EXPLORING CUE REACTIVITY IN NICOTINE DEPENDENT YOUNG ADULTS USING VIRTUAL REALITY WITH EXPANDED OLFACTORY CUES

by

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(Under the Direction of Patrick S. Bordnick)

ABSTRACT

Nicotine use among young adults is a serious health concern that should be addressed through the use of technologically-driven interventions. This study was designed to explore the effects of exposure to virtual reality (VR) nicotine cues in a sample of nicotine dependent, non-treatment-seeking young adults. In addition, the effects of exposure to VR olfactory cues were examined. The goals of this study were twofold: 1) to determine to what extent exposure to VR smoking cues increased subjective reactivity in nicotine dependent young adult smokers as opposed to exposure to VR neutral cues, and 2) to determine if and to what extent exposure to VR olfactory cues, along with VR auditory and visual cues, increased subjective reactivity as opposed to exposure only to VR auditory and visual cues. Twenty nicotine dependent young adults between the ages of 19 and 24 experienced VR environments that included visual, auditory, and olfactory cues or VR environments that provided only visual and auditory cues. Subjects provided ratings related to subjective craving and attention to cues in each room. Results of one way, repeated measures ANOVAs indicated that subjects experienced significantly more craving in VR smoking cue rooms than in VR neutral cue rooms, but results of univariate analysis of covariance indicated that exposure to olfactory cues did not significantly

increase subjective reactivity. This is the first VR study to focus specifically on young adult smokers and to explore the effects of VR-provided olfactory cues on young adult smokers' levels of craving, contributing to the literature concerning young adult smokers and VR cue exposure methodology.

INDEX WORDS: Smoking, Nicotine dependence, Young adults, Cue reactivity, Cue exposure, Virtual reality, Olfaction, Social work

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DEDICATION

This dissertation is dedicated to my family, who has supported this endeavor each in their own special way. I love you all and wish I had the words to truly express my love and gratitude. To my mother and father, I thank you for instilling in me the value of the pursuit of knowledge and expressing your confidence in my abilities, even when I was unsure of myself. Mom, Dad, and Karen, your support in each and every way during my time in this degree program has been an amazing demonstration of your love and I cannot thank you enough for all you have done to make this possible.

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CHAPTER 1

INTRODUCTION

Cigarette smoking has been found to be harmful to almost every organ in the body and to be responsible for hundreds of thousands of premature deaths in the United States (Centers for Disease Control, 2005). Young adults between the ages of 19 and 24 make up a large portion of the smoking population, with over 39% reporting past month usage, according to results from the National Survey on Drug Use and Health (Substance Abuse and Mental Health Services Administration, 2002).

While there has been much investigation into the characteristics, needs, and methods of intervention with nicotine addicted smokers, research in this area typically explores adolescent and adult smokers, largely ignoring the population of young adults in between these two groups. Arnett (2000) argues that studying young adults is important because this population is distinctive in regard to demographics, subjective perceptions, and identity explorations. He notes that several types of risk behaviors, such as smoking, peak during the young adult years as a reflection of their desire to engage in a wide variety of experiences before settling into the responsibilities of adult life (2000). If it is accepted that young adult smokers are neither adolescents, nor fully developed adults, but rather a distinctly separate population, it is appropriate to explore the unique characteristics and needs of this group.

Smoking cessation and relapse prevention programs for young adults have received little research attention. Many researchers argue that interventions developed for adults may not be the best approaches for young adults (Lantz, 2003) and that smoking intervention aimed at young

adults should be a major public health initiative with a unique set of population specific strategies (Ramsay & Hoffmann, 2004). Wechsler and colleagues (2001) agree with this assessment, stating that further work is needed to identify interventions that would appeal to college students. Some researchers argue in favor of utilizing emerging technologies, particularly computer-based resources, for intervention purposes, noting the potential appeal of such methods for young adults (Backinger et al., 2003; Escoffery, McCormick, & Bateman, 2004; MacDonald, Colwell, Backinger, Husten, & Maule, 2003; Obermayer, Riley, Asif, & Jean-Mary, 2004). While some studies have utilized such technologies to assist young adults in cessation attempts (Escoffery, McCormick, & Bateman, 2004; Glasgow, Schafer, & O'Neill, 1981; Obermayer, Riley, Asif, & Jean-Mary, 2004), further research exploring the potential uses of emerging technologies is needed.

In addition, the factors that maintain smoking behaviors in young adults merit additional exploration in order to develop effective assessment and cessation interventions. It is theorized by some that smoking-related visual, auditory, gustatory, tactile, and olfactory cues within the environment may have powerful conditioning properties that play an important role in maintaining smoking behavior and predicting relapse (Chiamulera, 2005; Donny et al., 1999; Drummond, Tiffany, Glautier, & Remington, 1995; O'Brien, Childress, Ehrman, & Robbins, 1998). Such cues increase physiological reactions, as well as psychological responses known as cravings. This phenomenon, known as cue reactivity (Chiamulera, 2005; Conklin, 2006), potentially can lead to drug use. Primarily, visual cues have been explored in relation to the effects of cue reactivity. However, olfaction, the sense of smell, plays a unique role in emotion, memory, and learning, all of which are involved in reaction to cues. Thus, a greater

understanding of the impact of olfactory cues may assist in the creation of improved assessment and intervention tools for young adult smokers.

Theoretical Framework

A variety of theoretical frameworks have been used to underpin the reasons why young adults initiate and continue smoking, as well as the assessments and interventions designed for smoking cessation treatment modalities. These theories do not address young adults specifically, but do provide insight into young adult smoking behavior, as well as inform assessment, prevention, and cessation options. Because this study focused on exploring young adults' reactions to cues provided in VR, a theoretical framework supported by principles of classical and operant conditioning as they relate to cue reactivity was utilized.

The phenomenon through which drug dependent individuals or formerly dependent individuals react strongly when exposed to cues or stimuli associated with current or previous drug use is known as cue reactivity (Chiamulera, 2005; Conklin, 2006). Research focused on environmental cues related to smoking has demonstrated that such cues have particularly powerful conditioning and reinforcing properties and, therefore, may play an important role in maintaining smoking behavior and predicting relapse (Chiamulera, 2005; Donny et al., 1999; Drummond, Tiffany, Glautier, & Remington, 1995; O'Brien, Childress, Ehrman, & Robbins, 1998). Traditional cue reactivity studies, conducted both naturalistically and in the laboratory, have relied upon exposing participants to photos, videos, or smoking paraphernalia. Upon exposure, various responses are recorded, including subjective craving level, physiological data, and subjective mood state. However, traditional cue exposure methods have many limitations due to issues related to safety, cost, and utility, including the inability to provide ecologically

valid complex cues utilizing social, physical, and affective interactions provided in an environment that incorporates appropriate visual, auditory, and olfactory stimuli.

Virtual reality cue exposure may be a potential solution to such limitations. Virtual reality incorporates a human-computer interaction that provides active participation with a three dimensional virtual environment. The participant derives a sense of presence in the virtual world as a result of integrated computer graphics and input technologies. VR has been utilized in fields as diverse as military, health care, aviation, and firefighting and since the 1990's, VR has been gaining acceptance in the mental health arena. Today it is being used successfully to address issues and provide interventions related to mental health concerns including phobias (Coelho, Santos, Silveria, & Silva, 2006; Davidson & Smith, 2003; Emmelkamp, Bruynzeel, Drost, & van der Mast, 2001; Klinger et al., 2005; Krijn, 2007; Maltby, Kirsch, Mayers, & Allen, 2002; Muhlberger, Herrmann, Wiedemann, Ellgring, & Pauli, 2001; Rothbaum, Hodges, Watson, Kessler, & Opdyke, 1996), eating disorders (Riva, Bacchetta, Baruffi, & Molinari, 2001; Riva, Bacchetta, Cesa, Conti, & Molinari, 2003), and PTSD (Beck, Palyo, Winer, Schwalger, & Eu, 2007; Difede, 2006; Ready, Pollack, Rothbaum, & Alarcon, 2006; Rothbaum et al., 1999; Spira, Pyne, & Wiederhold, 2006).

VR technology also has been used to explore issues related to substance abuse, primarily with older adults. Bordnick and his colleagues (2004) developed the virtual reality nicotine cue reactivity assessment system (VR-NCRAS) and tested it with ten nicotine dependent adult smokers. It was discovered that, in response to VR smoking cues, subjective craving and physiological responses increased. Exposure to VR neutral cues did not illicit the same response. Baumann and colleagues (Baumann et al., 2003) found similar results in their test of adult cigarette smokers, as did Lee and colleagues (2004) in their study of male adolescent smokers.

These studies indicated that VR cue exposure was effective in manipulating craving in nicotine addicted smokers; and, thus was a viable method of examining and assessing drug cravings and reactions. However, young adults have not been targeted specifically.

Statement of the Problem

Young adult smokers are at a stage in their lives where they are actively making decisions about their smoking habits, with many attempting cessation, but not necessarily succeeding, at a greater rate than older adults. It is important that researchers and clinicians explore the special needs of these individuals and, as noted earlier, many researchers call for the utilization of technology in developing successful interventions for young adult smokers.

In answer to the call for increased exploration of technological interventions specifically directed toward young adult smokers, testing the utility of a VR cue reactivity system with this population and determining the impact of olfactory cues in eliciting reactivity among young adult smokers may provide information leading to new, viable assessment and treatment modalities. Thus, it is important that the VRCE system, virtual reality—nicotine cue reactivity assessment system (VR-NCRAS), with expanded olfactory cues, be tested with this population to explore the utility of such an assessment system and to determine the impact of olfactory cues on subjective reactivity.

Purpose and Importance of the Study

This study explored the utilization of a virtual reality cue reactivity (VRCE) assessment system with young adult smokers and the effects of VR-presented olfactory cues on their reactivity elicited while using the VRCE system. Because this is the first known study to utilize a VRCE system exclusively with young adult smokers and to explore the effects of VR-presented

olfactory cues on reactivity while in VR, this study provides information that may have important research and practice implications.

Because nicotine dependence is common in this country, social workers undoubtedly have been active in prevention efforts targeted towards young adults, counseling young adults about nicotine dependence, offering smoking cessation programs, conducting research, and influencing policies regarding cigarette use in public places. While there is little information regarding their efforts with nicotine dependent young adults specifically, social workers are well placed to provide services to this diverse population. Social workers employed on college and university campuses, particularly in counseling services, have the opportunity to assess clients for nicotine dependency and provide services as necessary. They also have access to resources that facilitate development, implementation, and outcome study of smoking prevention and cessation programs targeted specifically toward nicotine dependent young adults. Because many social workers work with consumers facing some form of oppression, they have the opportunity to address issues of smoking prevention and nicotine dependence with groups who traditionally have been difficult to reach, such as those who are not attending college, unemployed, or homeless.

The study was designed to explore the effects of exposure to virtual reality (VR) nicotine cues in a sample of 20 nicotine dependent, non-treatment-seeking young adults. In addition, the effects of exposure to VR olfactory cues were examined. The purpose of this study was twofold: to explore and test a VRCE assessment system in a sample of nicotine dependent, young adult smokers and to explore the impact of olfactory cues on eliciting reactivity among nicotine dependent young adults in a VR environment. While VRCE systems have been tested in the past with adult smokers (P. S. Bordnick, Graap, Brooks, & Ferrer, 2004; P. S. Bordnick, Graap,

Copp, Brooks, & Ferrer, 2005; P. S. Bordnick et al., 2004), this is the first known study to focus specifically on young adult smokers and the first known study to explore the impact of VR-presented olfactory cues on reactivity experienced by young adult smokers. In the course of this study, it was hoped that the following research questions could be addressed in greater detail:

1) What impact does exposure to VR smoking cue environments have on subjective reactivity in young adult smokers as opposed to exposure to VR environments not related to smoking?
2) What is the effect of exposure to VR-presented olfactory, visual, and auditory smoking cues as opposed to VR-presented visual and auditory smoking cues only on subjective reactivity in young adult smokers?

Definition of Terms

Understanding concepts related to craving can be difficult because, throughout the literature, different definitions can be found for such terms. For this reason, several concepts explored throughout this paper merit discussion in order to clarify their meanings.

Nicotine Dependence

Subjects recruited for this study were required to meet criteria for nicotine dependence as established by the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*. The DSM-IV-TR defines nicotine, and other substance, dependence through the following criteria:

> "A maladaptive pattern of substance use, leading to clinically significant impairment or distress, as manifested by three (or more) of the following, occurring at any time in the same 12-month period:

1) tolerance, as defined by either of the following:
    a) a need for markedly increased amounts of the substance to achieve intoxication or the desired effect
    b) markedly diminished effect with continued use of the same amount of the substance
2) withdrawal, as manifested by either of the following:
    a) the characteristic withdrawal syndrome for the substance
    b) the same (or a closely related) substance is taken to relieve or avoid withdrawal symptoms
3) the substance is often taken in larger amounts or over a longer period of time than intended
4) there is a persistent desire or unsuccessful efforts to cut down or control substance use
5) a great deal of time is spent in activities necessary to obtain the substance, use the substance, or recover from its effects
6) important social, occupational, or recreational activities are given up or reduced because of substance use
7) the substance use is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by the substance" (American Psychiatric Association, 2000, p. 197).

Cue Reactivity

Cue reactivity is the process by which drug dependent individuals or formerly dependent individuals react strongly when exposed to cues or stimuli associated with current or previous drug use (Chiamulera, 2005; Conklin, 2006). Stimuli associated with past use can evoke

responses that the smoker may interpret as withdrawal or craving. These responses may, in turn motivate operant nicotine-seeking behaviors. If the smoker succeeds in self-administering nicotine, the chain of behaviors is reinforced by the primary reinforcing effects of the nicotine (O'Brien, Childress, McLellan, & Ehrman, 1993). Additionally, it has been posited that these reactions to drug related cues are supporting evidence that classical conditioning has occurred (Lazev, Herzog, & Brandon, 1999).

There are basically two broad categories of cues upon which researchers focus when exploring cue reactivity. External (or exteroceptive) cues of drug dependence are based on external stimuli such as the sight, taste, or smell of a drug, while internal (or interoceptive) cues of drug dependence relate to internal states such as mood, cognitions, or drug withdrawal reactions (Glautier & Tiffany, 1995). Additionally, there are three categories of reactions to drug cues. Behavioral outputs, or drug-use behaviors, are the least studied of the three categories (Carter & Tiffany, 1999). These outputs include behaviors such as latency to smoke, decreased duration of abstinence, increased number of cigarettes smoked, and relapse to smoking. The focus of more cue reactivity research is on the remaining two categories: physiological reactions and psychological reactions. Physiological reactivity refers to functions usually controlled by the autonomic nervous system such as heart rate, skin conductance, skin temperature, and blood pressure (Carter & Tiffany, 1999), while craving is the most widely studied form of psychological reactivity (Carter & Tiffany, 1999).

Craving

Craving is a difficult concept to define and researchers often use the term interchangeably with terms such as liking, wanting, urge, desire, need, intention, and compulsion (Drummond, Litten, Lowman, & Hunt, 2000). In general, it can be described as “the conscious experience of a

desire to take a drug" (Drummond, 2001, p. 35). Although it is not well understood, it is thought that craving is a response conditioned by drug use and brought about by environmental cues related to substance use (Childress et al., 1993; O'Brien, Childress, McLellan, & Ehrman, 1993; Prakash & Das, 1993; Satel, 1992; Wallace, 1991). Cue exposure and the resulting reactivity, including craving, among nicotine, cocaine, and alcohol dependent populations have been reported as factors related to both drug use and antecedent to relapse (Dakis & Gold, 1991; Gawin, 1991). In fact, it has been suggested that the most powerful predictor of continued abstinence is loss of craving (P. S. Bordnick & Schmitz, 1998; Smith & Frawley, 1993).

Two different manifestations of craving have been identified that reflect anticipation and pleasure, as well as relief from negative affect (Tiffany & Drobes, 1991). The first, pleasure-based craving type is sometimes referred to as cue-provoked craving and it signifies the intent to engage in pleasant smoking behavior (Marlatt & Gordon, 1985; Shiffman et al., 2003). The second, alleviation-focused craving type is withdrawal based and characterized by negative mood states related to reduced intake of nicotine.

