

SUBJECTIVE EFFECTS OF SMOKING: LABORATORY AND FIELD
INVESTIGATIONS

by

Chantal E. Meloscia

Dissertation proposal submitted to the Faculty of the
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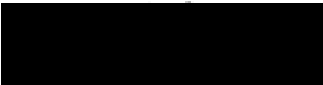
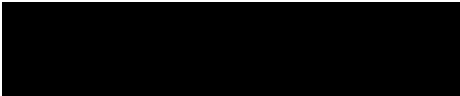


FINAL EXAMINATION/PRIVATE DEFENSE FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
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Name of Student: Chantal Meloscia

Date of Examination: September 9, 2016
Time: 9:45 AM
Place: Room G255

DECISION OF EXAMINATION COMMITTEE MEMBERS:

	PASS	FAIL
	<u>2</u>	_____
Dr. Marian Janofsky-Kraff DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY Committee Chairperson		
	<u>✓</u>	_____
Dr. Andrew J. Waters DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY Dissertation Advisor		
	<u>✓</u>	_____
Dr. David Kravitz DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY Committee Member		
	<u>✓</u>	_____
Dr. Laura Juana AMERICAN UNIVERSITY Committee Member		



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APPROVAL OF THE DOCTORAL DISSERTATION IN THE DEPARTMENT OF
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September 9, 2016

DISSERTATION AND ABSTRACT APPROVED:

DATE:

9/16/16

Dr. Marian Tañónsky-Kraff
DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY
Committee Chairperson

9/16/16

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

9/16/16

Dr. David Krantz
DEPARTMENT OF MEDICAL & CLINICAL PSYCHOLOGY
Committee Member

9/16/16

Dr. Laura Juliano
AMERICAN UNIVERSITY
Committee Member

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DEDICATION

For Norman and Elisabeth ~ grandparents who instilled a love of knowledge, provided a foundation for critical thinking, and endeavored to live each moment with joie di vivre (creativity, humor, and sincerity).

For Giuseppe and Rosina ~ nonno e nonna ~ who lived life with a tenacity and work ethic that allowed the next generations to fulfill unfathomable dreams.

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Chantal E. Meloscia

November 1, 2016

DISCLAIMER

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.

ABSTRACT

Subjective Effects of Cigarette Smoking: Laboratory and Field Investigations

Chantal E. Meloscia, M.S., 2016

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

Despite being the leading preventable cause of death in the United States, cigarette smoking prevalence remains high. However, most cigarette smokers find quitting smoking challenging and relapse is common. By understanding the psychological processes that underlie nicotine dependence more fully, novel smoking cessation interventions can be developed.

In this study, we investigated the role of Liking and Wanting in regards to smoking relapse and nicotine dependence. Historically, Liking has been thought to mediate nicotine addiction. Intuitively, drug Liking would seem to cause drug Wanting so that Liking and Wanting should be strongly related. However, the Incentive Sensitization Theory (Robinson and Berridge, 1993) argues that Liking and Wanting are mediated by separate pathways and can be dissociated. The theory also suggests that Wanting is more important in chronic addiction than Liking. Following Kahneman's (2011) distinction between experienced and remembered utility, we also analyzed the relationship between

Experienced and Remembered Liking and the relationship between Experienced and Remembered Wanting. Specifically, we tested the theory that the memory of pleasure for a cigarette should be biased by the Peak pleasure of a cigarette as well as the pleasure of the final puff (“Peak-End rule”).

The current study built on the findings of Meloscia (2014) and involved secondary analyses of pre-existing data. Specific Aim 1 examined the association between Experienced and Remembered Liking and Wanting. Specific Aim 2 examined the separability of self-report measures of Liking and Wanting in a sample of smokers preparing to quit. Specific Aim 3 examined the relative predictive efficacy of self-report measures of Liking and Wanting.

For Aim 1, we found that Remembered Liking of a cigarette is more heavily influenced by Peak and End ratings than the liking ratings of a puff selected at random. For Aim 2, exploratory factor analysis revealed two separate factors corresponding to Liking and Wanting. A confirmatory factor analysis revealed that a two-factor model provided a better fit than a single-factor model. For Aim 3, both Wanting and Liking were associated with dependence, but Wanting was more strongly associated with dependence in a multivariable model. Wanting was associated with relapse at end of treatment.

In sum, the current study provided some support for an early version of Incentive Sensitization Theory. In addition, there was evidence that by investigating the Liking and Wanting pathways of smoking, we added to the understanding of the addiction process which could ultimately aid in creating more effective and targeted smoking cessation interventions.

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List of Abbreviations and Acronyms

AB = 12 hour abstinent laboratory session (pre-quit)

CFA = Confirmatory Factor Analysis

CO = expired breath carbon monoxide (used to assess smoking status during lab sessions)

EFA = Exploratory Factor Analysis

EMA = Ecological Momentary Assessment

FTND = Fagerstrom Test of Nicotine Dependence

IAT = Implicit Association Test (implicit attitudes toward smoking)

IST = Incentive Sensitization Theory

LMM = Linear Mixed Models

MDACC = The University of Texas M. D. Anderson Cancer Center (Houston, Texas)

NEQ = Nicotine Effects Questionnaire

NON = Non-abstinent laboratory session (pre-quit)

PCA = Principal Components Analysis

PDA = Personal digital assessment (method of assessment for EMA data)

QD = Quit day laboratory session

QSU = Questionnaire of Smoking Urges (self-reported craving for cigarettes)

SABQ = Subjective Attentional Bias Questionnaire

SCQ = Smoking Consequences Questionnaire (self-reported outcome expectancies)

USUHS = Uniformed Services University of the Health Sciences (Bethesda, Maryland)

WK+1 = laboratory session one week following participants' quit day

WK+4 = laboratory session four weeks following participants' quit day

WSWS = Wisconsin Smoking Withdrawal Scale

CHAPTER 1: Background

Cigarette smoking is known as the leading preventable cause of death in the United States. Relapse to smoking is common, and current behavioral treatments and pharmacotherapies have only limited success in aiding people to quit smoking. To develop more effective interventions, a deeper understanding of the psychological processes underlying relapse to smoking may be necessary.

Prior research has considered several aspects of psychological processes potentially related to smoking relapse. For example, many studies have investigated the role of mood, including negative affect, in smoking relapse (e.g. Shiffman and Waters, 2004; Ferguson and Shiffman, 2014). Other studies have examined the impact of stress and perceived stress on smoking relapse and cessation attempts (e.g. Cohen and Lichtenstein, 1990; Steptoe et al., 1996). More recently, several reviews (e.g. Pool et al., 2016; Robinson et al., 2015; Tibboel et al., 2015) have emphasized the importance of understanding and measuring the concepts of Liking and Wanting to better understand the addiction processes and to adapt cessation treatments.

This study will explore several aspects of Liking and Wanting. The introduction sections are organized as follows. Chapter 1 first presents a review of the consequences of smoking and current smoking cessation treatments. Chapter 2 reviews the concepts of Liking and Wanting through a four-part framework of definitions. Liking and Wanting are described in terms of mental processes, effects, utilities, and neurobiology (Tibboel et al., 2015). Models of addiction including the Incentive Sensitization Theory are introduced and compared. We highlight the idea that Liking and Wanting are separate

pathways. Finally, contextual factors that could impact smoking self-report ratings are described.

SMOKING MORBIDITY AND MORTALITY

The Surgeon General's recent comprehensive report on smoking states that about one in five deaths in the United States is related to smoking (US Department of Health and Human Services [USDHHS], 2014). Smoking has been identified as a risk factor for the top ten causes of death in the United States and the leading preventable cause of death. For example, men and women who smoke increase their risk of dying from heart disease by four and five times respectively. Life-expectancy for smokers in the United States is about ten years less than their non-smoking counterparts. The list of health consequences related to smoking is endless and includes a range of conditions such as inflammation in the body, bone density loss, fertility issues, and arthritis. Over 16 million Americans suffer from a condition related to smoking (USDHHS, 2014; Centers for Disease Control [CDC], 2011).

Smoking morbidity and mortality rates affect more than the individual smoker. Families, communities, and societies are all affected by smoking costs. The economic burden for health care and loss of productivity associated with smoking totals about US\$289 billion annually (USDHHS, 2014). When considering the effect on families, CDC (2008) data shows a large loss in productivity, US\$5.6 billion, as a result of exposure to second hand smoke.

SMOKING PREVALENCE

The number of smokers is still relatively high given the health risks and economic costs attributed to smoking. For adults in the United States, the CDC (2011) reports the

prevalence of smoking at 20%. (Smoking was defined as: 1) current smoker - every day or most days and 2) has smoked greater than or equal to 100 cigarettes in their lifetime.) Declines in smoking prevalence have been minimal from 2005-2010 with about a 1.5% decrease in reported cigarette smoking in the United States. Also, every day, 2,100 young people are estimated to become daily smokers (CDC, 2011). Outside of the United States, smoking prevalence has also been increasing (Ng et al., 2013).

SMOKING AND THE UNITED STATES MILITARY

As the author is an active duty military member and will be serving as military psychologist, a brief review of how smoking impacts this specific community is warranted. Similar to the general population in the United States, the military has a high prevalence of smoking (30%) and high productivity loss associated with smoking (\$US346 million) (Department of Defense [DoD], 2008; Brown, 2010). For example, military members who smoke are more likely to develop musculoskeletal injuries and have slower wound-healing rates; both conditions contribute to productivity costs (Institutes of Medicine [IOM], 2009).

There are also operational costs associated with smoking in the military. These include decreased functionality during mission tasks related to: decreased cognitive ability, impaired respiratory functioning, lower visual acuity, and reduced night vision (IOM, 2009). The listed functionality deficits could put both an individual and the service members being supported at risk for injury or death. Further, mission accomplishment in support of national security efforts or humanitarian aid might be affected negatively.

ELECTRONIC CIGARETTES

Over the course of this dissertation research, electronic cigarettes have grown in popularity and must be acknowledged. Global sales and use rates of electronic cigarettes have grown steadily since their introduction into the market (King et al., 2015). The public health outcome of electronic cigarette use is unknown, and researchers have identified pros and cons associated with electronic cigarette use. Some potential positive aspects are that electronic cigarettes deliver fewer carcinogens, less carbon monoxide, and may help people quit smoking regular cigarettes. Negative aspects of electronic cigarette use include the unknown risks of long-term use, promoting nicotine addiction in adults, and an increased risk of adolescents trying smoking with an electronic cigarette (National Institute on Drug Abuse, 2016; Brandon et al., 2016).

SMOKING CESSATION

Many smokers are motivated to quit, but smoking cessation is challenging. Yeomans et al. (2011) found that the majority of smokers attempting to quit relapsed within four weeks. There are several methods or combinations of methods available to smokers to assist with smoking cessation. The current Public Health Service clinical practice guidelines for treating smoking lists pharmacotherapy and behavioral therapy as effective treatments for smoking cessation (USDHHS, 2008).

Pharmacotherapy

There are three FDA-approved medications for smoking cessation (FDA, 2010). Nicotine replacement can be an effective treatment (Silagy, Lancaster, Stead, Mant, & Fowler, 2004), however relapse is still common (Yeomans et al., 2011). Other medications, such as bupropion, have been found to be possible aids for smoking

cessation attempts (Hughes et al., 2014). For example, in a controlled trial using bupropion for smoking cessation, those using the medication had an abstinence rate of 30% after a year compared to an abstinence rate of 15% in the control group (Jorenby et al., 1999). Varenicline is the other main medication that has been found to be effective for aiding smoking cessation (USDHHS, 2008).

Behavioral

Behavioral treatments, such as counseling sessions, have been effective, but relapse among those treated is also common (Hajek et al., 2009). Lancaster and Stead (2008) conducted a review of 30 randomized controlled trials that compared individual smoking cessation counseling delivered by specialized counselors versus a control group that received a minimal level of support. They found that counseling was more effective than the minimal support provided in the control groups for smokers wishing to quit. Further, when comparing types of counseling, type of counseling did not seem to make a significant difference. The analysis showed that people who received counseling were more likely to be successful in smoking cessation than those smokers who received no counseling (Lancaster and Stead, 2008). Clinical practice guidelines suggest specific areas of focus for behavioral treatment including problem solving, skills training, and building social support (USDHHS, 2008).

Unaided

As noted above, many studies indicate that smoking cessation treatment increases the odds of quitting smoking, yet most smokers attempt to quit smoking unaided. Despite access to pharmacotherapies such as nicotine replacement therapy (NRT), it is likely that most smokers still attempt to quit without forms of pharmacotherapy (Chapman &

MacKenzie, 2010). Survey results in 2003 of over 29,500 United States' smokers revealed that 43% of the surveyed smokers attempted to quit smoking in the past year, and of those who attempted, 64% did not use any aid (pharmacotherapy, behavioral, etc.) to quit. About 9% attempted to use a behavioral treatment, and about 32% used a medication (Shiffman, Brockwell, Pillitteri, and Gitchell, 2008). Barriers to receiving treatment include the perception that medication is expensive and/or harmful. Researchers noted that additional investigations regarding barriers to care are needed (Shiffman, Brockwell, Pillitteri, and Gitchell, 2008).

Whether using pharmacotherapy, behavioral interventions, a combination of these two methods, or trying to quit unaided, smoking cessation attempts are much more likely to end in relapse to smoking than in continued abstinence.

CHAPTER 2: Current Study Background

Given the great harm to health that smoking causes, and the difficulty most smokers have quitting smoking despite awareness of harmful effects (Leidner, Shaw, & Yen, 2014), continued research into different types of treatments that target smoking relapse and nicotine addiction is important. Continued exploration of the mechanisms underlying smoking dependence and relapse will aid in shaping new forms of cessation treatment or in updating current treatment. The current study is concerned with the role that two specific concepts, Liking and Wanting, have in relapse and dependence. There is a large literature on these concepts, and three review articles have been published in the past two years (Tibboel et al., 2015; Pool et al., 2016, Robinson et al., 2016).

Tibboel et al. (2015) identified four types of definition for Liking and Wanting that provide a framework for reviewing the background information for this study (see Table 1). First, the most common definition type treats Liking and Wanting as mental processes. This is the definition type that is most relevant to the present dissertation. The second definition type treats the concepts as an “Effect”. As described later, this definition mainly refers to animal work that examines the effect of conditioned stimuli on behavior, and their ability to function as “motivational magnets”. The third definition treats the concepts from the perspective of utilities. As will be described in more detail later, Liking is identified with “experienced utility”, and Wanting as “decision utility”. Finally, the fourth definition type examines Liking and Wanting in terms of the neurobiological underpinnings of these processes. As described later, different neurobiological mechanisms are identified with Liking and Wanting.

LIKING AND WANTING AS MENTAL PROCESSES

Liking and Wanting are most typically conceptualized as mental processes. This conceptualization has been studied for many years in relation to addiction. Specifically, researchers have investigated these concepts in order to refine models of addiction. One of the main theories of addiction, Incentive Sensitization Theory (IST), directly addresses the potential that Liking and Wanting have very separate roles in addiction (Robinson & Berridge, 1993) (IST 93). In IST 93, Liking was identified as pleasure, and Wanting as a strong desire or craving. This theory and competing theories of addiction will be reviewed in detail later. To start, a detailed review of Liking and Wanting in the addiction literature will enhance understanding of addiction models described later; this review will also provide the framework and rationale for the procedures and measures used in parent studies that this dissertation analyzes.

LIKING

As noted by Meloscia (2014), classically, researchers have considered addiction to be mediated by pleasure. A simple observation that supports this intuitive view is that addictive drugs elicit pleasure. Moreover, addicts lay down pleasurable memories of past experiences, and memories for past pleasure might mediate addiction (Robinson & Berridge, 1993). Therefore, as argued by Meloscia (2014), both the real-time experience of smoking and the recall of pleasurable smoking experiences may underlie dependence and relapse.

Shiffman and Kirchner (2009) state, “More satisfied smokers might have greater difficulty quitting and staying quit because they value and miss cigarettes more” (p. 349). They suggested that subjective ratings of smoking, such as reported satisfaction, should

be the focus of research. For example, as noted by Meloscia (2014), individuals who report that smoking is more pleasurable may be more likely to progress to full relapse in the event that they experience a lapse to smoking during a smoking cessation attempt (Shiffman and Kirchner, 2009).

Liking Terminology

As is already apparent from the brief review above, several terms have been used in the addiction literature to assess Liking. The terms “satisfaction” and “pleasure” have been used in smoking studies as a measure of self-reported liking. Specifically, after smoking a cigarette, participants have been asked to report their level of satisfaction and pleasure. There has been no significant difference found between measuring Liking using the different terms of “satisfaction” or “pleasure”. Specifically, pleasure and satisfaction were highly correlated and exhibited a similar pattern of relationships with study variables, such as dependence and risk of relapse (Shiffman and Kirchner, 2009). The word “liking” has also been used to assess Liking (e.g. Perkins et al. (2012). As concluded by Meloscia (2014), “No major theoretical or empirical differences have been hypothesized or observed between the terms liking, satisfaction, and pleasure” (p.7).

Assessment of Liking

As alluded to above, various self-report measures for Liking have been used in the smoking literature and there does not seem to be a “gold standard” measurement. A review of Liking measurements is presented here with additional details regarding the specific measures used in this study provided in the chapter on study procedures.

To assess Liking, several studies have used a single question from the Rose Sensory Questionnaire rating Liking on a visual analog scale from 0-100 (e.g. Perkins et

al., 2012; Perkins et al. 2008). For example, in Perkins et al. (2012), after finishing the cigarette participants were asked to rate subjective responses to the question, “How much did you like the puffs you just took?” Perkins et al. (2012) reported “subjective measures from the ad libitum smoking of a single cigarette were highly reliable” (p. 492) and concluded that this measure could be useful for future studies attempting to measure individual differences in subjective ratings of smoking.

Other studies have asked participants to rate how satisfying or pleasurable smoking a cigarette was on a scale from 0-10 with anchors of “NO!!” and “YES!!” at each end of the scale (Shiffman and Kirchner, 2009). The studies in this dissertation used a seven point Likert scale asking the question “Overall, how much did you like the cigarette?”

Two other more detailed measures have been used to assess Liking. The Nicotine Effects Questionnaire (NEQ) is a self-report measure of 16 items that are grouped into several categories: urge (1 item), positive affect effects (4 items), negative affect effects (3 items), unpleasant physical effects (6 items), and cognitive effects (2 items). Items are ranked on a scale from 0 to 10 with anchors of “Not at all” to “Very much” (Strong et al., 2011). Strong and colleagues (2011) used this measure in study investigating how positive and negative affect effects of smoking are related to smoking relapse and nicotine dependence.

The Smoking Consequences Questionnaire (SCQ) is used to assess outcome expectancies from smoking. Smoking expectancies are related to smoking dependence and self-reported subjective effects of smoking (Juliano and Brandon, 2002). This measure is frequently used in studies that investigate different factors related to smoking

dependence and relapse. The original SCQ has ten factors that show high reliability; all factors had a reliability coefficient greater than .83 (Copeland et al., 1995). For the current study, as will be described in detail later, items derived from the factors associated with hedonic effects of acute smoking were utilized. These factors include Boredom Reduction, Stimulation/State Enhancement, and Negative Affect Reduction. Of note, the Negative Affect Reduction factor has been associated with nicotine dependence and relapse after cessation (Copeland et al., 1995).

Other measures of Liking, including versions of the Implicit Association Test (IAT), aim to assess implicit responses (Tibboel et al., 2015). While a detailed review of implicit measures is beyond the scope of this study, they will be discussed later given their potential role in measuring Liking and Wanting.

Recent Studies of Liking

Several recent studies, including two laboratory studies and one Ecological Momentary Assessment (EMA) study, provide useful data on self-reported Liking, often referred to as acute hedonic effects (see Figure 1) of smoking. These studies show associations between Liking with relapse or dependence.

Shiffman and Kirchner (2009) collected smoking satisfaction ratings from 394 heavy smokers on hand-held computers for 16 days of ad libitum smoking prior to a quit day. This study used EMA measures that collect data in a smoker's natural environment rather than in the laboratory. Controlling for nicotine dependence, they found that smokers with higher ratings of satisfaction and pleasure also had higher rates of relapse when subsequently attempting to quit. This finding suggests that memory of smoking satisfaction may promote relapse (Shiffman and Kirchner, 2009).

Perkins et al. (2012) investigated subjective ratings in 94 participants who smoked one cigarette in the lab. They found a correlation between liking ratings and dependence and concluded that subjective ratings of smoking in the lab could be a reliable way to assess for Liking (Perkins et al., 2012).

In Meloscia (2014), smokers (N=268) enrolled in a smoking cessation study were followed from two weeks pre-quit through four weeks post-quit. At each pre-quit session, participants smoked a cigarette. After the first seven puffs of the cigarette, they rated puff liking on a seven-point scale. The primary outcome variable was continuous abstinence for one week post quit day. Individuals who reported higher average Liking ratings were more dependent and more likely to relapse during the first week of a smoking cessation attempt. As a participant's smoking Liking rating increased by 1 unit, the odds of relapse at Week 1 increased by 45%. Stated another way, the odds of relapse in a smoker with a mean puff liking rating of 6 is 45% higher than the odds of relapse for smoker with a mean rating of 5. In sum, Meloscia (2014) found that simple, subjective measures of Liking may be useful for clinical application, and interventions that decrease the acute subjective pleasurable effects of cigarette smoking may facilitate smoking cessation.

WANTING

As noted earlier, in IST 93, Wanting was identified as a strong desire or craving, the common sense meaning of the term. Further, IST 93 also specified that Wanting was “the result of incentive salience attribution” as described by Robinson and Berridge (1993) (Table 1), i.e., the association of a rewarding value to a drug-related cue (Tibboel et al., 2015). In other words, Wanting was identified as the “end result” of another process (incentive salience attribution). This process is described in more detail later.

Wanting Terminology

Drug Wanting is often characterized as craving. Kozlowski and Wilkinson (1897) recommended that researchers consider the definition of craving in addiction research to be a “strong desire to take drugs”. Robinson and Berridge (1993) stated that Wanting can be measured through various constructs including craving and approach behavior. Subjective craving has been identified in many addiction models as an underlying factor of substance abuse and relapse (Franken, 2003). There is much research on the association between craving and relapse with some theories suggesting that craving is an important predictor of relapse (Ferguson et al. 2010; Shiffman et al. 2007). In particular, studies have shown that cue-induced craving is associated with dependence and relapse (Ferguson and Shiffman, 2010).

Interestingly, the Diagnostic and Statistical Manual, Fifth Edition (DSM-5) states: “An important characteristic of substance use disorders is an underlying change in brain circuits that may persist beyond detoxification...The behavioral effects of these brain changes may be exhibited in the repeated relapses and **intense drug craving when the individuals are exposed to drug-related stimuli**” (p. 483). Clearly, craving is also recognized as an important component of substance use disorders within the DSM-5.

Assessment of Wanting

Standard measures of Wanting include questions from the Questionnaire of Smoking Urges-Brief (QSU-Brief) and Wisconsin Smoking Withdrawal Scale (WSWS). The QSU-Brief was developed as a measure of craving and has been found to measure two factors of craving: 1) intention and desire to smoke, 2) relief of negative affect with an urgent desire to smoke (Cox, Tiffany, & Christen, 2001; Toll, Katulak, and McKee,

2006). The WSWS is a brief self-report measure that was created to accurately assess the domains associated with smoking withdrawal. The scale has seven factors, including a craving scale, that have been found to have high reliability. Importantly, scores on the WSWS were found to be significantly predictive of smoking relapse behavior (Welsch, Smith, Kenford, et al., 1999).

Recent Studies of Wanting

Many studies have investigated the role of craving in smoking addiction and relapse. A recent review (Wray, Gass, and Tiffany, 2013) found 62 studies (up to December 2011) that examined craving in smokers trying to quit. Inclusion criteria for the review were a self-report measure of craving and an analysis of the association between craving and relapse. After reviewing these studies, the authors concluded that about half of the studies reviewed documented an association between craving and relapse and half did not. Numerous considerations such as measurement of cues, timing of measurement, and psychometric limitations were provided to explain the divergence in findings. Overall, the authors concluded that craving is a relevant component of relapse (Wray, Gass, and Tiffany, 2013). A review of the literature makes evident that the concept of Wanting/craving plays an important role in the understanding and treatment of smoking addiction.

LIKING AND WANTING AS AN EFFECT

Although IST 93 defined Wanting (and Liking) as a mental process, in a later paper, Berridge et al. (2009) defined Wanting in terms of the effects that drug-related conditioned stimuli (CS+) have on animal behavior. In particular, as described by Tibboel et al. (2015), stimuli that are paired with unconditioned rewarding stimuli (US+) become

“motivational magnets” and elicit approach behavior. The presence of CS+ may also increase self-administration of the US+. In addition, animals will self-administer the CS+ in the absence of the US+. (Tibboel et al., 2015).

Although the “Effect” definition is mainly related to animal research, the idea of a motivational magnet has been applied to human addiction. Specifically, Robinson and Berridge (1993) also suggest that attention to drug cues may be a measure of Wanting. As Berridge (2009) writes:

“When attributed to a stimulus representation, 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.” (p. 379)

This “attentional bias” to drug cues can be assessed using a variety of measures including reaction time tasks or eye movements. In this study, we focused on the use of the Subjective Attentional Bias Questionnaire (SABQ) to investigate attention to smoking cues (Leventhal et al., 2010; see also Robinson et al., 2015). Although self-report assessments, such as the SABQ, do not reveal detailed information about the mechanisms of the fast cognitive processes that underlie attentional bias, self-reported attention may provide a summary measure of the end product of those processes.

LIKING AND WANTING AS UTILITIES

A utility can be defined as “the psychological value or desirability” of something versus the actual value or amount of something (Kahneman, 2011, p. 272). Tibboel et al. (2015) review four terms involving utility that are relevant for addiction. “Predicted utility” refers to the expected pleasure of an activity. “Decision utility” refers to the “essence of the decision at the moment it was made”. “Experienced utility” refers to the hedonic response after a reward is obtained. “Remembered utility” refers to the memory of the pleasure. Berridge and Aldridge (2009) identified “wanting” as “decision utility” and “liking” as “experienced utility”.

For the present study, the most important distinction is between “experienced utility” and “remembered utility”. The idea of Experienced versus Remembered is based on work in behavioral economics. This following section will provide a background and review of the literature pertaining to the ideas of experienced and remembered utility.

In general, behavioral economics research suggests that many factors contribute to judgment and decision-making including factors outside of an individual’s initial awareness. The following quotation summarizes this idea nicely and introduces the concept of utility.

“Just as people are not aware of the processing the brain engages in to translate vision into sight, they are not aware of the kinds of computations the brain makes in editing and evaluating choice. People make decisions according to how their brains process and understand information not solely based on the inherent utility that a certain option possesses for a decision maker.” (p.18) (McDermott, 2001)

Psychologist Daniel Kahneman, a prominent researcher in this subject, has spent much of his career researching the cognitive processes behind judgment and decision-making. In Kahneman's book "Thinking, Fast and Slow" (2011), he explains the concepts of "experienced" and "remembered" in a chapter entitled "Two Selves". He states that one "self" experiences pleasure and pain (and, presumably, craving) in the moment throughout the day (Experienced). The second self, the remembered self, evaluates experiences after the fact and generates summary memories of past pleasure and pain (Remembered).

For example, during a vacation an individual presumably experiences pleasure throughout the duration. When asked to evaluate the vacation when it is over, the remembered self will construct a memory that may influence future behavior more than the experienced self (Kahneman, 2011). A more detailed explanation of this phenomenon can be given with the following example. If the vacation were seven days long, and the individual rated his or her enjoyment on a scale from 0 (not enjoyable at all) to 5 (very enjoyable), one could obtain an average level of overall enjoyment that would be the experienced enjoyment of the vacation. So, if the traveler rates most days as 5 with a few 4s and the last day of travel being a 3 due to an airline delay, the average enjoyment for the vacation might be 4.5. However, if you asked the traveler to rate the overall (experienced) enjoyment of the vacation, the traveler is likely to provide a rating lower than 4.5, perhaps a 3.5. (The reason for this will be described later). This lower rating is not actually indicative of the experienced enjoyment from the vacation but of the remembered enjoyment the traveler had. And the remembered enjoyment is what the traveler will likely rely on for future decision making about vacations.

Kahneman (2011) explains that as “rational agents” future decisions should be made on what the full experience has been, but that frequently future decisions are based only on what is the remembered experience; the remembered experience is often not a simple average of experiences, and may be systematically biased (as explained in the section below).

Kahneman describes the difference between the two selves by suggesting the different types of questions that they answer. The experiencing self answers the question “Does it hurt now?” whereas the remembering self answers the question, “How painful was it, on the whole?” He states that we often rely on our remembering self to define the experience of an event while the actual experience in the moment can be forgotten. He sums this idea nicely in a quote, “Odd as it may seem, I am my remembering self, and the experiencing self, who does my living, is like a stranger to me” (p.390) (Kahneman, 2011).

Another term in the behavioral economics literature (and one that Kahneman uses when discussing Remembered versus Experienced) is utility. As noted above, Kahneman (2011) describes utility as “the psychological value or desirability” of something versus the actual value or amount of something. He uses an example involving money to further describe utility. If a person who has \$100 dollars is offered \$10 dollars, the \$10 dollars will likely have the same utility as \$20 dollar when someone who has \$200 is offered \$20 dollars (Kahneman, 2011). Kahneman further explains the idea of utility by discussing percentages of money and how people often talk about money in percentages, such as a 10% work bonus or 5% pay raise. It is likely that a 5% pay raise will have the same utility (psychological value or desirability) for people with two different salaries (for

example \$50,000 and \$100,000) even though the raise amount (for example, \$2,500 and \$5,000) will be different for them both.

Kahneman and Krueger (2006) suggest that there is not one type of utility and that “it is fruitful to distinguish among different conceptions of utility rather than presume to measure a single, unifying concept that motivates all human choices and registers all relevant feelings and experiences” (p. 4). In this study, we are examining two types of utility (Experienced and Remembered) in two areas (Wanting and Liking). Experienced utility has been described as the “continuous hedonic flow of pleasure or pain” (Kahneman and Krueger, 2006, p. 4) and is the same as the “experienced self” described above. Remembered utility has been described as a “retrospective report” used in evaluation of “experience as a whole” (Kahneman and Krueger, 2006, p. 5) and is the same concept as the “remembered self” described above. Kahneman and Krueger (2006) write in their article on measuring subjective effects that remembered utility cannot generally be considered an accurate measure of experienced utility.

As noted above, the literature on utility also includes the concept of decision utility. While we do not investigate decision utility in this study, we will briefly discuss the subject. Kahneman argues that experienced and remembered utility are distinct from decision utility (Kahneman, Wakker, and Sarin, 1997). Decision utility has been referred to as “the weight of an outcome in a decision” (Kahneman, Wakker, and Sarin, 1997, p.375; see also Tibboel et al. 2015). Dolan and Kahneman (2008) also define decision utility as the “preference or desire for an outcome” (p.215). Specifically in addiction, decision utility has been defined as Wanting or the “essence” of a decision (Tibboel et al., 2015). Operationally, decision utility is measured by choice. For example, in a smoking

cessation study decision utility could be measured by noting whether a smoker chooses to smoke or not in a laboratory setting (Read, 2004). A smoking study investigating decision utility could assess if this type of choice predicts future smoking behavior.

Peak-End Rule

A specific application of experienced and remembered utility applies to the heuristic known as the Peak-End Rule (analyzed in Aim 1 of the current study). The concept is that retrospective evaluations (Remembered) are more affected by two time points during an event (Experienced), the most extreme affective moment (peak) and the end moment (Kahneman, 2000).

