MRBURNS. General patterns of risk taking behavior were similar between the two studies such that in both studies, participants pumped the most for the $1 lottery amount and pumping declined as a function of escalating lottery amount. Similarly, in both studies, women in general pumped more than men on the MRBURNS.

Despite similarities between the present study and MacPherson et al.'s (2012) study, there were also differences in behavior on the MRBURNS between the two samples. Notably, although in general participants in the current study were quite risk averse (see below for a more comprehensive discussion of risk aversion), participants in this study were riskier than participants in the original study by MacPherson and colleagues (2012). Specifically, average number of pumps across all trials in the current study was 30.56 (23.81) whereas average number of pumps across all trials in the original MRBURNS study was 16.80 (17.50). Similar differences in risk taking between studies are also evident when examining risk taking within each lottery amount. Likewise, participants in the current study exploded considerably more balloons across the entire task (*M(SD)* = 6.71(5.32)) and within each lottery amount than participants in the original MRBURNS study (*M(SD)* explosions = 0.58(0.62)). It is unlikely that demographic differences between the two samples contributed to differences in risk taking on the MRBURNS as both studies were convenience samples of college students at the University of Maryland and the two samples were similar in age, race, symptoms of depression, and symptoms of anxiety. Although participants in the study by MacPherson and colleagues were only included in the study if they reported a period during which alcohol was consumed at least once per week and a similar drinking inclusion criteria was not used in the current study, 57.30% of the current sample did report consuming alcohol weekly during the last three months on the TLFB. These differences in pumps and explosions on the MRBURNS between these two demographically similar samples point to the need for more systematic research utilizing the MRBURNS with larger, more diverse samples.

Gender and MRBURNS Risk Taking

There was a significant main effect of gender on MRBURNS pumps and explosions such that women pumped more and exploded more balloons than men on average across all task trials, the \$3 lottery trials, and the \$9 lottery trials. This suggests that older female adolescent participants were riskier under conditions of negative reinforcement than their male counterparts and corroborates the findings of

MacPherson et al. (2012) who similarly found that the average number of pumps on the MRBURNS was higher for women than for men. Although an exploration of mechanisms explaining why men and women differed in negative reinforcement based risk taking was outside of the scope of the current study, this gender difference is consistent with literature suggesting that women may be more responsive than men to aversive stimuli such as negative affect mood manipulations or experimental stressors (Nolen-Hoeksema, 2012) and that women may be more susceptible to negative reinforcement motives for drug use than men (Bobzean, DeNobrega, & Perrotti, 2014; Potenza, 2013). If women are more responsive than men to negative affect manipulations such as the aversive noise used in the MRBURNS, then women may be more likely to take risks because of this heightened negative affect. In future studies utilizing the MRBURNS, it may be important to assess negative affect following each aversive noise administration in order to more systematically tease apart this proposed mechanism by which women may be riskier on the MRBURNS.

The main effect of gender may help, in part, to explain gender differences in real world risk taking behaviors, such as relapse to cigarette smoking after initiating a cessation attempt. For example, as suggested by Saladin and colleagues (2012), women may be more prone to experiencing craving in response to negative affect than men. In turn, this heightened craving in response to negative affect may place women at increased risk for lapse and eventual relapse after initiating a cessation attempt as compared to men. With aversive noise conceptualized as one form of negative affect induction, this gender difference on the MRBURNS fits with the model proposed by Saladin et al. (2012). Thus, the MRBURNS may be a useful behavioral task for understanding gender differences in cessation and future cessation studies should consider including the MRBURNS in order to understand the relationship between negative reinforcement based risk taking, gender, and cessation.