Virtual Reality

Virtual reality (VR) involves an immersive human-computer interaction that provides active participation and involvement with a three dimensional virtual environment. Through perceptions of being both immersed and involved in the VR environment, the participant derives a sense of presence in the virtual world. Immersion is achieved as the individual perceives himself as included in and interacting with an environment that continually is presenting stimuli and experiences (Witmer & Singer, 1998), while involvement in VR occurs as an individual focuses energy and attention on a specific set of stimuli and increases through participation in activities that stimulate or challenge one cognitively, physically, or emotionally (Witmer &

Singer, 2005). These perceptions of being immersed and involved in a VR environment contribute to the individual's sense of presence.

This sense of presence is a key feature distinguishing virtual reality from video games or inactive computer displays. It is essential in engaging the participant and allowing more realistic cue exposures to be implemented and also allowing the participant to be exposed to complex cues in the context of a realistic situation. Typically, VR has relied primarily on visual, auditory, and, to a lesser extent, vibrotactile stimuli to provide contextual elements of the real world in an immersive environment. However, olfactory systems have been developed, allowing scents to be introduced into the environment, in an effort to produce an even greater sense of presence.

Summary

Cigarette smoking is an activity in which, despite the potentially devastating health outcomes, many young adults engage. While much of the existing research on smoking primarily explores issues related to adolescent or adult smokers, researchers have realized the need to increase research focusing on the specific needs and treatment issues related to young adult smokers. This study explored and tested a virtual reality nicotine cue reactivity assessment system (VR-NCRAS) a sample of nicotine dependent, young adult smokers, as well as explored the impact of olfactory cues on eliciting reactivity among nicotine dependent young adults in a VR environment. The findings of this study contribute to the knowledge base of young adult smokers, as well as assessment and treatment modalities that may be suitable for this group.

CHAPTER 2

LITERATURE REVIEW

In this chapter, literature exploring cigarette usage through history and by young adults is discussed. Additionally, the theoretical basis of the study is explored, with particular consideration being given to topics such as cue reactivity and virtual reality cue reactivity methodology.

History of Tobacco and Cigarette Usage

While it is unknown when, where, or why someone came up with the idea of rolling up leaves, setting fire to them, and then inhaling the accompanying smoke, many historians agree that smoking tobacco dates back at least to the Mayan civilization in Central America in the first century B.C. (Parker-Pope, 2001). Indeed, it is believed that tobacco was grown and used by Native American cultures for many centuries before the arrival of European explorers and was viewed by the Native Americans as a mystical plant that played a significant role in religious and medical practices (Hughes, 2003).

Christopher Columbus is credited with bringing tobacco back to Europe after observing Native Americans smoking or chewing the leaves. Many of Columbus' sailors were said to have engaged in the custom; and, after observing his sailors as they continued to smoke, he noted that "it was not within their power to refrain from indulging in the habit" (Kluger, 1996, p. 9). Because tobacco initially was expensive, smoking became a pastime mostly of affluent members of European society during the sixteenth century. However, as supply increased, the price

dropped and that, coupled with the endorsement of tobacco's health properties by many doctors and herbalists, made tobacco popular throughout all levels of society (1996).

In the British colonies of North America, tobacco became a strong sociological and economic factor. Settlers moved south and west in search of good land to grow tobacco, the plantation society of wealthy landowners emerged in the southern colonies, and the African slave trade grew along with the need for laborers to tend to the plants (Parker-Pope, 2001). Tobacco was plentiful and many settlers smoked it through a pipe, dipped it as snuff, or enjoyed chewing tobacco. Indeed, by the middle of the nineteenth century, Americans had become the largest consumers per capita of tobacco in the world (Kluger, 1996).

Cigarettes, however, were rarely smoked in the United States as they were viewed as weak-tasting and effeminate (Kluger, 1996). During the Civil War, Confederate soldiers realized the utility of the cigarette, which was faster to consume than pipe tobacco. As more and more men tried them, they began to think of them as something more than a substitute. By 1875, figures showed that sales of manufactured cigarettes increased from 20 million in 1864 to 42 million units and by 1880, sales of manufactured cigarettes had increased to over 500 million units (1996). With the advent of the twentieth century and its move toward a faster-paced, highly populated urban lifestyle, pipes and chewing tobacco decreased in popularity, while cigarettes continued to enjoy success. Cigarettes were seen as a compliment to this fast-paced society as they were light and quickly smoked. They could be used easily during a break or going to or from home (Parker-Pope, 2001). In 1911, annual per capita consumption was 173 cigarettes per person and by 1916, annual consumption had increased to 395 cigarettes per person (2001).

War continued to play a strong role in increasing the popularity of cigarette smoking in the United States. World War I is said to be responsible for turning thousands of nonsmoking

young men into cigarette smokers as cigarettes became associated with camaraderie between soldiers (Parker-Pope, 2001). Paradoxically, during World War I, vocal opponents of tobacco use, such as the YMCA and Red Cross, helped supply cigarettes to soldiers (2001) and by 1919, annual cigarette consumption reached 727 per adult in the United States (2001). By World War II, Franklin D. Roosevelt declared tobacco to be a wartime crop. Army manuals advised leaders to smoke and encourage their troops to do so, as well, while General Douglas Macarthur demanded better tobacco for the troops and ordered $10 million to be raised for the purchase of American cigarettes overseas (2001). By 1945, Americans were smoking an average of 3,449 cigarettes per person annually (2001).

While the harmful effects of tobacco had been reported by various groups and individuals since 1586 (Parker-Pope, 2001), the 1950's saw the first news reports in the United States discussing the negative health effects of smoking (2001). These reports, however, appeared to lead to an increase in the popularity of cigarettes as they became seen as a rebellious rite of passage for teenagers and associated with both advertisement campaigns featuring masculine, rugged images such as the Marlboro Man and movies featuring glamorous Hollywood actresses smoking on screen (2001). In the 1960s and 1970s, concerns about the health risks of cigarettes began resulting in decreasing smoking rates in the United States (2001). However, it was not until 1988 that the Surgeon General of the United States issued a report outlining the addictive nature of the nicotine found in cigarettes (Department of Health and Human Services, 1988).

Cigarette Usage in the United States Today

Today, cigarette smoking is recognized as a major public health concern as it has been found to harm almost every organ in the body, cause disease, and lead to a reduction in quality of life and life expectancy (Centers for Disease Control, 2005a). The list of diseases and health

conditions in which smoking plays a role is extensive and includes lung, stomach, laryngeal, pancreatic, colorectal, liver, cervical, and oral cancers; coronary heart disease; stroke; acute and chronic respiratory diseases; and reproductive problems, such as infertility and poor pregnancy outcomes (CDC, 2004). It has been estimated that in each year between 1997 and 2001, both cigarette smoking and exposure to cigarette smoke were responsible for approximately 438,000 premature deaths, 5.5 million years of potential life lost, and $92 billion in productivity losses (2005a).

With the increasing, well-publicized health concerns surrounding cigarette use, per capita consumption of cigarettes has decreased. The US Department of Agriculture (2004) estimated that per capita consumption of cigarettes for adults 18 and older in 2003 was 1,903. This is a significant decrease from the 1963 peak of 4,354 (2004). However, results of the 2004 National Health Interview Survey indicated that approximately 20.9% of US adults over 18 were current smokers (CDC, 2005b). In addition, the 2004 National Survey on Drug Use and Health estimated that 59.9 million individuals in the United States age 12 and older had smoked cigarettes within the past month (SAMHSA, 2002). While these numbers demonstrate a decrease in smokers from past years, they are still representative of a large number of the American population at risk for a multitude of health problems.

Young Adults and Nicotine Use

Nicotine use among young adults is a serious public health problem in the United States. According to results from the National Survey on Drug Use and Health, young adults had the highest rate of past month cigarette usage of any age group at 39.5% (SAMHSA, 2002). Additionally, young adults recorded the largest numbers of nicotine dependent smokers across the age groups at 18.2% (2002). A study by Wechsler et al. (1998) found that among a surveyed

group of young adult smokers, only 11 percent began smoking after age 19, but approximately 28 percent of current smokers began smoking *regularly* after the age of 19. Furthermore, half of the surveyed group had, at some point, attempted to quit smoking for at least 24 hours. This corresponds with data provided by Healthy People 2010 (2000) that states that 52% of smokers in this age group attempt smoking cessation, which is the greatest percent of cessation attempts of any adult age group. Additionally, there is a difference in smoking behavior between young adults enrolled in college and those not enrolled in college. The prevalence of daily smoking among college students was 14% in contrast to 29% for high school graduates not enrolled in college on a full time basis (Johnston, O'Malley, & Bachman, 2003). These findings appear to indicate that the young adult years are a time of considerable change in smoking habits and that there is great opportunity among this age group for interventions focused on both preventing the transition from occasional smoking to regular smoking and to increase the success rate for those who are trying to quit smoking altogether. Surprisingly, however, smoking related behaviors and potential treatments among this age group have not been the subject of extensive research.

It should be noted, however, that some studies targeting young adults do exist. In a review of studies conducted on smoking cessation programs for youth and young adults, MacDonald and colleagues (2003) note an absence of programs utilizing emerging technologies for intervention purposes. They argue that technological interventions have great potential to reach young smokers. Escoffery and colleagues (2004), Obermayer and colleagues (2004), and Backinger and colleagues (2003) all agree with this assessment, noting the potential acceptability and appeal of such methods. While a more recent review of the literature revealed no studies utilizing emerging technologies for smoking prevention with young adults, researchers have begun to utilize technologies such as computer programs (Glasgow, Schafer, & O'Neill, 1981),

internet applications (Escoffery, McCormick, & Bateman, 2004), and cell phone text messaging (Obermayer, Riley, Asif, & Jean-Mary, 2004) to provide cessation services to young adults. Additionally, researchers have employed web technology as a method of survey distribution (James, Chen, & Sheu, 2005; Morrell, Cohen, Bacchi, & West, 2005) in an effort to gain further knowledge about this population and develop resources to address nicotine dependence among young adults.

Theoretical Models of Nicotine Dependence

There are many theoretical models to explore when studying aspects of nicotine dependence in any population. Theories explaining nicotine use and underpinning prevention and intervention strategies do not focus specifically on young adults; however, they offer insight into why young adults begin and continue smoking, as well as inform options for treatment and prevention. The behavioral theories of operant conditioning and respondent conditioning as they relate to cue reactivity both provide a unique framework for studying nicotine dependence in young adults and will be explored in detail in this section. Because cue reactivity is a complex phenomenon, this section will introduce cue reactivity, examining the theoretical basis of cue reactivity; the scientific basis of cue reactivity; and types of cues and reactivity, including craving. Finally, a comparison of traditional versus virtual reality cue reactivity methodology will be presented.

Cue Reactivity

The phenomenon through which drug dependent individuals or formerly dependent individuals react strongly when exposed to cues or stimuli associated with current or previous drug use is known as cue reactivity (Chiamulera, 2005; Conklin, 2006). According to the construct of cue reactivity, aside from nicotine's primary reinforcing properties, other smoking

cues have particularly powerful conditioning and reinforcing properties and, therefore, may play an important role in maintaining smoking behavior and predicting relapse (Chiamulera, 2005; Donny et al., 1999; Drummond, Tiffany, Glautier, & Remington, 1995; O'Brien, Childress, Ehrman, & Robbins, 1998). While the relationship between nicotine, its ability to establish and reinforce nicotine-related cues, and those cues' abilities to maintain drug usage behaviors is not completely understood (Baker, Brandon, & Chassin, 2004), it appears that further investigation of nicotine-related cues is warranted. Cue reactivity is a complex construct that merits careful explanation. The theoretical and scientific bases, as well as types of cues and types of reactivity will be discussed in detail. In addition, differences between traditional and virtual reality cue exposure methodology will be explored.

Theoretical Basis for Cue Reactivity

Respondent (or classical) conditioning. Respondent, or "classical", conditioning is a learning model based on the association of stimulus events and was first described by Russian scientist, Ivan Pavlov, while studying the digestive system of dogs (Wortman, Loftus, & Marshall, 1988). Pavlov, whose work focused on automatic responses known as reflexes (Windholtz, 1997) noticed that hungry dogs began salivating when an assistant, who fed the dogs, entered the room. Through the investigation of this phenomenon, Pavlov found that reflexive responses can be associated with stimuli that have no obvious biological relevance to the response (Zimbardo, Weber, & Johnson, 2003), thus establishing principles of classical conditioning, later renamed respondent conditioning.

The basic respondent conditioning paradigm involves interactions between a variety of stimuli and reactions. An unconditioned stimulus (UCS) is something that elicits a reflexive response in an individual without any previous exposure or training and the response that it

elicits is called an unconditioned response (UCR). For example, the chemical properties of nicotine may result in an individual perceiving a pleasurable "buzz" sensation even if the person has never previously smoked a cigarette and is unsure what to expect from the experience. An important feature of the UCS-UCR relationship is that the UCS *reliably* elicits the UCR (Hulse, Egeth, & Deese, 1980) and that no learning occurs through the UCS-UCR connection (Zimbardo, Weber, & Johnson, 2003).

The conditional stimulus (CS) is an originally neutral stimulus that, over time, through a process of pairing with the UCS known as acquisition, comes to elicit basically the same response caused by the UCS in an individual. There are two important features of a CS. First, this stimulus must be observable by the individual. The individual must be able to see, hear, touch, smell, or taste the stimulus. Second, the CS must be neutral in regard to the reflex being studied before it is paired with the UCS (Wortman, Loftus, & Marshall, 1988). For example, if a smoker generally has a cigarette while drinking coffee, eventually the sight, smell, and taste of coffee will become paired with the nicotine in the cigarette and will elicit the same response.

The conditioned response (CR) is the response that occurs when the CS is paired with the UCS. Such conditioning does not necessarily produce the exact same response in both the CR and the UCR, thus the CR may be described as a preparatory response for the arrival of the UCS (Hulse, Egeth, & Deese, 1980). Continuing with the above example, the smoker may not experience the same pleasurable feeling when smelling coffee as when smoking a cigarette. Instead the smoker may experience a different response, such as feeling an increased desire to smoke. This indicates that the smoker has engaged in a learning process by which an association between smoking a cigarette and the smell of coffee is created.

In order to achieve a strong conditioned response, there must appear to be a relationship, also called a contingency, between the CS and UCS so that the occurrence of one appears to depend on the occurrence of the other (Wortman, Loftus, & Marshall, 1988). Relating this to nicotine dependency, nicotine craving is believed to be a conditioned response triggered by environmental cues related to past drug use (O'Brien, Childress, McLellan, & Ehrman, 1993). These cues can be cigarettes, people, sights, odors, sounds, situations, or contexts that, over time, may signal the beginning of a chain of both behavioral and autonomic responses that lead to drug craving behavior. Therefore, according to the respondent conditioning model, a smoker faced with cues associated with previous smoking behavior will begin craving cigarettes.

Beyond this conditioning paradigm, there are other concepts central to respondent conditioning and how it provides a theoretical basis for cue reactivity. Extinction is the process through which a CR is discontinued by presenting the CS without the UCS over many trials (Crain, 1985). For example, a smoker who experiences craving when he sees a package of cigarettes will eventually stop experiencing craving sensations if he continually sees the cigarettes without smoking them. However, if the UCS and CS are paired together, even occasionally, extinction will not occur (Zimbardo, Weber, & Johnson, 2003). Extinction is not necessarily permanent, though. Through the process of spontaneous recovery, a conditioned response may reappear, albeit at a lower intensity (Wortman, Loftus, & Marshall, 1988). Thus, it appears that extinction does not result in elimination of a behavior, but rather a suppression of the CR, meaning that through the process of extinction, the individual is learning not to respond to the CR (1988). Another process that threatens extinction is renewal. Renewal occurs when extinction training takes place in a context different from the context in which the UCS and CS originally were paired (Bouton, 1993; Bouton & Bolles, 1979). For example, an individual

typically smokes at parties and bars decides to quits smoking using extinction training that is provided by a social worker in an office setting. The individual may demonstrate extinction of the smoking behavior within the context of the office setting; however, when he returns to the original smoking context of a bar or party, he begins responding to cues and smoking again. The environmental contexts of the original learning and the extinction training are so different that renewal takes place. Conklin (2006) states that this contextual renewal effect may explain the failure of many extinction based-treatments for substance abuse issues.