An example of the Peak-End rule comes from a study by Redelmeier and Kahneman (1996) that considers patient reported pain during and after a colonoscopy. Patients were asked to record pain intensity every minute during the procedure that could range in time from 4 minutes to 69 minutes. Intuitively, one would think that the patient who underwent the longer period of pain would report the overall procedure as more painful than a patient who had a shorter procedure (i.e., 4 minutes of pain would be less painful than 69 minutes of pain). However, researchers found that the overall rating of pain (Remembered) was predicted by the level of pain recorded at a patient's peak (highest) level of pain and end (last minute of procedure) level of pain, but not by the duration of the procedure.

In a specific medical example of the Peak-End rule, Patient 1 has a 4-minute procedure with a peak pain rating of 7 (on a scale from 1 – 10) and an end pain rating of 8. Patient 2 has a 69-minute procedure with a peak pain rating of 7 and an end pain rating of 5. Common sense would lead one to assume that Patient 2 would report the higher

level of overall (Remembered) pain. However, Patient 1 reported the higher level of overall, remembered pain. This counterintuitive response is caused by Patient 1's higher end rating of pain and by the tendency for the duration of the episode to be "neglected" (Redelmeier and Kahneman, 1996). The Peak-End rule suggests that overall memories have the potential to be biased in ways that do not always reflect the actual "in the moment" perception of pain or pleasure. Therefore, the aggregate rating may not be an accurate reflection of the actual rating of pleasure or pain.

Several other research studies have shown the validity of the Peak-End Rule heuristic. For example, Kahneman, Fredrickson, Schreiber, and Redelmeier (1993) found support for the Peak-End Rule when asking participants to select a repeat trial of placing their hand in painfully cold water. Participants could select to repeat a trial of longer duration with a temperature increase at the end of the trial (i.e., a better, less painful, end) or a shorter duration trial with the same initial temperature as the first trial. Participants tended to select the longer trial, even though the cumulative experienced pain was greater. Researchers point to the less aversive ending as a potential reason for this selection. What participants remembered (i.e., feeling better at the end of the longer trial) guided their decision instead of what they experienced (i.e., less overall pain with trial 2 due to shorter duration).

An additional study looked at the Peak-End rule (or "Peak-End bias") in food choice. This study is more closely aligned to addictive processes than the previous studies. The researchers found that unrestrained eaters reported higher levels of remembered enjoyment based on the ending they experienced during the eating procedure. In a second part of this study, researchers found that peak liking correlated

more highly with remembered liking than other parts of the experienced liking. They assessed this by comparing five food item ratings taken in the moment of eating to remembered enjoyment measured two hours later. The researchers concluded their article by discussing possible clinical interventions that manipulate experienced liking to instill healthier eating habits through remembered liking in unrestrained eaters (Robinson, Blisset, and Higgs, 2011). This type of clinical intervention is one that will be included in the discussion section of this study.

Finally, one may wonder whether there are individual differences in Peak-End bias. While the literature on individual differences in peak-end bias is scarce, a recent study analyzed individual differences for Peak-End bias in patients' recall of pain and fatigue. This study found that there were significant individual differences in how the peak-end bias affected responses to overall pain and fatigue ratings. The authors suggest that understanding which patient is more affected by the Peak-End bias may be useful for understanding that individual's decision making process (Schneider et al., 2011).

In sum, many studies have shown that the Peak-End bias affects the way that people rate past experiences, and this could influence future decision-making. Examining how the Peak-End bias may operate in self-reported Liking and Wanting in smoking behavior could be a useful addition to shape clinical interventions for smoking cessation.

Experienced and Remembered versus State and Trait

When reviewing the concepts of Experienced versus Remembered, some readers might consider these ideas to be similar to the personality characteristics of state versus trait. Traits have been defined as characteristics and patterns that are stable, consistent, internally driven, and endure as a response through various types of situations. States

have been defined as more fleeting responses that are inconsistent, do not endure across situations, and are externally driven by motives and situational factors (Chaplin, John, and Goldberg, 1988).

Some readers might identify equivalence between “trait” and “Remembered”, and between “state” and “Experienced”. However, there are differences. First, these concepts are generally applied to different affective domains. State and trait are often applied in domains such as anxiety or anger that are relevant for personality traits. Remembered and Experienced have most often been applied to pleasure and pain. Second, while “state” and “Experienced” might be similar with respect to the focus on the current moment, “trait” and Remembered are very different. There is no equivalent in state/trait literature of the Peak-End rule. With a trait, responses should theoretically stay consistent over time, whereas remembered utility is theoretically expected to vary according to the peak and ends pertaining to the recall period.

Peak-End Rule in Smoking

Now that the ideas of experienced and remembered utility have been explained, their connection with this study will be discussed. When investigating the effects of Liking and Wanting on smoking relapse and dependence, examining the differences between short-term (Experienced) ratings of Liking and Wanting (during smoking or right after smoking) and longer term (Remembered) ratings of Liking and Wanting after smoking may potentially be important for understanding dependence and relapse.

For example, Meloscia (2014) asked smokers to rate each of seven puffs of a cigarette and to give an overall rating of liking afterwards. There was evidence that Liking ratings from the puff with the Peak Liking rating and from the final puff (End

Liking) were more strongly associated with Remembered Liking than a rating from a cigarette puff selected at random. Further, the last puff, which had the lowest rating, may have particularly influenced overall liking ratings (Remembered Liking) as the overall liking ratings were lower than the average rating (Experienced Liking) across the seven cigarette puff ratings. This knowledge could allow clinical researchers to consider different ways to treat smoking addiction.

LIKING AND WANTING AS NEUROBIOLOGICAL PROCESSES

IST 93 relied heavily on the neurobiological pathways associated with Liking and Wanting to explain addiction. Understanding the neurobiological pathways can help explain why drugs can be craved to such a high degree and inform the idea of the separability of Liking and Wanting. In their initial discussion on IST, Robinson and Berridge (1993) introduced the idea that drugs of addiction activate the dopamine system. The general concept as stated by Franken (2003) is that “all drugs of abuse induce release of dopamine in the mesolimbic dopamine reward system (in particular the nucleus accumbens)” (p. 568). This activation triggers the process of incentive salience (described earlier). With continued drug use, the activation of dopamine leads to changes in the neural system that change incentive salience for drugs and drug-related cues from standard Wanting to intense feelings of Wanting (craving). This intense level of Wanting can exist without equivalent levels of Liking, and the neural pathway associated with Liking is not affected by the changes in the neural pathway of Wanting.

In a more recent review of Liking and Wanting, Berridge (2009) elaborated further and stated “different brain mechanisms seem to mediate wanting and liking for the same reward.” The Wanting system is governed by the mesolimbic dopamine system.

Berridge continues by describing the brain structures involved in the Wanting pathway. He begins describing the Wanting neuronal pathway with the midbrain, where dopamine neurons exist. The pathway continues with the nucleus accumbens, amygdala, and prefrontal neocortex.

In studies, manipulating dopamine has produced the greatest effect on changing Wanting. Berridge (2009) writes,

“Manipulations of dopamine neurotransmission have proven especially useful in manipulating and isolating incentive salience to reveal its psychological features, because of all neurotransmitters in this system dopamine activates “wanting” most selectively as a psychological function. Manipulations that selectively boost brain mesolimbic dopamine signals tend to specifically increase “wanting”, without increasing other reward aspects such as “liking” or hedonic pleasures.” (p.4-5)

Berridge (2009) further explains the difference with the Liking neurobiological pathway highlighting that “liking” is more restricted both by neurochemicals and by anatomy. He suggests that due to these restrictions, brain mechanisms may tend towards a state of Wanting more easily than Liking.

Some research suggests that there is a “hedonic hotspot” in the nucleus accumbens that is part of the Liking pathway and that other areas in the nucleus accumbens have been attributed to the Wanting pathway (Tibboel, Houwer, and Bockstaele, 2015). Another perspective on the neurobiological pathways of addiction describes a distinction between processes that occur in the “core” and the “shell” of the nucleus accumbens. In an early paper, Pecina and Berridge (2000) found that there is a

“liking hotspot” on the shell of the nucleus accumbens that increased “liking” behavior. A similar reaction was not found when testing areas in the core of the nucleus accumbens. Di Chiara (2002) suggested that the dopamine triggered by drug use stimulates both the core and the shell of the nucleus accumbens. This stimulation leads to increased incentive salience to drug cues. Further, in a recent animal study, Pecina and Berridge (2013) found that dopamine stimulation of both the core and the shell of the nucleus accumbens triggered “wanting” like behavior in the rats being tested. They concluded that dopamine stimulation of the entire nucleus accumbens could increase incentive salience and overall Wanting.

In sum, research on drug use, dopamine, and the nucleus accumbens seems to suggest that both the shell and core are involved in the Wanting process and that Liking may be more limited to specific areas of the shell. Further, Wanting seems to be connected to dopamine and the mesolimbic system whereas Liking seems to be connected to hedonic hotspots and affected by opioids only (Tibboel et al. 2015).

In a recent review on the neurological pathways of pleasure, Berridge and Kringelbach (2015) discussed recent ideas about dopamine, Wanting, and Liking. They state that in both animal and human studies increases in dopamine have not corresponded with increases in pleasure or Liking, and that often increases in dopamine from drug administration only result in intense Wanting with no corresponding intense Liking. They conclude that more research needs to be conducted to fully understand “how these neural mechanisms control what gets ‘wanted’ most in addiction” (Berridge and Kringelbach, 2015, p.657).

MODELS OF LIKING AND WANTING IN ADDICTION

Given all information from the review above, and the observation that addictive drugs elicit pleasure, one might consider two views of Liking and Wanting in addiction. One view is depicted in Figure 2 (part A), which provides a model (the “Toates Bindra” model, Toates, 1996) of motivation. In this model, one “wants” what one “likes”. For example, a chronic smoker would report Liking a cigarette that was Wanted (Robinson and Berridge, 1993).

However, this intuitive model of Wanting and Liking has been challenged, at least in the context of addiction. As described earlier, prominent researchers have suggested that drug Wanting and drug Liking can be separable (dissociated). As Tibboel, Houwer, and Van Bockstaele (2015) write, “Even though usually “wanting” mirrors “liking” (i.e. we “want” and pursue things that we “like” and we avoid things that we do not “like”), these processes do not need to overlap” (p. 351). More specifically, as noted earlier, Robinson and Berridge (1993) suggested that the neural system responsible for drug Wanting is somewhat independent of the neural system associated with drug Liking, and that in addicted individuals it is the Wanting system that drives addiction. Therefore, a chronic smoker would potentially report still Wanting a cigarette despite not Liking cigarettes. This view is provided in Figure 2 (Part B). To provide context for the incentive sensitization model, after further elaboration of IST, three of the major models of addiction will be reviewed below.

Elaboration of IST 93

The main tenet of IST is that as drug addiction develops, the incentive salience of drug cues increases due to neuronal changes such that while drug Liking may decrease,

drug Wanting will increase. Berridge and Robinson (1998) explain their incentive salience hypothesis by suggesting that dopamine mediates the neural pathway for Wanting in such a way to enhance the drug and any related drug cues. In regards to Liking, there is a separate neuronal pathway that does not respond similarly. There is a separate neural pathway for Liking that is not affected in tandem with Wanting during addiction, so that over time Wanting will increase while Liking stays the same or diminishes (see Figure 3).

More specifically, according to IST (see Figure 2, part B), there are two hypothesized routes that produce subjective effects of a stimulus. Under normal circumstances (i.e. not addiction), a stimulus is processed by the “Pleasure Integrator” and identified as a pleasant stimulus. This process leads to Liking. Liking is associated with subjective pleasure. The Liking system (Pleasure Integrator) informs the Wanting system that a pleasurable stimulus has been encountered. The “Incentive Salience Attributor,” part of the Wanting system, interacts with another mechanism “Associative Learning” and incentive salience is assigned to the mental representation of the stimulus paired with the drug. When incentive salience is assigned to a stimulus, the “incentive stimuli” leads to Wanting. The Wanting system mediates “subjective craving”, approach behavior, and “consumption” (Robinson and Berridge, 1993).

Usually, incentive salience is assigned to stimuli that are associated with pleasure. But Robinson and Berridge (1993) argue that drugs, such as nicotine, can cause neural pathway changes that allow for the direct attribution of incentive salience (Wanting) without the initial encounter with the Pleasure Integrator (Liking route). Crucially, after repeated drug use, “sensitization” occurs in some individuals (hence “incentive

sensitization” theory). Drugs and drug-related cues end up being craved more than would be expected based on the level of Liking.

Figure 3 further explains the dual process of Liking and Wanting in addiction. According to IST, as drug use continues, drug Liking will (if anything) decrease as drug Wanting increases. Wanting increases because in some individuals the incentive salience of certain cues becomes progressively greater, due to incentive sensitization (described above). The Wanting pathway generates intense craving whereas the Liking pathway is not sensitized and either stays at the same level or decreases. If anything, the theory indicates that there is tolerance (opposite of sensitization) to drug Liking over time. If the view shown in Figure 2 (Part B) is correct, a dissociation between Liking and Wanting in drug use is not so surprising.

Prior to a review of studies that show dissociation between Wanting and Liking, a brief review of other theories of addiction is briefly presented.

Negative Reinforcement Model

The Negative Reinforcement model of drug addiction (also referred to as Withdrawal model) states that relapse occurs due to the negative effects of withdrawal from the addictive substance. For example, smokers report negative symptoms associated with abstinence from smoking. According to this model, a smoker attempting to quit would relapse to reduce the negative symptoms of withdrawal. Robinson and Berridge (1993) refer to this model as “escape from distress.” This theory was one of the first studied in addiction likely because opiates were one of the first drugs to be studied. Opiates do elicit very pronounced withdrawal symptoms that would suggest the need to “escape from distress” (Robinson and Berridge, 1993). However, more recent studies

have shown weaknesses in the Negative Reinforcement theory of addiction. These weaknesses will be presented following a discussion of two other theories of addiction.

Positive Reinforcement Model

The Positive Reinforcement model of addiction states that drug addiction continues due to dependence on the hedonic (pleasurable) effects of the drug. For example, a smoker would continue smoking for the positive effects. This differs from the negative reinforcement model in that this model suggests that addiction occurs due to the positive state that drugs create versus alleviation of the negative state of withdrawal. Furthermore, someone trying to quit smoking may relapse due to memories of past pleasurable effects from smoking. Robinson and Berridge (1993) refer to this model as “pleasure-seeking.”

I-RISA Model

For another perspective on the neurobiological pathways associated with addiction, Goldstein and Volkow (2002) presented a model called impaired response inhibition and salience attribution (I-RISA) syndrome of drug addiction. In summary, this model includes the role of the frontal cortex in the addiction process. Goldstein and Volkow state, “The involvement of the frontal cortex through these cyclical stages of addiction is likely to play an important role in the cognitive behavioral and emotional changes that perpetuate drug self-administration...” (p. 1650). Neuroimaging has shown that dopaminergic pathways in the limbic system play a role in the addiction process (as discussed by Robinson and Berridge regarding the Incentive Sensitization Theory), however the I-IRISA model states that the mesolimbic dopamine pathways alone cannot fully explain addiction. This model introduces the idea that changes in brain structures

such as the frontal cortex that are affected by changes in dopamine in the mesocortical (rather than mesolimbic) pathway are likely to more fully explain the neurobiological underpinnings of addiction. These structural changes in the frontal lobe would then have an effect on motivational states and cognitive processes that become part of the addiction process (such as salience attribution and response inhibition).

In the next section, studies examining Wanting without Liking will be reviewed to provide support for the Incentive Sensitization Theory. Many of these studies, particularly in animals, investigate how changes in dopamine levels affect measures of Liking and Wanting.

SEPARABILITY OF LIKING AND WANTING

If Liking and Wanting are indeed separable, as suggested by IST, the most compelling demonstration of this would be examples of cases of “Wanting without Liking” and “Liking without Wanting”. Studies to evaluate the distinction between Liking and Wanting have been conducted using both animals and human participants across a wide range of addictions. (Research has shown that IST may be a good explanation for Wanting and Liking processes in many forms of drug addiction (Robinson and Berridge, 1993)). A brief review of several studies showing this disassociation of Wanting and Liking in both animals and humans follows. More studies looking at the separability of Liking and Wanting have been conducted with animals, but studies conducted with humans on this topic continue to grow in number.

Wanting Without Liking

Animal Studies

Animal studies investigating Liking and Wanting used specific behaviors to identify liking type behaviors and wanting type behaviors in the animals. Wanting type behavior was assessed by animal effort to obtain a reward whereas liking type behavior was assessed by orofacial expression, such as patterns of whisker movement (Robinson and Berridge, 1993; Pool et al. 2016).

Treit and Berridge (1990) showed that in using sucrose and quinine to obtain a taste reaction that adult rats showed pleasurable or aversive reactions as usual to these substances. Then, upon administration of dopaminergic agents to the rats, there were no changes in the taste reactions. These results indicate that despite prior studies showing that dopaminergic agents do affect food intake, in this study the agents did not affect the Liking response to food (Robinson and Berridge, 2003). A second animal study showed that electrical stimulation of a brain section (lateral hypothalamus) in rats led to increased feeding (“stimulus bound feeding”) but did not also lead to increases in pleasurable responses to feeding. Rats may have “wanted” the food source more due to the stimulus, however the rats’ taste reactions to the food source did not show increased pleasure with the feeding (Berridge and Valenstein, 1991).

A more recent animal study looked at both Liking and Wanting responses in hyperdopaminergic mutant mice (mice with a mutation that leads to increased dopamine production). Wanting behaviors were assessed using a runway task where mice were measured on “incentive runway behavior,” such as time to reach the reward, during multiple trials. Liking behavior was measured using a taste reactivity paradigm that assessed facial reactions to a sucrose solution. The researchers found that Wanting

behaviors in the hyperdopaminergic mice increased while Liking behaviors did not increase in a taste reactivity paradigm (Pecina et al., 2003).

While these animal studies did not directly address smoking, the results provide a model for how dopamine affects Liking and Wanting behaviors in smoking. In the smoking literature, it has been accepted that nicotine plays a dominant role in smoking addiction. Nicotine, similar to other addictive drugs, increases dopamine (Balfour, 2004). The animal studies described above show how increases in dopamine might lead to differences in Liking and Wanting behavior and suggest a possible separability of Liking and Wanting as proposed by the incentive sensitization theory.

Human Studies

There are fewer human studies investigating cases of Wanting without Liking and even fewer that focus on nicotine and smoking. However, several human studies in addiction support the possibility of having Wanting without Liking. For example, studies of cocaine users have shown Wanting behavior (increased self-administration of low doses of cocaine) without an increase in reported Liking. In these studies, cocaine addicts self-administered a low dose of cocaine or morphine versus a placebo dose. When given the opportunity to select a dose, participants usually selected the drug dose versus the placebo dose despite reporting no subjective effects of liking from either the drug dose or the placebo dose. The low dose of drug elicited drug seeking behavior, but no reported increase in self-reported drug Liking (reviewed in Robinson and Berridge, 1993). This behavior would suggest that drugs can be Wanted (craved) without being Liked.

Ostafin, Marlatt, and Troop-Gordon (2010) tested whether Liking and Wanting motivation were different for participants who were regular consumers of alcohol. Using self-report measures of Liking and Wanting after tasting a beer in the laboratory, the researchers found that Liking and Wanting measures were not significantly correlated. (The Liking measure was an aggregate of three ratings of how “delicious” the beer was and three ratings of how “satisfying” the beer was. The Wanting rating was an urge-to-drink Likert scale with one question.) They also found that Liking ratings decreased as the number of years a participant had reported drinking increased. The results from this study support central ideas of the Incentive Sensitization Theory including the separability of Liking and Wanting and that Liking may decrease as addiction to a substance progresses.

Researchers have found that nicotine use can cause increases in dopamine and continued nicotine use without an increase in reported Liking (West, 2009; Isomura, 2014). Robinson et al. (2015) noted that Wanting without Liking generally occurs when dopamine levels are increased. In addition, in Volkow et al. (2002), ratings of Wanting were more highly correlated with dopamine levels than with ratings of Liking. This finding again supports the Incentive Sensitization Theory in that despite continued use Liking indicators for some nicotine users do not correspond with the continued use (Wanting).

Liking Without Wanting

Animal Studies

Using the taste reactivity paradigm, several animal studies have revealed that “Liking without Wanting” can also be observed. Based on studies assessing Liking and

Wanting associated with dopamine deprived rats, Berridge and Robinson (1998) argue that dopamine depleted rats are still able to “like” rewards (such as sugar water), but that these rats do not “want” the reward. In these studies liking is again inferred from the pattern of whisker movements and facial movements exhibited by the rats. Most strikingly, mutant rats lacking the ability to produce dopamine retain the ability to like rewards in the absence of any apparent wanting (Cannon et al., 2003).

Human Studies

Liking without Wanting likely occurs when dopamine is blocked. For example, in studies where dopamine is reduced, Liking ratings tend to stay consistent while Wanting indicators (craving and cue responsivity) are significantly reduced. These findings have been found in human studies investigating tobacco, alcohol, and drug use (Robinson et al., 2015).

A recent human study investigated the effects of catecholamine precursor depletion (known to reduce levels of dopamine in the human system) on non-dependent, non-treatment seeking cocaine users. Participants ingested a liquid mixture (acute phenylalanine-tyrosine depletion (APTD)) that caused depletion in dopamine. They were then asked to complete measures of craving and euphoria. Self-administration of cocaine during a specific time period was also measured. Researchers found that with depleted dopamine, participant cue-induced craving and cocaine-induced craving decreased. However, self-reported euphoria and self-administration did not decrease. This study shows the potential for a different pathway of Wanting (craving) and Liking (euphoria) that is mediated by dopamine levels (Leyton et al., 2005).

In sum, animal and human studies in many areas of addiction (alcohol, nicotine, opiates, etc.) show that "Liking without Wanting" and "Wanting without Liking" can be observed. These findings support the separability of Liking and Wanting in addiction, a central idea of the Incentive Sensitization Theory.

COMPARING MODELS OF ADDICTION

After a thorough review of Liking and Wanting as related to the Incentive Sensitization Theory (IST), we turn to evaluation of IST in relation to other models of addiction.

In their first article introducing Incentive Sensitization Theory, Robinson and Berridge (1993) discuss the issues they have with the negative and positive reinforcement theories of addiction. Regarding problems in the negative reinforcement model, several studies are cited that indicate that in both animals and humans, drug self-administration will occur even when not in a withdrawal (negative) state. Robinson and Berridge (1993) also highlight that many studies show relapse can occur long after withdrawal symptoms have diminished.

Turning to the positive reinforcement theories of addiction, studies suggest that often a drug addict may not like the drug but that they want/need the drug. The review of issues with the positive reinforcement theory also suggests that the pleasurable/positive effects of a drug are relatively modest compared to the negative consequences associated with drug addiction (job loss, health issues, loss of friends) that the positive reinforcement explanation could not fully explain the process of addiction (Robinson and Berridge, 1993).

There are critiques of the Incentive Sensitization Theory as well. One critique is that the theory does not easily incorporate “habit-based” responding. Mogg, Field, and Bradley (2005) suggest that incentive sensitization may explain the initial phase of addiction, but that over time the long-term addiction process may be better explained by a theory proposed by Di Chiara. His theory states that after long-term smoking incentive sensitization learning switches to habit-based responding (Di Chiara, 2000).

A second critique of the theory regards the measurement of Liking and Wanting. Tibboel, Houwer, and Van Bockstaele (2015) highlight the difficulty of studying incentive sensitization in humans. Many of the studies regarding the separation of Liking and Wanting have been conducted using animal research models and operationalizing Liking and Wanting measures for humans is challenging. This is described in more detail below.

A third critique is that IST has evolved over time, and that “liking” and “wanting” described in more recent articulations of the theory are different from those outlined in IST 93. This is elaborated on below.

EVOLUTION OF IST

Berridge (1996) himself discussed the need to be flexible with defining Liking and Wanting as the research base grew. Tibboel et al. (2015) note that the definitions of Liking and Wanting have certainly evolved in regards to IST. Tibboel et al. (2015) note that while the initial definitions of Liking and Wanting in IST related to conscious mental processes (Robinson and Berridge, 1993), as IST evolved, Robinson and Berridge made a distinction between preconscious and conscious Liking and Wanting. Preconscious “liking” and preconscious “wanting” were placed in quotation marks (Berridge, 2010) to

differentiate them from their conscious counterparts, Liking and Wanting. As noted by Berridge (2010), “Wanting and liking without quotation marks were suggested to refer to wanting and liking in their common sense, whereas “wanting” and “liking” with quotations refer to their meaning in the IST context” (Tibboel et al., 2015, p.353).

This distinction is further explained in Berridge and Robinson (2003). Liking was referred to as conscious pleasure and “liking” as core hedonic impact. Wanting was described as cognitive incentive and “wanting” as incentive salience (Tibboel et al., 2015; Berridge and Robinson, 2003).

In the context of food addiction, Havermans (2011) also notes that “too little thought has been devoted to operationalizing and validating food ‘liking’ and ‘wanting’” (p.252). He cautions that researchers cannot assume that simply asking for self-reported Liking and Wanting can be assumed to be a valid operationalization of the Liking and Wanting that Robinson and Berridge (1993) refer to in their Incentive Sensitization Theory.

This evolution has generated discussion regarding how to operationalize definitions of Liking and Wanting (or “wanting” and “liking”) in regards to addiction and IST. Two recent reviews highlight this in detail (Tibboel et al. 2015, Pool et al., 2016). Our study does not directly measure the concepts of “liking” and “wanting” currently addressed by IST (preconscious Liking and preconscious Wanting). Our study focuses on conscious self-report measures of smoking Liking and Wanting and is more aligned with how the concepts were addressed in IST 93.

SUMMARY – LIKING AND WANTING

From the review presented above, it is evident that both Liking and Wanting play a role in the addiction process, are related to nicotine dependence, and may play a role in smoking relapse. Robinson and Berridge (1993, 2003) suggest in IST 93 that Liking and Wanting are separate factors in addiction pathways. In human studies, Liking for smoking has traditionally been measured through self-reported ratings of “liking” or “satisfaction”. Wanting for smoking can be measured through self-report measures of craving, approach behavior, and attentional bias.

CONTEXTUAL VARIABLES

One final topic to review is contextual variables that could moderate the effect of smoking. Contextual factors specific to smoking include nicotine deprivation, eating, drinking alcohol, caffeine use, and social smoking (Shiffman, 2002). While these contextual factors are not a central focus of this study, it is important to acknowledge their existence. In particular, nicotine deprivation, which can affect smoking behavior and ratings of Liking and Wanting, may be a factor in both Parent Studies given the use of a non-abstinent and abstinent state in each (i.e. different states of nicotine deprivation).

Smokers often report that the initial cigarette of the day, following a period of abstinence (sleep), often provides the largest subjective amount of pleasure and that subsequent cigarettes can produce less subjective pleasure (Pomerleau and Pomerleau, 1992). This effect can be attributed to the role nicotine plays in acute tolerance. Without nicotine present (after prolonged abstinence), there are more nicotinic receptors available to induce feelings of pleasure. As nicotine enters the system (first cigarette of the day),

these receptors are desensitized and overall ability of receptors to receive a pleasure signal is reduced (Perkins, 1994).

A second factor that may contribute to pleasure after deprivation is the reduction in negative affect that occurs after a period of smoking abstinence (e.g., Shiffman & Waters, 2004). For this study, it is important to note that Liking and Wanting ratings could be affected by the contextual variable of nicotine deprivation across the abstinent and non-abstinent states due to acute tolerance and/or reduction of negative affective induced by abstinence.

BACKGROUND SUMMARY

This chapter provided background information in two main areas 1) Liking and Wanting conceptualized from four perspectives (mental processes, effect, utilities, neurobiology) and 2) Models of addiction.

Liking and Wanting both have subjective qualities, and Robinson and Berridge (1993, 2003) suggest that Liking and Wanting are mediated by two different neural pathways. This idea has been supported by both animal studies and human studies. Also, patterns of Experienced Liking and Wanting versus Remembered Liking and Wanting could contribute to the understanding of how the peak-end rule may be related to smoking dependence and smoking relapse. The current study allowed for analyses in these two areas to provide information that can be built on to enhance smoking cessation treatment.

Chapter 3: Introduction to the Current Study

RATIONALE FOR THE CURRENT STUDY

From the review in the previous chapter, it is evident that Liking and Wanting are important components of addiction and an increasing focus of research (Tibboel et al., 2015; Pool et al., 2016; Robinson et al. 2016). Indeed, Ostafin, Marlatt, and Troop-Gordon (2010) state directly that “examination of the separability of wanting motivation and liking motivation would benefit from research that concurrently assesses wanting and liking responses to a substance and their respective ability to predict consumption of that substance” (p.158).

Despite such interest, research on the impact of the subjective effects of Liking and Wanting on smoking behavior in humans is limited. Pool and colleagues (2016) reviewed studies measuring liking and wanting in humans and found that there are more studies investigating Liking and Wanting in food intake and cocaine use than smoking. Reviewing 84 pertinent studies, they found that only 9 studies out of the 84 (about 11%) eligible studies focused on smoking or nicotine use. Of these studies, 1 study used implicit measures, 2 studies used self-report from a questionnaire subscale, 3 studies used a quantitative question (such as Likert scale), and 4 studies included measures of brain activity (fMRI). Most important to note is that 8 studies out of the 9 smoking related studies in this review only assessed Wanting and did not analyze Liking; the one study that did measure Liking and Wanting used implicit measures (Pool et al., 2016). Based on this thorough review of Liking and Wanting research for smoking, the current study clearly fills a gap. Specifically, there are no published studies that examined self-report of Liking and Wanting in a smoking population that is trying to quit.

Figure 1 shows an overall conceptual framework for the study, and helps to organize the specific aims (described below). First, the current study expanded on the author's master's work on self-reported measures of smoking Liking. Specifically, Meloscia (2014) included one of the first analyses on the Peak-End rule for Liking measures of smoking. In the current study, we attempt to replicate this finding and also to extend the analysis to include examination of the Peak-End rule for Wanting.

Second, the study examined the separability of self-reported Liking and Wanting. As described in detail later, this was done using factor analysis.

Third, the study examined the association between self-reported Liking/Wanting and dependence and relapse. Dependence was assessed using the Fagerström Test for Nicotine Dependence (FTND). Findings from Meloscia (2014) revealed that there could be an association between Liking and relapse. The current study extends this analysis by examining both Liking and Wanting.

In sum, the overall goal of this study was to investigate self-reported Liking and Wanting in smoking. The Specific Aims were as follows:

SPECIFIC STUDY AIMS AND HYPOTHESES

Specific Aim 1: To examine the association between Experienced and Remembered Liking, and Experienced and Remembered Wanting (see Table 3 for a list of Experienced and Remembered variables).

Hypothesis 1.1: Peak and End Liking will be more strongly related to Remembered Liking than Liking assessed at a puff selected at random.

Hypothesis 1.2: Peak and End Wanting will be more strongly related to

Remembered Wanting than Wanting assessed at an assessment selected at random.

For both hypotheses, we will also explore whether Peak and End ratings predict Remembered Liking and Wanting when controlling for mean ratings that use data from all assessments.

Specific Aim 2: To analyze the separability of self-report measures of Liking and Wanting using factor analysis.

Hypothesis 2.1: Two factors will be revealed that correspond to Liking and Wanting.

Specific Aim 3: To explore the relative predictive efficacy of self-report measures of Liking and Wanting. We will explore the relative predictive efficacy of Liking and Wanting measures for two dependent variables: FTND score and relapse.

Hypothesis 3.1: Self-report measures of Liking and Wanting will have a predictive relationship with FTND score.

Hypothesis 3.2: Self-report measures of Liking and Wanting will have a predictive relationship with relapse.

DATA SOURCES

The current study utilized data from two previous studies that will be described in detail in Chapters 4 (Parent Study 1) and 5 (Parent Study 2). For this dissertation, these two previous studies are referred to as Parent Study 1 and Parent Study 2. For a brief overview of the similarities and differences between Parent Study 1 and Parent Study 2,

please refer to Table 2. Table 4 shows what parent study data was utilized for each aim and hypothesis.