Additional MRBURNS Exploratory Analyses

Although there was not a significant interaction between gender and smoking status for predicting MRBURNS pumps, when probing within groups, there were several significant associations that will be cautiously interpreted below for guiding future investigations. The above discussed gender effect such that women, as compared to men, pumped more and exploded more balloons was observed within nonsmokers on average across all balloons and on average across the $3 lottery balloons, whereas this relationship was observed within smokers only for the $9 lottery balloons. These exploratory results suggest that there may be differential patterns of risk taking as a function of gender, smoking status, and MRBURNS lottery amount. For nonsmokers, although there was a significant gender difference in negative reinforcement based risk taking for the $3 lottery balloons, this difference became nonsignificant for the $9 trials, suggesting that gender differences in negative reinforcement based risk taking decrease as a function of increasing potential risk. In contrast, for smokers, it is interesting that the largest difference in average pumps between men and women was observed at the $9 lottery amount, which is the amount where there is the greatest potential loss associated with increased pumping. In sum, these group differences suggests that patterns of risk taking may vary as a function of smoking status, gender, and lottery amount. Moreover, female smokers may be less responsive than male smokers to the increasing lottery amounts, which is consistent with gender differences in mechanisms proposed to contribute to tobacco use. Taken together, this may suggest that women may be more likely than men to smoke due to heightened negative affect (e.g., Carpenter et al., 2014; Perkins et al., 2006; Saladin et al., 2012). Future studies utilizing the MRBURNS should consider examining the interaction between gender and smoking status as well as the three-way interaction between lottery amount, gender, and smoking status for predicting negative reinforcement based risk taking on the MRBURNS.

Alcohol Use as a Predictor of Smoking Status

Across analyses for the primary and secondary study aims, alcohol use emerged as the only significant predictor of smoking status. This result is consistent with a large body of research highlighting positive associations between alcohol and tobacco use across adolescence (e.g., Dierker et al., 2006; Jackson, Sher, Cooper, & Wood, 2002). Although examining potential interactions between negative reinforcement based risk taking on the MRBURNS, alcohol use, and cigarette smoking status was outside of the scope of the present study, in the future it may be important to examine the MRBURNS as an additional potential shared risk factor for alcohol and tobacco use during older adolescence, especially in light of previous research suggesting that the MRBURNS is related to alcohol-related problems during older adolescence (MacPherson et al., 2012).

Limitations

There were a number of limitations specifically to the MRBURNS task that may have impacted results of the current study. These limitations primarily cluster around 1) risk aversion and 2) lottery amounts. A discussion of these task limitations follows as well as suggested modifications for future research.

Risk Aversion

In the present study as well as in the original MRBURNS study by MacPherson et al. (2012), participants were, in general, risk averse. The optimal number of pumps that would maximize potential earnings in the lottery while limiting exposure to aversive noise is 64. Average number of pumps on the task across participants was considerably lower than 64 and only 6.8% of participants pumped on average more than 64 pumps. This risk aversion phenomenon is also observed in the BART, such that participants typically pump between 26 and 35 pumps and rarely pump more than 64 pumps (Lejuez et al., 2003; Lejuez et al., 2002). Risk aversion may have been problematic in the current study as it likely limited the between-subjects variability in pumps on the MRBURNS. MRBURNS risk aversion may also be problematic for future utilization of the task if the task is to be used with experimental manipulations aimed at understanding the role of contextual factors (e.g., mood manipulations, the acute effects of substances) on negative reinforcement based risk taking. Because such manipulations would be hypothesized to increase risk taking, the effect of this increased risk taking would be confounded with an effect of increased reward because as risk taking approaches 64 pumps, participants will optimize the balance between exposure to aversive noise and likelihood of winning each lottery at the end of the trial (Pleskac, Wallsten, Wang, & Lejuez, 2008).

Thus, it is important to consider potential task modifications that may help to reduce risk aversion, a line of work that has previously been pursued with the BART.

In order to reduce risk aversion, Pleskac and colleagues (2008) modified the BART in three ways by: 1) modifying task instructions to inform participants that the expected-value maximizing strategy is 64 pumps, 2) providing event feedback on all trials indicating where the previous balloon was set to explode, and 3) adding an additional task version that allowed participants to type in the number of pumps instead of making each individual pump. These modifications together produced a sample adjusted average pumps on the BART of 61. Similar modifications may be useful for the MRBURNS in order to address risk aversion on the task. Although the MRBURNS already requires that participants type in their number of pumps prior to balloon inflation, notifying participants of the expected-value maximizing strategy and providing event feedback may be useful modifications to the task which may help to limit risk aversion.