Once a response has been conditioned, the response appears to generalize to similar stimuli without any further conditioning. This phenomenon is called stimulus generalization (Crain, 1985) and the more similar a stimulus is to the original, the more likely this generalization is to occur (Wortman, Loftus, & Marshall, 1988). This may explain why a smoker who usually smokes with a particular group of individuals may experience craving when seeing someone he has never met before smoking a cigarette or sees an image of someone smoking, rather than a live person. Generalization is important because it allows individuals to apply what they have learned in similar, but new situations (1988). Conversely, individuals also engage in discrimination. This is the process by which an individual learns to differentiate between stimuli and respond to some, but not others (Zimbardo, Weber, & Johnson, 2003). Thus, people may elicit a craving response in a smoker, but not all people, only those with whom he smokes or sees smoking.

Conditioning that occurs without the UCS is called higher-order, or second-order conditioning. In this process, a neutral stimulus is paired with a well-established CS. After pairing the neutral stimulus with the CS several times, the neutral stimulus becomes a CS for the CR (Zimbardo, Weber, & Johnson, 2003). This enhances the importance of respondent

conditioning in that the number of stimuli that may elicit a CR increases through the introduction of higher-order conditioning (Chance, 2003). Therefore, smokers may develop craving responses to stimuli not directly related to smoking, but related on a secondary basis. For example, an individual experiences a craving response when he handles cigarettes (CS) upon buying them at the convenience store (neutral stimulus). He may, through higher-order conditioning, begin to experience craving, the CR, upon seeing a convenience store. The phenomenon of higher-order conditioning greatly increases the potential number of stimuli that may elicit craving in a young adult smoker. This is, in part, due to the fact that smoking is a socially accepted activity, thus many potential stimuli, such as places where cigarettes are sold, social situations, and environmental contexts favorable to smoking are encountered on a regular basis.

Operant conditioning. Operant conditioning is a learning model based on the work of E.L. Thorndike and B.F. Skinner. Thorndike (1911) was the first person to demonstrate that behavior is strengthened or weakened as a result of consequences, drawing attention from internal influences to external, environmental influences (Chance, 2003). Skinner (1938) built upon Thorndike's work, proposing that reinforcement is the basic mechanism for controlling human behavior. He argued that, in all areas of life, behavior is shaped by positive or negative consequences and all behavior is the result of an individual's history of reinforcement (Skinner, 1985).

Skinner called his system of conditioning "operant conditioning" because it focused on operant responses, which are observable, voluntary behaviors an individual uses to have an effect on his environment (Zimbardo, Weber, & Johnson, 2003). This is an important departure from respondent conditioning as it, therefore, involves a wider spectrum of behaviors, as well as new and complex behaviors beyond the reflexes described by respondent conditioning (2003).

Skinner focused on positive and negative reinforcement as the procedures of providing strengthening consequences for a behavior. In positive reinforcement, behavior is followed by the appearance of, or increase of, a stimulus, or positive reinforcer, which is generally something the individual seeks out. The effect of the positive reinforcer is to strengthen the behavior that preceded it (2003). Thus, a smoker who feels a "buzz" sensation after smoking a cigarette has had his behavior of smoking positively reinforced by the "buzz" sensation. In negative reinforcement, behavior is strengthened by the removal of, or decrease in intensity of, a stimulus, or negative reinforcer, which usually is something the individual seeks to avoid (2003). Therefore, the smoker who is feeling anxious may smoke to calm down. This feeling of decreased anxiety upon smoking a cigarette has negatively reinforced the smoker's smoking behavior by removing the feelings of craving or withdrawal.

There are two types of reinforcers. Primary reinforcers reinforce behavior on the basis of fulfilling basic physical needs or desires and are not dependent on their association with other reinforcers (Chance, 2003). In regards to smoking, many researchers focus on satiation effects, which refer to the decline in motivation seen after receiving a large dose of food, water, or drug (Glautier, 2004) or withdrawal effects, which focus on the negative reinforcement of alleviating or avoiding withdrawal symptoms (Eissenberg, 2004). Secondary reinforcers are stimuli that acquire their reinforcing properties through association with a primary reinforcer. Often, sequences of behavior are maintained by chains of secondary reinforcers and learning that occurs through this sequencing is called chaining (1988). Secondary reinforcers may create a chain of behaviors that a smoker may complete before receiving the primary reinforcement derived from smoking a cigarette.

Similarly to respondent conditioning, operantly conditioned responses that cease to be reinforced eventually are extinguished. In order to extinguish a behavior, all possible reinforcers must be withheld (Zimbardo, Weber, & Johnson, 2003). While most behavior which is not reinforced eventually declines in frequency, during initial stages of extinction, the response tends to be more forceful than usual (Wortman, Loftus, & Marshall, 1988). Thus, extinction paired with positive reinforcement usually is a more effective strategy than extinction alone (2003). As in respondent conditioning, spontaneous recovery of operant responses can occur (Chance, 2003).

Scientific Basis for Cue Reactivity

While respondent and operant conditioning provide a strong theoretical basis for cue reactivity, it also is important to understand the roles various portions of the brain play in conditioning and cue reactivity. Neurobiological models of nicotine addiction, along with fMRI studies, suggest that nicotine affects the brain reward system, also known as the mesocorticolimbic brain system (Due, Huettel, Hall, & Rubin, 2002; Lee, Lim, Wiederhold, & Graham, 2005; McClernon & Gilbert, 2004; Powell, Dawkins, & Davis, 2002; Smolka et al., 2006; Stein et al., 1998). This area of the brain consists of several core structures: the medial forebrain bundle, the nucleus accumbens, the ventral tegmental area, the lateral and ventromedial nuclei of the hypothalamus, and the medial prefrontal cortex (Ritz, 1999). Mediating this system is the reticular activating system areas of the aqueduct of Sylvius, and nerves ascending to the hypothalamus. These systems serve as a "punishment pathway", attenuating the rewarding effects of stimuli (1999). Limbic regions including the septum, amygdale, and thalamus provide input regarding emotional and motivational variables, while the basal ganglia and cerebellum control movement toward the desired reward (1999). This reward system, also known as the

"reward pathway", is so called because its activation is associated with appetitive behaviors directed toward reinforcers including brain electrostimulation, food, and sex (Wise, 1998). Because nicotine use activates this reward pathway, that behavior is reinforced. With continued use, neutral stimuli associated with nicotine become conditioned stimuli, and these stimuli are reinforced by the reward effects of nicotine. Eventually, cue reactivity develops and is maintained by the extended association between nicotine reward effects and nicotine cues, with the effects continuing to reinforce the cues (Balfour, Wright, Benwell, & Birrell, 2000; Caggiula et al., 2001).

Some researchers argue that the subjective indicator of the activation of reward pathways is a state of subjective cue reactivity known as craving (Robinson & Berridge, 2000), as it has been shown that exposing addicts to drug related cues elicits both subjective craving (Carter & Tiffany, 1999) and activation of the mesocorticolimbic system (Due, Huettel, Hall, & Rubin, 2002; Lee, Lim, Wiederhold, & Graham, 2005; Stein et al., 1998). Additional imaging studies have demonstrated that presentation of smoking cues result in greater activation of brain areas responsible for attention and affect in smokers than in non-smokers (Rose et al., 2003; Stein et al., 1998). Brody and colleagues (2002) also found correlations between cue elicited craving and cue induced brain activity in the orbito-frontal cortex, dorsolateral prefrontal cortex, and anterior insula, which are all areas hypothesized to be related to craving and affect. Finally, in exploring the process that occurs in the brain when exposed to cues, Kelley and colleagues (2005) found that the amygdala and hippocampus provide the prefrontal cortex with highly processed sensory information; and, in turn, the prefrontal cortex activates motivational and reward pathways by transmitting this information to the nucleus accumbens and hypothalamus, where behavioral actions are controlled. They suggest that olfactory, gustatory, and visual cues associated with

reward, through provision of sensory stimuli, play an important role in this process, and, thus, potentially in maintaining drug use and promoting relapse (2005). While additional research is warranted, these studies appear to support the theoretical bases of respondent and operant conditioning for cue reactivity and suggest that smoking cues are important stimuli for smokers; that cue-elicited response correlates with increased brain activity in systems associated with emotion, attention, and reward (McClernon & Gilbert, 2004); and that these cues, as they are reinforced by the reward effects of nicotine, influence smoking behavior (Balfour, Wright, Benwell, & Birrell, 2000; Caggiula et al., 2001).

Types of Cues

There are basically two broad categories of cues upon which researchers focus when exploring cue reactivity. External (or exteroceptive) cues of drug dependence are based on external stimuli such as the sight, taste, or smell of a drug, while internal (or interoceptive) cues of drug dependence relate to internal states such as mood, cognitions, or drug withdrawal reactions (Glautier & Tiffany, 1995). When these cues are encountered, respondent conditioning occurs as the unconditioned stimulus, or cue, becomes paired with a conditioned stimulus. When smoking occurs and is reinforced by a cue such as a pleasant feeling or the removal of an aversive feeling, operant conditioning occurs, increasing the likelihood that the smoker will repeat the behavior.

External cues. External cues can be separated into two categories of environmental stimuli that elicit conditioned responses: proximal and distal (Glautier & Tiffany, 1995). As seen in Figure 1, when these external cues are combined, they form a set of complex cues that influence young adult smoking behavior. Proximal cues, such as drug paraphernalia, are closely linked to drug administration and cue reactivity studies frequently explore these cues because

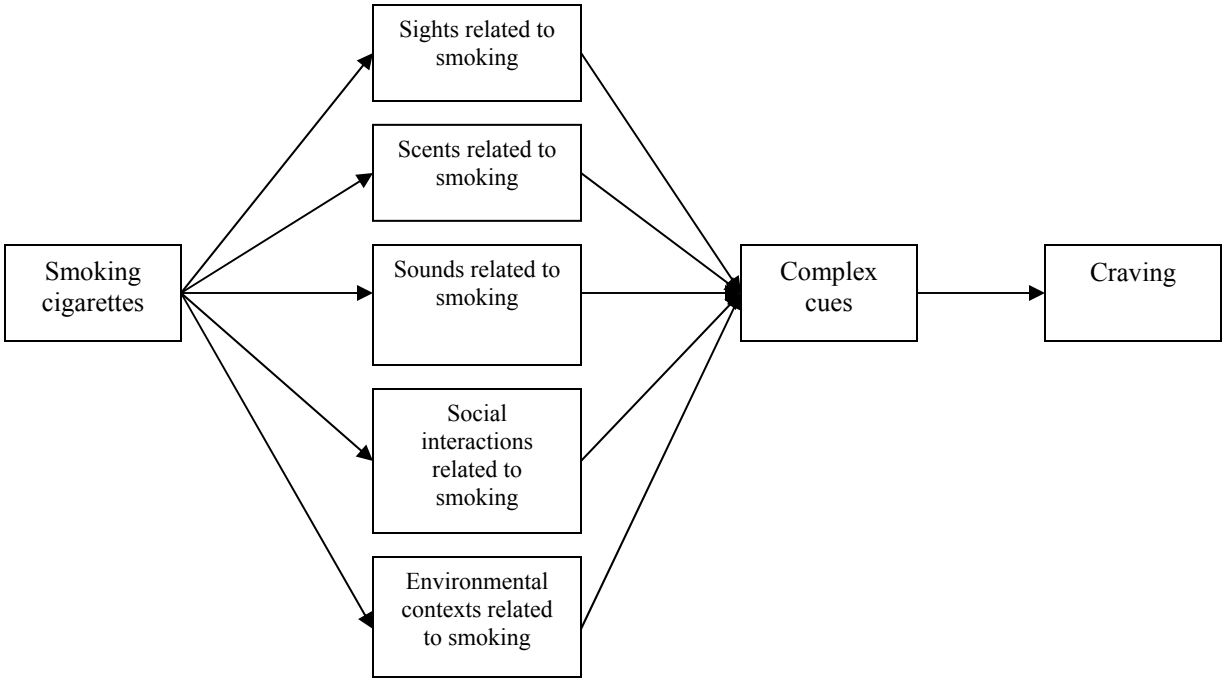


Figure 1. External cues as they relate to craving to smoke.

such stimuli are easy to manipulate (Brandon, Piaseki, Quinn, & Baker, 1995). Specific to nicotine dependence, external proximal cues include smoking paraphernalia such as cigarettes, lighters, matches, and ashtrays; as well as the sight and scent of environmental tobacco smoke. Sensory stimuli involving such cues are significantly associated with smoking and are very difficult for smokers to avoid upon cessation (1995).

External distal cues are not thought to be as closely linked to actual drug use and include social situations and environments in which drug use has occurred, as well as non-drug cues within those situations and environments, such as food or beverages (Conklin, 2006). Several studies have found social situations, including food and alcohol consumption and the presence of other smokers are associated with smoking relapse (Brandon, Tiffany, Obremski, & Baker, 1990; Shiffman, 1986). In their studies, Shiffman and colleagues (1994; , 2002) found that

consumption of alcohol was the strongest environmental correlate of cigarette smoking. Additionally, they found that coffee consumption increased smoking behavior by 19% after controlling for variables such as being in the presence of others or eating (2002). Other studies demonstrate there appears to be a strong relationship between smoking and social interaction for both adolescents (Andrews, Tildesley, Hops, & Li, 2002; Maxwell, 2002), as well as adults (Ockene et al., 2002) and Shiffman and colleagues (2002) noted a 78% increase of smoking when a heavy smoker was in the presence of other smokers. Interestingly, whether or not the other smokers were part of the smoker's social group was not a factor. Simply observing another individual smoking served as a distal cue in established smokers (Shiffman et al., 2002).

There has been some question regarding which type of external cue is more important for eliciting reactivity. Conklin (2006) conducted a study in which smokers viewed pictures of proximal cue images devoid of distal cue images (such as a close-up picture of a cigarette in an ashtray) and distal cue images devoid of proximal cue images (such as a bar with no people, smoking paraphernalia, or advertisements), then rated them according to several recognized reactions. She found that, while the distal images elicited reactivity, the proximal images resulted in significantly greater reactivity (2006). Bordnick and colleagues (P. S. Bordnick, Graap, Copp, Brooks, & Ferrer, 2005; P. S. Bordnick et al., 2004) found that subjective craving levels among study participants were higher in situations involving primarily distal cues, such as social situations in which an individual offered the participant a cigarette than in situations involving primarily proximal cues, such as an individual walking through a room filled with smoking paraphernalia. Indeed, exploring reactivity to both types of external cues among young adults may be especially salient as the tobacco industry actively targets young adult smokers, using marketing strategies to integrate smoking with bar/club environments, and music and sports

events (Ling & Glantz, 2002). Promotional events are designed to create environments conducive to smoking (Sepe, Ling, & Glantz, 2002), saturating these environments with smoking cues. Thus, young adults may be more likely to be bombarded with additional environmental cues targeted specifically towards them.

Olfaction as an external cue. While visual cues frequently are utilized in cue studies, the role olfactory stimuli play as external proximal cues for substance use has not been the subject of intensive investigation. However, recent research has shown the sense of smell, or olfaction, to possess unique characteristics that separate it from the other senses in terms of both neurophysiology and the role it plays in emotion, memory, and learning, all of which are involved in conditioned reactions to cues.