Chapter 4: Parent Study I Methods

The data from Parent Study 1 used in this dissertation overlap with the sample reported in Waters et al. (2007). Additionally, Parent Study 1 was part of a larger protocol that examined the effects of nicotine and nicotine deprivation on affective and motivational processes. The study was approved by the Institutional Review Board of the University of Texas M. D. Anderson Cancer Center.

PARTICIPANTS

Parent Study 1 included 79 smokers who were not seeking to quit smoking, recruited from the Houston metropolitan area through newspaper and radio advertisements. Inclusion criteria were: 18 - 59 years old; smoking ≥ 10 cigarettes per day; English speakers; and owning a working telephone. Exclusion criteria were: psychotropic medication prescription; reported psychiatric disorder; color-blindness; and self-reported pregnancy or nursing.

Of the 225 participants who completed the phone screening, 62 did not meet inclusion/exclusion criteria. 92 participants, out of the 163 eligible smokers, attended an orientation session at the lab. After orientation, 79 participants attended at least one follow-on session in the lab (79 participants completed session 1, 71 participants completed session 2, 70 participants completed session 3, and 68 participants completed all sessions). Table 5 shows the demographics of our final sample. In sum, sample characteristics were as follows: 55.9% black and 36.8% white; 35 men and 44 women; average age of 42.7 years ($SD = 9.73$); smoked an average of 21.1 cigarettes/day ($SD = 7.64$); average score of 5.51 on the Fagerström Test for Nicotine Dependence (FTND;

Heatherton et al., 1991) (SD = 1.75); and averaged smoking for 22.3 years (SD = 9.51) (see Table 5).

PROCEDURE

The procedures for Parent Study 1 are shown in Table 6 and discussed below. First, a phone screening was conducted during which the following occurred: 1) an initial description of the study design given; 2) data collected on participant age, smoking history, other tobacco use, major medical history, medication use, and pregnancy/lactation status; and 3) participants completed a version of the PRIME-MD, a screener for five major mental disorders listed in the DSM-IV (Spitzer, et. al., 1994). Of note for the PRIME-MD, Cinciripini et al. (2004) compared results from the Structured Clinical Interview for DSM-III-R with the phone-based PRIME-MD and found that the PRIME-MD was able to filter out most smokers with current psychiatric disorders.

Orientation

Next, eligible participants were asked to attend an orientation session, held at the University of Texas M. D. Anderson Cancer Center (MDACC). During this visit, the research team administered additional screeners to assess for tobacco dependence major depression (see Table 6).

Experimental Sessions

After completing the orientation, participants were invited to attend four experimental sessions. The following parameters were followed for the experimental sessions: 1) each session was scheduled at least three days apart; 2) sessions began at the same time of day for each participant; 3) participants were asked to limit intake of coffee

(or other caffeinated beverage) to no more than 2 cups prior to 8:00 am on the day of the experimental sessions; 4) participant was instructed to abstain from smoking for 12-hrs before two of the sessions (AB), and to smoke normally before the other two sessions (NON).

Structure

The four experimental sessions were: AB-NS, AB-S, NON-NS, or NON-S. Sessions were counterbalanced. At two sessions (labeled as NON-NS and NON-S), participants were asked to smoke as usual before the laboratory session. At the other two sessions (labeled AB-NS and AB-S), participants were directed to abstain from smoking on the day of the laboratory session. As shown in Table 6, participants either smoked (S) or did not smoke (NS) during the session, prior to the target cigarette.

Procedure

The procedures for each experimental session are shown in Table 6. First, CO expired breath levels were taken. Next, participants completed several assessments (all listed in Table 6). If a smoking session (S), participants were directed to smoke a cigarette at the appropriate time. Most pertinent to this study are the puff-by-puff Liking ratings of the target cigarette, described below.

MEASURES

Details of those assessments pertinent to the current study will be described. Copies of each assessment are available in Appendix D.

Liking Ratings

Participants smoked a cigarette (their preferred brand) at each of four sessions in the smoking laboratory at MDACC. Participants were asked to smoke seven puffs of one cigarette as they would usually. After each puff, participants were asked to enter a Liking rating after each puff (experienced Liking) on a computer in the lab. At the end of smoking the cigarette, they were asked to enter their overall Liking rating (Remembered Liking) on the lab computer. A research assistant observed from outside of the smoking lab to validate compliance.

The item that participants answered after smoking each puff was “How much did you like the last puff?” The question was on a scale of 1-7 with the anchor at number 1 of “Didn’t like at all” and the anchor at number 7 of “Liked it very much”. The item administered after the cigarette was “Overall, how much did you like the last cigarette?” which had the same 1-7 scale and anchors as the post-puff item. Previous studies have used this type of question to assess smoking Liking (Perkins et al., 2012; Perkins et al. 2008; Shiffman and Kirchner, 2009).

Abstinence

Abstinence for the AB sessions was measured in two ways. First, participants self-report of smoking prior to an AB session as noted. Second, carbon monoxide (CO) monitors (manufactured by Bedfont Micro Smokerlyzer, Harrietsham, England) were used in all lab sessions to assess participants’ CO expired breath levels. The research team followed the manufacturer’s instructions when using the device with participants. The CO monitors were regularly calibrated also using manufacturer procedures.

CO expired breath levels are used to assess recent smoking (in the last 48 hours). The CO monitor provides an indirect measure of the uptake of nicotine in the blood stream and this tool is widely used to validate self-reported smoking abstinence (SRNT, 2002). For Parent Study 1, CO expired breath levels were used to check for participant smoking abstinence for the abstinent visit session. Abstinence for the purposes of the study was defined as a CO expired breath level of less than or equal to 10 parts per million (ppm). CO expired breath levels less than 10 ppm are considered an indication of no smoking or very light smoking (SRNT, 2002).

Chapter 5: Parent Study 2 Methods

Parent Study 2, a multi-site smoking cessation study at the University of Texas M. D. Anderson Cancer Center in Houston (MDACC), Texas ($n=150$) and at the Uniformed Services University of the Health Sciences (USUHS) in Bethesda, MD ($n=118$), was titled “Cognitive Processes in Smoking Cessation”. Dr. Andrew J. Waters, Ph. D. was the principle investigator. The study was approved by the USUHS Institutional Review Board (IRB) as Protocol G172JY (see Appendix A) and the MDACC IRB.

PARTICIPANTS

Overall, 268 participants, attempting to quit smoking without the use of pharmacotherapy, attended the orientation session and signed the informed consent form. After the orientation session, 237 participants attended at least one experimental session. Participant demographics and smoking information are listed in Table 7. Highlights of the smoking information are that participants: 1) were moderate to heavy smokers with mean cigarettes smoked per day of approximately 20 cigarettes per day and 2) had a mean FTND score of 5.15 indicating moderate dependence.

INCLUSION AND EXCLUSION CRITERIA

The screening process for this study included a phone screening followed by an in-person screening at the orientation session. Inclusion criteria for the study were: 1) current smokers (at least 10 cigarettes per day for the past year); 2) 18 - 65 years old; 3) motivated to quit smoking; 4) have a home address; 5) have a working telephone number; 6) and have an 8th grade reading/writing/literacy level in English.

Exclusion criteria included: 1) regular use of tobacco products other than cigarettes (cigars, chewing tobacco, etc.); 2) use of nicotine replacement therapy (NRT); 3) use of other smoking cessation medications (such as Varenicline and bupropion); 4) an expired breath carbon monoxide (CO) level less than 10 parts per million (ppm) (this measure ensures regular cigarette use); 5) serious mental illness (major depression or active suicidal ideation); 6) current substance abuse; 7) and having another household member enrolled in the study.

PROCEDURE

The study included up to six laboratory visits (see Table 8). Sessions consisted of an orientation session, two pre-quit sessions (once when twelve hours abstinent from smoking and once when smoking normally, order of completion counterbalanced), the quit day visit, a visit one week after the quit day (“Week +1”), and a visit at the end of treatment (four weeks after quit day) (“Week +4”). Additionally, many participants (n = 120) provided data for a one-week Ecological Momentary Assessment (EMA) study starting on the quit day visit (visit #4) (see Waters et al., 2014).

During the orientation session, participants completed the FTND to measure tobacco dependence, the Rapid Estimate of Adult Literacy in Medicine (REALM) as a literacy screener, the Patient Health Questionnaire (PHQ) to assess for depressive and suicidal symptomology, the Mini International Neuropsychiatric Interview (MINI) to assess for non-alcohol substance use, the Shipley Institute in Living Scale (Shipley) to evaluate intellectual ability, and self-reported smoking status. Smoking status was verified using CO expired breath levels with a portable CO monitor in the lab.

TREATMENT

As this was not an intervention study, all participants received the same treatment to aid in quitting smoking. Initially, the research team gave each participant a standardized self-help manual that included relapse prevention/coping skills. Then at each laboratory visit, participants received brief (15-20 minute) individualized smoking cessation counseling from a licensed counselor based on standardized approaches described in Treating Tobacco Use and Dependence Clinical Practice Guideline (USDHHS, 2008). Between Week +1 and Week +4 (at Week +2 and Week +3, Table 8), participants also received two brief telephone-counseling sessions.

During the two pre-quit sessions, the timeline of assessments was as follows: WSWs; SABQ; QSU; SCQ; NEQ (pre-smoking); Puff-by-Puff Liking; NEQ (post-smoking); Overall Liking, Satisfaction, and Enjoyment. Data from the puff-by-puff Liking ratings were presented in Meloscia (2014) and are not reported in this dissertation.

MEASURES

Details of those assessments pertinent to the current study will be described. Copies of measures are available in Appendix D.

General Liking

To assess for Liking, participants were asked to rate overall liking, satisfaction, and enjoyment after smoking 7 puffs at the two experimental sessions prior to quit day. At the end of 7 puffs, they were asked to enter their overall liking, satisfaction, and enjoyment ratings on the lab computer. Ratings were assessed using a Likert scale from 1 -7 with the anchor at number 1 of “Didn’t like at all” and the anchor at number 7 of “Liked it very much”. The ratings are shown in Appendix D and were asked as follows:

liking (“Overall, how much did you like the last cigarette?”), enjoyment (“How much did you enjoy the cigarette?”), and satisfaction (“How satisfying was the cigarette?”). These types of ratings have been used before to assess overall cigarette Liking (Perkins et al., 2012; Perkins et al. 2008; Shiffman and Kirchner, 2009).

Nicotine Effects Questionnaire (NEQ)

The Nicotine Effects Questionnaire (NEQ) was used to assess the subjective effects of smoking. This fifteen-item questionnaire has been shown to have acceptable to good reliability for measuring the acute effects of smoking (Strong et al., 2011). Items are reported to measure four different areas. Four items measure positive affect (happy, friendly, calm, and content). Three items measure negative affect (worried, tense, and sad). Six items measure unpleasant physical effects (buzzing, nausea, unpleasant, dizzy, palm sweating, and heart pounding). Two items measure cognitive effects (trouble concentrating and drowsy). Items were on a scale ranging from 0 = Not At All, 10 = Very Much (Strong et al., 2011). For the current study, we utilized three of the measured categories including positive affect, negative affect, and physiological effects.

Smoking Consequences Questionnaire

Five items, based on items from the Smoking Consequences Questionnaire-Adult (SCQ-A), a validated questionnaire with 55 self-report questions (Copeland et al., 1995), assessed positive outcomes/expectancies from smoking: “Smoking now will help me relax”; “Smoking now will energize me”; “A cigarette will taste good now”; “Smoking now will satisfy my cravings”; “Smoking now will help reduce boredom”. Participant responses were on 11-point Likert-type scales, ranging from 1 = No!! to 11 = Yes!!.

Waters et al. (2009) found that responses to the five items were strongly inter-correlated

(mean coefficient alpha across 4 sessions = .91, range .87 - .93); an average score from the five items was used to represent positive outcome expectancies from smoking.

The Smoking Consequences Questionnaire-A has 10 scales. The five questions used from the SCQ-A in this study (listed above) were from the following scales:

Negative Affect Reduction (Smoking now will help me relax); Stimulation/State Enhancement (Smoking now will energize me.); Taste/Sensorimotor Manipulation (A cigarette will taste good now.); Craving/Addiction (Smoking now will satisfy my cravings.); and Boredom Reduction (Smoking now will help reduce boredom.)

Questionnaire for Smoking Urges – Brief (QSU-Brief)

The Questionnaire for Smoking Urges-Brief (QSU-Brief) (Cox et al., 2001) assesses desire and intention to smoke “right now”. The 10-item QSU-Brief assesses craving through two factors. These two factors are desire for the positive effects of smoking (Factor 1 Craving; 5 items; e.g. “I have a desire for a cigarette right now”), and desire for relief of negative affect and an urgent need to smoke (Factor 2 Craving; 5 items; e.g., “I could control things better right now if I could smoke”). The QSU-Brief provides an overall self-reported level of craving, which was used in this study.

Numerous studies have supported the reliability (Cronbach’s alpha =0.97) and validity of the QSU-Brief (Toll, Katulak, and McKee, 2006; Cox, Tiffany, and Christen, 2001).

Wisconsin Smoking Withdrawal Scale (WSWS)

The Wisconsin Smoking Withdrawal Scale (WSWS) is a questionnaire that assesses tobacco withdrawal (Welsch, Smith, Kenford, et al., 1999). It includes subscales for anger, anxiety, sadness, concentration difficulty, hunger, and, most relevant for the current study, craving. All subscales have excellent internal consistency and demonstrate

clear increases as a function of withdrawal. Higher scores suggest more difficulty with withdrawal symptoms. This measure has been found to be reliable, valid, and predictive of smoking relapse (Welsch et al., 1999; West, Ussher, Evans, & Rashid, 2006). For the current study, experience was assessed “during the past week (including today)”.

Subjective Attentional Bias Questionnaire (SABQ)

The Subjective Attentional Bias Questionnaire (SABQ) was used to assess self-reported attentional bias to cigarette-related cues. Examples of items include: “During the past week, how often have you found yourself staring at cigarettes and cigarette smokers?” and “So far today, how often have you found your attention drawn to cigarettes?” Responses are made on 5-point scales. These items have demonstrated good psychometric properties with Cronbach’s alpha greater than .8 and significant correlations with FTND scores (Robinson et al., 2015).

While there are other ways to assess attentional bias (through reaction time tasks or eye movement assessments), one rationale for focusing on the use of a self-report measure of attentional bias is that it means that all Liking and all Wanting measures for this study are self-report assessments. This means that there are no “method” differences between Wanting and Liking measures.

Ecological Momentary Assessment (EMA)

An Ecological Momentary Assessment (EMA) study was added to Parent Study 2 after the study had started. To that end, some participants volunteered to take part in the one week add-on EMA study. This study began at quit day (Week 0) and lasted for one week (Week +1). Participants were trained how to use the personal digital assistant (PDA), a HP iPAQ Pocket PC, to complete the EMA study. 129 participants (out of 200

possible) volunteered to participate in the EMA study. From those initial 129 participants, 2441 assessments were recorded from 120 participants (data were lost from 7 participants due to participant error with PDA and 2 PDAs were reportedly stolen).

There were several assessments that participants completed on the PDA. These assessments included: 1) four assessments delivered at random times (RAs) each day outside of the lab; and 2) participant-initiated assessments. For participant initiated assessments, they completed an assessment any time they experienced a temptation to smoke, defined as when they “felt an acute increase in the desire to smoke, or an occasion when they felt they came to the brink of smoking without actually smoking”. They also completed a self-initiated assessment if they lapsed. For each assessment, craving for cigarettes “Right now” was assessed (“I am craving a cigarette”; 1=strongly disagree to 7=strongly agree). Subjective attentional bias was also assessed with the item “My attention is often drawn to cigarettes” (1=strongly disagree to 7=strongly agree).

Studies have shown that collecting EMA data in substance abuse studies including smoking is feasible and beneficial (e.g. Shiffman et al., 2000; Waters and Li, 2008). Shiffman (2009) explained that assessing substance use related factors such as subjective effects using EMA allows for substance users to be in their usual environment (including cues and mood triggers) that can be challenging to recreate in the lab setting.

Dependence

The Fagerström Test of Nicotine Dependence (FTND), a six-item self-report measure, is a standard measure of tobacco dependence severity. The FTND was reported to have a Cronbach’s alpha of .61, and was shown to be valid (Heatherton, Kozlowski, Frecker, & Fagerström, 1991).

Relapse

To assess relapse post quit day, we used data from three sources: self-reported smoking, expired breath CO, and salivary cotinine. Relapse was assessed at the two post-quit sessions (Week +1 and Week +4) and was defined as “any smoking, even a puff, during the past 7 days”. Confirmation of self-reported abstinence was conducted using expired breath CO levels and salivary cotinine levels as described below.

To be considered abstinent at the end of treatment (Week +4), participants had to: 1) report no smoking on the smoking diary during the seven days prior to the Week +4 visit; 2) have expired breath CO level ≤ 10 ppm at Week +4; 3) and have a salivary cotinine level ≤ 15 nanograms per milliliter at Week +4. Given these criteria, 38 participants were coded as abstinent at Week +4; all others were coded as relapsed.

Carbon Monoxide (CO)

Carbon monoxide (CO) monitors were used to assess participants' CO expired breath levels at each lab session. This procedure is described in more detail in the previous chapter for Parent Study 1. For this study, CO level was used to assess if a participant was abstinent for the abstinent visit session. As in Parent Study 1, a breath CO level ≤ 10 ppm was required to be considered abstinent for that visit (SRNT, 2002). If a participant reported smoking on the day of the abstinent session or had high CO levels (> 10 ppm) their abstinent visit was rescheduled.

Salivary Cotinine

Salivary cotinine has been described as the “gold standard” for measuring nicotine exposure (Ossip-Klein et al., 1986) and was listed as the recommended measure for confirming smoking self-report ratings by the Society For Research on Nicotine and

Tobacco (SRNT, 2002). Participants followed instructions given by research team and Salimetrics LLC (State College, PA). The sample was then frozen and shipped to Salimetrics assays to be conducted. Salivary cotinine levels were measured through an enzyme immunoassay conducted by Salimetrics.

Chapter 5: Analytic Plan

ANALYTIC PLAN

All tests were 2-tailed, and alpha was set to .05.

SPECIFIC AIM 1

To examine the association between Experienced and Remembered Liking, and Experienced and Remembered Wanting.

Hypothesis 1.1: Peak and End Liking will be more strongly related to Remembered Liking than Liking assessed at a puff selected at random.

These analyses utilized puff-by-puff Liking data from Parent Study 1 ($n=79$). For Hypothesis 1.1, we defined Peak Liking as the rating of the puff with the maximum value. If there were more than two puffs with maximum values, a Peak puff was selected at random (from the puffs with maximum scores). We defined End liking as the rating of Puff 7. We defined random liking as the rating of a randomly selected puff. Note that the Peak, End, and random puffs could refer to the same puffs. (There is no requirement that they refer to different puffs).

As noted above, the Random Liking rating was a rating from a puff selected at random for each cigarette smoked by a program written in SAS (using the “ranuni” routine). Because the program selected a puff at random each time it was run, regression coefficients for all three predictor variables would vary across analyses.

Therefore, following Meloscia (2014) we ran 20 separate regressions using linear mixed models (LMM; SAS PROC MIXED) in which Peak Liking, End Liking, and Random Liking were entered simultaneously as predictor variables, and Remembered Liking (that assessed overall Liking) was the dependent variable. Data derived from all subjects who completed at least one assessment ($n=79$) in Parent Study 1. Each participant was tested on four occasions as described earlier. Pre-session Abstinence (binary) and within-session Smoking (binary) were included as covariates, as well as session number (continuous).

LMM analyses take into account the dependence between observations due to clustering of the data by participants, and allow for different numbers of observations (cigarettes) across participants. Each individual LMM used a random intercept, and an autoregressive model of order 1 for the residuals within subjects. The primary analyses tested whether the regression coefficients for the three primary predictor variables (Peak Liking, End Liking, Random Liking) were significant when controlling for each other.

To aggregate the information from the 20 LMMs we used SAS PROC MIANALYZE. This program is used in analysis of multiple datasets generated by multiple imputation procedures, and can be used here to aggregate the information from the 20 LMMs. PROC MIANALYZE combines the regression coefficients into a single set of statistics. The 20 regression coefficients are averaged, and a measure of their standard error is derived, along with 95% confidence intervals. Based on these statistics, a p value tests the null hypothesis that the average regression coefficient in the population is equal to zero.

In addition, we tested whether the Peak and End Liking ratings predicted Remembered Liking when controlling for two “Mean” Liking ratings. One mean was computed using ratings from all puffs (i.e., 5 puffs) except the Peak and End puff (“Mean-5”). The other mean averaged all seven ratings, including the Peak and End Puffs (“Mean”).

Hypothesis 1.2. Peak and End Wanting will be more strongly related to Remembered Wanting than Wanting assessed at a random assessment.

These analyses utilized Ecological Momentary Assessment (EMA) data from Parent Study 2 ($n=120$). In the foregoing analyses, we defined the Peak Wanting as an assessment with the highest level of craving. If there were multiple assessments with the maximum craving level, an assessment was selected at random to be the Peak Wanting assessment. We defined End Wanting as the craving at the final EMA assessment. We defined “Random” Wanting as the rating of a randomly selected craving assessment. Note that the Peak, End, and Random assessments can refer to the same assessments. (There is no requirement that they refer to different assessments).

To examine the association between Experienced Wanting and Remembered Wanting, we first followed the general approach of Meloscia (2014) by using a series of linear regression analyses using SAS PROC REG in which Peak Wanting, End Wanting, and Random Wanting during the EMA assessments were entered simultaneously as predictor variables, and retrospective craving (WSWS Craving Week +1) (that assessed craving over the past week) was the dependent variable. The total number of EMA assessments completed was included as a covariate.

As noted above, the Random Wanting rating was a rating from an assessment selected at random for each participant by a program written in SAS (using the “ranuni” routine). Because the program selected an assessment at random each time it was run, the regression coefficients for all three predictor variables varied across regressions.

Therefore, following Meloscia (2014) we ran 20 separate regressions. To aggregate the information from the 20 regression equations we used SAS PROC MIANALYZE. As noted earlier, this program can be used here to aggregate the information from the 20 regressions.

The same approach was used to examine the Experienced attentional bias (bias during EMA) and Remembered attentional bias (SABQ scores at Week +1). That is, Peak Bias, End Bias, and Random Bias during the EMA assessments were entered simultaneously as predictor variables, and retrospective bias (SABQ Week +1) (that assessed attentional bias over the past week) was the dependent variable.

We also computed craving ratings for each day, and calculated Peak, End, and Random, values over days, and used the same procedures as above to analyze associations between Peak Wanting, End Wanting, random wanting, and retrospective craving (WSWS Week +1). In this case, we defined the Peak Wanting as the mean level of craving on the day with the highest average level of craving. We defined End Wanting as the average craving on the final day. We defined Random Wanting as the average craving of a randomly selected day. We then used the same procedures as with the assessment-level analyses (using PROC MIANALYZE) to test Peak Wanting, End Wanting and Random Wanting. The same approach was also used for attentional bias.

Finally, we examined how Peak and End craving assessments fared when compared to Mean craving (and bias) ratings. (The mean was computed by aggregation over all assessments).

Analyses on craving data used all 120 participants who completed the EMA protocol. Analyses on attentional bias data used data from the 109 participants who completed this item during EMA (The self-reported attentional bias item was added mid-stream during the study).

SPECIFIC AIM 2

To analyze the separability of self-report measures of Liking and Wanting.

Hypothesis 2.1 Two factors will be revealed that correspond to Liking and Wanting.

We hypothesized that when analyzing the various self-report measures taken from Parent Study 2 that two factors would be revealed that correspond to Liking and Wanting. The following measures were considered in both the abstinent (ab) and non-abstinent (non) state: QSU (non); QSU (ab); WSWS (non); WSWS (ab); SABQ (non); SABQ (ab); Liking (non); Liking (ab); Satisfaction (non); Satisfaction (ab); Enjoyment (non); Enjoyment (ab); SCQ (ab); SCQ (non); Change in NEQ (non); Change in NEQ (ab). Change in NEQ included three separate variables: positive, negative, and physiological. Change in NEQ was the measurement post- smoking minus the measurement pre-smoking in the lab during the two pre-quit sessions of Parent Study 1. EMA measures were not used for these analyses because only 120 participants provided EMA data.

Factor extraction procedures are a way to investigate how different variables might cluster around broader constructs such as Liking and Wanting. There are two

categories of factor extraction procedures, exploratory and confirmatory (also referred to as hypothesis-testing). Tinsley and Tinsley (1987) nicely summarize the difference as follows. “Exploratory factor extraction procedures determine the most parsimonious explanation of the common variance underlying a correlation matrix. In contrast, hypothesis-testing factor extraction procedures determine whether the data are consistent with a hypothesized factor structure” (Tinsley and Tinsley, 1987, p. 419). Aspects to consider when deciding on what factor extraction procedures to use include whether the test is inferential or descriptive and that exploratory extraction procedures are a more stringent test of factor extraction (Tinsley and Tinsley, 1987).

Another consideration presents itself when looking only at exploratory factor extraction procedures. Two types of exploratory procedures exist, principal component analysis (PCA) and exploratory factor analysis (EFA). PCA is a useful analysis tool for exploring data with the potential to generate hypotheses from the findings, but results are not generalizable. Also, the analysis is most useful for variables that are highly correlated. Suhr (2015) further describes PCA as a procedure that “reduces the number of observed variables to a smaller number of principal components which account for most of the variance of the observed variables” (p. 1). Most pertinent to the current study, PCA is used as a data reduction tool and does not allow for exploration of latent variables (Field, 2013; Suhr, 2015). In addition, a PCA also does not take into consideration measurement error that is often common in social sciences studies.

EFA has been described as “a variable reduction technique, which identifies the number of latent constructs and the underlying factor structure of a set of variables” (Suhr, 2015, p. 2). This analysis procedure includes adjustment for unique factors such as

measurement error. This adjustment is visible in the correlation matrix (R matrix) that is adjusted for this error. EFA allows for investigation of latent variables, whereas – as noted previously – PCA does not.

Despite these conceptual and mathematical differences, research has found that generally there is little difference in the results derived from using PCA versus EFA (Field, 2013). However, given that in this dissertation we are specifically investigating latent variables of Liking and Wanting (that underlie scores on the various liking and wanting measures), it is important to acknowledge and understand the differences between the two analytic processes.

Moving from the EFA procedures, confirmatory factor analysis (CFA) provides a method to test hypotheses regarding latent variables. CFA is a confirmatory factor extraction method that is useful to test a hypothesized factor structure. Results from a CFA are inferential (Tinsley and Tinsley, 1987).

Considering all of the nuances of factor extraction procedures described above, we decided on a two-step process for exploring factor extraction. We first conducted an EFA for both the abstinent and non-abstinent states to determine the number of factors (corresponding to latent variables of Liking and Wanting). We also evaluated the data using PCA for comparison, as the literature states that these results are usually similar. (These secondary results using PCA are presented in Appendix F). Next, as described in more detail later we conducted three CFAs based on the two-factor model from the EFA, an alternative two-factor model, and a one-factor model.

For both EFA and CFA, we used raw (unstandardized) scores, as standardized scores are not required for factor extraction procedures. The factor extraction procedures

run from the initial correlation matrix (called the “R-Matrix”) thereby negating the necessity to standardize individual scores. Regarding sample size, Tinsley and Tinsley (1987) state that a 10 subjects to 1 variable ratio is the general advice, but potentially not necessary with higher sample sizes. With our sample size of about 200 and 10 variables to input in each state (abstinent and non-abstinent), we meet the criteria suggested by the literature. Further, we report results of the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy in the results section for this aim.

Exploratory Factor Analysis

We used EFA to investigate the potential factor structure of ten self-report measures collected in Parent Study 2. SPSS, Version 22 was used to conduct the analysis, and all results were confirmed using SAS PROC FACTOR. Initially, we verified sampling adequacy and assessed the correlation structure of inputted variables.

For this specific analysis, we conducted EFA using the “principal axis factoring” option in SPSS. The decision as to how many factors to extract was based on the examination of the scree plot, the magnitude of the eigenvalues, and the interpretability of the resulting factors. The central idea is that if Wanting and Liking are separable constructs at the level of self-report data, then EFA should reveal two separate factors that correspond to the latent variables of Wanting and Liking. Conversely, if Wanting and Liking are both an outgrowth of a single motivational system, then they might be expected to load onto a single factor. We conducted analyses of data from the abstinent and non-abstinent states separately.

After factor extraction we then decided on a rotation method. Rotation procedures are used to accentuate factor loadings for ease of interpretation. There are two broad

types of rotation: orthogonal and oblique. Orthogonal rotation assumes no correlation between factors. Oblique rotations assume that any factors are correlated; this assumption is more realistic in the social sciences field where it is highly unlikely to have any factors that have zero correlation (Field, 2013). Therefore, we conducted analyses using an oblique rotation, specifically direct oblimin.

Confirmatory Factor Analysis

To examine the construct validity of self-report measures of Liking and Wanting, three CFAs were conducted using STATA version 12.1. We considered three different factor structures for this step of the analytic process. First, we analyzed a factor structure based on results from the exploratory factor analysis described above.

The second factor structure was based on the conceptual status of the smoking outcome expectancies questions. There are questions in this measure that could pertain to both Liking and Wanting. The EFA suggested that our SCQ items loaded onto the Wanting factor. However, some questions included in the smoking outcome expectancies questions from Parent Study 2 were related to Liking (see specific questions in Methods section). Therefore, we wanted to explore a model with the SCQ responses forced onto the Liking latent variable to assess where the SCQ measure might be a better fit in the two-factor model of Liking and Wanting.

For the final CFA, we used a one-factor model to compare fit results with the two-factor models. Researchers suggest that even if the theory supports a two-factor model, one should consider analyzing a one-factor model in confirmatory factor analysis to compare to the two-factor model. This comparison allows the researcher to assess if a one-factor model has an equally good fit as a two-factor model, which would invalidate

the two-factor approach (Kline, 2011). Akaike Information Criteria (AIC), a predictive fit index, was used to compare models in the CFA. The lowest AIC indicates the model with a better fit (Kline, 2011.)

SPECIFIC AIM 3

To explore the relative predictive efficacy of self-report measures of Liking and Wanting.

Self-report measures of Liking and Wanting will have a predictive relationship with FTND score and cessation outcome.

Linear regression was used to examine associations between Liking/Wanting measures (if obtained) and FTND scores using SAS PROC REG. Analyses used data from Parent Study 2. The primary outcome variable was the FTND score. Separate regression analyses were conducted at each state separately. Order (NON vs. AB completed first) was also included as a covariate.

Logistic regression was used to examine associations between Liking/Wanting measures and cessation outcome using SAS PROC LOGISTIC. The primary outcome variable was relapse status at Week +4 (end of study). The models included Order as a covariate. These analyses used data from all participants who made a quit attempt (Parent Study 2).

Note that the Liking/Wanting measures included in these analyses depended in part on the outcome of Specific Aim 2. For example, if Specific Aim 2 reveals clear

evidence of two factors corresponding to Liking and Wanting, those two factor scores would be used as independent variables.

POWER

Power analyses were computed using G*Power 3.1.2. Power estimates for 2-tailed tests were set at alpha level of .05.

For Specific Aim 1, Hypothesis 1.1, we used Linear Mixed Models (PROC MIXED in SAS). The power to detect an association between depends on what is termed the “effective sample size” for the analysis. The larger the effective sample size, the greater the power. To compute the effective sample size, the *VIF* (Variance Inflation Factor) is computed $(1 + ((\text{average number of observations per person} - 1) * ICC))$, and the total number of assessments (i.e., average number of observations per person multiplied by the number of study participants) is divided by *VIF*. The *ICC* is the intraclass correlation coefficient for the dependent variable. If the *ICC* = .3, the $VIF = 1 + (3.8 - 1) * ICC = 3.5$, and so the effective sample size = $280 / 1.8 = 155$. Assuming an effective sample size of 155, we have power = .81 to detect a partial correlation, *rho*, of .23 (a small-to-moderate effect size) between Experienced and Remembered Liking.