Lottery Amounts

Despite the general risk aversion across participants, on average pumping most closely approached the expected-value maximizing strategy of 64 pumps at the $1 lottery amount (a similar pattern was observed by MacPherson et al., (2012)). As such, it is likely that had additional lower value lottery amounts been incorporated in the current study, participants may have been less risk averse and there would have been greater variability in pumps between subjects. Thus, modifying the MRBURNS to include lottery amounts lower in monetary value may be an important task manipulation to address this limitation. In the current study as well as in the study by MacPherson and colleagues (2012), for the $3 and $9 lottery trials, the potential consequence of risky behavior (the opportunity cost of not earning $3 or $9) almost entirely suppressed risk taking. In the current study, participants exploded on average only 2.46 balloons out of a possible 10 balloons for the $3 trials and 1.02 balloons out of 10 balloons for the $9 trials. Considering the comparatively higher risk taking at the $1 lottery amount, it is likely that if the lottery amount was further decreased, participants would be more willing to take risks in order to decrease the exposure to aversive noise. Further empirical testing should be conducted in order to examine risk taking on the MRBURNS at lower lottery amounts in order to determine the lottery amount at which participants reach the expected-value maximizing strategy for the task.

Conclusions and Future Directions

The present study examined the relationship between behaviorally assessed negative reinforcement based risk taking and smoking status as well as the relationship between gender, negative reinforcement based risk taking, and smoking status. Although the hypotheses for the primary and secondary aims of the study were not supported, this study provides further testing of the relatively new and novel MRBURNS task. In addition to the proposed task modifications to address study limiations discussed above, this study also highlights a number of additional important future directions.

Although in the present study we observed a significant main effect of gender on MRBURNS risk taking such that women were riskier than men on the MRBURNS, the mechanisms that explain this relationship are poorly understood. A number of candidate mechanisms have been proposed in other studies that may help to explain gender differences in risk taking and, by extension, in tobacco use including: 1) neurobiological mechanisms (Bobzean et al., 2014), 2) gender norms (Bottorff et al., 2014), and 3) psychopathology (Miettunen et al., 2014). In the future, in order to understand why negative reinforcement based risk taking differs as a function of gender, it will be important to systematically measure all of these proposed explanatory mechanisms in order to determine the underpinnings of this gender difference. Understanding the mechanisms of this gender difference in negative reinforcement based risk taking is crucial for understanding why interventions for real world negative reinforcement based risk taking such as smoking cessation interventions tend to be more efficacious for men than women (Amos et al., 2011; Hymowitz et al., 1997; Nides et al., 1995) as well as for improving these treatments specifically for women.

An additional interesting and important future direction consistent with utilizing the MRBURNS to understand the nature of cigarette smoking is to examine the MRBURNS as a predictor of smoking trajectories over time. A similar design has been used to examine the relative contributions of other negative reinforcement constructs including smoking expectancies and affective control for determining smoking trajectories (e.g., Weinstein et al., 2008; Wetter et al., 2004) and is currently being used to examine the positive reinforcement based BART as a predictor of risk taking behaviors over time (Collado, MacPherson, Kurdziel, Rosenberg, & Lejuez, 2014; MacPherson, Magidson, Reynolds, Kahler, & Lejuez, 2010; MacPherson, Reynolds, et al., 2010). Considering the strengths of behavioral analogue tasks as compared to self-reports (see the Introduction above for a comprehensive discussion of these issues), which have typically been used in these longitudinal designs, the

MRBURNS is an ideal candidate task that could be utilized in order to predict which adolescents may escalate in smoking over time. If the MRBURNS has predictive utility for determining which adolescents are at highest risk for escalation of cigarette smoking over time, then, in the future, the MRBURNS may be useful as a screening tool in order to intervene with high-risk adolescents before their tobacco use escalates.