The role olfactory stimuli play as external proximal cues may be linked, in part, to the physiology of smell. Smells are carried through the air on molecules known as vapors. When these vapors reach the nose, they are funneled to smell receptors located on the nasal epithelium at the top of the nasal cavity. Olfactory nerve fibers connect the receptors to the olfactory bulb, which is made up of the enlarged endings of the olfactory lobes of the brain and which begins processing the signals received from the smell receptors (Matlin, 2002). These signals are carried, either directly or through interneurons, by way of mitral cells to four structures of the brain: the primary olfactory cortex, the amygydala, the olfactory tubercle, and the septal area (Beatty, 2001). The olfactory tubercle is an area at the base of the forebrain, while the amygdala and septal area are structures within the limbic system. The primary olfactory cortex involves the piriform and entorhinal cortex and serves as a type of associative memory system which allows for the association of olfactory stimuli with memories of previously experienced events. The piriform cortex is involved in learning and memory and it projects to the thalamus,

hypothalamus, and nucleus accumbens (Royet & Plailly, 2004). The entorhinal cortex projects to the hippocampus, an area of the brain implicated in the formation of memory (2001). Additionally, these mitral cells also send information to the hypothalamus, the reticular formation, and several other structures within the limbic system and frontal cortex. The limbic system and frontal cortex comprise a major portion of the reward pathway discussed earlier and are areas of the brain that have demonstrated activity in cue related neurological studies (Balfour, Wright, Benwell, & Birrell, 2000; Brody et al., 2002; Caggiula et al., 2001; Due, Huettel, Hall, & Rubin, 2002; Kelley, Schiltz, & Landry, 2005; McClernon & Gilbert, 2004; Powell, Dawkins, & Davis, 2002; Rose et al., 2003; F. Schneider et al., 2001; Smolka et al., 2006; Stein et al., 1998; Wise, 1998). Therefore, the information carried by the olfactory system through the brain is intimately linked with the more primitive and motivational areas of the brain (Beatty, 2001) and is in a position to influence directly the information received by the reward pathway.

It should be noted that the physiology of olfaction is unique among the senses. While signals from most senses are relayed first by way of the thalamus to other parts of the brain, olfactory information is processed first through the structures within the limbic system (Levine, 2000). Because it has a direct linkage to the limbic system, portions of which are associated with emotion, emotional learning (F. Schneider et al., 2001) and conditioning processes (Grusser, Heinz, & Flor, 2000), it is not surprising that exposure to cues including scent have been shown to elicit greater reactivity than exposure to cues without scent (Towner, Ybasco, Rezai, Rose, & Contrada, 1991). Indeed, olfaction is involved in emotion and memory, both of which are functions that appear to play a role in cue reactivity.

Because the olfactory system is linked directly to the limbic system, it is the sense most closely related to emotion (Wrzesniewski, McCauley, & Rozin, 1999). Odors can become

associated with emotions so that when an odor is encountered, emotions are elicited and, through this conditioned association, odors have the capacity to exert directional influence on behavior (Herz, Schankler, & Beland, 2004). In addition, there is a direct correlation between the experience of emotion during the autobiographical recall of an odor cue and heightened activity in the amygdala—a correlation not triggered by visual cues (Herz, 2004). Herz (2004) also found that personally significant odors stimulate greater amygdala activation that non-significant odors, suggesting that significant odors hold greater emotional valence than those that are not significant. These findings point to a unique connection between olfaction and emotion during the recollection of memories.

This connection expands as the linkage between olfaction and memory is considered. The olfactory bulb is intrinsically linked to areas known to mediate episodic memory. As noted above, the amygdala is thought to be directly involved with the formation of emotional memories (Chu & Downes, 2002). Additionally, the olfactory system is comprised, in part, of the primary olfactory cortex, which is made up of the piriform and entorhinal cortices, both of which are involved in memory processes. Odor invoked memories are particularly resilient and potent reminders of autobiographical experiences (Herz, 2004). The reoccurrence of an odor, once it has been encoded, can reproduce an associated memory within milliseconds, even if the memory has not been recalled for decades (Soderquist, 2002). These memories tend to be imbued with strong emotional overtones. Indeed, research has demonstrated that odors are capable of generating more emotional memories than words or visuals (Martin, Apena, Chaudry, Mulligan, & Nixon, 2001). Additionally, odors have been shown to provide strong contextual cues that aid the recall of information originally presented in the presence of that odor (Aggleton & Waskett, 1999). It is believed that olfactory stimuli possess this ability, in part, due to the fact that emotional arousal,

which is mediated by the actions of the amygdala, can aid in the recall of associated information (Cahill & McGaugh, 1996). Additionally, Aggleton and Waskett (1999) propose that elements of an environment in which learning takes place are linked in the brain to the information or experience that is to be remembered. This would suggest that an olfactory stimulus, such as cigarette smoke, may become linked to the pleasant feelings one might experience when smoking, thus becoming a conditioned stimulus. Another interesting feature of odors in relation to memory is the fact that, while odors are potent memory cues, one cannot retrieve an odor from memory in the way one can retrieve a picture or a sound (Soderquist, 2002). This is an important distinction in exploring olfactory stimuli as cues because it suggests that, while other cues might be able to be imagined, odors must actually be present in order to cue memories, emotions, or actions.

Olfactory stimuli are recognized as powerful cues for substance abuse, in general. Sayette and Parrott (1999) discuss reactions to cues in terms of emotions and note that stimuli affecting emotional states, such as olfaction, heavily influence reactivity to cues. Several studies have addressed the impact of olfactory stimuli on various aspects of drug use (Baldinger, Hasenfratz, & Battig, 1995; Buchalter, Acosta, Evans, Breland, & Eissenberg, 2005; Grusser, Heinz, & Flor, 2000; Monti et al., 1987; Perkins, Ciccocioppo, Jacobs, Doyle, & Caggiula, 2003; Perkins et al., 2001; Sayette & Hufford, 1994; Sayette & Parrott, 1999; F. Schneider et al., 2001; Smith-Hoerter, Stasiewicz, & Bradizza, 2004; Stormark, Laberg, Bjerland, Nordby, & Hugdahl, 1995; Towner, Ybasco, Rezai, Rose, & Contrada, 1991). Specific to smokers there is relatively little research. However, Towner and colleagues (1991) found that when smokers were presented with cues that included scents related to smoking, they were more likely to experience an increase in craving than when presented with cues that did not include scents. Likewise, Grusser and

colleagues (2000) found that smokers experienced greater increases in craving when presented with olfactory cues than did non-smokers. Perkins and colleagues (2001) noted that because a pack-a-day smoker smokes over 7000 cigarettes a year, pairing olfactory stimuli with nicotine intake is one of the most common conditioned associations and that the subjective hedonic and reinforcing effects of smoking behavior likely are influenced by olfactory stimuli. Rose and Levin (1991) agree, stating that it is likely that the smell of tobacco smoke serves as a secondary reinforcer as the result of pairing with the primary reinforcer of nicotine.

Internal cues. Just as environmental stimuli can become conditioned to elicit a conditioned response, internal states, or internal cues, may trigger a conditioned response (Greeley & Ryan, 1995). Of course, the drug itself has internal effects as a cue for drug delivery, but three secondary internal cues to consider when exploring cue reactivity in drug dependence are physiological states, mood, and cognition (1995).

Two physiological states are frequently discussed in cue reactivity literature and there is great debate as to which one truly motivates drug use among dependent individuals. Some argue that drug use has an positive reinforcing nature and is driven by the achievement of pleasurable states (Lyvers, 1998; Powell, Dawkins, & Davis, 2002; Robinson & Berridge, 2000; Stewart, de Wit, & Eikleboom, 1984). Others argue that the negative reinforcing nature of withdrawal motivates drug use as users seek to alleviate or avoid it (DiFranza & Wellman, 2005; O'Brien, Childress, McLellan, & Ehrman, 1993; Siegel, 1999). Glautier (2004) notes that addiction research and the theories that drive it should explore both positive (appetitive) *and* negative (avoidance) reinforcing processes when examining the phenomenon of drug dependence. Regardless, it is evident that physiological state, in some manner, serves as an internal cue.

Similar to the above discussion of brain activity, Stewart and colleagues (1984) suggested that drugs of abuse activate neural systems associated with appetitive motivation and, thus, produce positive-affective states. They argued that the motivating effects of conditioned cues may be effective in that they activate the reward system of the brain. Robinson and Berridge (2000) note that the subjective indicator of this activation is the subjective conditioned response known as craving. Activation of this area would increase the likelihood of drug use, suggesting not only an emphasis on positive reinforcement, but also an emphasis on the idea that dependence would occur through a positive feedback loop (1984). Upon activating the reward pathway, conditioned stimuli would initiate drug use, which would lead to further stimulation of the reward system, which would lead to further drug use (1984).

Other researchers emphasize the importance of negative reinforcement, looking to the dependent user's decision to avoid or alleviate withdrawal symptoms through continued drug use. As noted above in the section addressing respondent conditioning, withdrawal symptoms can be seen as conditioned compensatory responses to drug use that are present in the absence of the drug effect (Eissenberg, 2004). The body develops a conditioned response to the effects of drug use that is designed to maintain equilibrium. Nicotine dependent smokers may experience irritability, insomnia, craving, headache, and impaired concentration as a result of nicotine withdrawal (Hatsukami, Hughes, Pickens, & Svikis, 1984). When the drug is present, this response moderates the drug's effect. However, if cues are presented and no drug is administered, this conditioned response is fully expressed and withdrawal symptoms become present (Siegel, 1999). This conditioned withdrawal can occur days or months after the last usage (Marlatt & Gordon, 1985), thus avoidance of it may contribute to relapse after a period of successful cessation (Childress, McLellan, Ehrman, & O'Brien, 1988; Greeley & Ryan, 1995).

Mood and cognitions are the two other internal cues frequently discussed in cue reactivity literature. The terms "mood" and "affect" are often used interchangeably in discussing internal cues. Generally, negative mood states are reported more commonly than positive mood states as drug use precipitants (Greeley & Ryan, 1995). In smokers who are aware that nicotine relieves their withdrawal symptoms, such mood states may become conditioned cues for smoking (Shiffman et al., 2002).

Cognitions, particularly expectancies, are considered to be internal cues. Juliano and Brandon (1998) found that cognitions such as anticipating, or expecting, drug use can serve as internal cues, eliciting physiological and behavioral responses. These cognitions eventually become conditioned cues which independently are able to elicit conditioned responses, thus motivating drug use. This finding is similar to more recent findings (Dols, van den Hout, Kindt, & Willems, 2002; Dols, Willems, van den Hout, & Bittoun, 2000; Thewissen, van den Hout, Havermans, & Jansen, 2005) which showed that external smoking cues elicited less subjective urge to smoke in a non-smoking situation than in a smoking situation. These studies go on to assert that environmental smoking cues are capable of eliciting subjective conditioned responses primarily due to the expectation of smoking.

Types of Reactivity

Figure 2 demonstrates the wide variety of internal and external cues which influence smoking behavior among young adults. In response to exposure to this constellation of cues, there are three broad categories of reactions. Behavioral outputs, or drug-use behaviors, are the least studied of the three categories (Carter & Tiffany, 1999). These outputs include behaviors such as latency to smoke, decreased duration of abstinence, increased number of cigarettes

smoked, and relapse to smoking. The focus of more cue reactivity research is on the remaining two categories: physiological reactions and psychological reactions.

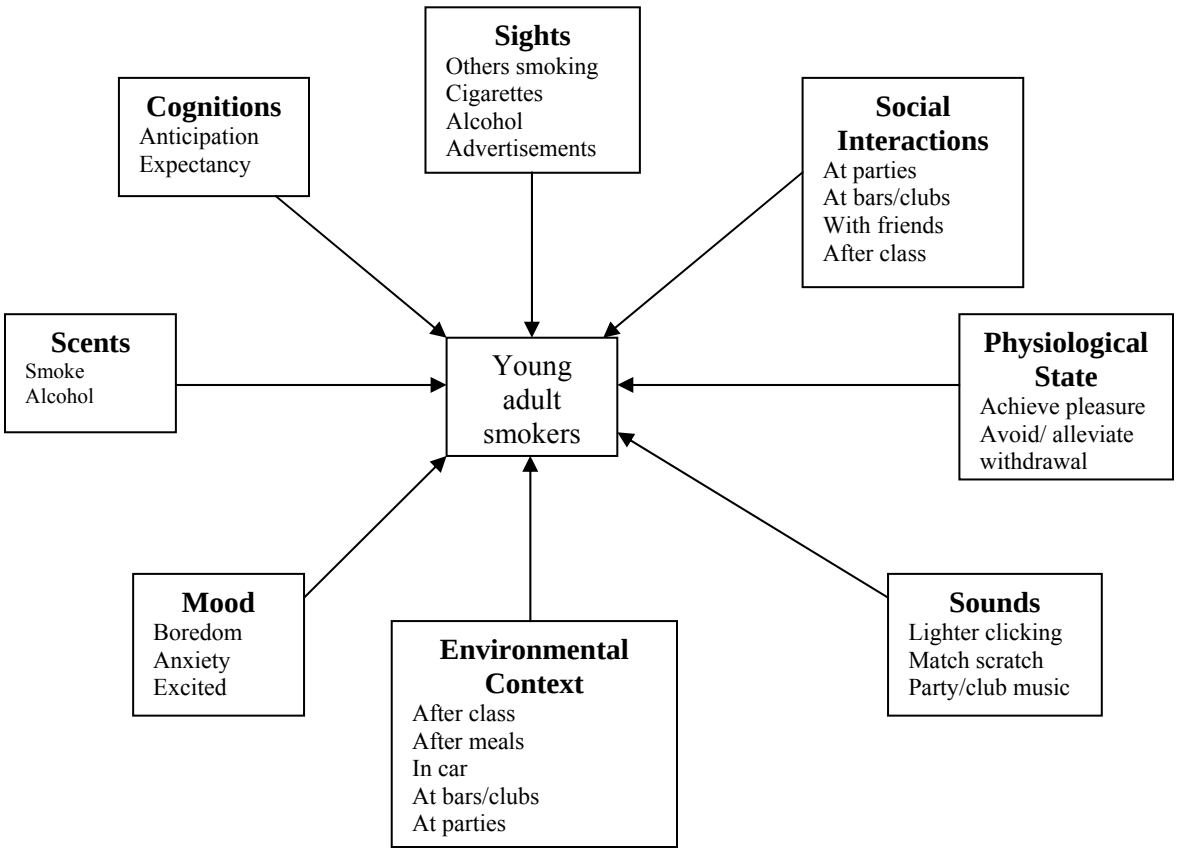


Figure 2. Constellation of cues affecting young adult smokers.

Physiological reactivity. The many studies exploring physiological reactivity among adult smokers have found that smokers demonstrate increased physiological arousal, including changes in heart rate, skin conductivity, temperature, and facial muscle activity when presented with smoking cues (P. S. Bordnick, Graap, Copp, Brooks, & Ferrer, 2005; P. S. Bordnick et al., 2004; Drobes & Tiffany, 1997; Lee et al., 2003; Lee et al., 2004; Niaura, Abrams, Demuth,

Pinto, & Monti, 1989; Niaura et al., 1998; Tiffany, Cox, & Elash, 2000). The reason for exploring functions controlled by this system is that changes in autonomic measures are indirect indicators of brain activity; and, until recently, direct measures of brain activity were difficult to utilize in cue reactivity studies due to cost and unavailability of the necessary technologies (Glautier & Tiffany, 1995). Some researchers have started utilizing brain imaging technologies to explore which areas of the brain are affected by drug cues (Lee, Lim, Wiederhold, & Graham, 2005; Smolka et al., 2006; Wilson, Sayette, & Fiez, 2004). However, this technology continues to be difficult for many researchers to employ, thus autonomic measures continue to be utilized.

Psychological reactivity (or craving). In relation to nicotine dependence, measure of craving may be the most widely used index of cue reactivity (Waters et al., 2004). The importance of craving as a measure of cue reactivity is underscored by the larger effect sizes associated with this measure than with physiological measures (Carter & Tiffany, 1999) and by the evidence relating it to use and relapse (Catley, O'Connell, & Shiffman, 2000; Shiffman et al., 2002). Indeed, Catley, O'Connell, and Shiffman (2000) reported that 94% of lapses to smoking were preceded by strong, conscious cravings. Craving also tends to last longer than recognized nicotine withdrawal symptoms. Withdrawal symptoms tend to diminish over 4 weeks' time, while craving appears for up to 6 months or longer (Durcan et al., 2002).

Two different manifestations of craving have been identified that, similar to physiological responses, reflect anticipation and pleasure or relief from negative affect (Tiffany & Drobes, 1991) and demonstrate that cues may become associated with smoking by processes of both positive and negative reinforcement (Dodgen, 2005). Cue-provoked craving is based on positive reinforcement processes relating to nicotine's effects on the reward system of the brain and can appear at any time when a conditioned cue is presented, even when the smoker is not deprived of

nicotine (2005). The second, alleviation-focused craving type is withdrawal based and characterized by negative mood states related to reduced intake of nicotine. Relieving this negative state by consuming nicotine is negatively reinforcing (Shiffman et al., 2003).