For Hypothesis 1.2, with a sample size of 120 (the number of participants in a given condition in Study 2 with EMA data) we have power = .82 to detect a standardized partial regression coefficient of 0.26 (a small-to-moderate effect size).

For Specific Aim 2, it has been suggested that sample sizes of 100 to 200 are necessary for EFA (Gorsuch, 1983), and that there should be 10 cases (subjects) for each variable. The data for Specific Aim 2 meet these criteria in that we will have sample sizes

greater than 200 at each state and only 10 variables. Sampling adequacy was formally tested using Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy.

For Specific Aim 3, for the relationship between Liking/Wanting and FTND, a sample size of 215 (the approximate number of participants in a given condition in Study 2 with FTND data) has power = .80 to detect a standardized partial regression coefficient of 0.19 (a small-to-moderate effect size). For the relationship between Liking/Wanting and relapse, a sample size of 200 (the number of participants who attempted to quit in Study 2) has power = .80 to detect an adjusted Odds Ratio of 1.71 for an independent variable with $M = 0$ and $SD = 1$, assuming a relapse rate of 85%.

Chapter 6: Results

SAMPLE CHARACTERISTICS

Subject demographics and smoking information are provided in Table 5 for Parent Study 1 and Table 7 for Parent Study 2.

SPECIFIC AIM 1

Specific Aim 1 examined the association between Experienced and Remembered Liking, and between Experienced and Remembered Wanting.

Hypothesis 1.1

The mean puff liking ratings (1-7 scale) across the 288 cigarettes were as follows: Peak Liking ($M = 5.68$, $SD = 1.59$), End Liking ($M = 4.82$, $SD = 2.01$), Random Liking ($M = 5.07$, $SD = 1.73$). These mean ratings were highly correlated across cigarettes (mean $r = .85$). The mean liking rating on the retrospective rating (1-7 scale) was 5.06 ($SD = 1.88$).

Results of LMM analyses for cigarette-level analyses are reported in Table 9. As can be seen, Peak and End Liking predict Remembered Liking when controlling for Random Liking. However, Random Liking was not a significant predictor when controlling for Peak and End Liking. This result is illustrated in Figure 4.

The results above show that Peak and End Liking are better predictors of Remembered Liking than the liking rating of a puff simply selected at random. We further tested Peak and End liking ratings against a Mean Liking rating which took at mean rating of the 5 puffs which were not designated as the Peak or End puff ("Mean-5"). In a LMM that included Mean-5, Peak, and End, both Mean-5, $PE = 0.49$, $SE = 0.08$, $t = 5.83$, $p < .001$, and End Liking, $PE = 0.30$, $SE = 0.05$, $t = 5.71$, $p < .001$, predicted

Remembered Liking, whereas Peak Liking did not, $PE = 0.15$, $SE = 0.07$, $t = 1.97$, $p = .051$. Finally, we tested Peak and End against a Mean Liking rating over all seven puffs (“Mean-7”). Mean-7 therefore incorporated information on Peak and End Liking ratings. In a LMM that included Mean-7, Peak, and End, both Mean-7, $PE = 0.69$, $SE = 0.12$, $t = 5.83$, $p < .001$, and End Liking, $PE = 0.20$, $SE = 0.06$, $t = 3.13$, $p = .002$, predicted Remembered Liking, whereas Peak Liking did not, $PE = 0.05$, $SE = 0.09$, $t = 0.54$, $p = .59$.

Hypothesis 1.2

Craving

The mean craving ratings at assessments (1-7 scale) were as follows: Peak Craving ($M = 5.90$, $SD = 1.34$), End Craving ($M = 3.17$, $SD = 1.90$), and Random Craving ($M = 3.58$, $SD = 1.46$). These mean ratings were significantly correlated (mean $r = .53$).

Results of the multivariable regression analyses for assessment-level analyses are reported in Table 10. As can be seen, Peak and End Craving predict Week +1 WSWS Craving when controlling for Random Craving. However, Random Craving was not a significant predictor.

Finally, we tested Peak and End Craving against a Mean Craving rating aggregated over all assessments (“Mean-EMA”). Mean-EMA therefore incorporated information on Peak and End Craving ratings. In a LMM that included Mean-EMA, Peak, and End, Mean-EMA predicted WSWS +1, $PE = 1.58$, $SE = 0.30$, $t = 5.33$, $p < .001$, whereas Peak Craving, $PE = 0.13$, $SE = 0.26$, $t = 0.49$, $p = .62$, and End Craving, $PE = 0.21$, $SE = 0.19$, $t = 1.14$, $p = .26$, did not.

The mean craving ratings for days were as follows: Peak Craving ($M = 4.96$, $SD = 1.54$), End Craving ($M = 3.19$, $SD = 1.80$), and Random Craving ($M = 3.59$, $SD = 1.43$). These mean ratings were significantly correlated (mean correlation = .73).

Results of the multivariable linear regression analyses for day-level analyses are reported in Table 10. As can be seen, Peak Craving predicts Week +1 WSWS Craving when controlling for End Craving and Random Craving. However, End Craving and Random Craving were not significant predictors, although the effect for End Craving was close to significant (.06).

Attentional Bias

The mean attentional bias ratings at assessments (1-7 scale) were as follows: Peak Bias ($M = 5.51$, $SD = 1.52$), End Bias ($M = 2.94$, $SD = 1.83$), Random Bias ($M = 3.18$, $SD = 1.26$). These mean ratings were significantly correlated (mean correlation = .59).

Results of the multivariable regression analyses for assessment-level analyses are reported in Table 10. As can be seen, Peak Bias and End Bias predict Week +1 SABQ when controlling for Random Bias. However, Random Bias was not a significant predictor.

The mean attentional bias ratings for days were as follows: Peak Bias ($M = 4.41$, $SD = 1.52$), End Bias ($M = 2.89$, $SD = 1.59$), Random Bias ($M = 3.20$, $SD = 1.27$). These mean ratings were significantly correlated (mean correlation = .77).

Results of the multivariable linear regression analyses for day-level analyses are reported in Table 10. As can be seen, Peak Bias predicts Week +1 SABQ when controlling for End Bias and Random Bias. However, End Bias and Random Bias were

not significant predictors. Neither Peak Bias nor End Bias predicted Week +1 SABQ when controlling for Mean Bias.

SPECIFIC AIM 2

The goal of Specific Aim 2 was to analyze the separability of self-report measures of Liking and Wanting.

Data from participants included in this analysis were from Study 2. We used data from both the abstinent and non-abstinent state (two pre-quit sessions in the overall study); 214 participants had complete data at the abstinent state and 224 participants had complete data for the non-abstinent state. Given that differences across abstinence state was not a focal point of the current study, we used all available data for analyses.

Exploratory Factor Analysis

EFA was conducted to explore how the self-report variables might form into factors after data reduction procedures. To be comprehensive, PCA was also conducted (as noted in the analysis plan), and results from PCA are included in Appendix F. As is common, the results from PCA were similar to the EFA results. The results from PCA are not discussed further.

Following Field (2013), the first step was to review the correlation matrices. (Correlation matrices for the non-abstinent variables and abstinent variables are shown in Table 12). According to Field (2013), factor analysis procedures will only yield valuable results if variables are somewhat correlated but not too highly correlated. Field (2013) suggests removing any variables with several correlations either below .3 or above .9 (Field, 2013). When reviewing the two correlation matrices, we noted that the change in NEQ-Physiological variable met this criterion. All correlations except one were below .3

for the Change in NEQ-Physiological variable. Therefore, for the proceeding analyses, we removed one variable (change in NEQ-Physiological). This removal will be further addressed in the discussion.

After removing Change in NEQ-Physiological, we conducted EFA with rotation for both the non-abstinent and abstinent states separately. Variables included for each state (non-abstinent and abstinent) were self-report scores from the following: Liking, Enjoyment, Satisfaction, QSU, WSWs, SABQ, SCQ, NEQ-positive, and NEQ-negative. In general, EFA of non-abstinent and abstinent states yielded similar results suggesting the presence of two factors amongst the nine self-report variables. Specific results for each analysis are described below. For the non-abstinent state, the underlying matrix algebra and matrices are shown in Appendix E, which uses the terminology of Tabachnik and Fidell (2007).

Non-abstinent State

The correlation matrix is shown in Table 13. KMO indicated “superb” sampling adequacy, $KMO = .82$, according to Field (2013). Bartlett’s test of sphericity showed that correlations were adequate for this test, $\chi^2(45) = 1445.86, p < .000$. This test rejects the null hypothesis that the R matrix is an identity matrix, i.e., all off-diagonal correlations are equal to 0.

An EFA was then conducted on the nine self-report measure scores using principal axis factoring and direct oblimin rotation, with $\delta = 0$ (oblique rotation). The analysis showed that two factors had eigenvalues greater than 1 (Kaiser’s criterion for retention), suggesting a two-factor solution. These two factors explained 65.98% of the variance. The scree plot had inflexions supporting a two-factor solution (see Figure 5).

Additionally, all communalities were above .2 (see Table 14). Communalities above .2 “indicate the percent of variance in a variable that overlaps variance in the other factors” (p.660, Tabachnik and Fidell, 2007). If communalities are below .2 this suggests too much heterogeneity in the variables (Tabachnik and Fidell, 2007).

Another aspect to consider when assessing model fit is the residuals computed between observed correlations (i.e., off-diagonal values in the R matrix) and predicted (or “reproduced”) correlations. For the non-abstinent state, there were 10 residuals (27%) with absolute values greater than 0.05 (see Table 15). Field (2013) suggests that a proportion of residuals below 50% is adequate and indicate that default factor extraction (Kaiser’s criterion) in SPSS worked well.

In sum, the eigenvalues, scree plot, communality values, and residual values all suggest a 2-factor solution is a good fit with the data. Next, we review in more detail the factor structure produced by the EFA.

Table 17 shows rotated factor loadings for each factor for the pattern matrix and the structure matrix. These two matrices are important to report when using direct oblimin rotation (Field, 2013). The pattern matrix reports regression coefficients between each variable and each factor, whereas the structure matrix reports the correlation coefficients between each variable and each factor (Field, 2013). Both matrices are interpretable, although most researchers interpret the pattern matrix because the factor structure is usually more easily interpreted from this matrix (Tabachnik and Fidell, 2007). As regards interpretation of the magnitude of loadings (in either the pattern or structure matrix), the literature suggests that the researcher can decide on an appropriate cut-off point for interpreting factor loading (Tabachnik and Fidell, 2007), but Comrey and Lee

(1992) listed a framework for evaluating cutoff points: .71 = excellent; .63 = very good; .55 = good; .45 = fair; and .32 = poor. Given these considerations, we reviewed both the pattern and structure matrix and describe the results in the next paragraph.

As seen in Table 17, there seems to be evidence for a Liking factor (latent variable) (the first factor), and a separate Wanting factor (latent variable) (the second factor). The following self-report measures loaded more strongly onto Liking in both the pattern and structure matrix: Satisfaction, Liking, Enjoyment, Change in NEQ-positive, and Change in NEQ-negative. The following self-report measures loaded more strongly onto Wanting for both the pattern and the structure matrix: QSU, WSWs, SABQ, and SCQ. All loadings were above .4 for both matrices and most loadings were well above .45.

Cronbach's alpha indicated internal reliability of .89 and .67 for the Liking and Wanting factors respectively.

When looking at the relationship between the two factors, the factor correlation matrix (designated as theta by Tabachnik and Fidell, 2007) indicated that Liking and Wanting factors were correlated at .484 which is considered a strong correlation (Field, 2013). Field (2013) explains that if these factors were not correlated, we could consider using orthogonal rotation, but based on theory we assumed that the factors of Liking and Wanting would be correlated and conducted an oblique rotation.

Abstinent State

The correlation matrix is shown in Table 13. For the abstinent state, an EFA was conducted on nine self-report measure scores using principal axis factoring with direct oblimin rotation, $\delta = 0$ (oblique rotation). KMO indicated "superb" sampling

adequacy ($KMO = .84$), according to Field (2013). Bartlett's test of sphericity showed that correlations were adequate for this test, $\chi^2(45) = 1385.93, p < .000$.

EFA revealed that two factors had eigenvalues that were greater than 1. These two factors explained 68.56% of the variance. The scree plot had inflexions supporting a two-factor solution (see Figure 6). All communalities were above .2 (see Table 14). As noted earlier, if communalities are below .2 this suggests too much heterogeneity in the variables (Tabachnik and Fidell, 2007).

When comparing the observed and reproduced correlation matrices for the abstinent state, there were 4 residuals (11%) with absolute values greater than 0.05 (see Table 16).

In sum, the eigenvalues, scree plot, communality values, and residual values all suggest a 2-factor solution is a good fit with the data for the abstinent state. Next, we review in more detail the factor structure produced by the EFA.

Table 18 shows rotated factor loadings for each factor including the pattern matrix and the structure matrix. Similar to the non-abstinent state, there seems to be evidence for a Liking latent variable and a separate Wanting latent variable. As in the non-abstinent state, the following self-report measures loaded more strongly onto Liking: Satisfaction, Liking, Enjoyment, Change in NEQ-positive, and Change in NEQ-negative. The following self-report measures loaded more strongly onto Wanting: QSU, WSWs, SABQ, and SCQ. Liking and Wanting factors were correlated at .519.

Cronbach's alpha indicated internal reliability of .88 and .74 for the Liking and Wanting factors respectively.

Confirmatory Factor Analysis

After analyzing the data using PCA and EFA, the analytic plan called for three confirmatory factor analyses (CFA) for the two states (non-abstinent and abstinent). We tested two measurement models with two factors (Liking and Wanting) and one measurement model with one factor (which, following Robinson & Berridge (1993), was labeled “Incentive Motivation”). For the two-factor models, we assumed Liking and Wanting factors were correlated. As discussed earlier most latent variables in the social sciences are correlated (Field, 2013) and EFA results support a strong correlation between the two factors for both states.

The results from these three CFAs are described next. As with the EFAs, for CFA procedures we removed Change in NEQ-physiological due to its low correlation with other variables. Results are described for each CFA and summarized in Table 19.

Model 1: EFA-Driven CFA

Based on the results from the EFA, we constructed a two-factor model with Liking and Wanting as the latent variables. For Liking, the following variables were included: Satisfaction, Liking, Enjoyment, Change in NEQ-positive, and Change in NEQ-negative. For Wanting, the following variables were included: QSU, WSWS, SABQ, and SCQ.

We assessed model fit using the root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI). For RMSEA, estimates that are less than 0.06 are considered a good fit and estimates at 0.08 are considered a reasonable fit. For CFI and TLI, a value of 0.95 or higher indicates a good fit for the model (Hu & Bentler, 1999).

Non-Abstinent

This model showed mixed results regarding fit. After running the measurement model in STATA, we found that two modifications were needed to enhance the fit of the model. Specifically, the best-fitting model included a covariance in the error terms between Change in NEQ-Positive/NEQ-Negative and WSWs/SABQ (see Figure 7).

We assessed model fit using the root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI). RMSEA was 0.064 with a CFI of 0.984 and TLI of 0.976.

Abstinent

This model showed mixed results regarding fit. After running the measurement model in STATA for the abstinent state, we found that two modifications were needed to enhance the fit of the model. Specifically, the best-fitting model included a covariance in the error terms between Change in NEQ-Positive/NEQ-Negative and WSWs/SABQ (see Figure 8). We assessed model fit using the root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI). For the EFA-Driven model in the non-abstinent state, RMSEA was 0.054 with a CFI of 0.989 and TLI of 0.983.

Model 2: Alternative Two-Factor CFA

Based on the ambiguity of the self-report measure questions in the SCQ, we constructed a different two-factor model than the EFA results suggested. We forced SCQ to load on the Liking factor rather than the Wanting factor. For Liking, the following variables were included: Satisfaction, Liking, Enjoyment, SCQ, Change in NEQ-positive,

and Change in NEQ-negative. For Wanting, the following variables were included: QSU, WSWs, and SABQ.

Non-Abstinent

This model also showed mixed results regarding fit. After running the measurement model in STATA for the non-abstinent state, we found that three modifications were needed to enhance the fit of the model. Specifically, the best-fitting model included a covariance in the error terms between NEQ-Positive/NEQ-Negative, WSWs/SABQ, and QSU/SCQ (see Figure 9).

For the alternative two-factor model in the non-abstinent state, RMSEA was 0.092 with a CFI of 0.969 and TLI of 0.951.

Abstinent

This model also showed mixed results regarding fit. After running the measurement model in STATA for the abstinent state, we found that three modifications were needed to enhance the fit of the model. Specifically, the best-fitting model included a covariance in the error terms between NEQ-Positive/NEQ-Negative, WSWs/SABQ, and QSU/SCQ (see Figure 10).

For the alternative two-factor model in the abstinent state, RMSEA was 0.109 with a CFI of 0.956 and TLI of 0.931.

Model 3: Single-Factor Comparison CFA

The final CFA that we conducted was a single-factor model (latent variable “Incentive Motivation”) that we created as a comparison for our two-factor models. All nine self-report variables were included in this model.

Non-Abstinent

This model also showed mixed results regarding fit. After running the measurement model in STATA for the non-abstinent state, we found that three modifications were needed to enhance the fit of the model. Specifically, the best-fitting model included a covariance in the error terms between NEQ-Positive/NEQ-Negative, WSWs/SABQ, and QSU/SCQ (see Figure 11).

For the Single-Factor model in the non-abstinent state, RMSEA was 0.091 with a CFI of 0.968 and TLI of 0.952.

Abstinent

This model also showed mixed results regarding fit. After running the measurement model in STATA for the abstinent state, we found that two modifications were needed to enhance the fit of the model. Specifically, the best-fitting model included a covariance in the 2 error terms between NEQ-Positive/NEQ-Negative and QSU/SCQ (see Figure 12).

For the Single-Factor model in the abstinent state, RMSEA was 0.117 with a CFI of 0.947 and TLI of 0.921.

Model Comparison

There are two ways we can compare the results from each of the three different measurement models across the two states (non-abstinent and abstinent). The first is to look at the value of Akaike's information criterion (AIC) for the model in each state to compare which model is a better fit. Lower AIC values indicate a better fitting model. When looking at Table 19, we note that the AIC in both states is lowest in the EFA-driven two-factor model (two-factor EFA driven AIC non-abstinent = 6743.02; two factor

EFA driven AIC abstinent = 6678.63). From our analysis, it seems that both two-factor models are a better fit than the one factor model (one factor AIC non-abstinent = 6766.30; one factor AIC abstinent = 6735.18). Further, the EFA-driven model is a better fit than the alternative model (two-factor alternative AIC non-abstinent = 6766.21; two factor alternative AIC abstinent = 6724.33).

A second way to formally test model fit difference when using nested models is to formally test a single factor versus two-factor model using the Chi Square difference test. This allows testing whether one model is a significantly better fit than a second model. The one factor and two factor models are potentially nested because the only difference is that the two factor model allows correlation between the two factors which can be conceptualized as being fixed as a correlation of 1 in the one-factor model. However, for a nested model, no modification indices can be applied. As none of our tested models reached a good fit without modification indices (see Table 20) - which is very common in CFA analysis - we were unable to conduct this more formal test.

SPECIFIC AIM 3

To explore the relative predictive efficacy of self-report measures of Liking and Wanting.

Table 21 shows Pearson's r between Liking and Wanting factor scores extracted by EFA. Liking and Wanting measures are strongly correlated at both NON ($r = .54$) and AB states ($r = .56$). Liking scores at NON correlate strongly with Liking scores at AB. The same is true for Wanting scores.

As can be seen, the weakest correlations are observed between Liking and Wanting factor scores assessed at different states. Indeed, when comparing the magnitude

of two correlations, Liking (NON) is more strongly correlated with Liking (AB) than with Wanting (AB), $z = 2.16, p = .03$, and Wanting (NON) is more strongly correlated with Wanting (AB) than with Liking (AB), $z = 5.02, p < .001$.

Hypothesis 3.1

Table 22 shows Pearson's r between Liking and Wanting measures and FTND by State. Both Liking and Wanting measures were significantly correlated with FTND. In a multivariable regression model containing both Liking and Wanting measures, Wanting measures were associated with FTND scores when controlling for Liking measures. In the NON state, Wanting was associated with FTND when controlling for Liking, $b = 0.79, SE = 0.17, t = 4.72, p < .001$, but Liking was not associated with FTND when controlling for Wanting, $b = 0.08, SE = 0.15, t = 0.50, p = .62$. Similarly, in the AB state, Wanting was associated with FTND when controlling for Liking, $b = 0.56, SE = 0.17, t = 3.23, p < .001$, but Liking was not associated with FTND when controlling for Wanting, $b = 0.09, SE = 0.17, t = 0.54, p = .59$.

Hypothesis 3.2

Table 22 shows the point biserial correlation (Pearson's r between a continuous and binary variable) between Liking and Wanting measures and Relapse at Week +4 by state. Using logistic regression, Wanting at AB state predicted relapse at Week +4, $OR = 1.54, 95\% CIs = 1.02 - 2.32, p = .038$. An increase of 1 SD in Wanting scores increased the odds of relapse at Week +4 by 54%. Wanting at the NON state did not predict relapse at Week +4, $OR = 1.26, 95\% CIs = 0.84 - 1.90, p = .27$.

Liking did not predict relapse at either the NON, $OR = 1.40, 95\% CIs = 0.97 - 2.02, p = .075$, or AB state, $OR = 1.44, 95\% CIs = 0.99 - 2.08, p = .055$.

Wanting at the AB state did not predict relapse when controlling for Liking at the AB state, $OR = 1.36$, 95% CIs = 0.82, 2.24, $p = .24$.

Chapter 7: Discussion

The overall goal of this study was to examine two different aspects of subjective effects of smoking (Liking and Wanting) with the intent to further understand the role of Liking and Wanting in smoking. The first aim explored the application of the Peak-End rule (Kahneman, 2011) to self-reported smoking Liking and Wanting. Aims 2 and 3 investigated the theory that Liking and Wanting are different components of addiction.

The main findings of the study were as follows. First, there was evidence to support the Peak-End rule for both Liking and Wanting. Retrospective reports of Liking and Wanting were more heavily influenced by the peak rating and the final rating than a rating selected at random from assessments. Second, factor analysis of subjective ratings revealed two separate correlated factors corresponding to Liking and Wanting. A two-factor fit was clearly superior to a single-factor model. Third, measures of Liking and Wanting were both associated with dependence, but Wanting was the stronger predictor. Wanting during abstinence was also associated with relapse. We discuss the results for each aim of this study below.

SPECIFIC AIM 1

For the first aim, we analyzed data to test the Peak-End rule (Kahneman, 2011). Kahneman (2011) states, “The remembering self is sometimes wrong, but it is the one that keeps the score, governs what we learn from living, and makes decisions.”

Therefore, it was important to understand how Experienced and Remembered self-report measures of Liking and Wanting are related.

The results for Liking were similar to those reported by Meloscia (2014). For Liking, there was good evidence that the Peak and End Liking ratings were more predictive of Remembered Liking than Liking at a random puff. This was revealed in the finding that Peak and End Liking predicted Remembered Liking when controlling for Random Liking. Note that Random Liking did not predict Remembered Liking when controlling for Peak and End Liking. Taken at face value, this indicates that participants appear to weight the final and best moments of a cigarette more strongly than other moments in their evaluation of a cigarette, even when the retrospective assessment is made just moments after finishing the cigarette.

A strong form of the Peak-End rule would predict that Peak and End Liking should predict Remembered Liking better than all other moments of the cigarette. There was mixed evidence for this prediction. Although End Liking continued to predict remembered Liking when controlling for Peak and Mean-5 Liking (mean rating at the five puffs other than the Peak and End puffs), Peak Liking no longer predicted Remembered Liking. In addition, Mean-5 Liking was a robust predictor of Remembered Liking. This suggests that there is information in assessments other than the Peak and End ratings that contribute to the remembered Liking rating. Similarly, the simple average of all puffs was a robust predictor of Remembered Liking.

The results were similar for Wanting. For Wanting, there was good evidence that the Peak and End Wanting ratings during EMA were more predictive of Remembered Wanting than Wanting at a random assessment (or day). This indicated that participants appear to weight the final and most extreme moments of craving more strongly than other

moments. However, neither Peak nor End Wanting predicted Remembered Wanting when controlling for average levels of craving during EMA.

These results raise the question as to how the Peak-End rule should be formally tested. When compared against an assessment selected at random, both the Peak and End perform better (i.e., predict the remembered rating) than a randomly selected assessment. This was true for both Liking and Wanting. A second approach was taken by Schneider et al. (2011) who argued that a Remembered rating can be shown to be biased if the Peak and End continue to predict the remembered rating when controlling for the mean. In the current dissertation study, when controlling for a mean (that incorporates information about the Peak and End), then the End (but not Peak) continued to predict Liking, and neither predicted Wanting. When using the second approach, one might conclude that the Remembered rating is biased for Liking (due to the influence of the End) but not for Wanting. Interestingly, Schneider et al. (2011) found that Peak and End pain ratings, but not fatigue ratings, continued to predict the retrospective ratings when controlling for a mean.

In future analyses, one might also compare the predictive efficacy of the End rating against that of the “First” rating (in this case, liking from first puff). Additionally, one might test whether the magnitude of the regression coefficients (e.g., for the Peak, End and Random) are significantly different from one another (rather than just significantly different from zero). Further research should be conducted on the appropriate methodological tests of the Peak-End rule.

Kahneman (2011) notes that “Memories are all we get to keep from our experience of living, and the only perspective that we can adopt as we think our lives is

therefore that of the remembered self.” Memories may be important in motivating smoking behavior, and it is therefore important to measure them. Our results support this statement in that peak and end ratings of both Liking and Wanting are more predictive of a Remembered experience than a rating selected at random.

SPECIFIC AIM 2

Using both an EFA and CFA, we found support for the hypothesis that Liking and Wanting are separable. Further, we identified self-report measures that loaded onto each of these latent variables in two different states, non-abstinent and abstinent.

The EFA allowed for exploration of the hypothesis of separate factors. (EFA is a hypothesis-generating tool). This analysis showed that a two-factor model does have potential for a good fit. While an EFA contains several subjective decision points, such as when deciding on the number of factors to retain, there were many strong indicators that a two-factor solution was a good model. First, a two-factor solution was preferred in both the non-abstinent and abstinent state. Second, a number of indicators suggested a two-factor model, to include the scree plots, the communalities, the reasonably high factor loadings with minimal cross-loadings, and the relatively low percentage of non-redundant residuals with absolute value greater than 0.05.

Third, evidence from CFAs supported a two-factor solution. The results start to build the construct validity of the Liking and Wanting two-factor model. Specifically, for the CFAs, the results of the analyses show that the different measures of Liking and Wanting do fit well with a model that includes separate concepts of self-reported Liking and Wanting versus a single overall latent variable. We compared three models: one

factor, two-factor based on exploratory factor analysis results, and an alternative two-factor model. Overall, the two-factor model derived from the EFA had the best fit in the CFA for both the abstinent and non-abstinent state. In fact, there appeared to be little difference between states in these analyses indicating that abstinence may have little impact on the factor structure associated with Liking and Wanting.

We included an alternative two-factor model to examine how the SCQ would load onto the opposite factor predicted by the EFA. For many of the self-report measures there was a clear expectation as to which factor they would load on. For example, the Liking, Satisfaction, and Enjoyment questions were expected to load on the Liking factor. The WSWs and QSU asked directly about craving and therefore were expected to load on the Wanting factor. Based on theory described in the introduction, attentional bias was considered a measure of Wanting so we were not surprised that the SABQ loaded on the Wanting factor. The loading for the SCQ was not so obvious. In this study, a better fit in the CFA was revealed when the SCQ was part of the Wanting factor.

All analyses revealed that the Liking and Wanting factors were strongly correlated. This may reflect a number of processes. First, a strong disassociation between Liking and Wanting is not expected to occur in casual drug users but in populations who are heavily addicted to the drug (Tibboel, Houwer, and Van Bockstaele, 2015). It is possible that our sample contained sufficiently numerous “less dependent” smokers such that Liking and Wanting were related. A future study designed to examine separation of Liking and Wanting in smokers could consider recruiting only very highly dependent smokers. For example, smokers with FTND scores of no less than 6 could be recruited. (FTND score of 6 or higher has been designated as high dependence (Fagerstrom, 1996).

A sample with highly dependent smokers attempting to quit might show even greater separability between Liking and Wanting measures, particularly in the CFA. Second, the correlation between Liking and Wanting may reflect method factors (see limitations sections). For example, response biases may inflate the correlations between all items (and therefore between Liking and Wanting).

Interestingly, upon initial examination of correlations among variables, we had to remove the measure of the NEQ-physiological before conducting analysis due to low correlation with all other measures. It is preferable that measures have at least a minimal level of correlation with other variables (Field, 2013). The NEQ-Physiological questions were the only measure that did not directly ask about Liking or Wanting (craving). It could be interesting in a future study to analyze how physical reactions and sensations to withdrawal, craving, or smoking cues may affect relapse.

SPECIFIC AIM 3

The results from Specific Aim 3 suggest that Liking and Wanting are both associated with dependence, as assessed by the FTND. This was true for both the non-abstinent state and the abstinent state. The association between Liking and dependence is consistent with data from Meloscia (2014). Meloscia (2014) reported data from puff-by-puff Liking ratings, and so the current study extends these findings to the case of Remembered (post-cigarette) ratings. In future research it would be interesting to compare the relative predictive utility of Experienced versus Remembered Liking.

Interestingly, when Liking and Wanting were included in a multivariable model, Wanting was a stronger predictor of dependence. This provides some support that processes underlying motivation are more important than pleasure in dependence and

could be interpreted as evidence for IST 93 (but see later discussion). In any case, the data suggest that interventions that reduce Wanting may be more effective in reducing dependence than those that reduce Liking.

Of the measures, only Wanting at the abstinent state predicted relapse at Week +4. Thus, one might argue that the data for this dependent variable (relapsed) also supported the importance of Wanting. However, this conclusion is tempered by the fact that Liking measures came close to significance, and there was little difference in the magnitude of the *ORs* for the Wanting and Liking measures at the abstinent state. In addition, the relatively low rate of abstinence (19%) likely decreased power to detect associations with relapse.

LIMITATIONS

There are several limitations in this study. First, as noted earlier, the current study focused on self-reported (conscious) Liking and Wanting measure. The sole use of self-report measures could be considered a limitation in that self-report measures may not be able to reveal the entire workings of the Wanting and Liking systems. One might argue that, at a minimum, the self-report measures should certainly be able to reveal important “end products” of the Wanting and Liking systems (Figure 2) as argued by IST 93. However, as described earlier, Tibboel et al. (2015) note that in later articles, Robinson and Berridge identify “wanting” and “liking” (in quotations) with solely preconscious processes, meaning that any linkage with self-report measure is at best unclear. Tibboel et al. (2015) interpret these articles to mean that “wanting” and “liking” should be uncorrelated with each other and with explicit (self-report) measures.

In sum, the current study is therefore limited in that the data speak only to conscious Liking and Wanting. One can say that while the data (arguably) test the theoretical predictions of IST 93 (Robinson & Berridge, 1993), they may shed little light on the theoretical predictions of IST as described in more recent publications (e.g., Berridge, 2010).

Tibboel et al. (2015) argued that implicit measures such as variants of the Implicit Association Test (IAT) might potentially assess “liking” and “wanting” measures. That said, they described a number of theoretical and empirical problems with research using IATs. In addition, although both parent studies in this dissertation used a valence IAT (see Table 6 and 8), inclusion of implicit measures was beyond the scope of the current study. In addition to the theoretical issues outlined by Tibboel et al., there is a practical difficulty that current implicit measures generally do not correlate with each other or with the self-report measures at a sufficient magnitude (i.e., with correlations $> .3$ with other variables, Field 2013) to be useful in the factor analysis.