Table 1: Demographics

	Total Sample (n=103)			Smokers (n=51)			Non-Smokers (n=52)		
	Total Sample (n=103)	**Males (n=51)**	**Females (n=52)**	**All Smokers (n=51)**	**Males (n=26)**	**Females (n=25)**	**All Non-Smokers (n=52)**	**Males (n=25)**	**Females (n=27)**
Age (M(SD))	19.41(1.06)	19.41(1.08)	19.40(1.05)	19.51(1.16)	19.58(1.17)	19.44(1.16)	19.31(0.96)	19.24(0.97)	19.37(0.97)
Race									
White	56.9%	58.0%	55.8%	64.0%	64.0%	64.0%	50.0%	52.0%	48.1%
Black	12.7%	10.0%	15.4%	8.0%	4.0%	12.0%	17.3%	16.0%	18.5%
Hispanic	10.8%	10.0%	11.5%	8.0%	12.0%	4.0%	13.5%	8.0%	18.5%
Asian	16.7%	20.0%	13.5%	14.0%	16.0%	12.0%	19.2%	24.0%	14.8%
Other	2.9%	2.0%	3.8%	6.0%	4.0%	8.0%	0.0%	0.0%	0.0%
CES-D (M(SD))	14.55(10.47)	13.09(9.61)	15.99(11.17)	17.77(10.72)	16.19(8.71)	19.41(12.45)	11.40(9.29)	9.87(9.59)	12.81(8.94)
STAI-T (M(SD))	39.77(11.10)	37.06(10.68)	42.43(10.97)	43.08(9.92)	41.27(8.45)	44.96(11.11)	36.53(11.34)	32.68(11.14)	40.09(10.49)
STAI-S (M(SD))	35.43(11.55)	34.57(11.73)	36.27(11.42)	38.58(10.63)	37.85(10.57)	39.34(10.85)	32.34(11.68)	31.16(12.10)	33.43(11.39)
DPDD(M(SD))	4.07(3.16)	4.91(3.38)	3.25(2.71)	5.31(2.55)	6.10(2.45)	4.49(2.44)	2.86(3.24)	3.68(3.80)	2.10(2.47)

Note: DPDD = Drinks per drinking day. Gender was coded dichotomously with 0 = female and 1 = male. There were significant gender differences between females and males on the STAI-T ($F(1, 101) = 6.34$, $p = 0.01$) and DPDD ($F(1, 101) = 7.61$, $p = 0.01$) such that females had significantly higher trait anxiety and consumed signficantly fewer DPDD. Smoking status was coded dichotomously with 0 = non-smoker and 1 = smoker. There were significant group differences between smokers and non-smokers on the CES-D ($F(1, 101) = 10.41$, $p = 0.002$), STAI-T ($F(1, 101) = 9.73$, $p = 0.002$), STAI-S ($F(1, 101) = 8.04$, $p = 0.01$), and number of drinks per drinking day ($F(1, 101) = 18.12$, $p < 0.001$). As compared to non-smokers, smokers had significantly higher depressive symptoms, higher trait anxiety, higher state anxiety, and consumed significantly more DPDD.

Table 2: Smoking Characteristics of Smokers

Variable	Total Sample	Male	Female
CPSD (M(SD))	5.49(3.34)	6.05(3.12)	4.91(3.53)
Age of initiation (M(SD))	15.54(2.42)	15.34(2.86)	15.75(1.87)
Age of regular smoking (M(SD))	17.52(1.62)	17.38(1.55)	17.67(1.71)
mFTQ (M(SD))	2.84(1.32)	3.03(1.51)	2.64(1.08)

Note: CPSD = Cigarettes per smoking day. There were no gender differences in any of the above smoking variables (all *p*'s > .05). Age of initiation = age at which a participant first tried cigarettes, Age of regular smoking = age at which participant started smoking regularly.

Table 3: MRBURNS

	Average Pumps			
	Average Pumps	Average Pumps $1	Average Pumps $3	Average Pumps $9
Total Sample	30.56(23.81)	42.91(36.81)	32.48(25.89)	16.25(18.06)
Male	24.40(22.29)	37.43(35.36)	24.92(24.01)	10.80(15.73)
Female	36.60(23.92)	48.29(37.75)	39.89(25.73)	21.59(18.74)
Smokers	33.12(25.21)	47.28(38.80)	34.37(28.45)	17.66(19.56)
Male	27.61(22.99)	43.29(38.21)	29.29(27.73)	10.17(14.03)
Female	38.85(26.58)	51.44(39.75)	39.66(28.77)	25.44(21.64)
Non-Smokers	28.05(22.32)	38.63(34.59)	30.63(23.25)	14.87(16.54)
Male	21.06(21.48)	31.34(31.75)	20.38(18.93)	11.46(17.60)
Female	34.52(21.46)	45.37(36.31)	40.11(23.12)	18.01(15.13)
	Explosions			
	Explosions	Explosions $1	Explosions $3	Explosions $9
Total Sample	6.71(5.32)	3.23(2.84)	2.46(1.94)	1.02(1.61)
Male	5.43(4.87)	2.84(2.81)	1.94(1.78)	0.65(1.23)
Female	7.96(5.50)	3.62(2.84)	2.96(1.97)	1.38(1.85)
Smokers	7.57(5.84)	3.67(3.04)	2.71(2.22)	1.20(1.81)
Male	6.50(5.16)	3.46(3.11)	2.42(2.10)	0.62(1.17)
Female	8.68(6.39)	3.88(3.00)	3.00(2.35)	1.80(2.16)
Non-Smokers	5.87(4.67)	2.81(2.58)	2.21(1.60)	0.85(1.38)
Male	4.32(4.37)	2.20(2.35)	1.44(1.23)	0.68(1.31)
Female	7.30(4.55)	3.37(2.71)	2.93(1.59)	1.00(1.44)