Little craving research has focused on adolescent or young adult nicotine dependent smokers. Studies which have focused on adolescents have found that this population demonstrates craving responses similar to adults when presented with smoking cues in both in vivo (Upadhyaya, Drobes, & Thomas, 2004) and virtual reality situations (P. S. Bordnick, Traylor, Graap, Copp, & Brooks, 2005; Lee et al., 2004).

Traditional Cue Exposure vs. Virtual Reality Cue Exposure

Traditionally, laboratory cue reactivity studies have relied upon exposing participants to photos, videos, or smoking paraphernalia. These studies suggest that exposure to visual, auditory, olfactory, and tactile smoking cues effectively increase physiological arousal (Drobes & Tiffany, 1997; Niaura, Abrams, Demuth, Pinto, & Monti, 1989; Niaura et al., 1998; Tiffany, Cox, & Elash, 2000) as well as subjective reports of craving compared to exposure to neutral stimuli (Drobes & Tiffany, 1997; Droungas, Ehrman, Childress, & O'Brien, 1995; Juliano & Brandon, 1998; Lazev, Herzog, & Brandon, 1999; Niaura, Abrams, Demuth, Pinto, & Monti, 1989; Niaura et al., 1998; Sayette, Martin, Wertz, Shiffman, & Perrott, 2001; Tiffany, Cox, & Elash, 2000; Tiffany & Drobes, 1990). Naturalistic studies have demonstrated the relationship between cues and relapse outside of the laboratory setting (O'Connell et al., 1998; Shiffman, Engberg et al., 1997; Shiffman et al., 1996; Shiffman, Hickcox et al., 1997; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996). Such findings suggest that social interactions are important cues to consider in treatment settings, but most cue exposure studies do not incorporate these important complex cues.

While laboratory and naturalistic studies have demonstrated that smoking cues can lead to increases in subjective craving, and changes in both mood and physiological states, there are problems with the utilization of traditional cue exposure methods. First, generalization of traditional cue exposure results outside of the laboratory setting remains a concern. Incorporation of ecologically valid complex cues utilizing social, physical, and affective interactions provided in an immersive environment that incorporates visual, auditory, and olfactory stimuli may provide a more appropriate context for studying cue reactivity, thus increasing generalization of cue exposure techniques, such as extinction, to the "outside" world encountered by smokers everyday.

Second, very few traditional studies have concentrated on young adult smokers or olfaction. Given the data suggesting the critical changes in smoking behaviors taking place in individuals between ages 18 and 24, it is important that research more closely target this population. In addition, few traditional studies have explored the impact of olfactory stimuli on subjective reactivity among smokers. A better understanding of the influence of olfactory stimuli on subjective cue reactivity may be helpful in developing more effective assessment and treatment tools and providing an environmental context appropriate for those tools.

One potential solution is to utilize virtual reality systems to test cue reactivity. Because such systems can provide an immersive sensory environment that incorporates appropriate contextual cues including social, physical, and affective interactions, generalization for exposure to cues can be increased. Furthermore, such a system could easily be employed to conduct much needed research on this young adult population of smokers, as well as the impact olfactory stimuli have on subjective reactivity.

Virtual reality incorporates a human-computer interaction that provides active participation with a three dimensional virtual environment. The participant derives a sense of presence in the virtual world as a result of integrated computer graphics and input technologies. According to Witmer and Singer (1998), a sense of presence in virtual environments occurs through truly experiencing an environment provided by a computer as opposed to the "real life" environment. Several factors related to control, sensory experiences, distraction, and realism influence the degree to which an individual feels both involved and immersed in a virtual environment and thus, experiences a sense of presence. This sense of presence is a key feature distinguishing virtual reality from video games or inactive computer displays. It is essential in engaging the participant and allowing more realistic cue exposures to be implemented in addiction treatment and also allowing the participant to be exposed to complex cues in the context of a realistic situation.

Typically, VR has relied primarily on visual, auditory, and, to a lesser extent, tactile stimuli to provide contextual elements of the real world in an immersive environment. However, olfactory systems are being developed that allow scents to be introduced into the environment, hopefully producing an even greater sense of presence and contributing to the creation of a real world environmental context of many smokers.

Clinically, VR has been gaining acceptance in the mental health arena and is being used currently to address eating disorders (Riva, Bacchetta, Baruffi, & Molinari, 2001; Riva, Bacchetta, Cesa, Conti, & Molinari, 2003), post-traumatic stress disorder (Beck, Palyo, Winer, Schwalger, & Eu, 2007; Difede, 2006; Ready, Pollack, Rothbaum, & Alarcon, 2006; Spira, Pyne, & Wiederhold, 2006), pain management (Gold, Kim, Kant, Joseph, & Rizzo, 2006; Oyama, 1998; Patterson, Weichman, Jensen, & Sharar, 2006; S. Schneider & Hood, 2007), and phobias

(Coelho, Santos, Silveria, & Silva, 2006; Davidson & Smith, 2003; Emmelkamp, Bruynzeel, Drost, & van der Mast, 2001; Klinger et al., 2005; Krijn, 2007; Maltby, Kirsch, Mayers, & Allen, 2002; Rothbaum, Hodges, Smith, Lee, & Price, 2000; Rothbaum, Hodges, Watson, Kessler, & Opdyke, 1996). In addition to emotional responses, studies focused on fear of flying have shown that physiological reactivity occurs in response to the VR environment (Muhlberger, Herrmann, Wiedemann, Ellgring, & Pauli, 2001; Weiderhold, Davis, & Weiderhold, 1998; Weiderhold & Weiderhold, 2001).

In regards to substance abuse, this technology has been developed and tested successfully, primarily with older adult populations. Bordnick and his colleagues (2004) developed the virtual reality nicotine cue reactivity assessment system (VR-NCRAS) and tested it with ten nicotine dependent adult smokers. It was discovered that, in response to VR smoking cues, subjective craving and physiological responses increased, indicating that VR cue exposure was effective in manipulating craving in nicotine addicted smokers, thus was a viable method of examining and assessing drug cravings and reactions.

VR systems that elicit craving responses by exposing participants to complex drug stimuli in the context of a real world smoking environment one day may be utilized to allow arousal, assessment, skill development, scenario repetition, and skill generalization in an effort to assist individuals in their cessation efforts. Indeed, there potentially are many advantages to conducting substance abuse assessments and treatments within a VR environment. VR systems have the ability to create contextual, immersive cue environments utilizing visual, auditory, olfactory, and tactile stimuli which can be provided to a client via an enclosed, head-mounted display, thus increasing the feeling of a real world experience as opposed to a laboratory setting. Inclusion of social interactions within the VR environment provides a contextually appropriate

alternative to traditional role playing activities. In addition, VR systems allow for safety, confidentiality, control, predictability, and repeatability across exposure situations, while allowing the social worker to communicate with the consumer in real-time.

While visual and auditory stimuli in a VR environment have been shown to elicit craving among adult smokers, the effects of the addition of olfactory stimuli provided in VR have not been tested in any population of smokers. Given the relationship between olfaction, emotion, and memory, olfactory stimuli may contribute substantially to the smoker's environmental context, leading to greater subjective reactivity than elicited by only visual and auditory stimuli.

Additionally, these systems have been tested successfully on adults, but little attention has been focused on younger adult smokers. Young adult smokers are at a stage in their lives where they are actively making decisions about their smoking habits, with many attempting cessation, but not necessarily succeeding, at a greater rate than older adults. Thus, it is crucial VR-NCRAS, with expanded olfactory cues, be tested with this population to explore the utility of such an assessment system and to determine the impact of olfactory cues on subjective reactivity.

CHAPTER 3

RESEARCH METHODS

The overall purpose of this experimental study was twofold: to explore and test a virtual reality cue exposure (VRCE) assessment system in a sample of nicotine dependent, young adult smokers and to explore the ability of olfactory cues to elicit reactivity among nicotine dependent young adults in a VR environment. The following section outlines the methods utilized in this study, including the design, subjects, instrumentation, and procedures.

Hypothesis

The present study was designed to test VR-NCRAS, with expanded olfactory cues, in young adult smokers to increase knowledge of this population of smokers and to evaluate the effect of olfactory stimuli presented within a VR environment. Two hypotheses were tested in this experimental study:

1) Exposure to VR smoking cues will increase subjective reactivity in nicotine dependent young adult smokers compared to exposure to VR neutral cues.
2) Exposure to olfactory, visual, and auditory cues in a VR environment will increase subjective reactivity in nicotine dependent young adult smokers compared to nicotine dependent young adult smokers who receive exposure to visual and auditory, but not olfactory, cues in a VR environment.

The dependent variable for hypotheses 1 and 2 was “subjective reactivity”. In this study, subjective reactivity was defined by the measures used to rate levels of self-reported craving for nicotine before, during, and after the VR-NCRAS session and attention paid to cues related to

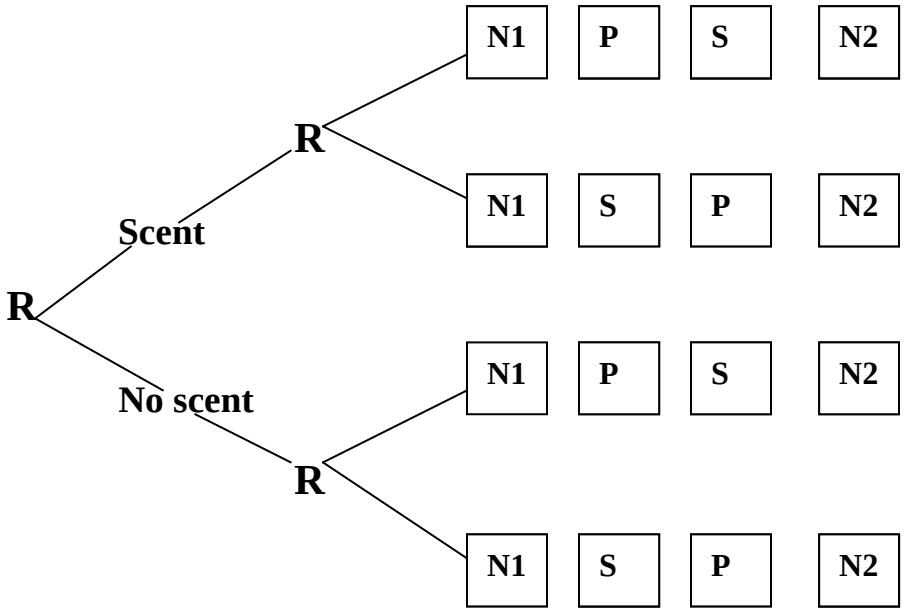
nicotine during the VR-NCRAS session. Changes in these scores were compared. The independent variable for hypothesis 1 was “VR smoking cues”. The VR-NCRAS and cues it utilizes are described in greater detail below. For purpose of this study, VR smoking cues were those stimuli, including paraphernalia and social interactions, that, when presented via virtual reality technology, elicited conditioned responses from nicotine dependent individuals. The independent variable for hypothesis 2 was “olfactory cues in a VR environment”. For the purpose of this study, these cues were scents related to smoking and smoking activities, such as eating and drinking that were presented within a virtual reality situation and were posited to bring about conditioned responses in nicotine dependent individuals.

Research Design

The VRCE utilized was the VR-NCRAS, which consisted of four separate rooms: two neutral stimuli rooms and two rooms containing smoking cues. The neutral stimuli rooms that the participants encountered as the first and last rooms of the experience were completely devoid of smoking cues. They consisted of two narrated nature videos that had the option of being presented with a neutral floral scent. The first smoking cue room consisted of smoking paraphernalia, such as cigarette packages, burning cigarettes, ashtrays, and coffee. Smells, such as cigarette smoke and coffee, can accompany the visual and audio cues in this room. The second smoking cue room involved a social situation at a party where people are smoking and interacting with the participant. During this scene, the participant was offered a cigarette. As with the first smoking cue room, appropriate olfactory stimuli, such as cigarette smoke, alcohol, and food, have the option of being presented.

There were two programming sequences. In sequence two, participants encountered the same rooms, but no olfactory stimuli were presented. Participants were randomized into one of

the two sequences. In addition, participants were randomized into one of two paths. The first path took the participant into the paraphernalia room first and the party room second, while the second path took the participant to the rooms in reverse order. This was done to control for room order effects. Figure 3 depicts the design utilized in this study. Participants were guided through each room; and, upon exiting each room, they completed self-report rating scales which were projected onto the wall in the virtual environment. Participants used a hand controller to provide their responses, which were recorded for analysis. All exposure times were standardized and controlled by the computer software, with participants spending 3 minutes in each room, for a total of 12 minutes in the VR environments.



N1= neutral room 1
P= paraphernalia room
S= social (party) room
N2= neutral room 2

Figure 3. Study design.

Participants

Twenty nicotine dependent, young adults, ages 18 to 24, were enrolled in this study. The participants were self-recruited or referred via advertising in a local free newspaper for participation in a study exploring virtual reality cue exposure. Participants of all races and ethnic backgrounds were eligible to participate. Attempts were made to recruit participants not currently enrolled in college, as well as those attending two-year and four-year institutions.

Inclusion criteria included providing informed written consent to participate, meeting the DSM-IV criteria for nicotine dependence; being between the ages of 19 and 24; being in good physical health; having transportation to the laboratory; having English literacy skills sufficient to read, understand, and complete measurements; and being able to wear a VR helmet for approximately 40 minutes.

Exclusion criteria included having a current or past diagnosis of DSM-IV recognized severe mental illness or current DSM-IV diagnosis of dependence for a substance other than nicotine; taking medication that may have an effect on nicotine craving or consumption or mood in the past 30 days; being pregnant; using opiates, cocaine, amphetamines, benzodiazepines, or other prescription or non-prescription drugs that may effect participation; engaging in treatment focused on smoking cessation; fearing closed spaces; being unable to wear a VR helmet; having visual problems that would effect viewing VR environments; or having a history of seizure, seizure disorder, or other serious health problems. Additionally, individuals with asthma, known respiratory allergies, smell disorders, active colds or other active respiratory illnesses, or who were taking nasally administered medications were be excluded from the study as these are common exclusionary criteria for olfactory studies.

Instrumentation

Several measures were utilized during this study. Below are listed descriptions of the primary study measures. Each of these measures previously has been used in studies exploring cue reactivity and craving in the VR-NCRAS environment (P. S. Bordnick, Graap, Copp, Brooks, & Ferrer, 2005; P. S. Bordnick et al., 2004; P. S. Bordnick, Traylor, Graap, Copp, & Brooks, 2005) . Additionally, visual analog scale questions regarding smells within the environments were added.

Structured Clinical Interview for the DSM-IV (SCID I/P) (First, Spitzer, Gibbon, & Williams, 1996)(Appendix A): Using this assessment, the researcher assured that participants met the criteria for nicotine dependence as outlined by the DSM-IV (Association, 1994). Additionally, this assessment was used to exclude participants who meet criteria for other diagnoses.

Smoking History (Appendix B): This self-report measure was used to gather information regarding how long the individual has been smoking, number of cessation attempts, and current and past usage levels.

Nicotine Dependence Questionnaire (NDQ) (Appendix C): Modified from the Fagerstrom Test for Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991), this 8-question measure was designed to measure an individual's dependence on nicotine. Higher scores suggest greater dependence on nicotine. While internal consistency is moderate at 0.61, this measure has been used in other studies conducted in this laboratory that focused on nicotine dependent smokers.

Questionnaire of Smoking Urges (QSU) (Tiffany & Drobes, 1991)(Appendix D): This 32-item measure assesses craving to smoke according to four distinct conceptualizations of

craving: anticipation of withdrawal, positive outcomes, desire, and intention (1991). Participants are asked to rate the items on a scale of 1 (strongly agree) to 7 (strongly disagree) before exposure to the VR-NCRAS. The QSU has demonstrated high internal consistency of 0.95 (1991), as well as sensitivity to both cue-provoked and withdrawal based craving (Morgan, Davies, & Willner, 1999).