Second, there is much debate in the literature on how to measure subjective Liking. There is no standard measure of subjective Liking used in the smoking literature. For example, Perkins et al. (2008) use one question from the Rose Sensory Questionnaire that uses a 0-100 visual analog scale to measure Liking. In both parent studies, Liking was assessed on a 1-7 scale. As discussed earlier, some studies use “satisfaction” and “liking” when asking about subjective pleasure from smoking and have found similar results regardless of word choice (Shiffman and Kirchner, 2009).

Third, as noted by Meloscia (2014), the subjective effects of smoking assessed in a well-controlled laboratory setting may not capture the subjective effects experienced in

the participants' natural environment, which diminishes the external validity of the study. (The EMA component of craving in Study 2 is not subject to this criticism). For example, Kalman (2002) notes "evidence suggests that the subjective effects of nicotine are moderated to an important extent by situational contingencies and individual differences". Moreover, the subjective effects of only two cigarettes were assessed.

Fourth, there were some significant method limitations in the study relating to differences in assessment for Liking and Wanting. This was due in part to the fact that the parent studies were not designed with the intention to examine patterns of Experienced versus Remembered Wanting. For Specific Aim 1, a method limitation was the time points in the procedures of those studies. We were only able to consider Remembered Liking and Wanting over a short period of time (during 7 puffs of a cigarette for Liking and over one week for Wanting). A study designed to more fully explore Experienced and Remembered Liking and Wanting would include assessments of subjective effects over longer periods of time to more accurately assess the possible effects of Remembered versus Experienced Liking and Wanting on smoking relapse. This type of study design would allow for experimentation of duration neglect as discussed by Kahneman (2011). Additionally, a future study would have the same time points for both Remembered Liking and Wanting with several time points (e.g. 1 day, 3 days, 1 week, 2 weeks, etc.). We are also unable to make a direct comparison between Remembered Liking and Wanting due to the different time points used for the two (after one cigarette vs. after one week).

For Specific Aim 2, although Liking and Wanting self-report measures are assessed in close proximity, the Liking measures ask about responses to a specific

cigarette or cigarette puff whereas the assessment of Wanting asks about craving that is not tied to a specific cigarette (e.g., “I have a desire for a cigarette”). Note, however, that the SCQ, which loads onto Wanting, is specific to the cigarette. In addition, the Liking items are focused in the immediate present or recent experience, whereas some (but not all) wanting measures assess experience over the past week. Importantly, the QSU (a Wanting measure) does measure craving “in the moment” meaning that the Liking/Wanting distinction is not completely confounded by the time period assessed by the questions. In future studies it may be advisable to yoke the Liking and Wanting items to the same smoking time points to facilitate comparisons. For example, Shiffman and Kirchner (2009) used questions regarding both satisfaction (liking) and craving (wanting) for the same cigarettes using an electronic smoking diary over 16 days of ad libitum smoking.

Further, Wanting is necessarily assessed prior to drug self-administration, and Liking is necessarily assessed during drug self-administration (Pool et al., 2016). Assessment of Liking prior to drug self-administration (expected pleasure) does not yield a straightforward Liking measure. As noted by Pool et al. (2016) “Expected pleasantness underlies cognitive desires and does not correspond to animal liking, a hedonic experience, or to animal wanting...”. For assessment of “liking” and “wanting” (preconscious Liking and Wanting), implicit assessments may be administered at the same time point, although these implicit assessments have their own challenges (Tibboel et al., 2015) (p. 104).

Fifth, the results from Specific Aim 3 are correlational. Therefore, it is possible that a third factor may underlie the association between Liking/Wanting and outcomes. In

other words, the study cannot prove a causal relationship between Liking and FTND/relapse, or between Wanting and FTND/relapse. Future studies using larger samples sizes can examine the influence of potential confounding variables, such as gender (Shiffman & Kirchner, 2009).

Sixth, self-report measures may be subject to response biases, such as social desirability bias. Such responses biases may inflate the correlation between variables and lead to an overestimation of the degree of correlation between Liking and Wanting. There are several non-specific factors that could complicate data interpretation related to the nature of our measures (self-report). The biggest threat to self-report data is a response set or response style such as extremity bias and social desirability bias (Paulhus and Vazire, 2007). Extremity bias (e.g., someone who always answers at the highest level of the scale or always answers yes) will inflate correlations. Social desirability responding will lead to a consistent pattern that can confound results away from the true pattern of results. A future study looking at Liking and Wanting ratings across proximal time points could include a scale to measure biases (such as the Social Desirability Scale) and a measure of boredom to assess for these non-specific factors.

Seventh, although the EFA provided good evidence for a two-factor solution, the study did not employ modern factor extraction methods such as a parallel analysis which may be superior to the methods used in the current study (Field, 2013). For example, parallel analysis may be able to identify with greater precision the number of factors in the dataset. In future research it would be useful to bolster the current analyses with this method. In addition, although the factor structures appeared to be similar for the non-

abstinent and abstinent states, we did not employ a formal test of this. This test could be conducted in future analyses.

Eighth, one might question the appropriateness of conducting CFA after EFA in the same dataset. EFA generates a hypothesis about the factor structure that ideally should be tested on a new sample, otherwise the results will likely capitalize on chance, i.e., overfit the data (Wagenmakers et al., 2012). For example, Wagenmakers et al. (2012) note that “a hypothesis that is developed on the basis of exploration of a data set is unlikely to be refuted by that same data” (p.633).

These points notwithstanding, conducting EFA followed by CFA on the same data set has been done before and is not completely without merit (Strickland, Watkins, and Caterino, 2015; Chesney et al., 2006). Similar to the approach taken in the current dissertation, a study exploring the factor structure of the Yale-Brown Obsessive Compulsive Scale (YBOCS) started with EFA and used EFA results as one of four CFA measurement models to test. Using EFA, a three-factor model was found to be supported. The three-factor model was then compared to a one, two, and four-factor model using CFA. This study found that the model driven by EFA results was the best fitting model in CFA and helped define a potential third factor in the YBOCS (Moritz et al., 2002).

Finally, one might question the adequacy of the assessment of Wanting in the current study. In their review and conceptualization, Pool et al. (2016) stressed the importance of assessing Wanting by use of a cue presentation. They noted that the majority of studies (~63%) examining Wanting had used a cue presentation. Pool et al. note, “the interaction between the individual’s physiological state and the perception of

the relevant reward-associated cue determines incentive salience or wanting”. They further suggest that assessment of Wanting should use the presentation of a cue.

If this methodological stipulation is correct, then the absence of a cue presentation could be considered a limitation of the study. However, there are two counterarguments. One might argue that in completing a state assessment such as the QSU, the individual imagines smoking cues (e.g., in response to an item such as “I have a desire for a cigarette”). Second, when responding to items on the SABQ and the WSWs, the participant is recalling interactions with smoking cues in the real world (e.g., in response to the item “During the past week, how often have you found yourself noticing people smoking?”).

STRENGTHS

There are several strengths in this study pertaining to the study design. First, sample sizes in both Parent Study 1 and Parent Study 2 were sufficiently large for the study to have adequate power to detect correlations of small-to-moderate magnitude. Additionally, the sample sizes were adequate to conduct factor analyses in Specific Aim 2. Second, the use of two assessments (non-abstinent and abstinent) was a strength because it permitted an examination of the generalizability of the factor structure across different states (albeit in the same sample of participants). Third, Parent Study 2 included biochemical validation of abstinence, the gold standard for validating abstinence. Fourth, the use of the attentional bias measures from Parent Study 2 was strength. Although self-report assessments do not reveal detailed information about the mechanisms of the fast cognitive processes that underlie attentional bias, as noted earlier, self-reported attentional bias may provide a measure of the result of those detailed processes. Fifth, in

Aim 1, we used both laboratory and EMA assessments. A final strength is that this is one of the few studies to include analyses based on puff-by-puff ratings for Liking.

THEORETICAL IMPLICATIONS

The main theoretical implication of the current study is that there is some evidence for two underlying factors corresponding to Liking and Wanting that are correlated but also distinct, as anticipated by IST 93 (Robinson & Berridge, 1993). The fact that the Wanting factor exhibited stronger associations with dependence and relapse also provides some support for IST 93 that Wanting is more strongly linked to dependence than Liking.

However, one might argue that one result was contrary to IST 93. Individuals with higher Liking scores reported greater dependence. Perkins et al. (2012) and Shiffman and Kirchner (2009) also found a positive correlation between Liking and dependence. Arguably, IST 93 should predict a negative correlation (or a zero correlation) between Liking and dependence, because Liking effects should be reduced by tolerance over time in more chronic, dependent, smokers. In sum, the data appear to suggest that conscious Liking may be more important than anticipated by IST 93.

CLINICAL IMPLICATIONS

There are several clinical implications of this study. First, by understanding how Liking and Wanting are experienced - taking into account the Peak-End rule - we could develop a program that brings awareness of this cognitive bias to smokers through psychotherapy. Bias awareness may help to reduce ratings of Wanting and Liking thus reducing the risk of relapse.

Cognitive bias awareness and mitigation has been tested in several fields. For cognitive biases in decision-making, the Defense Advanced Research Projects Agency (DARPA) has been working to create a video game that reduces cognitive biases in decision-making of intelligence analysts. The Air Force recently conducted a study in support of this showing that a game that brings bias awareness to a person's attention may reduce frequency of that bias (Symborski et al., 2014).

Another study showed how highlighting information could aid in “taming” the Peak-End bias (Morewedge, Gilbert, and Wilson, 2005). This study found that when participants were asked to recall one or more atypical events (“peak” type events), their forecasts about future events were less extreme than those participants who were not asked to recall an atypical event. This behavior suggests that when left to their own thoughts people may evaluate future decisions in a more extreme way based on a prior atypical (peak) event. In contrast, if people are asked to remember the atypical event, they are then aware that that event was atypical and moderate their predictions appropriately (Morewedge, Gilbert, and Wilson, 2005).

A second focus for clinical interventions is the potential difference between “Likers” and “Wanters”. For example, some smokers may be high on the Wanting dimension but not the Liking dimension (“Wanters”) and others high on the Liking dimension but not the Wanting (“Likers”). “Wanters” and “Likers” may benefit from different types of treatments. Interventions that target liking, such as aversion therapy or medications that attenuate the subjective effects, may be more particularly beneficial for “Likers”. Interventions that reduce craving may be particularly beneficial for “Wanters”.

This idea can be connected with bias awareness, but also has separate applications. We examine several examples of interventions aimed at Likers or Wanters below.

Fardadi and Cox (2009) conducted a study aiming to reduce attentional bias in alcohol drinkers. Attentional bias work has been conducted in the smoking field as well. Fardadi and Cox (2009) argue that making the bias explicit could be helpful for cessation. They hypothesized that increased awareness of bias could lead to a reduction in drinking. This kind of awareness could be useful for Peak-End bias and potentially to affect Liking and Wanting ratings. From Aim 3, we see that Liking and Wanting ratings are predictive of dependence. Given that attentional bias is linked to craving, this type of intervention may be more beneficial for “Wanters”.

Third, researchers could also “exploit” Peak-End bias clinically. For example, one could design “experimental cigarettes” for use in smoking cessation that taste normal except for the last puff that would have a taste aversive quality embedded. This type of intervention would presumably make the last puff less pleasurable, which should lead to less favorable memories of smoking (see Kahneman et al., 2000). This type of intervention might be more effective for Likers.

Fourth, different pharmacotherapies could be used to alter ratings of Wanting and Liking. As discussed in Meloscia (2014) reducing Liking ratings may reduce potential for smoking relapse. Several studies have found that medications can reduce subjective pleasure associated with smoking. For example, Varenicline reduces acute self-reported Liking for cigarettes (Perkins et al. 2010; Sofuoglu, 2009). Also, Sofuoglu et al. (2012) found that the medication Galantamine reduced subjective ratings of smoking. If research

continues to support the separability of Liking and Wanting pathways for addiction, pharmacotherapies could focus on reducing only Wanting or only Liking.

Fifth, interventions that target Liking might plausibly target 1) Experienced pleasure from smoking, or 2) Memory for past pleasure. For the latter, one approach would be to implant false memories of smoking. While this research has not yet been conducted in the smoking literature, a recent study using false memories was conducted for alcohol. Clifasefi and colleagues (2013) used suggestion to implant false memories regarding alcohol preferences; 19.6% of participants believed the false memory and there was significant difference in preference ratings for alcohol based on experimental manipulation of belief. False memories could be a tool that would work well with some smokers and potentially those who tend more towards higher Liking ratings than Wanting ratings (“Likers”).

Overall, a more detailed understanding of the pathways of Liking and Wanting in addiction may aid scientists and clinicians in creating more targeted interventions to improve smoking cessation outcomes.

FUTURE DIRECTIONS

The preceding discussion points to many areas where future studies could improve upon the current study. As researchers struggle with the challenges of operationalizing Liking and Wanting (Tibboel et al., 2015), there are many other interesting facets of Liking and Wanting that can be included in future studies as the findings in this area grow.

Plans for future research will be discussed in the context of the different definition types for Liking and Wanting shown in Table 1.

Mental Process

Based on our findings from Aim 2 showing separability of Liking and Wanting from self-report measures, future studies should seek further evidence for discriminant validity. If Liking and Wanting are different pathways, we should find evidence that Liking predicts one dependent variable (y_1) and not another (y_2), and vice versa for Wanting. With this in mind, a future study could compare one group of chronic, very dependent smokers against a group of lighter, less dependent smokers. A crucial prediction is that Group should correlate positively with Wanting and negatively with Liking. That is, the dependent group (vs. non-dependent group) should show more Wanting and less Liking. In addition, future studies could compare the relative predictive efficacy of Liking and Wanting in non-dependent and dependent samples. For example, Liking and Wanting may be highly correlated in non-dependent or adolescent samples, meaning that it may be difficult to find differences in prediction. Perkins (2008) also discusses how interesting it would be to explore genetic association with Liking. Future studies could also examine the discounting of rewards over time (delay discounting) as an index of Wanting.

While the current future study focused on self-report measures, future studies could also consider including implicit measures to test hypotheses more related to preconscious “liking” and “wanting”. Tibboel et al. (2015) review attempts to do this. For example, Tibboel et al. describe the use of IATs to assess “liking” and “wanting”. In the former, category labels for the IAT are “I like cigarettes/I do not like cigarettes” and in the latter they are “I want cigarettes/I do not want cigarettes”. This work is in its infancy but represents an alternative approach to assessment of wanting and liking as mental processes.

As interesting question is how expectations of pleasure relates to Liking and Wanting. The study used a 5-item measure of expectancies that derived from various scales from the original SCQ measure (Negative Affect Reduction (Smoking now will help me relax); Stimulation/State Enhancement (Smoking now will energize me.); Taste/Sensorimotor Manipulation (A cigarette will taste good now.); Craving/Addiction (Smoking now will satisfy my cravings.); and Boredom Reduction (Smoking now will help reduce boredom.) It would be interesting to use additional items from different scales from the original SCQ. For example, the following scales from the SCQ-A might load onto a Liking factor: Negative Affect Reduction, Taste/Sensorimotor Manipulation, and Boredom Reduction. Likewise, the following SCQ-A scales might load onto a Wanting factor: Craving/Addiction and Stimulation/State Enhancement. Additional scales from the SCQ-A are more closely aligned with the physiological state similar to the one variable we removed from our analyses in Aim 2 (NEQ-physiological). Those scales are Negative Physical Feelings, Weight Control, and Health Risk. Using those scales from the SCQ could be helpful for understanding the self-reported physiological connection to smoking relapse and dependence.

To combat response bias in self-report measures, a future study looking at Liking and Wanting ratings could include a scale to measure biases (such as the Social Desirability Scale) and a measure of boredom or irritation to assess for these non-specific factors. Additionally, as noted above, a study could employ an Implicit Association Test (IAT) for Liking and Wanting that is presumably less sensitive to social desirability biases.

Effect

As noted in the background, the “motivational magnet” feature of conditioned incentive stimuli can be assessed not only with self-report, but also with eye movements and reaction time tasks (e.g., Cox et al., 2006; Field et al., 2009). Future studies could employ these types of assessments to assess the motivational magnet feature of conditioned stimuli. These assessments will provide more detailed information about the cognitive processes underlying the attention-grabbing properties of smoking cues. Future research should also examine the extent to which self-report measures of the attention-grabbing properties of cues are associated with the more objective measures (see Waters et al. 2014).

Utility

Other than Meloscia (2014) the current study is the first to examine the Peak-End rule in the context of smoking. The study only examined these effects for a single cigarette (Liking) and a single week of EMA (Wanting). Therefore, much more research is required to more comprehensively examine the role of memory biases in smoking.

Future studies could examine whether the Peak-End rule differs across different states such as abstinent or non-abstinent. This could be examined in the current dataset.

Additionally, although the current study examined experienced and remembered utility, future research could also incorporate predicted utility (expected pleasure) into analyses. For example, Wirtz et al. (2003) examined the role of predicted, experienced, and remembered utility in the decision to repeat a vacation. They used a path analysis approach to determine the relative contribution of these different utilities in predicting the decision. We could include all facets of utility including predicted, experienced, and remembered, in analyses.

Further, after exploring peak-end bias in Aim 1, one may wonder whether there are individual differences in peak-end bias. While the literature on individual differences in peak-end bias is scarce, a recent study analyzed individual differences for Peak-End bias in patients' recall of pain and fatigue (Schneider et al. 2011). This study found that there were significant individual differences in how the peak-end bias affected responses to overall pain and fatigue ratings. The authors suggest that understanding which patient is more affected by the peak-end bias may be useful for understanding that individual's decision making process (Schneider et al., 2011), and this information may be useful clinically. A future study examining individual differences in peak-end bias would add to understanding of Liking and Wanting as utilities.

Another next step is to examine the relative predictive utility of different components (both Experienced and Remembered) of both Liking and Wanting. For example, research should examine which measures are most strongly related to important outcomes, such as relapse. If future research shows that the Peak-End or other memory biases are likely to promote smoking, for example by giving rise to more favorable memories, then interventions that target such biases (as described earlier) could be developed.

Finally, a study including assessments of utility at various time points would allow for experimentation of "duration neglect" as discussed by Kahneman (2011) and as described in the introduction. For example, consider two smokers, one who had 1 day of very severe withdrawal and 6 days of no withdrawal, and another who had 7 days of merely severe withdrawal. It would be interesting to compare their memories of the

withdrawal experience, and to examine whether those memories influenced future behavior.

Neurological

While our study did not explore the neurological underpinnings of Liking and Wanting, we can see from the background that the brain pathways associated with subjective effects of smoking are important to consider. The DSM-5 (2013) states, “All drugs that are taken in excess have in common direct activation of the brain reward system, which is involved in the reinforcement of behaviors and production of memories” (p. 481). This statement is indicative of how understanding the brain pathways can assist with understanding other aspects of Liking and Wanting (such as mental process and utility). Finalyson, King, and Blundell (2007) write:

“Our preferred view is that liking and wanting should be viewed as intervening variables that help us understand the role of hedonics.... Their existence should not be taken to mean that these processes are structurally embodied in a neural substrate. Rather, that different neurochemical pathways can separately influence the events that can be measured objectively (in animals and humans) and which imply the existence of processes here referred to as liking and wanting.”

(Finalyson, King, and Blundell, 2007, pp. 26-27)

Future studies could use fMRI techniques to better understand neurological processes connected with Liking and Wanting in humans. Further, fMRI studies may provide insight into the connection between brain processes and subjective report of Liking and Wanting. The use of methods with fine temporal resolution, such as magneto-encephalography, may be particularly useful given the importance of temporal

information. Future studies could also try to integrate the utility and neurological perspectives. For example, the peak rating may be closely related to biological factors, such as receptor sensitivity, whereas application of the peak-end rule is more cognitive in nature. This level of analysis could potentially allow for the development of increasingly more targeted clinical cessation treatments.

CONCLUSION

Despite the many challenges associated with measuring and operationalizing Liking and Wanting, the research on these concepts in addiction and smoking is growing. The framework of definitions for Liking and Wanting provided by Tibboel et al. 2015 helps to organize research on these concepts. The current study provided some support for an early version of Incentive Sensitization Theory, but clearly much further research is required. Ultimately, increased understanding about all aspects of Liking and Wanting and their relations to addiction and relapse will be important as researchers translate findings into clinical application for smoking cessation.

Table 1. Overview of Different Definitions of “Wanting” and “Liking”

	Definition Type	“Wanting”	“Liking”
1	Mental Process	Attribution of “incentive salience” feature Conscious craving (IST 93) (Preconscious) craving	“Pleasure integrator” feature Conscious pleasure (IST 93) (Preconscious) pleasure
2	Effect	“Motivational magnet” feature	None
3	Utility	Decision utility: the essence of the decision to pursue reward at the moment it is made	Experienced utility: the hedonic experience by the reward after it is obtained
4	Neurological	Activity in the mesolimbic dopamine-systems. Affected by dopamine, opioids, and GABA	Activity in subcortical “hedonic hotspots”, affected only by opioids

Note. Adapted from Table 1 from Neuroscience and Biobehavioral Reviews, 57, Tibboel, H., De Hower, J., and Van Bockstaele, B., Implicit measure of “wanting” and “liking” in humans, 350-364, Copyright (2015), with permission from Elsevier

Table 2. Overview of Parent Study 1 versus Parent Study 2

	Study 1	Study 2
<i>Participants</i>	Non-treatment seekers	Treatment-seekers
<i>Site</i>	MDACC	MDACC + USUHS
<i>Sample Size</i>	N=79	N=268
<i>Abstinence States</i>	4 sessions: NON-NS, NON-S, AB-NS, AB-S	2 sessions: NON vs. AB
<i>Setting</i>	Lab	Lab + EMA
<i>Specific Aim 1</i>	Liking	Liking* + Wanting
<i>Specific Aim 2</i>	n/a	Factor Analysis
<i>Specific Aim 3</i>	n/a	FTND + Relapse

Note. MDACC = The University of Texas M. D. Anderson Cancer Center, USUHS = Uniformed Services University of the Health Sciences, NON-NS = non-abstinent prior to lab visit and non-smoking in the lab, NON-S = non-abstinent prior to lab visit and smoking in the lab, AB-NS = abstinent prior to the lab visit and non-smoking in the lab, AB-S = abstinent prior to the lab visit and smoking in the lab, NON = non-abstinent prior to the lab visit, AB = abstinent prior to the lab visit, EMA = ecological momentary assessment. *Reported in Meloscia (2014).

Table 3. Experienced and Remembered Variables for Specific Aim 1

	Liking	Wanting
Hypothesis	1.1	1.2
Setting	Lab	EMA
Units	Puffs	Assessments/Days
<i>Experienced Peak</i>	Peak Liking Rating	Peak Craving Rating
<i>Experienced End</i>	Liking at Puff 7	Craving at Final Assessment
<i>Experienced Random</i>	Liking at Puff selected at random	Craving at Assessment selected at random
<i>Mean-5</i>	Mean excluding Peak & End	n/c
<i>Mean</i>	Mean of all 7 Puffs	Mean of all Assessments/Days
<i>Remembered</i>	Overall Liking	WSWS Craving Week +1

Note. EMA = Ecological Momentary Assessment, WSWS = Wisconsin Smoking

Withdrawal Scale. Week +1 = Assessment one week post quit day. For assessment-level analysis, Peak Wanting was defined as the craving at an assessment with the maximum level of craving during EMA, End Wanting as the craving at the final EMA assessment, and Random Wanting as the craving at an EMA assessment selected at random. For day-level analysis, Peak Wanting was defined as the average craving on the day with the highest average level of craving, End Wanting as the average craving on the final day, and Random Wanting as the average craving of a day selected at random. As noted in text, self-reported attentional bias was also examined in Hypothesis 1.2. n/c = not computed.

Table 4. Parent Study Data for Current Study Aims and Hypotheses

Aim	Hypothesis	Parent Study
1	1.1 Peak and End Liking will be more strongly related to Remembered Liking than Liking assessed at a random puff.	1
1	1.2 Peak and End Wanting will be more strongly related to Remembered Wanting (craving) than craving assessed at a random puff.	2
2	2.1 Two factors will be revealed that correspond to Liking and Wanting.	2
3	3.1 Self-report measures of Liking and Wanting will have a predictive relationship with FTND score.	2
3	3.2 Self-report measures of Liking and Wanting will have a predictive relationship with relapse status.	2

Table 5. Parent Study 1: Participant Demographics and Smoking Characteristics

	<i>M (%)</i>	<i>SD</i>
Sex (% Male)	44.3	
Race (% White)	36.8	
Age in years	42.7	9.73
FTND	5.51	1.75
Cigarettes/Day	21.1	7.64
Years smoked	22.3	9.51

Note. Data shown are for the 79 participants who attended at least one experimental session. FTND = Fagerström Test of Nicotine Dependence

Table 6. Parent Study 1: Procedure and Timeline for Experimental Sessions

Smoking Status	Procedure	Assessments	Time (min)
AB or NON	Exhaled CO	CO	2
	QDS assessments (#1)	SABQ, WSWs	10
	Hook-Up Participants to Biopac		20
	Startle-Probe Assessment (#1)	Startles: N, S, P, Ng pictures	15
SMOKED or REST ↓	Cigarette smoking or rest		10
	Startle-Probe Assessment (#2)	Startles: N, S, P, Ng pictures	15
	QDS assessments (#2)	PANAS, QSU	5
	Computerized Cognitive Assessment	Smoking Stroop Task	5
	Un-Hook Participants from Biopac		20
	QDS assessments (#3)	SSQ, PANAS, QSU	5
	Computerized Cognitive Assessment	IAT	10
	Behavioral Choice Task		2
	QDS assessments (#4)	5 Expectancy Items	1
Smoke cigarette ↓	Cigarette smoking	NEQ	1
	Puff 1	NEQ, liking	1
	Puff 2	NEQ, liking	1
	Puff 3	NEQ, liking	1
	Puff 4	NEQ, liking	1
	Puff 5	NEQ, liking	1
	Puff 6	NEQ, liking	1
	Puff 7	NEQ, liking	1
	Post-Cigarette	NEQ	1
		Liking , Enjoyment, Satisfaction items	1

Note. Assessments are listed in the order they were completed. SABQ = Subjective Bias Questionnaire; WSWs = Wisconsin Smoking Withdrawal Scale; QSU = Brief Questionnaire of Smoking Urges; NEQ = Nicotine Effects Questionnaire; QDS = questionnaire development system; SSQ = Subjective Stroop questionnaire; IAT = Implicit Association Test; N = neutral pictures; S = smoking pictures; P = positive pictures; Ng = negative pictures. **Bolded assessments** are used in the current proposal. See text for further details. *Adapted from:* Waters, A. J., Carter, B. L., Robinson, J. D., Wetter, D. W., Lam, C. Y., & Cinciripini, P. M. 2007. Implicit attitudes to smoking are associated with craving and dependence. *Drug Alcohol Depen.* 91:178-186

Table 7. Parent Study 2: Participant Demographics and Smoking Characteristics

	<i>M (%)</i>	<i>SD</i>
Sex (% Male)	55.4	
Race (% White)	54.9	
Age in years	43.98	11.79
FTND	5.15	2.02
Time to first cigarette ^a	2.17	0.77
Cigarettes/Day	19.5	8.27
Baseline CO level (ppm)	21.05	10.07
Cotinine levels in saliva (ng/ml) ^d	385.16	223.7
Years smoked	24.15	11.96
Past quit attempts	5.30	3.10
Shipley IQ	104.41	10.78
Education completed in years	14.25	2.2
Annual family income ^{b,c}	5.2	3.36
Site (% USU)	42.0	

Note. Data shown are for the 237 participants who provided puff ratings from at least one smoking assessments. ^aFTND Item 1: Time to the first cigarette of the day (0=after 1hr; 1=31-60mins; 2=6-30mins; 3=within 5mins), ^bIncome before taxes assessed on an 11-pt ordinal scale; ^c*n*=235; ^d*n*=225 from whom data were available at the non-abstinent session.

Table 8. Parent Study 2: Procedures and Timeline for Experimental Sessions

	Phone Scr.	Orien. Visit	Week -2	Week -1	Week 0 (QD)	Week +1	Week +2	Week +3	Week +4
Modality/Location of Contact	Phone	Lab	Lab	Lab	Lab	Lab	Phone	Phone	Lab
Inclusion/Exclusion Criteria	X	X							
TREATMENT									
			X	X	X	X	X	X	X
COGNITIVE ASSESSMENTS									
Stroop			X	X	X	X			X
IAT			X	X	X	X			X
EA			X	X	X	X			X
RIPT			X	X	X	X			X
SMOKING ASSESSMENTS									
NEQ			X	X					
Satisfaction Ratings			X	X					
OTHER LAB ASSESSMENTS									
SABQ			X	X	X	X			X
Semantic Differential Items			X	X	X	X			X
SCQ			X	X	X	X			X
WSWS			X	X	X	X			X
CESD		X	X	X	X	X			X
QSU			X	X	X	X			X
PANAS			X	X	X	X			X
Smoking Status			X	X	X	X	X	X	X
Demographics Questionnaire	X								
FTND		X							
PHQ		X							
MINI (section K only)		X							
Tobacco History	X	X							
Shipley Institute on Living Scale		X							
REALM		X							
AUDIT		X							
SIAS		X							
BIOCHEMICAL ASSESSMENT									
Carbon monoxide (CO)		X	X	X	X	X			X
Cotinine			X	X	X	X			X

Note. NEQ = Nicotine Effects Questionnaire; WSWS= Wisconsin Withdrawal Smoking Scale;

QSU = Questionnaire for Smoking Urges; PANAS = Positive and Negative Affect Schedule;

SCQ-A = Smoking Consequences Questionnaire; SABQ = Subjective Attentional Bias

Questionnaire; PHQ = Patient Health Questionnaire; MINI = Mini International Neuropsychiatric Interview; REALM = Rapid Estimate of Adult Literacy in Medicine; AUDIT = Alcohol Use Disorders Identification Test; SIAS = Social Anxiety Interaction Scale; NDSS = Nicotine Dependence Syndrome Scale; Scr. = screening; Orien. = Orientation; QD = quit day. **Bolded** assessments are used in the current dissertation. See text for details. *Adapted from:* Waters AJ, Szeto EH, Wetter DW, Cinciripini PM, Robinson JD, Li Y. 2014. Cognition and craving during smoking cessation: An Ecological Momentary Assessment Study. *Nicotine Tob. Res.* 16:111-18

Table 9. Aim 1: Results of Multivariable Linear Mixed Models for Hypothesis 1.1

Predictor ↓	Estimate	SE	Lower CI	Upper CI	df	Min	Max	t	p
Random	0.15928	0.12323	-0.091	0.40958	34.476	0.02432	0.34343	1.29	0.2048
Peak	0.35136	0.09491	0.16218	0.54054	72.659	0.20684	0.43201	3.70	0.0004
End	0.42077	0.06546	0.29118	0.55037	120.28	0.32201	0.47204	6.43	<.0001

Note. Data shown derive from PROC MIANALYZE conducted on LMM analyses of all cigarettes smoked (n=288 cigarettes). Each LMM included Random Liking, Peak Liking, and End Liking, as well as Session number, pre-session Abstinence, and within-session Smoking. (Results for Session number, pre-session Abstinence, and within-session Smoking are not shown). The dependent variable was Remembered Liking, assessed after smoking. Estimate shows the mean regression coefficient for each predictor, aggregated across 20 analyses. Min and Max reflect the lowest and highest coefficients respectively. Lower and Upper CI reflect the confidence intervals for the mean coefficient, and the p value reflects a test of the null hypothesis that the mean regression coefficient is equal to zero in the population. *SE* = Standard Error; *df* = degrees of freedom.