Note: There was not a significant main effect of smoking status on MRBURNS average pumps ($F(1, 101) = 1.17$, $p = 0.28$) or average pumps at the \$1 ($F(1, 101) = 1.43$, $p = 0.23$), \$3 ($F(1, 101) = 0.54$, $p = 0.47$), or \$9 ($F(1, 101) = 0.61$, $p = 0.44$) lottery amounts. Similarly, there was not a significant main effect of smoking status on explosions on the MRBURNS ($F(1, 101) = 2.68$, $p=0.11$) or explosions within the \$1 ($F(1, 101) = 2.39$, $p = 0.13$), \$3 ($F(1, 101) = 1.69$, $p = 0.20$), or \$9 ($F(1, 101) = 1.22$, $p = 0.27$) trials. There was a significant main effect of gender on MRBURNS average pumps ($F(1, 101) = 7.17$, $p = 0.01$) and explosions ($F(1, 101) = 6.11$, $p = 0.02$), average pumps ($F(1, 101) = 9.31$, $p = 0.003$) and explosions ($F(1, 101) = 7.59$, $p = 0.01$) at the \$3 lottery amount, and average pumps ($F(1, 101) = 9.98$, $p = 0.002$) and explosions ($F(1, 101) = 5.66$, $p = 0.02$) at the \$9 lottery amount. There was not a significant main effect of gender on MRBURNS average risk taking ($F(1, 101) = 2.27$, $p = 0.14$) or explosions ($F(1, 101) = 1.93$, $p = 0.17$) at the \$1 lottery amount.

Table 4: Hierarchical Logsitic Regression of MRBURNS Average Pumps Predicting Smoking Status

	B	SE(B)	Wald	OR	95% CI		*p*
Step 1							
CES-D	0.07	0.04	2.58	1.07	0.99	1.17	0.11
STAI-T	0.02	0.04	0.18	1.02	0.94	1.11	0.67
STAI-S	-0.01	0.03	0.09	0.99	0.93	1.05	0.77
DPDD*	0.34	0.09	14.42	1.41	1.18	1.68	<0.001
Step 2							
CES-D	0.07	0.04	2.32	1.07	0.98	1.17	0.13
STAI-T	0.02	0.04	0.14	1.02	0.93	1.11	0.71
STAI-S	-0.01	0.03	0.03	0.99	0.94	1.06	0.86
DPDD*	0.35	0.09	14.52	1.41	1.18	1.69	<0.001
MRBURNS	0.01	0.01	0.67	1.01	0.99	1.03	0.41

Table 5: Hierarchical Logsitic Regression of MRBURNS Average Pumps for the $1 Trials Predicting Smoking Status

	B	SE(B)	Wald	OR	95% CI		*p*
Step 1							
CES-D	0.07	0.04	2.58	1.07	0.99	1.17	0.11
STAI-T	0.02	0.04	0.18	1.02	0.94	1.11	0.67
STAI-S	-0.01	0.03	0.09	0.99	0.93	1.05	0.77
DPDD*	0.34	0.09	14.42	1.41	1.18	1.68	<0.001
Step 2							
CES-D	0.07	0.04	2.28	1.07	0.98	1.17	0.13
STAI-T	0.02	0.04	0.12	1.02	0.93	1.10	0.73
STAI-S	-0.004	0.03	0.02	1.00	0.94	1.06	0.90
DPDD*	0.34	0.09	14.32	1.41	1.18	1.69	<0.001
MRBURNS $1	0.01	0.01	0.74	1.01	0.99	1.02	0.39

Table 6: Hierarchical Logsitic Regression of MRBURNS Average Pumps for the $3 Trials Predicting Smoking Status