Attitudes Towards the Sense of Smell Questionnaire (SoSQ) (Martin, Apena, Chaudry, Mulligan, & Nixon, 2001)(Appendix E): The SoSQ is a 36-item questionnaire that measures beliefs about the sense of smell, the importance of smell, and its uses. It is divided into 4 sections that focus on the following themes: perceived importance of smell, role of olfaction in health, the use of smell in everyday life, and the ability of smell to alter emotion and thinking. The individual sections have demonstrated good internal validity with alphas ranging from .81 to .95.

Cigarette Craving Visual Analog Scale (CCVAS): The CCVAS, or VAS, was incorporated into the VR-NCRAS session in order to measure real-time craving and to maintain immersion in the virtual environment. After exposure to each cue room, participants were asked to rate several attention and craving aspects of their experience in the virtual room on a 100-point visual analog scale projected onto the wall of the virtual environment. Specifically, participants were asked the following questions:

"Adjust the slider to indicate your greatest craving for smoking at this time."

"How much attention did you pay to the sight of cigarettes in the room?"

"How much attention did you pay to the smell of cigarettes in the room?"

"How much did you think about smoking when you were in the room?"

Using a hand controller, participants were able to select a position along the line from "not at all" to "more than ever" for the craving question and from 0 to 10 for the attention and thought

questions. Additionally, subjects completed a paper version of the CCVAS before and after involvement with VR-NCRAS.

Research Procedures

This study was approved by The University of Georgia Institutional Review Board on March 29, 2007. Initial contact with participants took place via telephone. Participants gave consent to be screened initially over the phone, answering a series of questions regarding demographics, physical and psychiatric health, and cigarette and drug habits. This initial screening, which can be reviewed in Appendix F, was designed to improve efficiency as unsuitable candidates were likely to be detected at this time and excluded from the study.

Participants who passed the telephone screening were asked to come to the lab for additional screening and a VR-NCRAS session. This screening session provided participants with information about the study, including rationale, risks, and IRB involvement. Participants then provided written consent to continue with the study. After obtaining informed consent, the researcher administered questionnaires and rating scales, including the SCID I/P, Smoking History, and CCVAS. The researcher reviewed all collected data for completeness before the participant left the laboratory. Participants were not allowed to not continue with the study if they did not comply with study guidelines or decided to discontinue participation. Only one potential participant was screened out during this part of the study due to potential mental health concerns.

After completion of the measures, participants participated in a 15-minute VR acclimation session with an environment unrelated to the study in an effort to provide familiarity with the overall experience, operation of input devices, and procedural aspects of the study. The participant was seated in a non-reclining chair and asked to put on the VR helmet, which was

equipped with a monitored video display and noise-canceling headphones. Participants adjusted the helmet for comfort and were shown how to utilize the hand controller in conjunction with the scales that appeared on the VR screen. They were then introduced to a VR office environment that contained neither scent nor smoking cues and were encouraged to look around and interact with the actors in the environment. Once participants felt comfortable wearing the helmet and utilizing the controller and any new questions about the procedures were answered, they were asked to smoke one cigarette outside in order to standardize the time since last exposure to nicotine. Two stage randomization to path and scent condition took place while the participant was out of the room. Additionally during this time, the VR program was adjusted so that the participant's cigarette brand of choice would appear throughout the VR smoking cue environments.

The VR-NCRAS session took place in the laboratory. The VR helmet and headphones again were placed on the participant's head and adjusted for comfort. Participants were asked to sit and relax for approximately five minutes. During this time in which the baseline physiological data was gathered, the lights in the room were turned off, the participant's visual field was dark, and music was played.

After this portion of the program was completed, the VR-NCRAS program began. Participants were exposed to four VR cue (two neutral and two smoking) rooms. Time in each room was standardized by the computer, with participants spending 3 minutes in each room, for a total of 12 minutes in VR.

Both groups began in a neutral cue room. Neutral cues rooms were those in which the participant could look around in the absence of smoking cues. The same neutral cue room was used in both neutral cue presentations and, for the group randomized to scent, floral scent was

used as a neutral scent in both rooms. Participants viewed two narrated nature videos that were devoid of smoking cues. Before leaving the room, participants filled out an on-screen CCVAS using a game pad.

The participants then moved to the first of two separate smoking cue rooms. One contained smoking paraphernalia such as ash trays, burning cigarettes, and cigarette packs, as well as alcoholic beverages. For the group randomized to scent, olfactory cues, including cigarette smoke and alcohol, were present. The other smoking cue room introduced a party setting in which the participant was engaged in social interaction with smokers and offered a cigarette. For the group randomized to scent, the cues in this room were enhanced by olfactory cues including cigarette smoke, food, and alcohol. The group randomized to no scent received the same auditory and visual stimuli in each room, but received no olfactory stimuli. Participants completed a CCVAS before leaving each of the smoking cue rooms.

The last room encountered was the exact same neutral room encountered previously, including the same floral scent for the group randomized to scent. The participants filled out a CCVAS before leaving the room.

At the end of the VR-NCRAS session, participants completed a paper version of the CCVAS. Additionally, participants were engaged in a de-briefing interview by a Ph.D. candidate-level clinician to gain qualitative information about their VR experience. At this time they assessed for any signs of distress or problems related to increased craving as a result of the VR environments and were offered information about local cessation programs.

CHAPTER 4

RESULTS

Sample Characteristics

Demographic Characteristics

Initially, 22 nicotine dependent young adult smokers participated in this study. The gender makeup of this sample was 59.1% (13) male and 40.9% (9) female. In regards to race, the majority of the sample, 15 (68.2%), identified themselves as White. Three participants (13.6%) identified themselves as African-American and three participants (13.6%) identified themselves as Asian. One (4.5%) participant identified himself as Hispanic. Most of the participants, 15 (68.2%), stated that they attended a 2-year institution of higher education. Six (27.3%) of the participants were not enrolled in school and 1 participant (4.5%) was enrolled in a 4-year university.

However, after reviewing the data and testing for outliers, it was determined that data from two of the subjects should be discarded. This was done after results of testing for outliers indicated that these subjects scored 2 to 3 standard deviations above or below the mean on most measures. Thus, the final sample consisted of 20 nicotine dependent young adult smokers. Descriptive statistics on participant characteristics are presented in Table 1. The gender makeup of this sample was 60% (12) male and 40% (8) female. The majority of the sample, 15 (75%), identified themselves as White. Three participants (15%) identified themselves as African-American, while 1 (5%) participant identified himself as Hispanic and another participant (5%) identified herself as Asian. Over half of the participants, 13 (60%), stated they attended a 2-year

institution of higher education. Six (30%) of the participants were not enrolled in school and 1 participant (5%) was enrolled in a 4-year university.

Table 1

Participant Gender, Race, and Educational Status (n= 20)

Variable/Label	*n*	%
Gender		
Male	12	60
Female	8	40
Race		
White	15	75
African American	3	15
Hispanic	1	5
Asian	1	5
Educational Status		
2-year institution	13	60
Not in school	6	30
4-year institution	1	5

According to data presented in Table 2, participant ages ranged between 19 and 24 with a mean age of 20.9 years (SD= 1.4). The mean age at which participants began smoking was 14.8 years (SD= 2.5), with the means number of years smoking being 6.0 (SD= 2.5). The number of

cigarettes smoked each day ranged between 6 and 20, with the average number smoked per day being 13.4 (SD= 4.5).

Table 2

Participant Age and Smoking Data (n= 20)

Variable/Label	M	SD
Age	20.9	1.4
Age of smoking initiation	14.8	2.5
Number of years smoking	6.0	2.5
Cigarettes smoked per day	13.4	4.5

Eleven subjects were randomized to the scent condition, while 9 subjects were randomized to receive no scent in VR. One (variable) by two (scent condition) one way analysis of variance were performed on all interval scaled demographic and cigarette usage variables. Chi-square tests were conducted for the categorical demographic variables of gender, race, and student status. There were no statistically significant differences on any of the demographic and cigarette usage variables between the participants assigned to the scent condition and participants assigned to the no scent condition.

Nine subjects were randomized to path 1, and 11 subjects were randomized to path 2. One (variable) by two (path) one way analysis of variance were performed on all interval scaled demographic data and chi-square tests were conducted on categorical demographic variables of gender, race, and student status to identify any significant differences between the group

assigned to path 1 and the group assigned to path 2. There were no statistically significant differences on any of the demographic or cigarette use variables.

Pre-VR Measure Characteristics

Before participating in the VR session, subjects completed the following measures: the Nicotine Dependence Scale (NDS), Questionnaire of Smoking Urges (QSU), Attitude Towards Sense of Smell Questionnaire (SoSQ), and Cigarette Craving Visual Analog Scale (CCVAS). As indicated in Table 3, scores on the NDQ ranged from 5 to 11, with the average score being 8.0 (SD= 2.2), indicating a medium to high level of dependence for all participants. Scores on the QSU ranged from 15 to 59, with a mean score of 36.4 (SD=14.0), indicating that the participants demonstrated moderate craving to smoke. Participants' total scores on the SoSQ ranged from 25.3 to 49.8, with a mean score of 38.6 (SD= 5.8). This indicates that participants placed moderate importance on the sense of smell and its ability to influence emotions and thoughts.

Table 3

Mean Pre-VR Measure Scores (n= 20)

Variable/Label	M	SD
NDQ	8.0	2.2
QSU	36.4	14.0
SoSQ	38.6	5.8
CCVAS craving	54.4	25.4
CCVAS urge	62.1	25.8

The CCVAS consisted of questions that were scored independently of one another. When questioned about their current level of craving, participants' answers ranged from 14 to 99. The average score was 54.4 (SD= 25.4), indicating a moderate craving level before engaging in the VR session. Participants' scores ranged from 18 to 99 when asked about their current urge to smoke cigarettes. The average score was 62.1 (SD=25.8), indicating a moderate to high urge to smoke.

One way ANOVA's with post hoc Bonferoni tests were conducted on all mean scores of the pre-VR measurements to determine any pre-VR differences between the scent and no scent groups. There were no significant differences between the groups in relation to mean scores on the NDQ, QSU, or CCVAS. However, results of the one way ANOVA for the SoSQ total score indicated significant differences between the groups (p = .049). Based on these results, the SoSQ will be used as a covariate in all analysis comparing the scent versus no scent conditions.

One way ANOVA's with post hoc Bonferoni tests also were conducted on all mean scores of the pre-VR measurements to determine any pre-VR differences between the groups assigned to each of the paths. There were no significant differences between the groups in relation to mean scores on the NDQ, QSU, SoSQ, or CCVAS.

Craving Results

Hypothesis 1 of this study is: Exposure to VR smoking cues will increase subjective reactivity in nicotine dependent young adult smokers compared to exposure to VR neutral cues.

Craving in VR Cue Rooms

One way repeated measures analysis of variance was used to analyze craving ratings with VR cue rooms as within subject factors. The assumption for sphericity was not met (p = .006), therefore a Huynh-Feldt correction was used. A significant main effect for craving was found,

F(2.279, 43.299) = 12.527, $p < .000$. There was no significant interaction between room and path ($p = .139$), indicating that there was no order effect according to path (see Table 4).

Table 4

Analysis of Variance for Craving Ratings in VR Cue Rooms

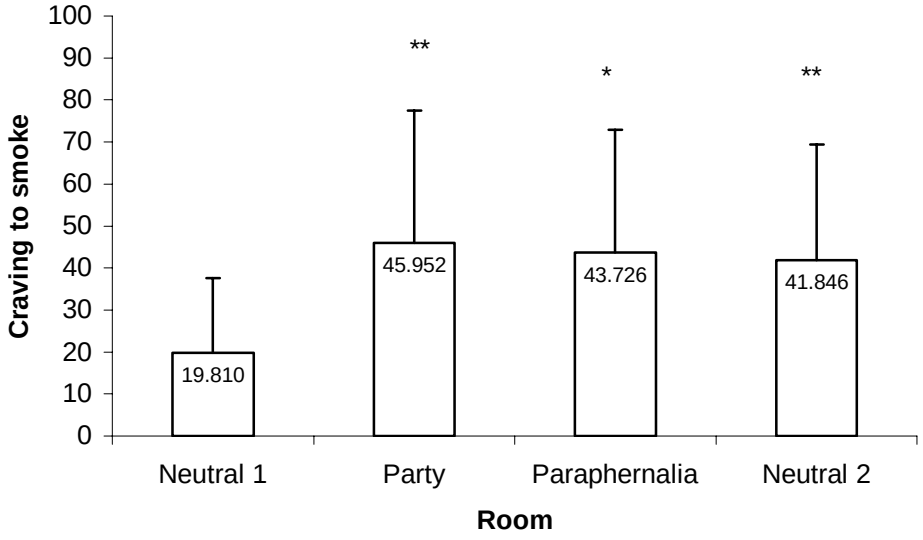
Source	*df*	*SS*	*MS*	*F*	*p*
Room	2.279	8831.717	3875.415	12.527	.000
Error	43.299	13395.148	309.362		

Post hoc comparisons with Bonferoni correction for multiple tests revealed significant differences at the overall 0.05 level between neutral room 1 and the paraphernalia room ($p < .002$), the party room ($p < .004$), and neutral room 2 ($p < .004$). Specifically, average craving ratings in the VR cue rooms were 19.810, 45.9523, 43.72.56, and 41.8458 on a scale from 0 to 100 for neutral room 1, party room, paraphernalia room, and neutral room 2 respectively. There were no significant differences between the party and paraphernalia smoking cue rooms ($p < 1.00$). Likewise, there were no significant differences between the party and paraphernalia smoking cue rooms and neutral room 2 ($p < 1.00$). These results are seen in Figure 4.

Attention to Sight of Cigarettes in VR Cue Rooms

As reported in Table 5, one way repeated measures analysis of variance was used to analyze ratings of attention paid to the sight of cigarettes with VR cue rooms as within subjects factors. The assumption for sphericity was met ($p = .140$) and a significant main effect for attention paid to the sight of cigarettes was found, F(3, 57) = 66.769, $p < .000$. There was no

significant interaction between room and path ($p = .171$), indicating that there was no order effect according to path.



* $p < .002$ (Neutral 1 vs. paraphernalia room)
** $p < .004$ (Neutral 1 vs. party room and neutral room 2)

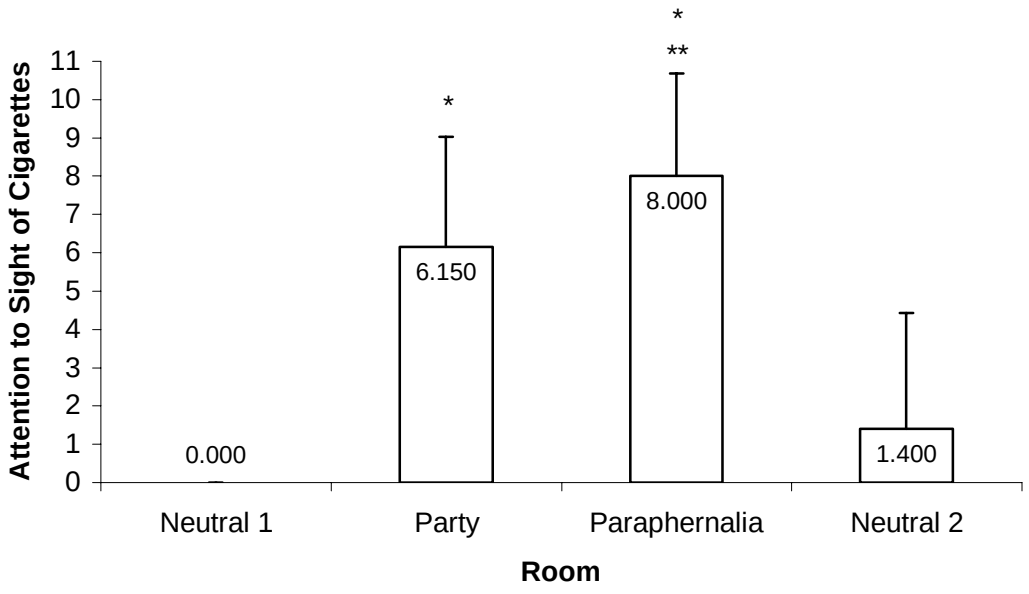
Figure 4. Mean craving to smoke by VR room.