Table 10. Aim 1: Results of Multivariable Linear Regressions for Hypothesis 1.2

Craving

Predictor	Estimate	SE	Lower CI	Upper CI	df	Min	Max	t	P
<i>Assessment</i>									
N	-0.058	0.0389	-0.1342	0.01826	6392.5	-0.0734	-0.0411	-1.49	0.1361
Random	0.46408	0.25884	-0.0533	0.9815	61.95	0.07954	0.80409	1.79	0.0779
Peak	0.69251	0.26187	0.17856	1.20646	900.17	0.52823	0.86207	2.64	0.0083
End	0.66046	0.19319	0.28095	1.03998	525.39	0.52995	0.82303	3.42	0.0007
<i>Day</i>									
N	-0.1843	0.18364	-0.5443	0.17569	11486	-0.2248	-0.1051	-1	0.3157
Random	0.44571	0.36968	-0.2968	1.18822	50.046	-0.0139	1.01702	1.21	0.2336
Peak	0.85679	0.33195	0.20138	1.5122	165.25	0.36397	1.13986	2.58	0.0107
End	0.42677	0.22532	-0.0157	0.86918	678.62	0.25737	0.54819	1.89	0.0586

Attentional Bias

Predictor	Estimate	SE	Lower CI	Upper CI	df	Min	Max	t	P
<i>Assessment</i>									
N	-0.0009	0.00877	-0.0181	0.01628	26807	-0.0039	0.00295	-0.1	0.9173
Random	0.07983	0.06324	-0.0463	0.20596	69.818	-0.0398	0.16494	1.26	0.211
Peak	0.14866	0.05329	0.04416	0.25316	2393.7	0.12953	0.19441	2.79	0.0053
End	0.09252	0.04652	0.00119	0.18385	702.91	0.04993	0.13677	1.99	0.0471
<i>Day</i>									
N	-0.0089	0.04166	-0.0906	0.07276	18452	-0.0169	0.01301	-0.21	0.8309
Random	0.06488	0.09455	-0.1241	0.25381	63.245	-0.0268	0.21162	0.69	0.4951
Peak	0.17281	0.07012	0.03496	0.31066	399.23	0.1036	0.21431	2.46	0.0141
End	0.10937	0.06243	-0.0132	0.23195	667.38	0.05251	0.14411	1.75	0.0803

Note. Data shown derive from PROC MIANALYZE conducted on regression analyses of EMA data using PROC REG (n=120 subjects). Each regression included Random Wanting, Peak Wanting, and End Wanting, as well as the number of assessments that each participant completed (n). Analyses were conducted on self-reported craving (upper table) and attentional bias (lower table). The dependent variable was WSWS Craving (upper table) or SABQ (lower table) assessed in the lab at Week +1. Estimate shows the mean regression coefficient for each predictor, aggregated across 20 analyses. Min and Max reflect the lowest and highest coefficients respectively. Lower and Upper CI reflect the confidence intervals for the mean coefficient, and the p value reflects a test of the null hypothesis that the mean regression coefficient is equal to zero in the population. *SE* = Standard Error; *df* = degrees of freedom. WSWS = Wisconsin Smoking Withdrawal Scale; SABQ = Subjective Attentional Bias Scale.

Table 11. Aim 2: Summary Statistics for Self-Report Measures of Liking and Wanting from Parent Study 2

Non-Abstinent

Variable ↓	NON	
	<i>M</i>	<i>SD</i>
Liking	4.69643	1.79855
Enjoyment	4.68750	1.77441
Satisfaction	4.67411	1.75291
Ch_NEQ_negative	0.41146	1.37671
Ch_NEQ_positive	0.28683	1.97136
Ch_NEQ_physiological	0.69286	1.53709
QSU	3.58348	2.55539
WSWS	9.24554	3.03011
SABQ	1.28292	0.59892
SCQ	5.39286	2.47091

Abstinent

Variable ↓	AB	
	<i>M</i>	<i>SD</i>
Liking	4.8785	1.84727
Enjoyment	4.78037	1.87231
Satisfaction	4.9486	1.84166
Ch_NEQ_negative	0.56231	1.79091
Ch_NEQ_positive	0.56893	2.49193
Ch_NEQ_physiological	1.6757	1.74831
QSU	6.06838	2.31693
WSWS	9.33178	2.74541
SABQ	1.41756	0.70773
SCQ	6.92056	2.20666

Note. Mean (M) and Standard Deviation (SD) of Study 2 measures in the non-abstinent (NON) (n = 224) and abstinent (AB) (n = 214) states. Ch_ prefix denotes change in NEQ measures. Using a paired sample t-test, the between-state difference was significant for QSU, SABQ, SCQ, and Ch_NEQ_physiological (all $ps < .001$).

Table 12. Aim 2: Correlation Matrix of Self-Report Measures in *Non-Abstinent State* (n = 224) and *Abstinent State* (n = 214) with All Variables

Non-Abstinent

	Sat.	Lik.	Enj.	QSU	WSWS	SABQ	SCQ	NEQ-Pos.	NEQ-Neg.	NEQ-Phy.
Sat.	1.000	0.931	0.898	0.444	0.092	0.258	0.421	0.547	-0.413	-0.206
Lik.	0.931	1.000	0.928	0.475	0.126	0.300	0.431	0.532	-0.439	-0.193
Enj.	0.898	0.928	1.000	0.461	0.113	0.307	0.432	0.547	-0.417	-0.171
QSU	0.444	0.475	0.461	1.000	0.277	0.369	0.780	0.402	-0.307	-0.114
WSWS	0.092	0.126	0.113	0.277	1.000	0.420	0.308	0.239	-0.129	-0.018
SABQ	0.258	0.300	0.307	0.369	0.420	1.000	0.375	0.359	-0.128	0.019
SCQ	0.421	0.431	0.432	0.780	0.308	0.375	1.000	0.362	-0.326	-0.206
NEQ – Pos.	0.547	0.532	0.547	0.402	0.239	0.359	0.362	1.000	-0.510	-0.262
NEQ – Neg.	-0.413	-0.439	-0.417	-0.307	-0.129	-0.128	-0.326	-0.510	1.000	0.503
NEQ – Phy.	-0.206	-0.193	-0.171	-0.114	-0.018	0.019	-0.206	-0.262	0.503	1.000

Abstinent

	Sat.	Lik.	Enj.	QSU	WSWS	SABQ	SCQ	NEQ-Pos.	NEQ-Neg.	NEQ-Phy.
Sat.	1.000	0.913	0.887	0.525	0.267	0.263	0.437	0.537	-0.466	-0.098
Lik.	0.913	1.000	0.888	0.523	0.218	0.216	0.422	0.512	-0.459	-0.090
Enj.	0.887	0.888	1.000	0.486	0.201	0.206	0.416	0.557	-0.464	-0.088
QSU	0.525	0.523	0.486	1.000	0.416	0.497	0.813	0.592	-0.360	-0.052
WSWS	0.267	0.218	0.201	0.416	1.000	0.441	0.394	0.266	-0.234	-0.083
SABQ	0.263	0.216	0.206	0.497	0.441	1.000	0.450	0.295	-0.195	-0.010
SCQ	0.437	0.422	0.416	0.813	0.394	0.450	1.000	0.447	-0.344	-0.097
NEQ – Pos.	0.537	0.512	0.557	0.492	0.266	0.295	0.447	1.000	-0.535	-0.212
NEQ – Neg.	-0.466	-0.459	-0.464	-0.360	-0.234	-0.195	-0.344	-0.535	1.000	0.345
NEQ – Phy.	-0.098	-0.090	-0.088	-0.052	-0.083	-0.010	-0.097	-0.212	0.345	1.000

Note. Sat. = Satisfaction; Lik. = Liking; Enj. = Enjoyment, QSU = Questionnaire for Smoking Urges; WSWS = Wisconsin Smoking Withdrawal Scale; SABQ = Subjective Attentional Bias Questionnaire; SCQ = Smoking Consequences Questionnaire; NEQ-Pos. = Change in Nicotine Effects Questionnaire Positive; NEQ-Neg. = Change in Nicotine

Effects Questionnaire Negative; NEQ-Phy. = Change in Nicotine Effects Questionnaire
Physiological

Table 13. Aim 2: Correlation Matrix (R Matrix) of Self-Report Measures in *Non-Abstinent State* (n = 224) and *Abstinent State* (n = 214) with Variables Used in Calculations

Non-Abstinent

	Sat.	Lik.	Enj.	QSU	WSWS	SABQ	SCQ	NEQ-Pos.	NEQ-Neg.
Sat.	1.000	0.931	0.898	0.444	0.092	0.258	0.421	0.547	-0.413
Lik.	0.931	1.000	0.928	0.475	0.126	0.300	0.431	0.532	-0.439
Enj.	0.898	0.928	1.000	0.461	0.113	0.307	0.432	0.547	-0.417
QSU	0.444	0.475	0.461	1.000	0.277	0.369	0.780	0.402	-0.307
WSWS	0.092	0.126	0.113	0.277	1.000	0.420	0.308	0.239	-0.129
SABQ	0.258	0.300	0.307	0.369	0.420	1.000	0.375	0.359	-0.128
SCQ	0.421	0.431	0.432	0.780	0.308	0.375	1.000	0.362	-0.326
NEQ – Pos.	0.547	0.532	0.547	0.402	0.239	0.359	0.362	1.000	-0.510
NEQ – Neg.	-0.413	-0.439	-0.417	-0.307	-0.129	-0.128	-0.326	-0.510	1.000

Abstinent

	Sat.	Lik.	Enj.	QSU	WSWS	SABQ	SCQ	NEQ-Pos.	NEQ-Neg.
Sat.	1.000	0.913	0.887	0.525	0.267	0.263	0.437	0.537	-0.466
Lik.	0.913	1.000	0.888	0.523	0.218	0.216	0.422	0.512	-0.459
Enj.	0.887	0.888	1.000	0.486	0.201	0.206	0.416	0.557	-0.464
QSU	0.525	0.523	0.486	1.000	0.416	0.497	0.813	0.592	-0.360
WSWS	0.267	0.218	0.201	0.416	1.000	0.441	0.394	0.266	-0.234
SABQ	0.263	0.216	0.206	0.497	0.441	1.000	0.450	0.295	-0.195
SCQ	0.437	0.422	0.416	0.813	0.394	0.450	1.000	0.447	-0.344
NEQ – Pos.	0.537	0.512	0.557	0.492	0.266	0.295	0.447	1.000	-0.535
NEQ – Neg.	-0.466	-0.459	-0.464	-0.360	-0.234	-0.195	-0.344	-0.535	1.000

Note. Sat. = Satisfaction; Lik. = Liking; Enj. = Enjoyment, QSU = Questionnaire for Smoking Urges; WSWS = Wisconsin Smoking Withdrawal Scale; SABQ = Subjective Attentional Bias Questionnaire; SCQ = Smoking Consequences Questionnaire; NEQ-Pos.

= Change in Nicotine Effects Questionnaire Positive; NEQ-Neg. = Change in Nicotine Effects Questionnaire Negative

Table 14. Aim 2: Communalities in *Non-Abstinent State* (n = 224) and *Abstinent State* (n = 214)

Non-Abstinent

	<i>Initial</i>	<i>Extraction</i>
Satisfaction	.881	.905
Liking	.915	.937
Enjoyment	.874	.891
QSU	.640	.653
WSWS	.224	.224
SABQ	.312	.289
SCQ	.635	.671
NEQ-Positive	.464	.415
NEQ-Negative	.327	.249

Abstinent

	<i>Initial</i>	<i>Extraction</i>
Satisfaction	.868	.886
Liking	.867	.886
Enjoyment	.883	.885
QSU	.727	.788
WSWS	.267	.287
SABQ	.326	.371
SCQ	.672	.688
NEQ-Positive	.457	.431
NEQ-Negative	.343	.302

Note. The Initial Communality estimates reflect the squared multiple correlation between each item and all other items. The Extraction Communality estimates reflect multiple correlation between each item and all factor scores. QSU = Questionnaire for Smoking Urges; WSWS = Wisconsin Smoking Withdrawal Scale; SABQ = Subjective Attentional Bias Questionnaire; SCQ = Smoking Consequences Questionnaire; NEQ-Pos. = Change in Nicotine Effects Questionnaire Positive; NEQ-Neg. = Change in Nicotine Effects Questionnaire Negative

Table 15. Aim 2: Reproduced and Residual Correlations in *Non-Abstinent State* (n = 224)

Reproduced Correlation Matrix

	Sat.	Lik.	Enj.	QSU	WSWS	SABQ	SCQ	NEQ-Pos.	NEQ-Neg.
Sat.	0.905	0.920	0.897	0.438	0.104	0.264	0.405	0.554	-0.445
Lik.	0.920	0.937	0.914	0.466	0.120	0.283	0.434	0.573	-0.458
Enj.	0.897	0.914	0.891	0.461	0.122	0.281	0.431	0.561	-0.449
QSU	0.438	0.466	0.461	0.653	0.356	0.434	0.661	0.540	-0.330
WSWS	0.104	0.120	0.122	0.356	0.224	0.243	0.369	0.190	-0.131
SABQ	0.264	0.283	0.281	0.434	0.243	0.289	0.441	0.288	-0.210
SCQ	0.405	0.434	0.431	0.661	0.369	0.441	0.671	0.440	-0.321
NEQ – Pos.	0.554	0.573	0.561	0.450	0.190	0.288	0.440	0.415	-0.320
NEQ – Neg.	-0.445	-0.458	-0.449	-0.330	-0.131	-0.210	-0.321	-0.320	0.249

Residual Correlation Matrix

	Sat.	Lik.	Enj.	QSU	WSWS	SABQ	SCQ	NEQ-Pos.	NEQ-Neg.
Sat.		0.011	0.002	0.006	-0.012	-0.006	0.016	-0.007	0.032
Lik.	0.011		0.015	0.009	0.005	0.017	-0.003	-0.040	0.020
Enj.	0.002	0.015		0.000	-0.009	0.026	0.001	-0.014	0.032
QSU	0.006	0.009	0.000		-0.079	-0.065	0.119	-0.048	0.023
WSWS	-0.012	0.005	-0.009	-0.079		0.178	-0.061	0.049	0.002
SABQ	-0.006	0.017	0.026	-0.065	0.178		-0.065	0.071	0.082
SCQ	0.016	-0.003	0.001	0.119	-0.061	-0.065		-0.078	-0.005
NEQ – Pos.	-0.007	-0.040	-0.014	-0.048	0.049	0.071	-0.078		-0.190
NEQ – Neg.	0.032	0.020	0.032	0.023	0.002	0.082	-0.005	-0.190	

Note. There are 10 residuals (27%) with absolute value greater than 0.05. Sat. =

Satisfaction; Lik. = Liking; Enj. = Enjoyment, QSU = Questionnaire for Smoking Urges;

WSWS = Wisconsin Smoking Withdrawal Scale; SABQ = Subjective Attentional Bias

Questionnaire; SCQ = Smoking Consequences Questionnaire; NEQ-Pos. = Change in

Nicotine Effects Questionnaire Positive; NEQ-Neg. = Change in Nicotine Effects

Questionnaire Negative

Table 16. Aim 2: Reproduced and Residual Correlations in *Abstinent State* ($n = 214$)

Reproduced Correlation Matrix

	Sat.	Lik.	Enj.	QSU	WSWS	SABQ	SCQ	NEQ-Pos.	NEQ-Neg.
Sat.	0.886	0.885	0.883	0.528	0.240	0.239	0.450	0.570	-0.495
Lik.	0.885	0.886	0.885	0.499	0.220	0.216	0.421	0.558	-0.487
Enj.	0.883	0.885	0.885	0.485	0.211	0.205	0.408	0.553	-0.484
QSU	0.528	0.499	0.485	0.788	0.467	0.523	0.735	0.515	-0.406
WSWS	0.240	0.220	0.211	0.467	0.287	0.325	0.441	0.274	-0.210
SABQ	0.239	0.216	0.205	0.523	0.325	0.371	0.496	0.295	-0.223
SCQ	0.450	0.421	0.408	0.735	0.441	0.496	0.688	0.462	-0.361
NEQ – Pos.	0.570	0.558	0.553	0.515	0.274	0.295	0.462	0.431	-0.359
NEQ – Neg.	-0.495	-0.487	-0.484	-0.406	-0.210	-0.223	-0.361	-0.359	0.302

Residual Correlation Matrix

	Sat.	Lik.	Enj.	QSU	WSWS	SABQ	SCQ	NEQ-Pos.	NEQ-Neg.
Sat.		0.028	0.004	-0.003	0.027	0.023	-0.013	-0.032	0.029
Lik.	0.028		0.003	0.024	-0.002	0.000	0.001	-0.047	0.028
Enj.	0.004	0.003		0.001	-0.010	0.000	0.009	0.004	0.020
QSU	-0.003	0.024	0.001		-0.051	-0.027	0.079	-0.023	0.046
WSWS	0.027	-0.002	-0.010	-0.051		0.115	-0.047	-0.008	-0.023
SABQ	0.023	0.000	0.000	-0.027	0.115		-0.046	0.000	0.028
SCQ	-0.013	0.001	0.009	0.079	-0.047	-0.046		-0.015	0.016
NEQ – Pos.	-0.032	-0.047	0.004	-0.023	-0.008	0.000	-0.015		-0.176
NEQ – Neg.	0.029	0.028	0.020	0.046	-0.023	0.028	0.016	-0.176	

Note. There are 4 residuals (11%) with absolute value greater than 0.05. Sat. = Satisfaction; Lik. = Liking; Enj. = Enjoyment, QSU = Questionnaire for Smoking Urges; WSWS = Wisconsin Smoking Withdrawal Scale; SABQ = Subjective Attentional Bias Questionnaire; SCQ = Smoking Consequences Questionnaire; NEQ-Pos. = Change in Nicotine Effects Questionnaire Positive; NEQ-Neg. = Change in Nicotine Effects Questionnaire Negative

Table 17. Aim 2: Pattern and Structure Matrix from Exploratory Factor Analysis in *Non-Abstinent State* ($n = 224$)

<i>Item</i>	<i>Rotated Factor Loadings</i>			
	Liking		Wanting	
	<i>Pattern Matrix</i>	<i>Structure Matrix</i>	<i>Pattern Matrix</i>	<i>Structure Matrix</i>
Satisfaction	.989	.948	-.083	.396
Liking	.990	.967	-.048	.431
Enjoyment	.960	.943	-.035	.430
QSU	.163	.509	.717	.795
WSWS	-.105	.144	.515	.464
SABQ	.070	.312	.501	.534
SCQ	.111	.478	.760	.813
Change in NEQ – positive	.476	.602	.261	.492
Change in NEQ – negative	-.404	-.480	-.156	-.352
<i>Initial Eigenvalues</i>	4.49		1.45	
<i>% of Variance</i>	49.90		16.08	
<i>Rotation Sums of Squared Loadings</i>	3.92		2.69	

Note. Direct Oblimin rotation for exploratory factor analysis. Primary loadings shown in bold.

Table 18. Aim 2: Pattern and Structure Matrix from Exploratory Factor Analysis in *Abstinent State* ($n = 214$)

<i>Item</i>	<i>Rotated Factor Loadings</i>			
	Liking		Wanting	
	<i>Pattern Matrix</i>	<i>Structure Matrix</i>	<i>Pattern Matrix</i>	<i>Structure Matrix</i>
Satisfaction	.949	.941	-.016	.476
Liking	.974	.940	-.065	.439
Enjoyment	.983	.938	-.086	.423
QSU	.159	.571	.795	.877
WSWS	-.021	.262	.546	.535
SABQ	-.071	.262	.643	.606
SCQ	.081	.488	.785	.826
Change in NEQ – positive	.460	.609	.288	.526
Change in NEQ – negative	-.434	-.528	-.180	-.405
<i>Initial Eigenvalues</i>	4.69		1.48	
<i>% of Variance</i>	52.16		16.41	
<i>Rotation Sums of Squared Loadings</i>	4.00		3.15	

Note. Direct Oblimin rotation for exploratory factor analysis. Primary loadings shown in bold.

Table 19. Aim 2: Summary of Three Confirmatory Factor Analyses for *Non-Abstinent State* ($n = 224$) and *Abstinent State* ($n = 214$)

Non-Abstinent

Factor Model	χ^2	<i>df</i>	<i>p</i>	TLI	CFI	RMSEA	90% RMSEA	AIC
EFA 2 Factor	46.72	24	0.004	0.976	0.984	0.064	0.036-0.091	6743.02
Alternative 2 Factor	67.91	23	0.000	0.951	0.969	0.092	0.067-0.118	6766.21
1 Factor	70.01	24	0.000	0.952	0.968	0.091	0.067-0.118	6766.30

Abstinent

Factor Model	χ^2	<i>df</i>	<i>p</i>	TLI	CFI	RMSEA	90% RMSEA	AIC
EFA 2 Factor	39.573	24	0.024	0.983	0.989	0.054	0.020-0.083	6678.63
Alternative 2 Factor	83.276	23	0.000	0.931	0.956	0.109	0.084-0.135	6724.33
1 Factor	96.121	24	0.000	0.921	0.947	0.117	0.093-0.141	6735.18

Note. TLI = Tucker-Lewis index; CFI = Comparative fit index; RMSEA = Root mean squared error of approximation; AIC = Akaike Information Criteria

Table 20. Aim 2: CFA Modifications in *Non-Abstinent State* ($n = 224$) and *Abstinent State* ($n = 214$)

Non-Abstinent

Measurement Model	Modifications – Covariance		
	<i>NEQ-Pos and NEQ-Neg</i>	<i>WSWS and SABQ</i>	<i>QSU and SCQ</i>
EFA 2 Factor	x	x	
Alternative 2 Factor	x	x	x
1 Factor	x	x	x

Abstinent

Measurement Model	Modifications – Covariance		
	<i>NEQ-Pos and NEQ-Neg</i>	<i>WSWS and SABQ</i>	<i>QSU and SCQ</i>
EFA 2 Factor	x	x	
Alternative 2 Factor	x	x	x
1 Factor	x	x	x

Table 21. Aim 3: Correlations between Liking and Wanting Measures

	Liking (NON)	Liking (AB)	Wanting (NON)	Wanting (AB)
Liking (NON)	1			
Liking (AB)	.55**	1		
Wanting (NON)	.54**	.26**	1	
Wanting (AB)	.43**	.56**	.55**	1

Note. Pearson's r between Liking and Wanting measures. Liking-AB and Wanting-AB (n=214), and Liking-NON and Wanting-NON (n=224). NON=non-abstinent state, AB = abstinent state

Table 22. Aim 3: Correlation between Liking/Wanting Measures and FTND/Relapse

Factor	State	FTND	Relapse Week+4
Liking	NON	.22**	.12
	AB	.19**	.14
Wanting	NON	.37**	.07
	AB	.28**	.15*

Note. Pearson's r for bivariate correlations between Liking/Wanting measures and primary outcomes. For FTND, n s are 224 (NON) and 214 (AB). For Relapse, n 's are 197 (NON) and 192 (AB). ** $p < .01$; * $p < .05$.

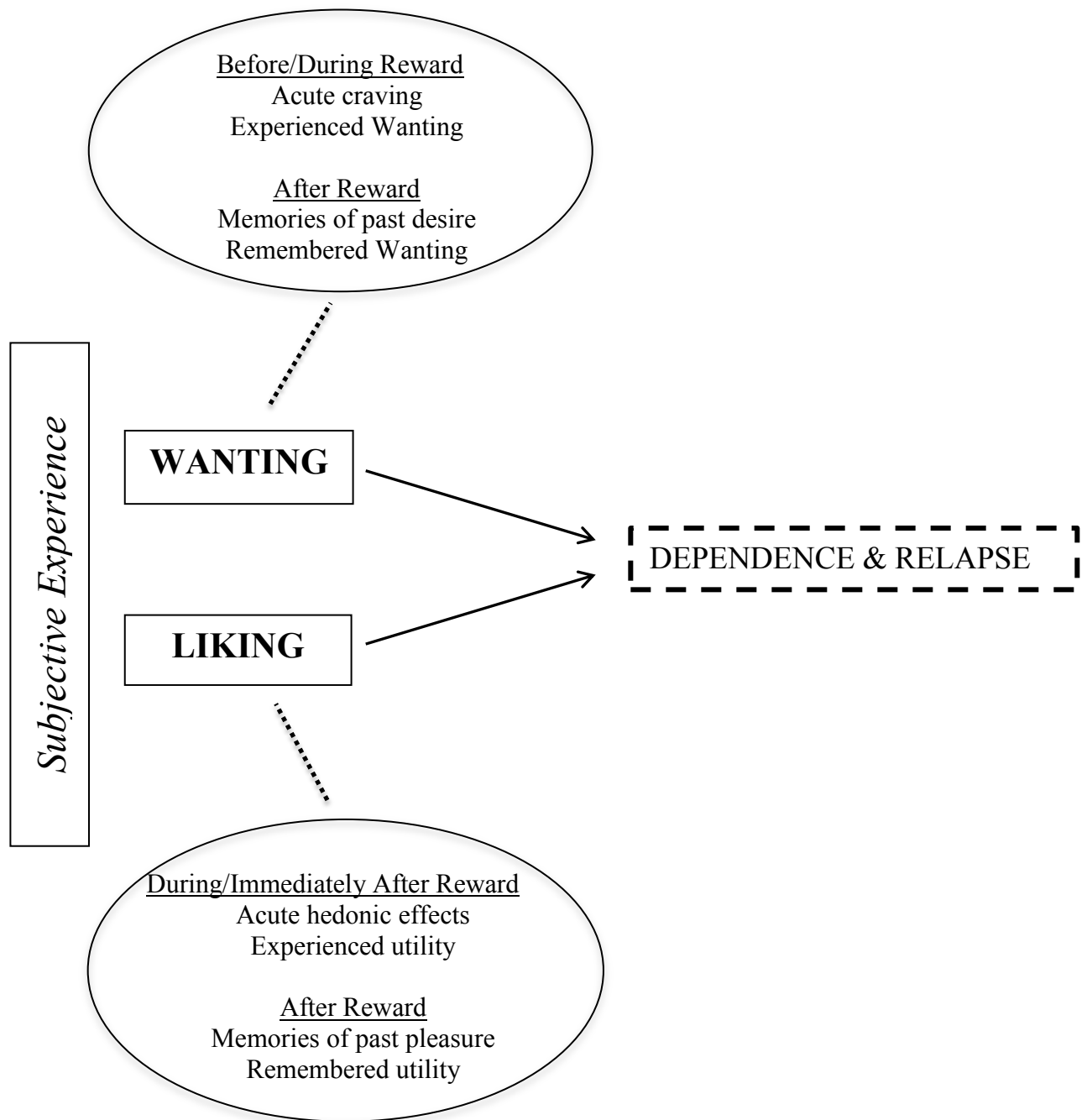


Figure 1. Conceptual model of Wanting and Liking processes involved in the current study. Aim 1 investigates how memories of Liking/Wanting are associated with

Experienced Liking/Wanting. Aim 2 examines the separability of Liking and Wanting. Aim 3 examines how Liking and Wanting predict dependence and relapse.

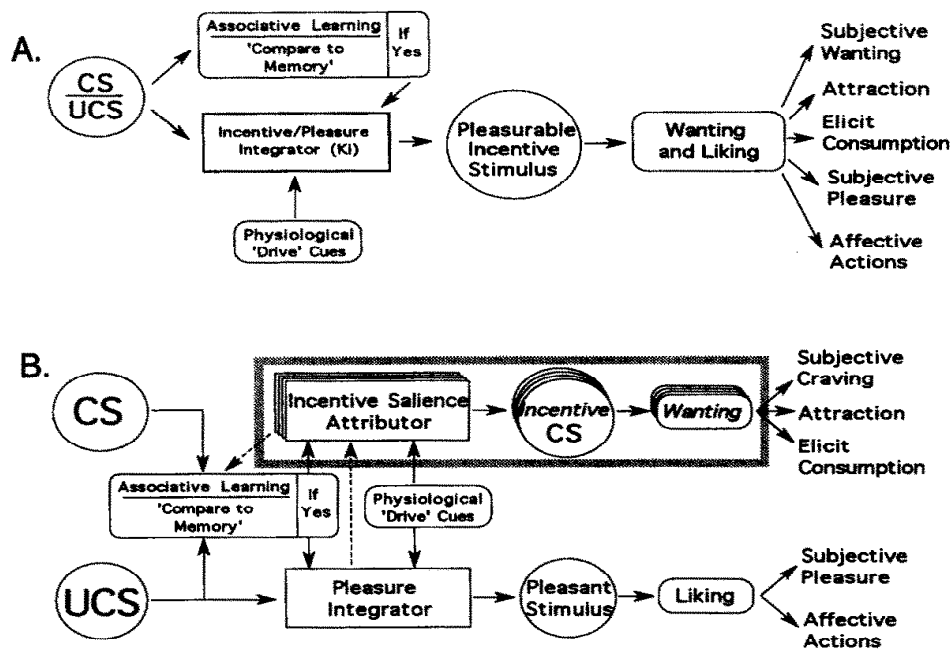


Figure 2. Conceptual models from Robinson and Berridge (1993) explaining the difference between their incentive salience theory of addiction (part B) and other theories that assume Liking and Wanting as one process (part A), often termed "Incentive Motivation". *Note.* Reprinted from Brain Research Reviews, 18, Robinson, T. E. and Berridge, K. C., The neural basis of drug craving: an incentive-sensitization theory of addiction, 247-291, Copyright (1993), with permission from Elsevier.

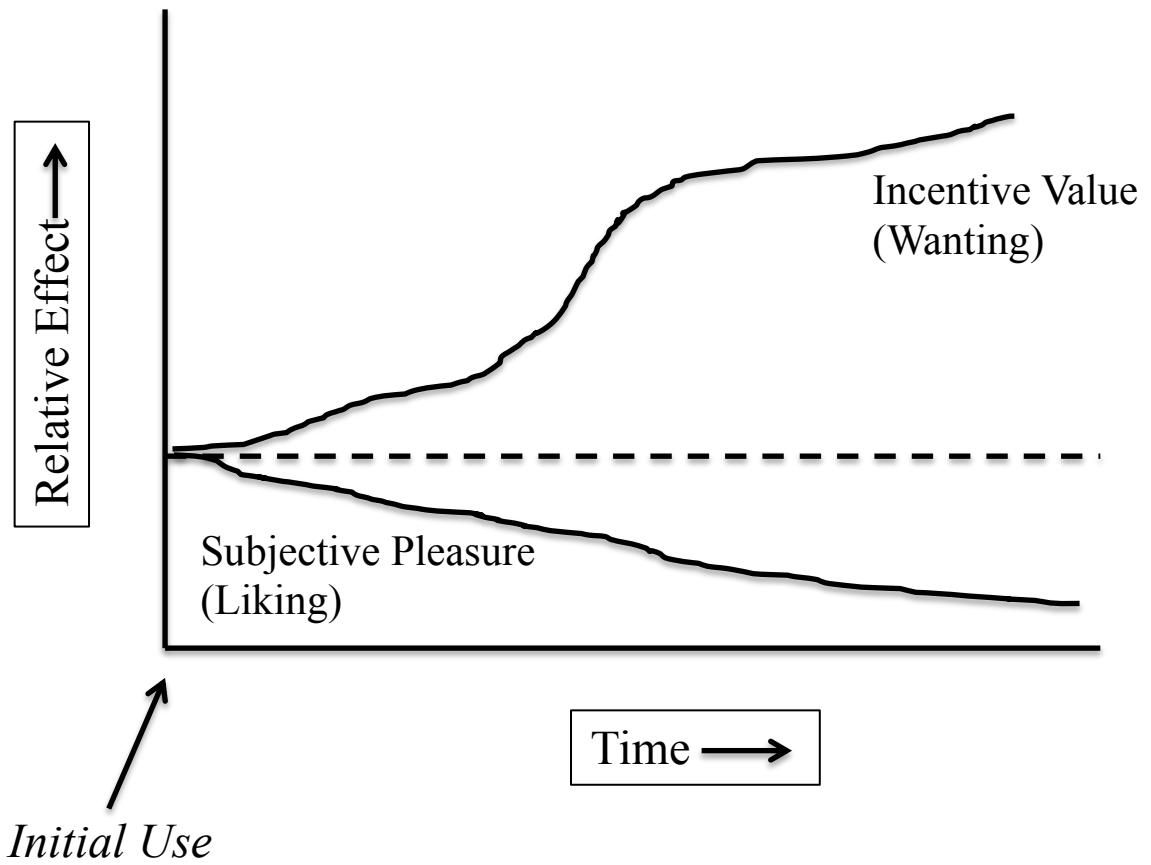


Figure 3. Robinson and Berridge (1993) suggest that over time, Wanting levels while Liking levels decrease. *Note.* Reprinted from Brain Research Reviews, 18, Robinson, T. E. and Berridge, K. C., The neural basis of drug craving: an incentive-sensitization theory of addiction, 247-291, Copyright (1993), with permission from Elsevier.