	B	SE(B)	Wald	OR	95% CI		*p*
Step 1							
CES-D	0.07	0.04	2.58	1.07	0.99	1.17	0.11
STAI-T	0.02	0.04	0.18	1.02	0.94	1.11	0.67
STAI-S	-0.01	0.03	0.09	0.99	0.93	1.05	0.77
DPDD*	0.34	0.09	14.42	1.41	1.18	1.68	<0.001
Step 2							
CES-D	0.07	0.04	2.54	1.07	0.98	1.17	0.11
STAI-T	0.02	0.04	0.15	1.02	0.94	1.11	0.70
STAI-S	-0.01	0.03	0.07	0.99	0.93	1.05	0.79
DPDD*	0.34	0.09	14.47	1.41	1.18	1.68	<0.001
MRBURNS $3	0.003	0.01	0.08	1.00	0.99	1.02	0.78

Table 7: Hierarchical Logsitic Regression of MRBURNS Average Pumps for the $9 Trials Predicting Smoking Status

	B	SE(B)	Wald	OR	95% CI		*p*
Step 1							
CES-D	0.07	0.04	2.58	1.07	0.99	1.17	0.11
STAI-T	0.02	0.04	0.18	1.02	0.94	1.11	0.67
STAI-S	-0.01	0.03	0.09	0.99	0.93	1.05	0.77
DPDD*	0.34	0.09	14.42	1.41	1.18	1.68	<0.001
Step 2							
CES-D	0.07	0.04	2.20	1.07	0.98	1.16	0.14
STAI-T	0.02	0.04	0.26	1.02	0.94	1.11	0.61
STAI-S	-0.01	0.03	0.08	0.99	0.93	1.05	0.78
DPDD*	0.35	0.09	14.90	1.42	1.19	1.69	<0.001
MRBURNS $9	0.01	0.01	1.16	1.01	0.99	1.04	0.28

Table 8: Hierarchical Logistic Regression Examining the Interaction between Average MRBURNS Pumps and Gender for Predicting Smoking Status

	B	SE(B)	Wald	OR	95% CI		*p*
Step 1							
CES-D	0.07	0.04	2.58	1.07	0.99	1.17	0.11
STAI-T	0.02	0.04	0.18	1.02	0.94	1.11	0.67
STAI-S	-0.01	0.03	0.09	0.99	0.93	1.05	0.77
DPDD*	0.34	0.09	14.42	1.41	1.18	1.68	<0.001
Step 2							
CES-D	0.07	0.05	2.36	1.07	0.98	1.17	0.13
STAI-T	0.01	0.05	0.09	1.01	0.93	1.11	0.77
STAI-S	-0.01	0.03	0.03	1.00	0.94	1.06	0.86
DPDD*	0.35	0.09	13.82	1.42	1.18	1.71	<0.001
Gender	-0.12	0.52	0.05	0.89	0.32	2.46	0.82
MRBURNS	0.01	0.01	0.56	1.01	0.99	1.03	0.45
Step 3							
CES-D	0.07	0.05	2.35	1.07	0.98	1.17	0.13
STAI-T	0.01	0.05	0.10	1.01	0.93	1.11	0.75
STAI-S	-0.01	0.03	0.06	0.99	0.93	1.06	0.81
DPDD*	0.36	0.10	13.85	1.43	1.18	1.72	<0.001
Gender	-0.12	0.52	0.05	0.89	0.32	2.47	0.82
MRBURNS	0.01	0.01	0.13	1.01	0.98	1.03	0.72
Gender x MRBURNS	0.01	0.02	0.11	1.01	0.97	1.05	0.74

Table 9: Hierarchical Logistic Regression Examining the Interaction between MRBURNS Average Pumps for the $1 Trials and Gender for Predicting Smoking Status

	B	SE(B)	Wald	OR	95% CI		*p*
Step 1							
CES-D	0.07	0.04	2.58	1.07	0.99	1.17	0.11
STAI-T	0.02	0.04	0.18	1.02	0.94	1.11	0.67
STAI-S	-0.01	0.03	0.09	0.99	0.93	1.05	0.77
DPDD*	0.34	0.09	14.42	1.41	1.18	1.68	<0.001
Step 2							
CES-D	0.07	0.05	2.37	1.07	0.98	1.17	0.12
STAI-T	0.01	0.05	0.06	1.01	0.93	1.10	0.80
STAI-S	-0.003	0.03	0.01	1.00	0.94	1.06	0.92
DPDD*	0.35	0.10	13.78	1.42	1.18	1.71	<0.001
Gender	-0.16	0.51	0.10	0.85	0.31	2.31	0.75
MRBURNS $1	0.01	0.01	0.68	1.01	0.99	1.02	0.41
Step 3							
CES-D	0.07	0.05	2.14	1.07	0.98	1.17	0.14
STAI-T	0.02	0.05	0.12	1.02	0.93	1.11	0.74
STAI-S	-0.01	0.03	0.04	0.99	0.93	1.06	0.84
DPDD*	0.36	0.10	14.00	1.43	1.19	1.72	<0.001
Gender	-0.16	0.51	0.09	0.86	0.31	2.33	0.76
MRBURNS $1	0.003	0.01	0.10	1.00	0.99	1.02	0.75
Gender x MRBURNS $1	0.01	0.01	0.23	1.01	0.98	1.03	0.63