Table 5

Analysis of Variance for Attention to Sight of Cigarettes in VR Cue Rooms

Source	*df*	*SS*	*MS*	*F*	*p*
Room	3	866.638	288.879	66.769	.000
Error	57	246.613	5.545		

After finding a significant main effect for attention paid to the sight of cigarettes in the VR rooms, post hoc comparison analysis with Bonferroni correction for multiple tests was performed. Overall, ratings of attention paid to the sight of cigarettes in the room were significantly higher in the VR smoking cue rooms as opposed to the VR neutral cue rooms ($p <$ .000). Specifically, on a scale from 0 to 10, average attention paid to the sight of cigarettes in the VR rooms was .000 for neutral room 1, 6.150 for the party room, 8.0 for the paraphernalia room, and 1.4 for neutral room 2, as seen in Figure 5. In addition, pairwise comparisons showed a significant difference at the overall 0.05 level between the party and paraphernalia rooms ($p =$ .002). There was no significant difference between neutral room 1 and neutral room 2 ($p = .318$).



* $p <$ .000 (Neutral 1 vs. party and paraphernalia rooms)
** $p <$ .002 (Party vs. paraphernalia room)

Figure 5. Mean attention to the sight of cigarettes by VR room.

Attention to Smell of Cigarettes in VR Cue Rooms

Data regarding attention paid to the smell of cigarettes in the VR rooms is reported in Table 6. This data were analyzed using one way repeated measures analysis of variance with VR cue rooms as the within subjects factors. The assumption for sphericity was not met ($p = .001$), thus a Huynh-Feldt correction was used. A significant main effect for attention paid to the smell of cigarettes was found, $F (2.202, 41.832) = 17.035$, $p < .000$. There was no significant interaction between room and path ($p = .243$), indicating that there was no order effect according to path.

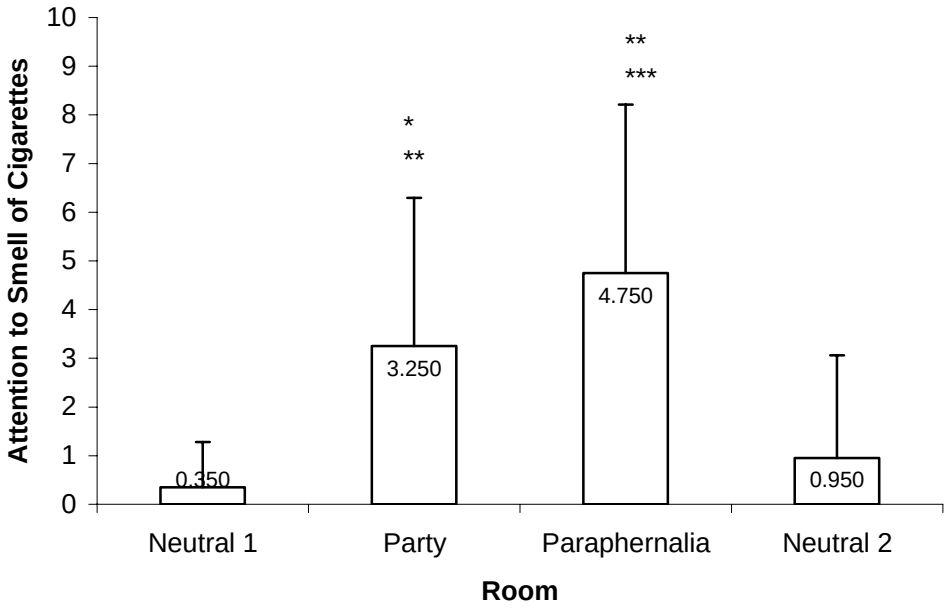
Table 6

Analysis of Variance for Attention to Smell of Cigarettes in VR Cue Rooms

Source	*df*	*SS*	*MS*	*F*	*p*
Room	2.202	250.550	83.517	17.035	.000
Error	41.832	279.450	6.680		

Post hoc comparisons with Bonferoni correction for multiple tests revealed significant differences at the overall 0.05 level between ratings of attention paid to the smell of cigarettes in the VR smoking cue rooms as opposed to the VR neutral cue room. Figure 6 shows that, utilizing a scale from 0 to 10, average ratings of attention to smell in the VR rooms were .35 in neutral room 1, 3.25 in the party room, 4.75 in the paraphernalia room, and .950 in neutral room 2. There were significant increases between neutral room 1 and the party room ($p < .002$) and

neutral room 1 and the paraphernalia room ($p < .000$). Similarly, there were significant differences between the smoking cue rooms and neutral room 2 ($p < .002$). Analysis revealed no significant differences between the party and paraphernalia rooms ($p < .643$) or between neutral rooms 1 and 2 ($p < .784$).



* $p < .002$ (Neutral room 1 vs. party room)
** $p < .000$ (Neutral room 1 vs. paraphernalia room)
*** $p < .002$ (Neutral room 2 vs. party and paraphernalia room)

Figure 6. Mean attention to the smell of cigarettes by VR room.

Thoughts about Smoking in VR Cue Rooms

Data concerning participants' thoughts about smoking in the VR rooms were analyzed by means of a one way repeated measures analysis of variance with VR cue rooms as the within subjects factors as reported in Table 7. The assumption for sphericity was met ($p = .291$) and a significant main effect for thinking about smoking was found, $F(3, 57) = 19.103$, $p < .000$. There

was no significant interaction between room and path ($p = .289$), indicating that there was no order effect according to path.

Table 7

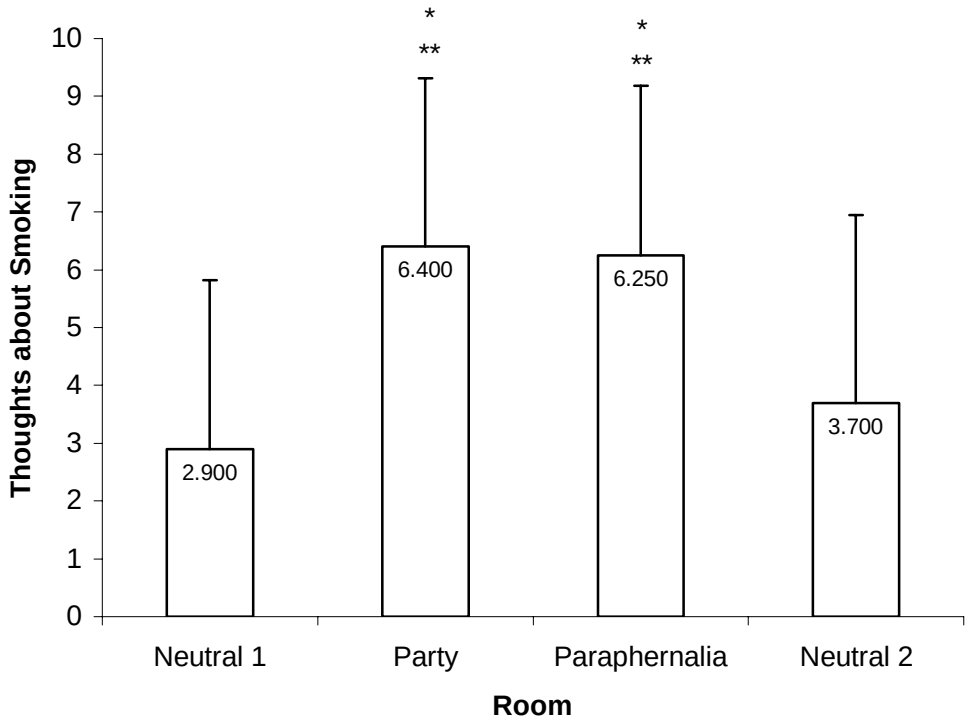
Analysis of Variance for Thoughts about Smoking in VR Cue Rooms

Source	*df*	*SS*	*MS*	*F*	*p*
Room	3	189.638	63.213	19.103	.000
Error	57	188.613	3.309		

Upon finding a significant main effect for thinking about smoking in the VR rooms, post hoc comparison analysis with Bonferoni correction for multiple tests was performed. As shown in Figure 7, participant thoughts about smoking were recorded on a scale from 0 to 10, with average scores about thoughts about smoking being 2.9 in neutral room 1, 6.4 in the party room, 6.25 in the paraphernalia room, and 3.7 in neutral room 2. At the overall 0.05 level, there were significant differences between neutral room 1 and the party and paraphernalia rooms ($p < .000$) and significant differences between the party and paraphernalia rooms and neutral room 2 ($p < .001$). However, no significant differences were found between the party and paraphernalia smoking cue rooms ($p < 1.00$) or between the neutral cue rooms ($p < .975$).

Olfactory Cue Results

Hypothesis 2 of this study is: Exposure to olfactory, visual, and auditory cues in a VR environment will increase subjective reactivity in nicotine dependent young adult smokers



* $p < .000$ (Neutral room 1 vs. party and paraphernalia rooms)
** $p < .001$ (Neutral room 2 vs. party and paraphernalia rooms)

Figure 7. Mean thoughts about smoking by VR room.

compared to nicotine dependent young adult smokers who receive exposure to visual and auditory, but not olfactory, cues in a VR environment.

Because results of the one way analysis of variance for the SoSQ total score indicated significant differences ($p = .049$) between the group that received olfactory cues and the group that did not receive olfactory cues, univariate analysis of covariance utilizing scent as independent variable and the SoSQ total score as a covariate was employed to analyze data exploring the effect of exposure to VR cue environments with olfactory cues versus VR cue environments without olfactory cues on craving levels among nicotine dependent young adults smokers.

Craving by Scent Condition

Univariate analyses of covariance with scent conditions as between subject factors and total SoSQ score as covariant was used to analyze craving ratings in each of the VR cue rooms. Results showed that between the group receiving olfactory cues and the group that did not receive olfactory cues there was no significant difference between craving ratings in the first neutral room, $F (2, 17) = .088$, $p < .917$; the party room, $F (2, 17) = .857$, $p < .442$; the paraphernalia room, $F (2, 17) = 1.554$, $p < .240$; or the second neutral room, $F (2, 17) = 1.014$, $p < .384$.

There were differences in mean craving scores between the groups in each room, but these differences were not significant. Specifically, mean craving scores on a scale from 0 to 100 for subjects assigned to the scent condition were 21.494 in the first neutral room, 45.654 in the party room, 44.492 in the paraphernalia room, and 45.098 in neutral room 2. Mean craving scores reported by subjects in the no scent condition were 18.125 in the first neutral room, 46.250 in the party room, 42.959 in the paraphernalia room, and 38.594 in the second neutral room. Figure 8 depicts these results.

Attention to Sight of Cigarettes by Scent Condition

Data exploring the effect of presentation of olfactory cues on attention paid to the sight of cigarettes in each VR room was analyzed using univariate analysis of covariance with scent condition as the between subject factor and total SoSQ score as covariant. Results showed that there was no significant difference between the group receiving olfactory cues and the group not receiving olfactory cues in the first neutral cue room, $F (2, 17) = 0$; the party room, $F (2,17) = 1.520$, $p < .247$; and the second neutral room, $F (2, 17) = 2.526$, $p < .110$. However, a significant main effect was found in the paraphernalia room $F (2, 17) = 4.028$, $p < .037$.

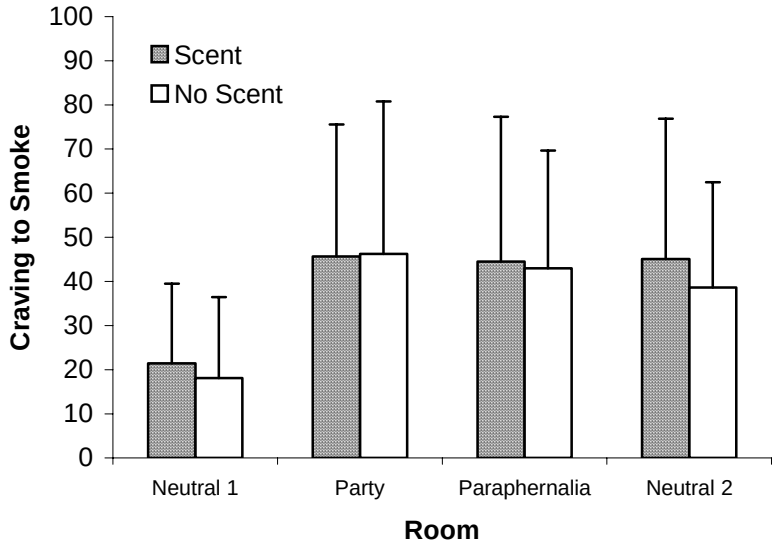


Figure 8. Mean craving to smoke by scent condition.

Differences on attention paid to the sight of cigarettes in the VR rooms were detected between the groups, although not at a statistically significant level. Using a scale from 0 to 10, the group assigned to the scent condition reported the following mean attention to the sight of cigarettes scores: 0.0 in the first neutral room, 5.4 in the party room, 7.4 in the paraphernalia room, and 2.6 in the second neutral room. The group assigned to the no scent condition reported the following scores: 0.0 in the first neutral room, 6.9 in the party room, 8.6 in the paraphernalia room, and 0.2 in the second neutral room. Results are depicted below in Figure 9.

Attention to Smell of Cigarettes by Scent Condition

Univariate analysis of covariance with scent conditions as between subjects factor and total SoSQ score was used to analyze the effect of presentation of olfactory cues on attention paid to the smell of cigarettes in the VR room. Results showed no significant differences between the groups in the first neutral cue room, $F(2, 17) = 2.553$, $p < .107$; the party room, F

(2, 17) = .604, $p < .558$; the paraphernalia room, F (2, 17) = .426, $p < .660$; or the second neutral room, F (2, 17) = 1.912, $p < .178$.

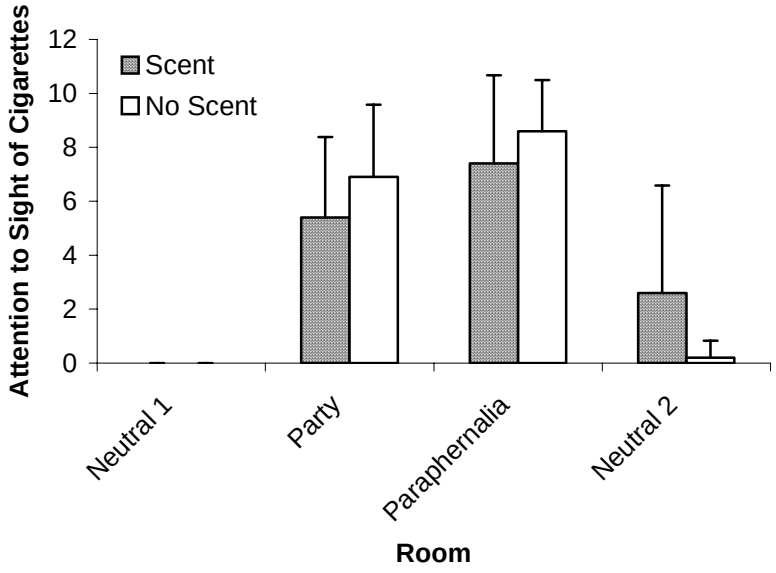


Figure 9. Mean attention to the sight of cigarettes by scent condition.

As seen in Figure 10, no significant differences were detected between the two conditions in regard to attention paid to the smell of cigarettes in the VR rooms. On a scale from 0 to 10, the subjects in the scent condition reported 0.7 in the first neutral room, 4.0 in the party room, 4.9 in the paraphernalia room, and 1.7 in the second neutral room. Subjects in the no scent condition reported 0.0 in the first neutral room, 2.5 in the party room, 4.6 in the paraphernalia room, and 0.2 in the second neutral room.

Thoughts about Smoking by Scent Condition

Data concerning the effects of presentation of olfactory stimuli in the VR rooms on participants' thoughts about smoking while in the VR rooms was analyzed through univariate analysis of covariance using scent conditions as the between subjects factor and total SoSQ score

as the covariant. Analysis revealed no significant differences between the groups in the first neutral room, F (2, 17) = 1.344, $p < .287$; the party room F (2, 17) = 1.711, $p < .210$; the paraphernalia room, F (2, 17) = 2.753, $p < .092$; or the second neutral room, F (2, 17) = 2.535, $p < .109$.