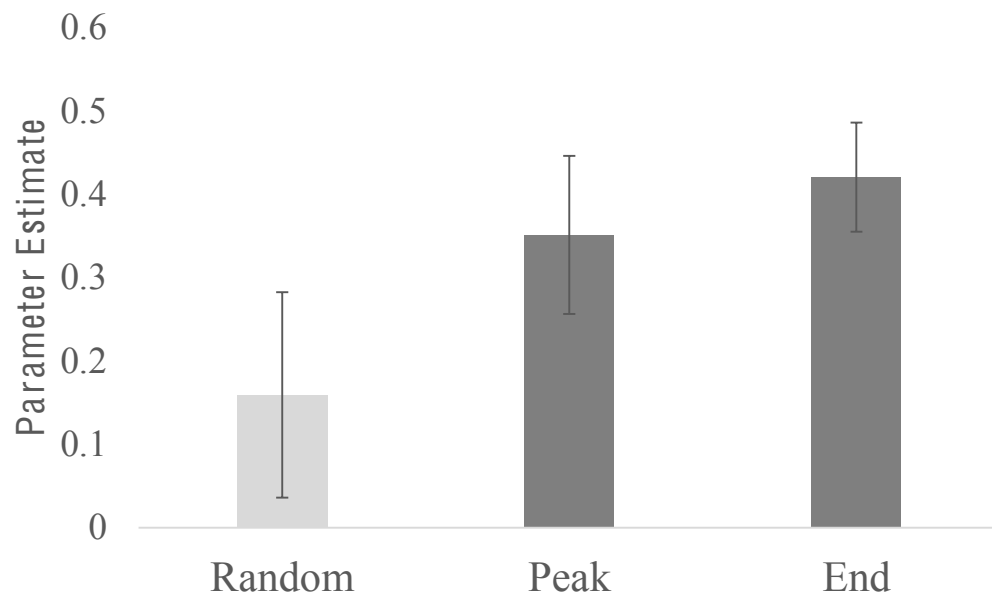


Figure 4. Data are Parameter Estimate (1 SE) relating Random Liking, Peak Liking, and End Liking to Remembered Liking derived from PROC MIANALYZE for Hypothesis 1.1 (see text for details).

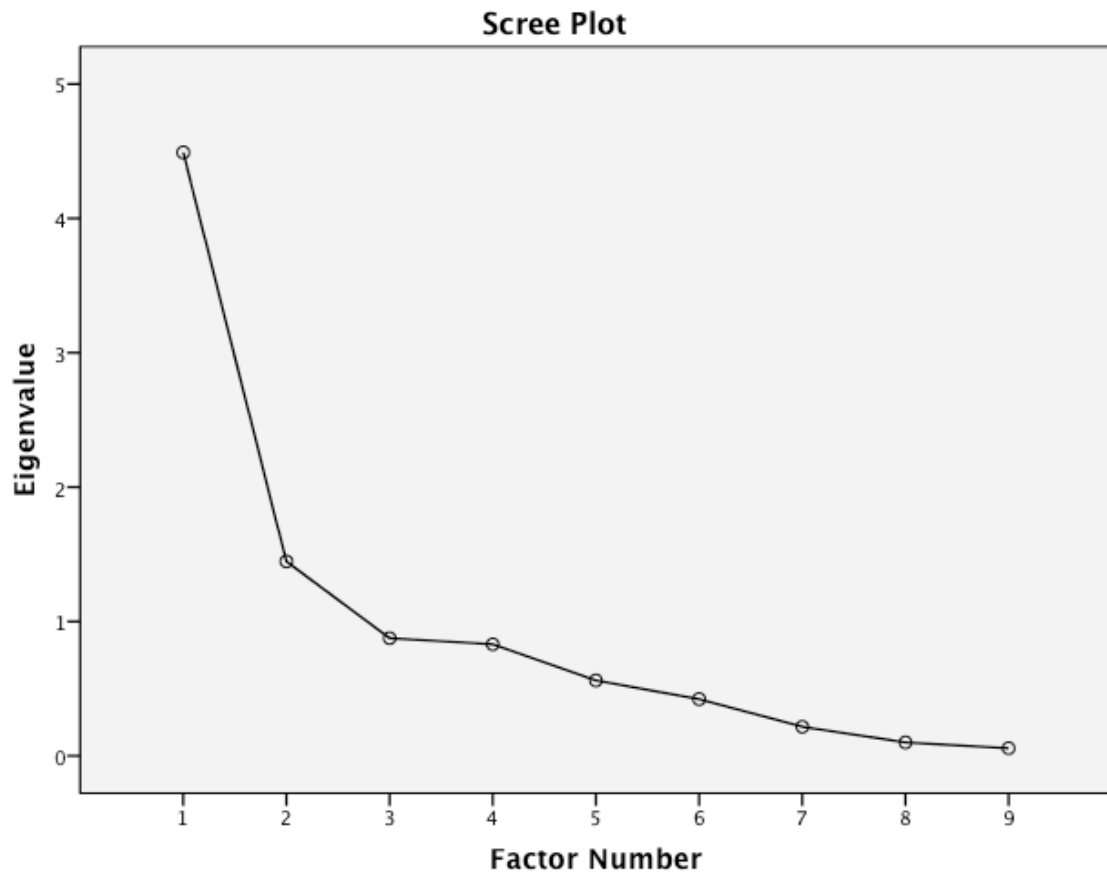


Figure 5. Scree plot from Aim 2 analyses: Exploratory Factor Analysis (principal axis factoring extraction) with Direct Oblimin rotation for the *non-abstinent* state data including all variables except change in NEQ-physiological (2 factor solution).

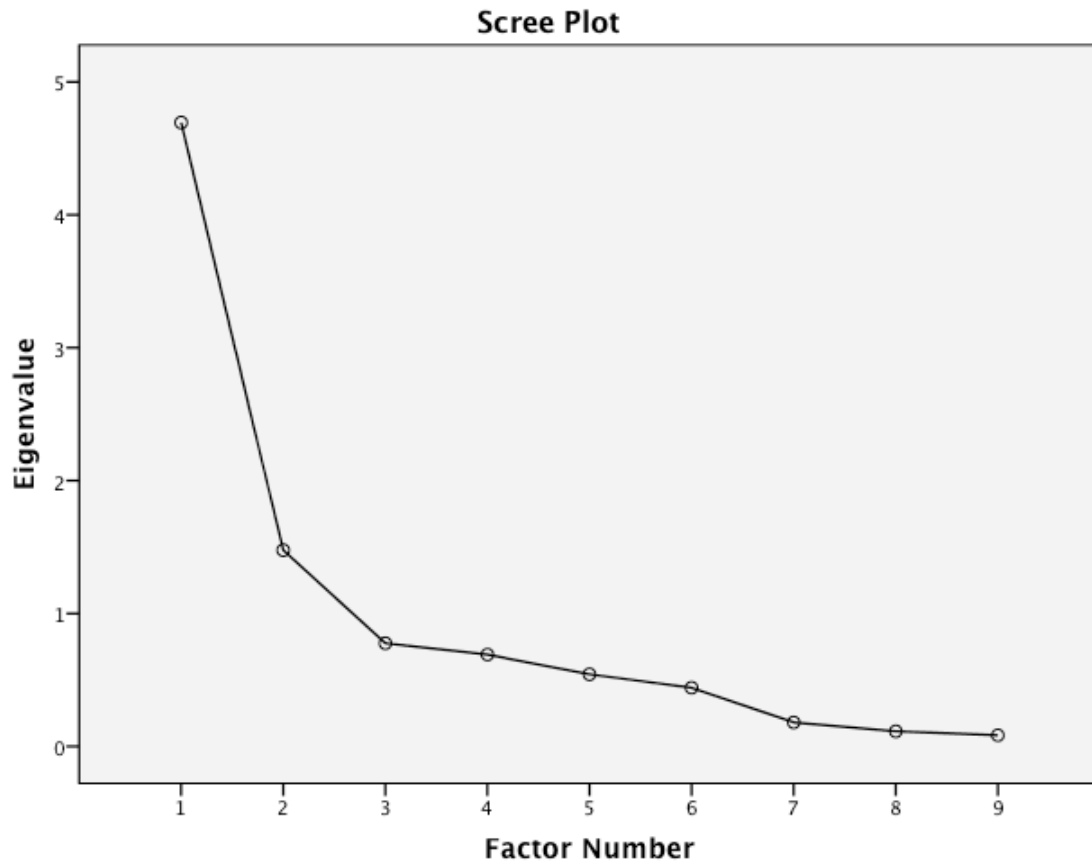


Figure 6. Scree plot from Aim 2 analyses: Exploratory Factor Analysis (principal axis factoring extraction) with Direct Oblimin rotation for the *abstinent* state data including all variables except change in NEQ-physiological (2 factor solution).

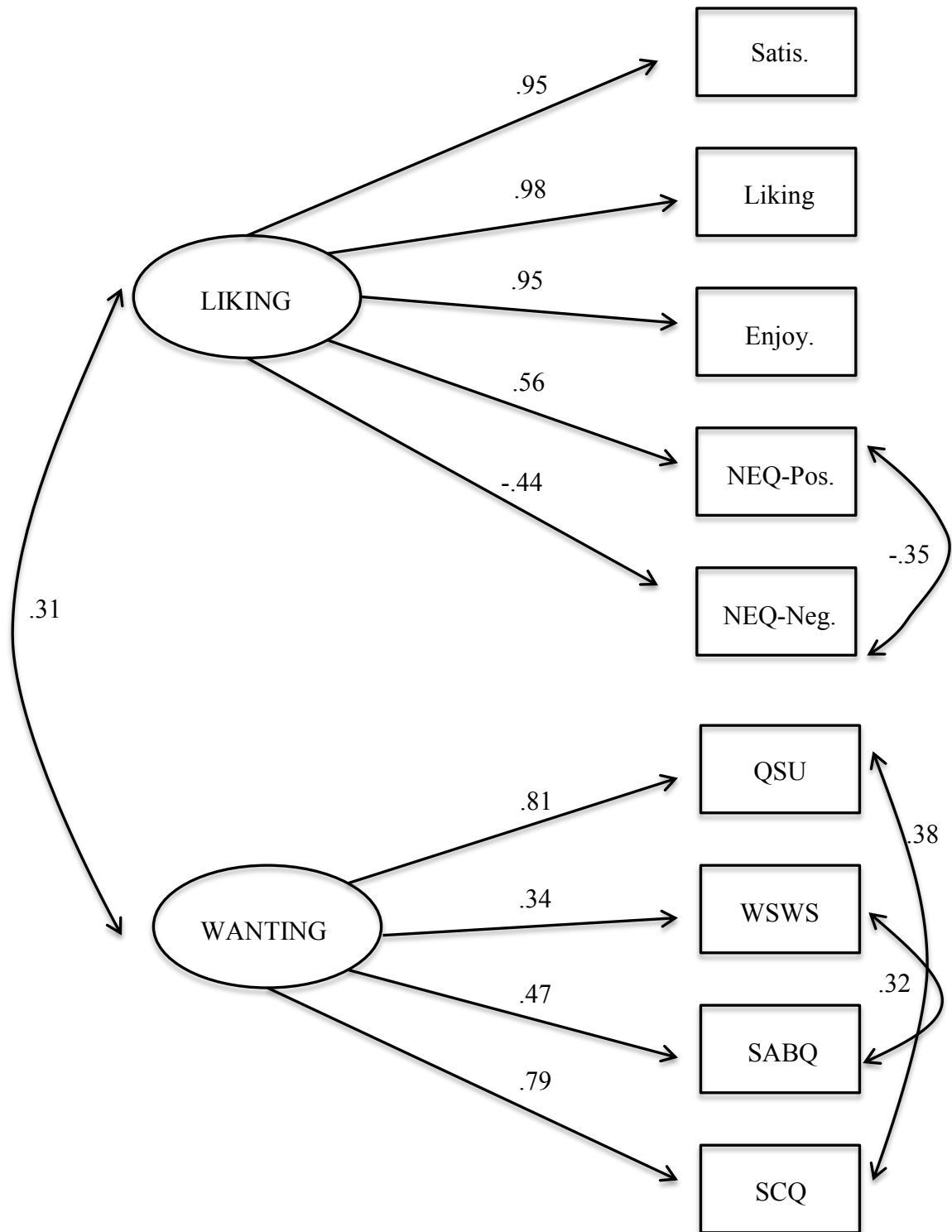


Figure 7. Aim 2: EFA Driven Two-Factor Measurement Model for CFA in *Non-Abstinent State* ($n = 224$).

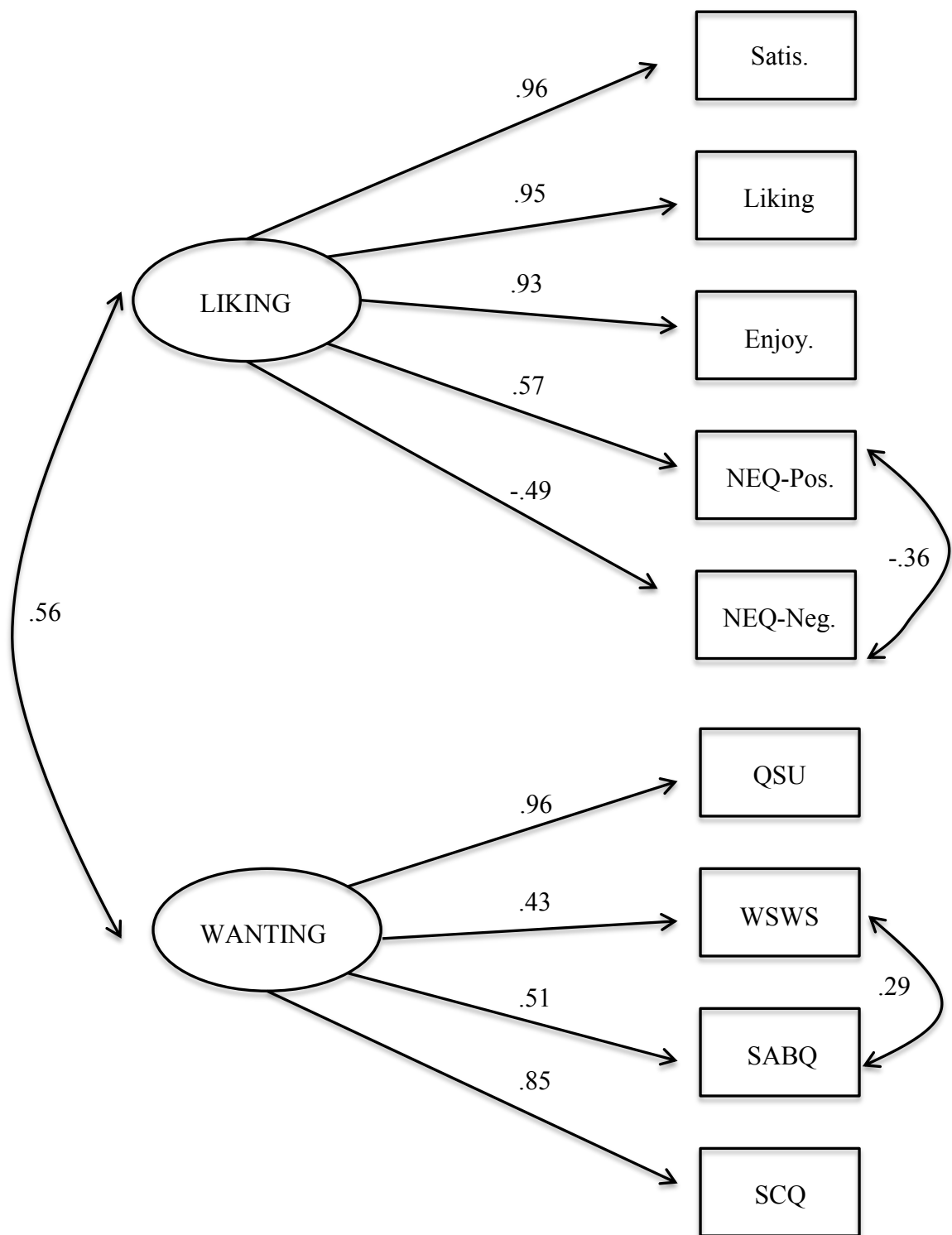


Figure 8. Aim 2: EFA Driven Two-Factor Measurement model CFA in *Abstinent State* ($n = 214$).

for

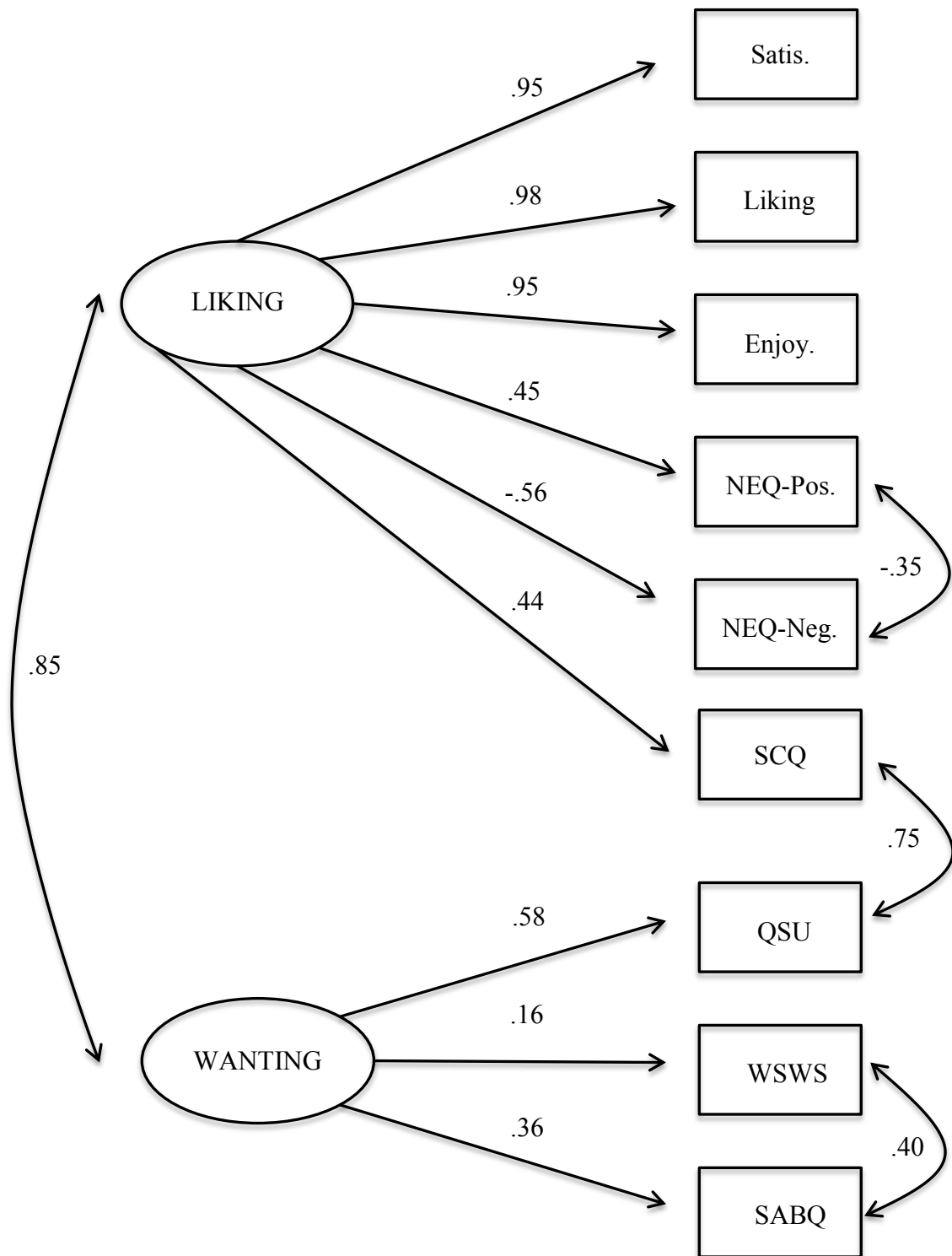


Figure 9. Aim 2: Alternative Two-Factor Measurement Model for CFA in *Non-Abstinent State* ($n = 224$).

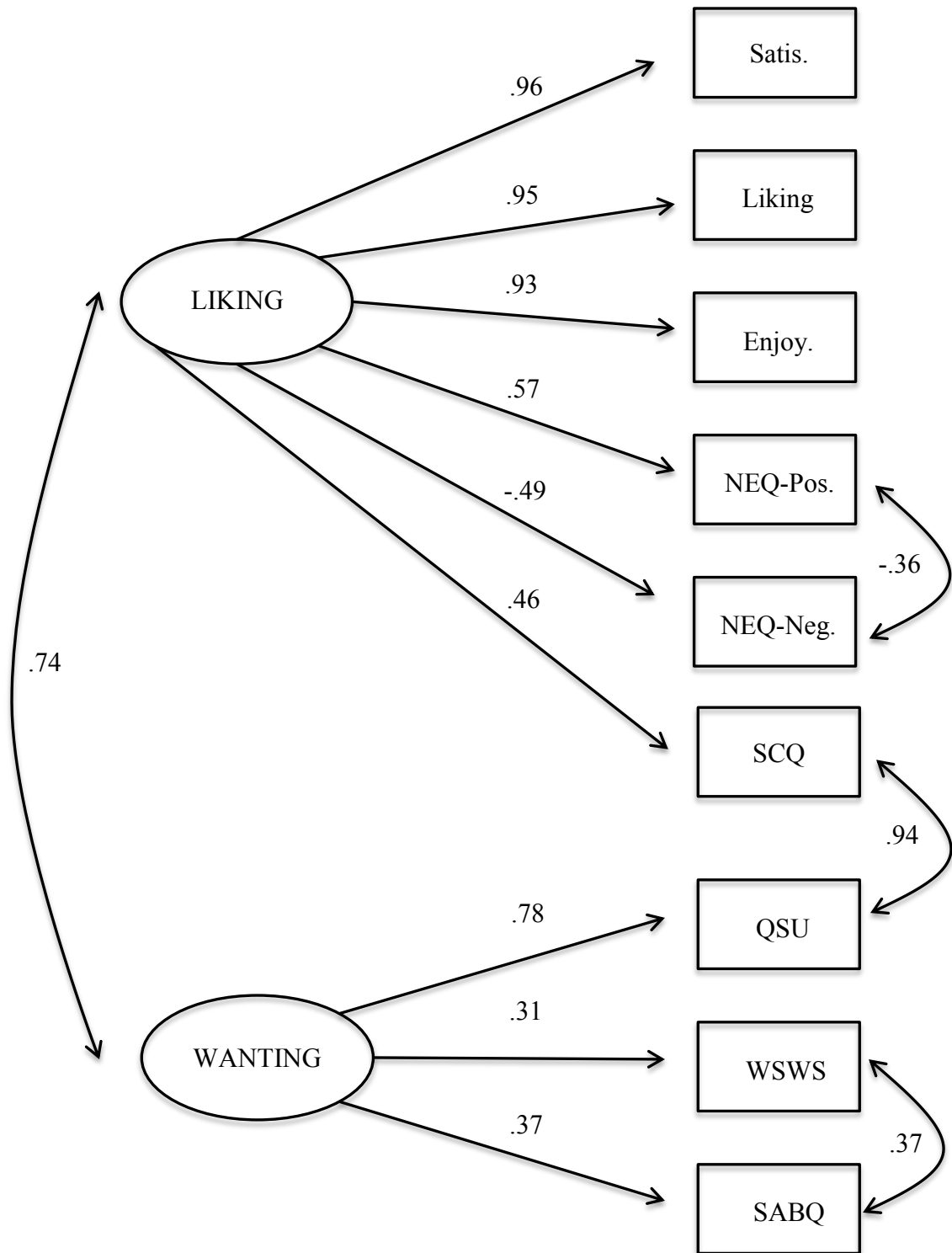


Figure 10. Aim 2: Alternative Two-Factor Measurement Model for CFA in *Abstinent State* ($n = 214$).

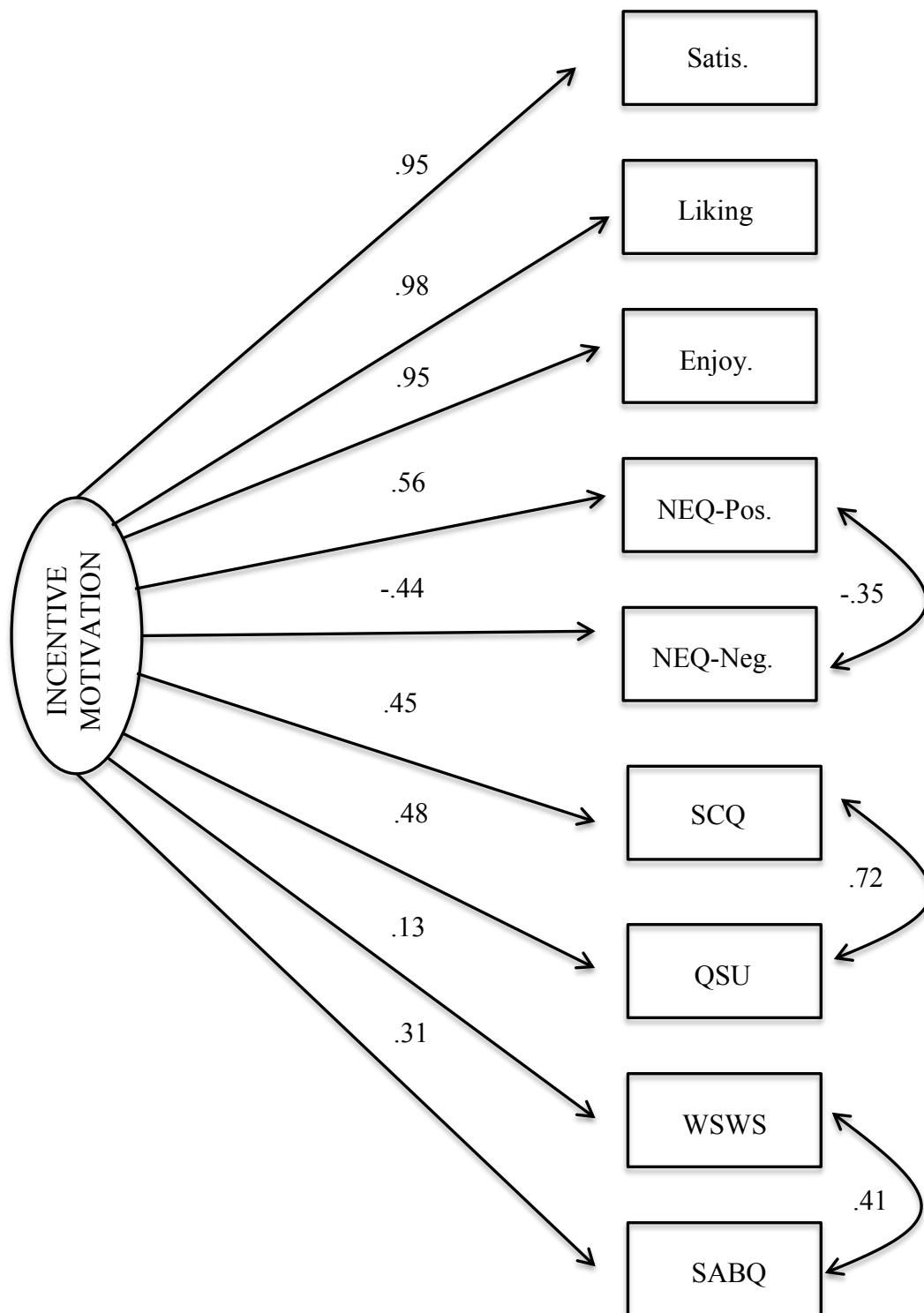


Figure 11. Aim 2: One-Factor Measurement Model for CFA in *Non-Abstinent State* (n = 224).

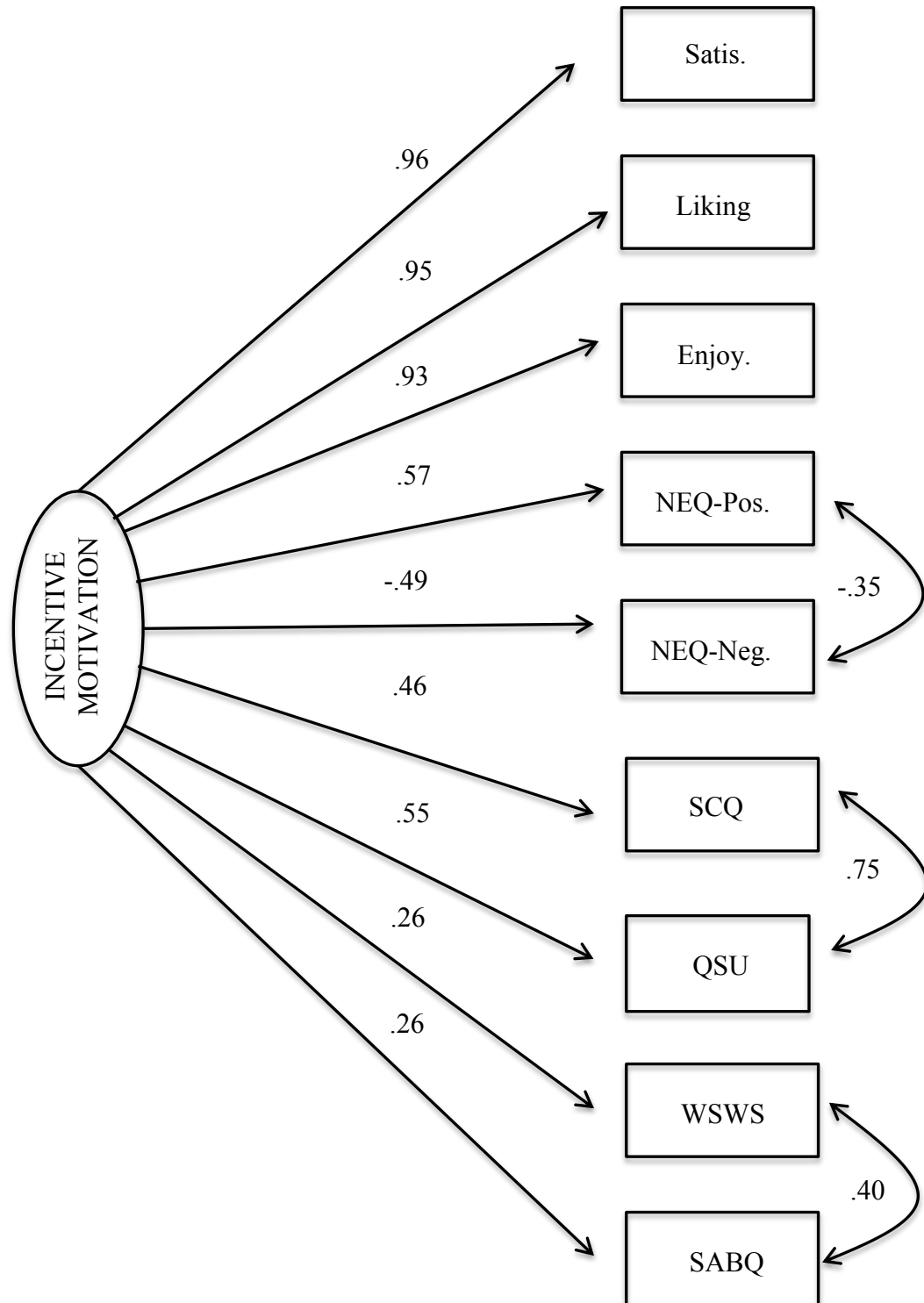


Figure 12. Aim 2: One-Factor Measurement Model for CFA in *Abstinent State* ($n = 214$).