Table 10: Hierarchical Logistic Regression Examining the Interaction between MRBURNS Average Pumps for the $3 Trials and Gender for Predicting Smoking Status

	B	SE(B)	Wald	OR	95% CI		*p*
Step 1							
CES-D	0.07	0.04	2.58	1.07	0.99	1.17	0.11
STAI-T	0.02	0.04	0.18	1.02	0.94	1.11	0.67
STAI-S	-0.01	0.03	0.09	0.99	0.93	1.05	0.77
DPDD*	0.34	0.09	14.42	1.41	1.18	1.68	<0.001
Step 2							
CES-D	0.07	0.05	2.65	1.08	0.99	1.17	0.10
STAI-T	0.01	0.04	0.08	1.01	0.93	1.11	0.78
STAI-S	-0.01	0.03	0.06	0.99	0.94	1.05	0.80
DPDD*	0.35	0.09	14.00	1.42	1.18	1.71	<0.001
Gender	-0.18	0.52	0.12	0.83	0.30	2.32	0.73
MRBURNS $3	0.002	0.01	0.04	1.00	0.98	1.02	0.85
Step 3							
CES-D	0.07	0.05	2.72	1.08	0.99	1.17	0.10
STAI-T	0.01	0.05	0.09	1.01	0.93	1.11	0.76
STAI-S	-0.01	0.03	0.17	0.99	0.93	1.05	0.68
DPDD*	0.36	0.10	14.12	1.43	1.19	1.72	<0.001
Gender	-0.17	0.53	0.10	0.85	0.30	2.39	0.75
MRBURNS $3	-0.003	0.01	0.08	1.00	0.97	1.02	0.78
Gender x MRBURNS $3	0.01	0.02	0.46	1.01	0.97	1.06	0.50

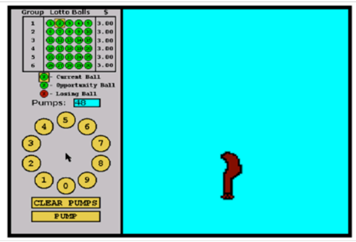
Table 11: Hierarchical Logistic Regression Examining the Interaction between MRBURNS Average Pumps for the $9 Trials and Gender for Predicting Smoking Status

	B	SE(B)	Wald	OR	95% CI		*p*
Step 1							
CES-D	0.07	0.04	2.58	1.07	0.99	1.17	0.11
STAI-T	0.02	0.04	0.18	1.02	0.94	1.11	0.67
STAI-S	-0.01	0.03	0.09	0.99	0.93	1.05	0.77
DPDD*	0.34	0.09	14.42	1.41	1.18	1.68	<0.001
Step 2							
CES-D	0.07	0.05	2.14	1.07	0.98	1.17	0.14
STAI-T	0.02	0.05	0.21	1.02	0.93	1.12	0.65
STAI-S	-0.01	0.03	0.08	0.99	0.93	1.05	0.78
DPDD*	0.35	0.10	13.97	1.42	1.18	1.71	<0.001
Gender	-0.04	0.54	0.01	0.96	0.34	2.75	0.94
MRBURNS $9	0.01	0.01	1.00	1.01	0.99	1.04	0.32
Step 3							
CES-D	0.06	0.05	1.74	1.06	0.97	1.16	0.19
STAI-T	0.03	0.05	0.32	1.03	0.94	1.12	0.57
STAI-S	-0.01	0.03	0.04	0.99	0.94	1.06	0.84
DPDD*	0.34	0.10	12.57	1.40	1.16	1.69	<0.001
Gender	-0.02	0.54	0.001	0.98	0.34	2.81	0.97
MRBURNS $9	0.02	0.02	1.43	1.02	0.99	1.06	0.23
Gender x MRBURNS $9	-0.02	0.03	0.48	0.98	0.93	1.04	0.49