Appendix A: Study 2 - USUHS IRB Approval



UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799



September 8, 2009

MEMORANDUM FOR DR. ANDREW WATERS, PH.D., MEDICAL AND CLINICAL PSYCHOLOGY

SUBJECT: Uniformed Services University Institutional Review Board (FWA 00001628; DoD Assurance P60001) Approval regarding Human Subjects Research Protocol G172JY.

Congratulations! The amendment for your No More Than Minimal Risk human subjects research protocol G172JY, entitled "*Cognitive Processes in Smoking Cessation*," was reviewed and approved for execution on Tuesday, September 8, 2009 by Edmund G. Howe III, M.D., J.D., Chairperson, Uniformed Services University IRB, under the provisions of 32 CFR 219.110(b)(2). This approval will be reported to the full Uniformed Services University IRB scheduled to meet on Thursday, October 15, 2009.

The purpose of this behavioral research study is to find out which types of smokers are in need of more help with quitting smoking.

This action approves amendment #5 that: (1) adds two study personnel (CITI complete 7/18/09 and 8/13/09); (2) revises recruitment numbers up to 250 to account for participants who sign the ICD but are later deemed ineligible; (3) makes minor revisions to the ICD regarding compensation; and (4) adds venues for study advertisements (utilizing the previously approved advertisements).

Authorization to conduct protocol G172JY will automatically terminate on Tuesday, January 5, 2010. You are authorized to enroll up to 250 subjects in this study. If you plan to continue data collection or analysis beyond this date, IRB approval for continuation is required. Please submit a USU Form 3204A/B (application for continuing approval) to the IRB Office 60 days prior to the termination date. The IRB Office will attempt to assist you by sending you a reminder; however, submission of an application for continuation is your responsibility. Please note the termination date and the date for submission of your USU Form 3204A/B in your calendar!

You are required to submit amendments to this protocol, changes to the informed consent document (if applicable), adverse event reports, and other information pertinent to human research for this project to this office for review. No changes to this protocol may be implemented prior to IRB approval. If you have questions regarding this IRB action, or questions of a more general nature concerning human participation in research, please contact the undersigned at mstretch@usuhs.mil or (301) 295-0819.

Micah Stretch, M.A., J.D.
IRB Coordinator

cc: Chair, MPS
VPR/OSP
✓ File

Appendix B: MDACC Approval of Data Transfer

THE UNIVERSITY OF TEXAS
MD ANDERSON
CANCER CENTER
Office of Protocol Research

Institutional Review Board (IRB)
Unit 1437
Phone 713-792-2933
Fax 713-794-4589

To: Paul Cinciripini 03/31/2009
From: Marlon B. Olson
CC: Sunetra Martinez, Victoria L. Brown, Evanna L. Thompson, Veronica Roberts
MDACC Protocol ID #: 2005-0741
Protocol Title: Cognitive Processes in Smoking Cessation
Version: 13
Subject: Administrative IRB Approval – Protocol 2005-0741

On Tuesday, 03/31/2009, the Institutional Review Board (IRB) 4 chair or designee reviewed and approved your revision dated 03/27/2009 for Protocol 2005-0741

These Pages Include:

- Protocol Body – Document header Date: 03/27/2009

Revision Included the following changes:

Clarifying that the de-identified data will be sent to Dr. Andrew Waters and his statistical team at the Uniformed Services University of the Health Sciences.

Additional Revision History:

Please note that along with this revision the M. D. Anderson IRB approves the transfer of de-identified study data for analysis to Dr. Andrew Waters, collaborator on this study, and his statistical team at the Uniformed Services University of the Health Sciences.

The revision can now be implemented. Please inform the appropriate individuals in your department or section and the collaborators of these changes.

Please inform the appropriate individuals in your department/section and your collaborators of these revisions.

Please Note: This approval does not alter or otherwise change the continuing review date of this protocol.

In the event of any questions or concerns, please contact the sender of this message at (713) 792-2933.

Marlon B. Olson 03/31/2009 10:02:17 AM

This is a representation of an electronic record that was signed electronically and below is the manifestation of that electronic signature:

Marlon B. Olson
03/31/2009 09:51:14 AM

IRB 4 Chair Designee
FWA #: IRB 4 IRB00005015

Appendix C: Study 2 - USUHS Informed Consent Form

This consent form is valid only if it contains the IRB stamped date

Consent for Voluntary Participation in a Non-Clinical Research Study

1. INTRODUCTION OF THE STUDY

You are being asked to be in a research study entitled, “Cognitive Processes in Smoking Cessation”, at the Uniformed Services University (USU), Bethesda, Maryland. You have been asked to take part in this study because you are a smoker, and you want to quit smoking. Your participation is voluntary. Refusal to participate will not result in any punishment or loss of benefits to which you are otherwise permitted. Please read the information below, and ask questions about anything you do not understand, before deciding whether to take part in the study.

2. PURPOSE OF THE STUDY

The purpose of this behavioral research study is to find out which type of smokers are in need of more help with quitting smoking. This study may help researchers create more effective cessation (quitting) programs. Researchers want to learn the reasons why some smokers who quit smoking choose to start up again (relapse) more quickly than other smokers. Also, researchers want to use computerized tasks to help predict who is likely to relapse.

Other studies have shown that some computerized tasks are helpful in determining which smokers are likely to relapse more quickly. We want to carry out more research using additional tests.

3. PROCEDURES TO BE FOLLOWED

If you agree to be in this study, you will be asked to attend a total of 6 sessions at USU. At the first session (orientation), you will complete a breath test that allows the investigators to know how much you smoke. You will also complete about 7 questionnaires, which will take a total of about 1 hour to complete. The questionnaires will ask about you and your health, your smoking habits, and your drinking habits. There will also be a brief reading test, which will take about 5 minutes to complete. It will check your reading ability. The orientation will help researchers learn if you are eligible to participate in this study.

If you are found to be eligible and you wish to take part in this study, you will attend 5 laboratory sessions at USU. You will attend 2 sessions before trying to quit, 1 session on your quit day, 1 session one week after your quit day, and a final session 1 month after your quit day. At each of these laboratory sessions, you will complete a series of

computerized evaluations, which will take about 90 minutes to complete. These evaluations are reaction-time tests.

At the 2 pre-quit sessions, you will be asked to smoke a cigarette (after the computerized evaluation). Before one of these pre-quit sessions, which will be picked randomly, you will be asked to stop smoking for 12 hours before the session.

During each of the laboratory sessions, you will also complete about 7 questionnaires that ask about your mood, cigarette cravings, and smoking habits. These questionnaires will take about 30 minutes in total to complete at each session. You will also be asked to complete a breath test and to provide a saliva sample. The breath test and the saliva sample will help the researchers find out how much you have smoked.

You will also be called on 2 occasions after your quit day, and you will be asked some questions about your smoking. Each phone call will last about 15 minutes. During the study, a staff member will meet with you for 10 to 20 minutes and help you to try and quit. You will meet with the staff member at each of the laboratory sessions. Every participant will receive the same help.

Some participants will be asked to carry a handheld computer (PDA) around for 1 week after their quit day. The PDA will beep randomly about 4 times a day (random assessments). Participants will answer some questions about their mood and craving, and complete a computerized reaction time task. Each assessment takes about 5 minutes.

Participation in this study will be over after your final visit to USU, which will be 4 weeks after your quit day.

4. NUMBER OF PEOPLE THAT WILL TAKE PART IN THIS STUDY

Up to 250 subjects are expected to take part in this study at USU.

5. AMOUNT OF TIME FOR YOU TO COMPLETE THE STUDY

If you are eligible, you will be part of this study for about 7 weeks.

ELIGIBILITY AND PAYMENT FOR BEING IN THIS STUDY

Civilians and military personnel may be paid for participation in this study. Payments will be made after each visit, as described above.

Civilians (non-federal). You will receive \$25 for completing the orientation (the first session). You will also receive \$50 for completing each laboratory session. You will receive compensation after each session. You will also receive \$15 for each telephone assessment that you complete, and you will receive this at the final laboratory session.

Participants who carry around the PDA for a week will receive \$2.50 for each random assessment that they complete.

Civilians (federal). You will only receive compensation for laboratory sessions/telephone assessments if those sessions occur during non-duty hours. In addition, if you wish to be compensated for participation during non-duty hours, you must file a request for outside activity. If

the request is approved and the sessions occur during non-duty hours, payment will be made as follows. You will receive \$25 for completing the orientation (the first session). You will also receive \$50 for completing each laboratory session. You will receive compensation after each session. You will also receive \$15 for each telephone assessment that you complete (if those assessments occur during non-duty hours), and you will receive this at the final laboratory session. Federal civilians may participate in the PDA part of the study, but they can only be compensated for the PDA assessments that occur during non-duty hours.

Uniformed Personnel. You will only receive compensation for laboratory sessions if those sessions occur during non-duty hours. In addition, if you wish to be compensated for participation during non-duty hours, you must file a request for outside activity. If the request is approved and the sessions occur during non-duty hours, payment will be made as follows. You will receive \$25 for completing the orientation (the first session). You will also receive \$50 for completing each laboratory session. You will receive compensation after each session. You will also receive \$15 for each telephone assessment that you complete (if those assessments occur during non-duty hours), and you will receive this at the final laboratory session. Uniformed personnel may participate in the PDA part of the study, but they can only be compensated for the PDA assessments that occur during non-duty hours.

Please Note: Federal Civilians and Uniformed Personnel should inform their supervisors about the study for which they are volunteering whether or not they will receive compensation.

At the orientation session, if you are ineligible for the study because the breath test indicates that you have low levels of carbon monoxide in your breath, the orientation session will end right away and you will receive \$10 for your time and travel expenses. If you are ineligible for another reason, the session will last for a longer duration and you will receive \$25 for your time and travel expenses. Payments to ineligible participants follow the same rules as those written above for the eligible participants.

7. POSSIBLE RISKS OR DISCOMFORTS FROM BEING IN THIS STUDY

The expected risks or discomforts from being in this study are expected to be minimal. There are no known risks associated with the computerized evaluations. On 1 pre-quit session, you will arrive having not smoked on that day. You may experience symptoms of nicotine withdrawal, which include restlessness, difficulty concentrating, and/or mood changes. You will also smoke a cigarette at each of the pre-quit visits. Though smoking is

considered bad for your health, your smoke intake is not likely to be increased by participating in this study. (Your smoke intake is likely to be decreased by participating in the study).

You may refuse to answer any question that makes you feel uncomfortable. If you have concerns after completing the questionnaires, you are encouraged to contact your doctor or the study chair.

If something in this research makes you uncomfortable or upset, you may choose to stop taking part in this research at any time without loss of benefits; you may contact the investigator for referral. If the investigators note any distress or anxiety associated with the research, you will receive referrals, if appropriate.

POSSIBLE BENEFITS FROM BEING IN THIS STUDY

You may benefit from this study because if you are able to quit, this may be very beneficial to your health. Future smokers may benefit from what is learned. The information we learn may help us learn to develop better smoking cessation programs.

However, no benefit can be guaranteed.

9. CONFIDENTIALITY/PRIVACY AND HOW YOUR IDENTITY AND YOUR RESEARCH RECORDS WILL BE MAINTAINED

All information you provide as part of this study will be confidential and will be protected to the fullest extent provided by law. Your responses to our interviews and questionnaires, as well as audio-taped sessions will be maintained in a locked filing cabinet in lab offices in the Department of Medical and Clinical Psychology. All records related to this study will be accessible to those persons directly involved in conducting this study and members of the USUHS Institutional Review Board (IRB), which provide oversight for protection of human research volunteers. In addition, the IRB at USUHS and other federal agencies that help protect people who are involved in research studies, may need to see the information you give us. Other than those groups, records from this study will be kept private to the fullest extent of the law. Scientific reports that come out of this study may include your ideas, but they will not use your name or identify you in any way.

10. CONDITIONS WHICH YOUR PARTICIPATION IN THIS STUDY MAY BE STOPPED WITHOUT YOUR CONSENT

The investigator may stop you from taking part in this study if being in the study is unsafe or dangerous to you or if you lose your right to receive medical care at military hospitals. The investigator may also stop you participating if you experience difficulty in following the procedures.

11. IF YOU DECIDE TO STOP TAKING PART IN THIS STUDY AND THE INSTRUCTIONS FOR STOPPING EARLY

You have the right to withdraw from this study at any time. If you decide to stop taking part in this study, you should tell the principal investigator as soon as possible; by leaving this study at any time, you in no way risk losing your right to medical care.

12. RECOURSE IN THE EVENT OF INJURY

If at any time you believe you have suffered an injury or illness as a result of participating in this research project, you should contact the Director of Human Research Protections Program at the Uniformed Services University of the Health Sciences, Bethesda, Maryland 20814-4799 at (301) 295-9534. This office can review the matter with you, can provide information about your rights as a subject, and may be able to identify resources available to you. If you believe the government or one of the government's employees (such as a military doctor) has injured you, a claim for damages (money) against the federal government (including the military) may be filed under the Federal Torts Claims Act. Information about judicial avenues of compensation is available from the University's General Counsel at (301) 295-3028.

CONTACT FOR QUESTIONS OR PROBLEMS

If you have questions about this research, you should contact Andrew J. Waters, Ph.D. the person in charge of the study. His phone number at USUHS is 301 295-9675. Even in the evening or on weekends, you can leave a message at that number. If you have questions about your rights as a research subject, you should call the Director of Human Research Protections Program at USUHS at (301) 295-9534. She is your representative and has no connection to the researcher conducting this study.

SIGNATURE OF RESEARCH PARTICIPANT OR LEGAL REPRESENTATIVE

You have read (or someone has read to you) the information in this consent form. You have been given a chance to ask questions and all of your questions have been answered to your satisfaction.

BY SIGNING THIS CONSENT FORM, YOU FREELY AGREE TO TAKE PART IN THE RESEARCH IT DESCRIBES.

Participant's Signature

Date

Participant's Printed Name

SIGNATURE OF INVESTIGATOR/RESEARCH TEAM MEMBER

Investigator's/Research Team Member's Signature Date (must be the same as the participant's)

SIGNATURE OF WITNESS

Witness' Signature _____ Date (must be the same as the participant's) _____

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Appendix D: Self-Report Measures Used in Study 1 and Study 2

FAGERSTRÖM TEST FOR NICOTINE DEPENDENCE

	Within 5 minutes	6 to 30 minutes	31 to 60 minutes	After 60 minutes
1. How soon after you wake up do you smoke your <u>first</u> cigarette?			Yes	No
2. Do you find it difficult to refrain from smoking in places where it is forbidden, e.g., in church, at the library, in the cinema, etc.?			1st one in the A.M.	All others
3. Which cigarette would you hate to give up most?				
	10 or less	11-20	21-30	31 or more
4. How many cigarettes per day do you smoke?				
			Yes	No
5. Do you smoke more frequently during the first hours after waking than the rest of the day?				
			Yes	No
6. Do you smoke if you are so ill that you are in bed most of the day?				

WISCONSIN SMOKING WITHDRAWAL SCALE (WSWS)

Please answer the following questions based on how you generally have felt or what you have noticed during the past week, including today.

0	1	2	3	4
<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Feel Neutral</i>	<i>Agree</i>	<i>Strongly Agree</i>

- | | |
|--|---|
| <p>1. Food is not particularly appealing to me.
0 1 2 3 4</p> <p>2. I am getting restful sleep.
0 1 2 3 4</p> <p>3. I have been tense or anxious.
0 1 2 3 4</p> <p>4. My level of concentration is excellent.
0 1 2 3 4</p> <p>5. I awaken from sleep frequently during the night.
0 1 2 3 4</p> <p>6. I have felt impatient.
0 1 2 3 4</p> <p>7. I have felt upbeat and optimistic.
0 1 2 3 4</p> <p>8. I have found myself worrying about my problems.
0 1 2 3 4</p> <p>9. I have had frequent urges to smoke.
0 1 2 3 4</p> <p>10. I have felt calm lately.
0 1 2 3 4</p> <p>11. I have been bothered by the desire to smoke a cigarette.
0 1 2 3 4</p> <p>12. I have felt sad or depressed.
0 1 2 3 4</p> <p>13. I have been irritable, easily angered.
0 1 2 3 4</p> <p>14. I want to nibble on snacks or sweets.
0 1 2 3 4</p> <p>15. I have been bothered by negative moods such as anger, frustration, and irritability.
0 1 2 3 4</p> | <p>16. I have been eating a lot.
0 1 2 3 4</p> <p>17. I am satisfied with my sleep.
0 1 2 3 4</p> <p>18. I have felt frustrated.
0 1 2 3 4</p> <p>19. I have felt hopeless or discouraged.
0 1 2 3 4</p> <p>20. I have thought about smoking a lot.
0 1 2 3 4</p> <p>21. I have felt hungry.
0 1 2 3 4</p> <p>22. I feel that I am getting enough sleep.
0 1 2 3 4</p> <p>23. It is hard to pay attention to things.
0 1 2 3 4</p> <p>24. I have felt happy and content.
0 1 2 3 4</p> <p>25. My sleep has been troubled.
0 1 2 3 4</p> <p>26. I have trouble getting cigarettes off my mind.
0 1 2 3 4</p> <p>27. It has been difficult to think clearly.
0 1 2 3 4</p> <p>28. I think about food a lot.
0 1 2 3 4</p> |
|--|---|

QUESTIONNAIRE OF SMOKING URGES (BRIEF)

Questionnaire of Smoking Urges

Instructions: Indicate how much you agree or disagree with each of the following statements by circling the number between strongly disagree and strongly agree. The closer you choose a number to one end or the other indicates the strength of your disagreement or agreement. Please complete every item. We are interested in how you are thinking or feeling right now as you are filling out the questionnaire.

	Strongly Disagree			Strongly Agree		
1. I have a desire for a cigarette.	0	1	2	3	4	5
2. Nothing would be better than smoking a cigarette.	0	1	2	3	4	5
3. If it were possible, I probably would smoke a cigarette.	0	1	2	3	4	5
4. I would control things better if I could smoke.	0	1	2	3	4	5
5. All I want is a cigarette.	0	1	2	3	4	5
6. I have an urge for a cigarette.	0	1	2	3	4	5
7. A cigarette would taste good.	0	1	2	3	4	5
8. I would do almost anything for a cigarette.	0	1	2	3	4	5
9. Smoking would make me less depressed.	0	1	2	3	4	5
10. I am going to smoke as soon as possible.	0	1	2	3	4	5

SUBJECTIVE ATTENTIONAL BIAS QUESTIONNAIRE

For each of the following items, please circle a number that best describes you.

- **During the past week, how often have you found your attention drawn to cigarettes?**

0	1	2	3	4
Not at all	A little bit	A moderate amount	A lot	An extreme amount

- **During the past week, how attractive have you found the sight of cigarettes?**

0	1	2	3	4
Not at all attractive	A little attractive	Moderately attractive	Very attractive	Extremely attractive

- **During the past week, how sensitive have you been to the smell of smoke?**

0	1	2	3	4
Not at all sensitive	A little sensitive	Moderately sensitive	Very sensitive	Extremely sensitive

- **During the past week, how attractive have you found the smell of smoke?**

0	1	2	3	4
Not at all attractive	A little attractive	Moderately attractive	Very attractive	Extremely attractive

- **During the past week, how often have you found yourself noticing people smoking?**

0	1	2	3	4
Not at all	A little bit	A moderate amount	A lot	An extreme amount

- **During the past week, how often have you found yourself staring at cigarettes and cigarette smoke?**

0	1	2	3	4
Not at all	A little bit	A moderate amount	A lot	An extreme amount

- **During the past week, how often have thoughts or images of smoking popped into you mind?**

0	1	2	3	4
Not at all	A little bit	A moderate amount	A lot	An extreme amount

- **During the past week, how attractive have thoughts or images of smoking been?**

0	1	2	3	4
Not at all attractive	A little attractive	Moderately attractive	Very attractive	Extremely attractive

NICOTINE EFFECTS QUESTIONNAIRE

Rate how you feel right now by circling the number that best fits.

	Not at all				Moderate				Very much			
	0	1	2	3	4	5	6	7	8	9	10	
Calm												
Dizzy or light headed												
Contented												
Palms sweating												
Happy												
Trouble concentrating												
Tense												
Drowsy												
Unpleasant												
Friendly												
Nauseous												
Sad												
Buzzing												
Heart pounding												
Worried												

SMOKING CONSEQUENCES QUESTIONS

Smoking Consequences Questions (5 items)

The questions below describe different beliefs people have about the consequences of smoking a cigarette. For each of the following items, please circle a number that best describes you.

(a) Smoking now would help me relax

1	2	3	4	5	6	7	8	9	10	11
NO!!										YES!!

(b) Smoking now would energize me

1	2	3	4	5	6	7	8	9	10	11
NO!!										YES!!

(c) A cigarette would taste good now

1	2	3	4	5	6	7	8	9	10	11
NO!!										YES!!

(d) Smoking now would satisfy my cravings

1	2	3	4	5	6	7	8	9	10	11
NO!!										YES!!

(e) Smoking now would help reduce boredom

1	2	3	4	5	6	7	8	9	10	11
NO!!										YES!!

PUFF-BY-PUFF RATINGS

How much did you like the last puff?

1	2	3	4	5	6	7
Didn't like it at all						Liked it very much

OVERALL CIGARETTE RATINGS

Cigarette Ratings

Overall, how satisfying did you find the cigarette?

1	2	3	4	5	6	7
Not satisfying at all						Extremel y satisfying

Overall, how much did you like the cigarette?

1	2	3	4	5	6	7
Didn't like it at all						Liked it very much

Overall, how much did you enjoy the cigarette?

1	2	3	4	5	6	7
Didn't enjoy it at all						Extremel y enjoyable

SMOKING DIARY

Study ID: _____

Tobacco Use Record Form

Instructions for Participant:

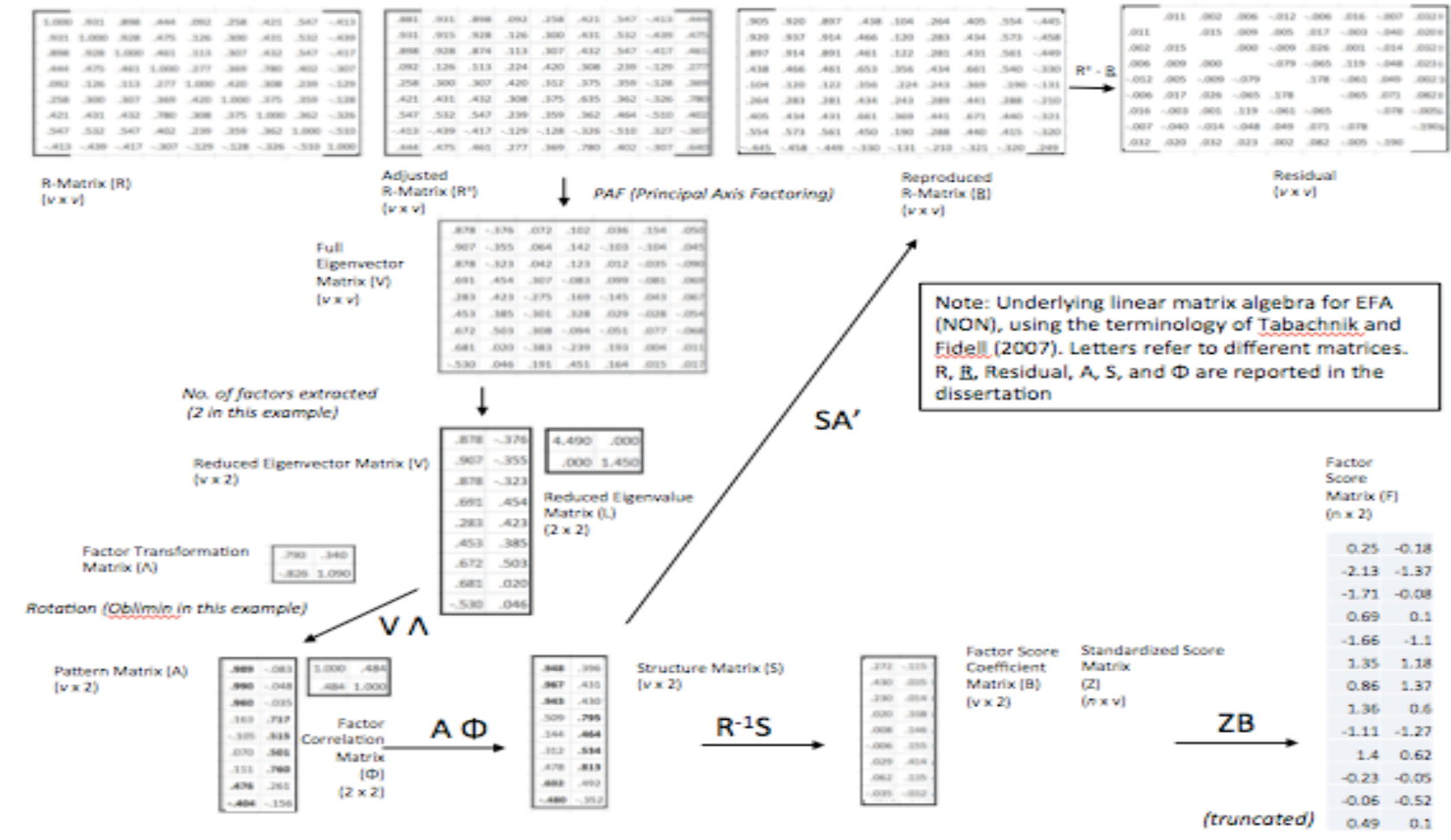
- Complete this form each day.
- Just before going to sleep, indicate how many cigarettes you have smoked that day.
- Be honest... Accurate information is important!

I agree to complete this form every night. I will provide information that is as accurate as possible.

SIGNATURE AND DATE:

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1							
Week 2							
Week 3							

Appendix E: Exploratory Factor Analysis Matrices



Appendix F: Aim 2 Principal Component Analysis Results

Principal component analysis (PCA) was conducted to observe how the self-report variables might form into components after data reduction procedures. Following procedures outlined in Field (2009), we assessed initial results from the PCA (in both the non-abstinent and abstinent state) for various tests indicating that the data were appropriate for component analysis. Initial results showed a Kaiser-Meyer-Olkin measure of $KMO = .81$ (non-abstinent state) and $KMO = .84$ (abstinent state) indicating a “great” level of sampling adequacy (Hutcheson and Sofroniou, 1999).

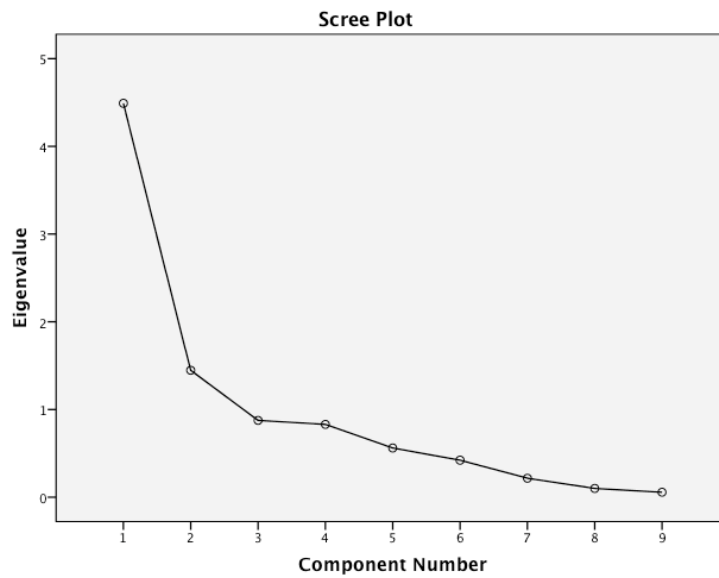
The next step was to review the correlation matrix of self-report variables. Factor analysis procedures, including PCA, will only yield valuable results if variables are somewhat correlated but not fully correlated; the literature suggests removing any variables with several correlations either below 0.3 or above 0.9 (Field, 2009). When reviewing the correlation matrices for both states, we noted that the change in NEQ-Physiological variable met this criteria suggesting removal. All correlations except one were below 0.3 for the change in NEQ-Physiological variable. (Correlation matrices for the non-abstinent variables and abstinent variables are shown in Table 12).

After removing the one variable, we conducted PCA with rotation for both the non-abstinent and abstinent states to investigate the component structure of the nine self-report variables. Variables included for each state (non-abstinent and abstinent) were: Liking, Enjoyment, Satisfaction, QSU, WSWs, SABQ, SCQ, NEQ-positive, and NEQ-negative. Both non-abstinent and abstinent states had similar results suggesting the presence of two factors amongst the 10 self-report variables. Specific results for each analysis are described below.

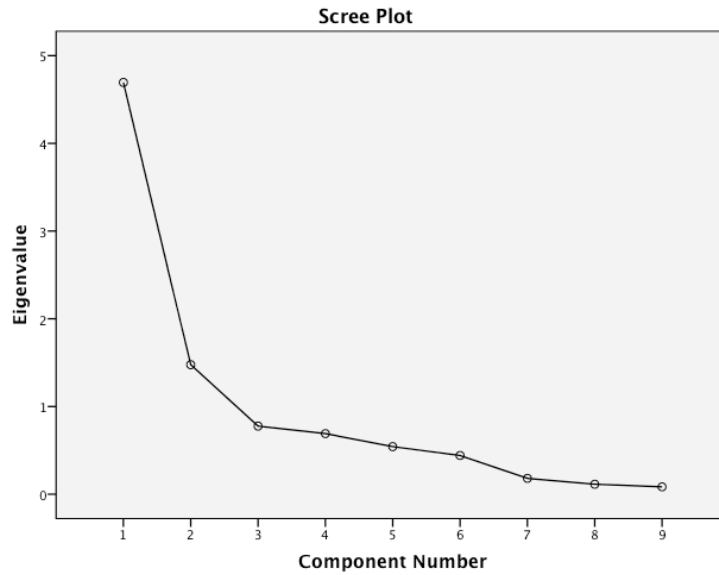
For the non-abstinent state, a PCA with direct oblimin rotation was conducted on nine self-report measure scores. KMO indicated superb sampling adequacy, $KMO = .82$, according to Field (2009). Bartlett's test of sphericity showed that correlations were adequate for this test, $\chi^2(45) = 1445.86, p < .000$. The correlation matrix is shown in Table 13. The analysis showed that two components had eigenvalues greater than one thus suggesting a two-component solution. The scree plot supported a two-component solution as well (shown below). These two components explained 65.98% of the variance.

For the abstinent state, a PCA with direct oblimin rotation was conducted on nine self-report measure scores. KMO indicated superb sampling adequacy, $KMO = .85$, according to Field (2009). Bartlett's test of sphericity showed that correlations were adequate for this test, $\chi^2(45) = 1356.07, p < .000$. The correlation matrix is shown in Table 13. This analysis showed that two components had eigenvalues that were greater than 1 with total variance explained of 68.56. The scree plot (shown below) also supports a two-component solution. These results suggest the same patterns as the non-abstinent state. Given our analysis plan for Aim 2, initial PCA was conducted to review the data, but the focused analysis will occur in the next step, Exploratory Factor Analysis. PCA showed that the data had adequate sampling adequacy and pointed to a two-component solution for the nine self-report measures.

Non-Abstinent State Scree Plot from PCA with Direct Oblimin Rotation ($n=224$)



Abstinent State Scree Plot from PCA with Direct Oblimin Rotation ($n=214$)



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