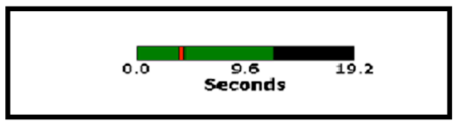
Figure 1: The MRBURNS

- 30 trials total with 3 task phases: Automatic Pump Selection, Aversive Noise, and Consequence and Lottery

Automatic Pump Selection: Selection of number of balloon pumps



Aversive Noise: Aversive noise plays while a red indicator is over the green portion of a green and black bar. Each pump reduces the duration of aversive noise by 0.15 seconds. This screen lasts a total of 19.2 seconds.



Consequence and Lottery: Balloon inflates according to the number of pumps selected during Automatic Pump Selection and is either safe or pops at the end of inflation. Participant receives a winning lottery ball if balloon is safe and a losing lottery ball if balloon pops.

- The task begins with a guaranteed lottery win. Each explosion reduces the likelihood of winning.
- If the balloon explodes, the participant receives a red (losing) lottery ball. If the balloon is safe, the participant receives a green (winning) lottery ball.
- Lottery: Occurs after completion of all 30 trials. Divided into 6 drawings with each successive 5 balloons constituting one drawing. Lottery values are \$1, \$3, or \$9. The lottery order is \$1, \$9, \$3, \$9, \$1, \$3 for the 6 drawings.

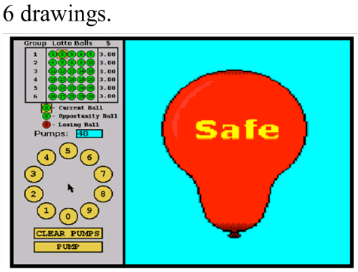
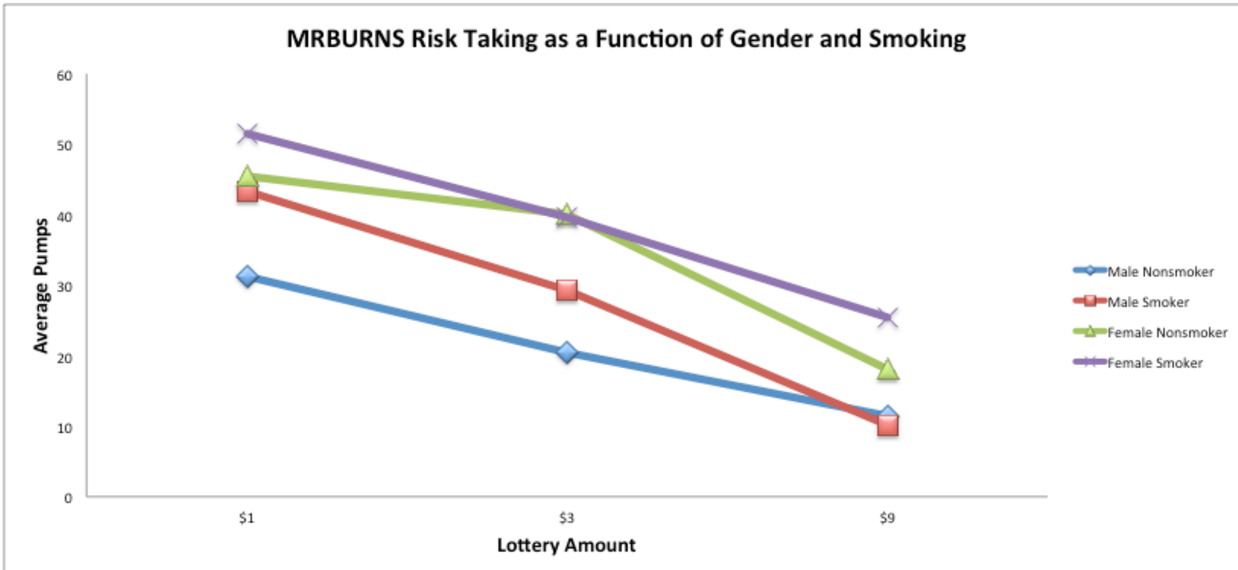


Figure 2. MRBURNS Risk Taking as a Function of Gender and Smoking



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