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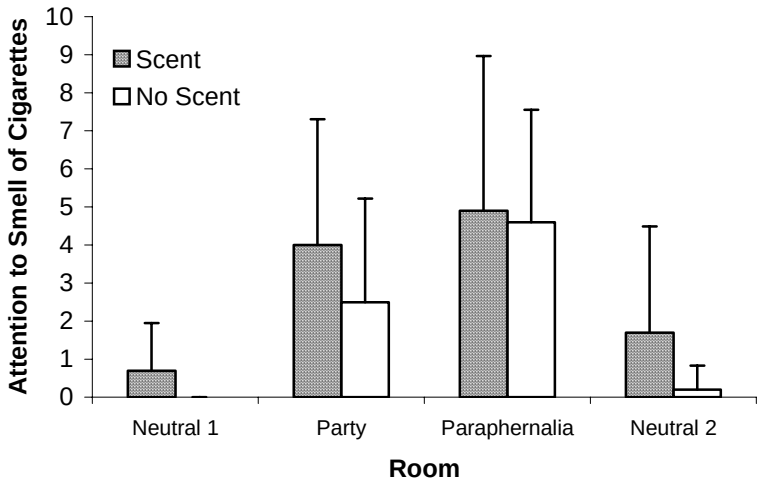

Figure 10. Mean attention to the smell of cigarettes by scent condition.

Figure 11 shows that no significant differences were found between the two groups in regard to thoughts about smoking. However, differences that did not meet statistical significance were observed between the scent and no scent condition. Using a scale from 0 to 10, subjects in the scent condition reported the following mean scores for thinking about smoking: 3.7 in neutral room 1, 6.7 in the party room, 6.2 in the paraphernalia room, and 4.7 in the second neutral room. The subjects assigned to the no scent condition reported mean scores of 2.1 in the first neutral room, 6.1 in the party room, 6.3 in the paraphernalia room, and 2.7 in the second neutral room.

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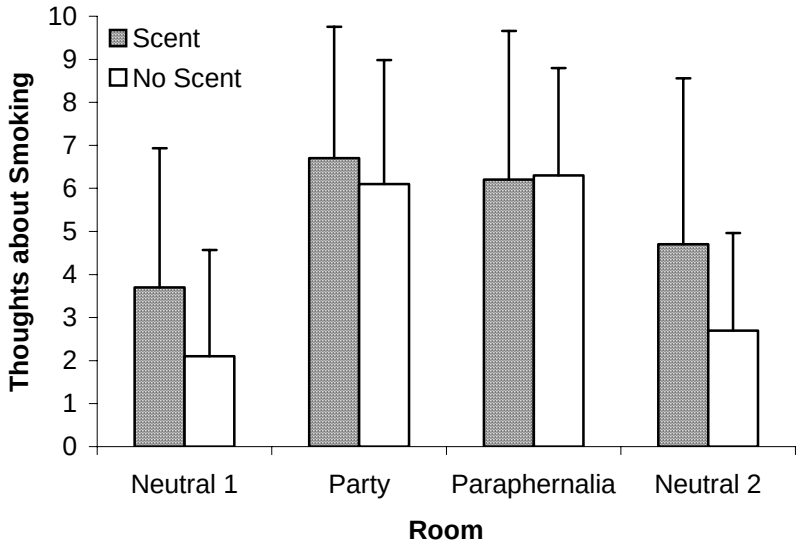

Figure 11. Mean thoughts about smoking by scent condition.

CHAPTER 5

DISCUSSION

Summary of Results

Participant Demographics and Pre-VR Measures Scores

The purpose of this experimental study was to explore and test a virtual reality cue exposure (VRCE) assessment system in a sample of nicotine dependent, young adult smokers and to explore the ability of olfactory cues to elicit reactivity among nicotine dependent young adults in a VR environment. Twenty nicotine dependent young adult smokers participated in this study. Over half of the sample (60%) was male and 75% of the sample identified themselves as White. Three participants (15%) identified themselves as African-American, while 1 (5%) participant identified himself as Hispanic and another participant (5%) identified herself as Asian. Most of the participants (60%) attended a 2-year institution of higher education. Thirty percent of the participants were not enrolled in school and 1 participant (5%) was enrolled in a 4-year university. The average age was 20.9 years and the average age at which participants began smoking was 14.8, with the average number of years smoking being 6. The average number of cigarettes smoked each day by participants was 13.4.

Nine subjects were randomized to path 1 and 11 subjects were randomized to path 2. Eleven subjects were randomized to receive scent in VR, while 11 subjects were randomized to receive no scent. Results of one way analysis of variance and chi-square tests exploring differences between the groups assigned to path 1 and path 2, as well as the scent and no scent conditions in regards to demographic and cigarette usage data were not statistically significant.

This indicates that the groups assigned to the two paths and to the two scent conditions were statistically equivalent groups in terms of demographic and cigarette use variables.

Subjects completed several measures before participating in the VR session. Results of the Nicotine Dependence Questionnaire (NDQ) demonstrated that participants had a medium to high level of nicotine dependence, while results from the Questionnaire of Smoking Urge (QSU) indicated participants had a moderate craving to smoke. Scores from the Attitudes Towards the Sense of Smell Questionnaire (SoSQ) showed participants to place moderate importance on the sense of smell and its influence on thoughts and emotions.

Results of one way analysis of variance and chi-square tests exploring differences between the groups assigned to path 1 and path 2, as well as the scent and no scent conditions in regard to the results of these pre-VR measures were not statistically significant with one exception. The mean total SoSQ score for the group assigned to the scent condition was significantly lower than the mean total SoSQ score for the group assigned to the no scent condition. Thus, the group assigned to receive olfactory cues in this study reported on the SoSQ to place a statistically significantly lower importance on the sense of smell and its influence on thoughts and emotions. This indicates that the groups assigned to the two paths and to the two scent conditions were statistically equivalent groups in terms of nicotine dependence and craving, but not statistically equivalent in terms of the importance placed on the sense of smell. This could be an important distinction between the groups as the group scoring lower on the SoSQ could focus more attention on sensory experiences not related to smell or could place less importance on scent as an emotional or sensory cue for smoking, while the group scoring higher on the SoSQ might place greater importance on the ability of scent to trigger emotions and thoughts related to craving. Because groups assigned to the scent conditions were not equivalent

in regard to their mean total scores on the SoSQ, and potentially the importance they placed on scent as an influence on thoughts and emotions, the SoSQ score was used as a covariate in all analysis concerning the scent conditions.

Craving Results and Discussion

The results of this study appear to support hypothesis 1, which stated that exposure to VR smoking cues would increase subjective reactivity in nicotine dependent young adults smokers compared to exposure to VR neutral cues. In this study, subjective reactivity was defined as self-reported craving for nicotine before, during, and after the VR-NCRAS session and attention paid to cues related to nicotine during the VR-NCRAS session.

Results showed that nicotine dependent young adults smokers reported statistically significantly higher levels of craving in the party and paraphernalia rooms as opposed to the first neutral cue room. Subjects recorded slightly higher levels of craving in the party room as opposed to the paraphernalia room, although this difference did not reach statistical significance. This is consistent with subjects' responses during the post-VR debriefing interview when asked which most made them crave. Seventeen subjects (85%) noted that the party room was the environment most likely to induce strong feelings of craving. These results are similar to other VR smoking cue studies conducted with older adults (Baumann et al., 2003; P. S. Bordnick, Graap, Copp, Brooks, & Ferrer, 2005; P. S. Bordnick et al., 2004), as well as traditional smoking cue studies conducted with older adults (Drobes & Tiffany, 1997; Droungas, Ehrman, Childress, & O'Brien, 1995; Juliano & Brandon, 1998; Lazev, Herzog, & Brandon, 1999; Niaura, Abrams, Demuth, Pinto, & Monti, 1989; Niaura et al., 1998; Sayette, Martin, Wertz, Shiffman, & Perrott, 2001; Tiffany, Cox, & Elash, 2000; Tiffany & Drobes, 1990). However, there are two notable differences between the results of those studies and the results of this study.

First, while studies conducted with older adults have shown a general return to baseline craving levels, carryover effects on craving were apparent in neutral room 2, as evidenced by the failure of the craving scores to return to baseline levels. The possible reason that these young adults did not report a return to baseline craving levels in neutral room 2 may be related to a condition in which these participants frequently reported smoking—boredom. When asked about situations or times during which they smoke, seventy percent, or 14, of the participants said they smoked when they were bored. In the post-VR debriefing interview, when participants were asked of their impressions of the VR environments, many commented on the novelty of the first neutral room. They were not sure what to expect and were excited about using the VR technology. When asked about the second neutral cue room, eleven participants (55%) said that they were disappointed to be in the neutral cue room because it was boring. This neutral room, which many older adults reported to be relaxing or calming, and therefore conducive to reducing craving levels, may have had an opposite effect on younger adults who found the environment boring and thus a deterrent to a reduction of craving. This is consistent with findings from other studies that cite boredom as one of the reasons why adolescents and young adults smoke (Amos, Wiltshire, Haw, & McNeill, 2006; Stromberg, Nichter, & Nichter, 2007; Tuakli, Smith, & Heaton, 1990; Wahl, Turner, Mermelstein, & Flay, 2005; Wang, Cowdery, Trucks, & Fitzhugh, 1994; Wang, Fitzhugh, Cowdery, & Trucks, 1995). This finding suggests that unlike adults who find calming, relaxing neutral VR environments helpful in reducing craving, young adults may need to be provided with neutral VR environments that are energizing or exciting in order to return to a baseline level of craving.

This finding may also speak to the idea that, unlike many older adults, most young adults are comfortable accessing and using technology, having grown up surrounded by computers and

video games. Many have come to expect impressive graphics and interactions when they use computers or engage in gaming activities. While older adults appear to find the neutral rooms relaxing, these younger adults may need environments that engage them in a manner to which they are accustomed when utilizing computers and other technology. The novelty of the VR experience appears to have kept them engaged and interested through most of the session; however, the return to the same neutral room in the end was not a novel experience and, thus, elicited boredom that maintained craving levels instead of relaxation that reduced craving. Also, it is possible that because young adults appear to become bored with the same environments, additional smoking settings, such as multiple party rooms and other environments in which young adults smoke should be developed, tested, and used to maintain interest. This would reduce boredom and keep young adults engaged in cessation activities, potentially reducing the number of those who might withdraw from treatment. Future research should explore the impact of boredom on young adult smokers' craving, as well as focus on designing and testing a wide variety of neutral and smoking VR environments that are engaging and prevent young adults from becoming bored.

Results focusing on attention paid to the sight and smell of cigarettes and thoughts about smoking cigarettes in the VR rooms also appear to be consistent with results from similar studies employing older adult samples (Baumann et al., 2003; P. S. Bordnick, Graap, Copp, Brooks, & Ferrer, 2005; P. S. Bordnick et al., 2004). Nicotine dependent young adult smokers reported paying significantly more attention to the sight and smell of cigarettes, as well as thinking more about smoking in VR environments that contained smoking cues than in rooms that contained no smoking cues. Subjects reported slightly higher levels of attention to the sight and smell of cigarettes in the paraphernalia room as opposed to the party room, but slightly higher levels of

thinking about smoking in the party room as opposed to the paraphernalia room. None of these results, however, reached a level of statistical significance.

Subjects may have paid more attention to visual and olfactory cues in the paraphernalia room than the party room because of the lack of social interaction in that room. Because there were no people present, the focus solely was on cigarettes and accompanying paraphernalia, such as lighters or matches. The presence of people interacting in a social setting in the party room may have drawn subjects' attention away somewhat from visual and olfactory smoking cues. In addition, the novel experience of interacting with the actors in VR may have provided some distraction from the smoking cues in that room. When asked in the post-VR debriefing of their impressions of the party room, every subject first mentioned the social aspects of the room and eight subjects (40%) commented on the relative lack of smoking cues in the party room as opposed to the paraphernalia room.

Conversely, when looking at results regarding the thoughts about smoking in the different rooms, there is a slight increase in thoughts about smoking from the paraphernalia room to the party room that corresponds with the slight increase in craving levels from the paraphernalia room to the party room. While there was no significant difference in thoughts about smoking from the paraphernalia room to the party room, this small change in both thoughts about smoking and craving level may suggest a link between cognition and craving—when young adult smokers think more about smoking, they crave more (or vice versa). In addition, this slight change speaks to the idea that social interactions and environmental contexts are important cues for smoking. When placed in a setting where these young adults might expect to smoke (a party) with others who are smoking, their craving and thoughts about smoking increased. While not statistically significant in this study, this increase in craving and thoughts about smoking is consistent with

literature suggesting that smokers crave more in situations where they would expect to smoke (Dols, van den Hout, Kindt, & Willems, 2002; Dols, Willems, van den Hout, & Bittoun, 2000; Thewissen, van den Hout, Havermans, & Jansen, 2005).

Looking at these findings together, they suggest that both proximal and distal cues play distinct roles in the craving experience of young adults. While proximal cues, such as smoking paraphernalia, appear to elicit greater attention to the sight and smell of cigarettes, distal cues, such as social interactions, appear to increase craving and thoughts of smoking. Together these elements form a constellation of responses to smoking cues that lead to smoking behavior. While this finding was not significant, this finding is notable in that it demonstrates the importance of incorporating both proximal and distal cues in cue exposure. The environment and its contents cannot be separated from one another. Exposure to complex cues provides an experience for young adult smokers that cannot be provided by exposure to isolated cues. This is particularly pertinent in exploring the experience of young adult smokers as they often are the focus of the cigarette industry and are bombarded with proximal and distal cues targeted specifically towards them. Future research should continue to explore the importance of complex cues including environmental context and social interactions as they relate to young adult smokers.

Olfactory Cue Results

The results of this study did not appear to support hypothesis 2, which stated that exposure to olfactory, visual, and auditory cues in a VR environment would increase subjective reactivity in nicotine dependent young adult smokers compared to nicotine dependent young adult smokers who receive exposure to visual and auditory, but not olfactory, cues in a VR environment.

Results showed that nicotine dependent young adult smokers who received VR-presented olfactory stimuli along with VR-presented visual and auditory stimuli reported no significant differences in craving levels compared with nicotine dependent young adult smokers who received VR-presented visual and auditory stimuli only. There was a slight difference between the two conditions which indicated subjects in the scent condition reported higher craving levels, however this trend did not reach statistical significance. Larger sample sizes, capable of detecting more subtle differences, need to be employed in future studies in order to gain a greater understanding of the impact olfactory cues have on nicotine dependent young adult smokers. While determining subtle differences between larger groups of young adult smokers may not be of great practical importance, there may be other reasons to explore this impact. VR is used to provide a realistic, immersive experience. Undoubtedly, we live in a world full of scents and VR environments lacking scent are not fully suggestive of a "real world" experience. Gaining a greater understanding of the qualitative effect of scent on individuals' experience in VR environments may assist clinicians in providing a higher quality of cue exposure treatment, which may, potentially, lead to longer lasting cessation results.

Results focusing on the attention paid to the sight of cigarettes in the VR cue rooms also showed no significant differences between subjects in the scent and no scent conditions. Again, there were slight differences between the groups, showing that in the party and paraphernalia rooms subjects assigned to the no scent condition paid somewhat more attention to the sight of cigarettes in the rooms. While this difference was not statistically significant, it could suggest that while subjects receiving scent were provided with visual and olfactory stimuli between which they had to divide their sensory perception abilities, subjects receiving no olfactory stimuli were better able to focus on the visual cues presented to them. This finding is in agreement with

research conducted on cross-modal sensory links showing that attention to stimuli presented in one modality may have a problematic effect on the ability to attend to stimuli simultaneously presented in another modality (Spence & Driver, 1997). While this finding is interesting and seems to suggest that fewer stimuli would result to greater attention to cues, it is important to remember that the focus of VR cue exposure is to present cues in a real world context, which includes audio, visual, and olfactory stimuli. It would take away from the realistic context of the environments if sensory stimuli were limited to only one modality.

This study also showed no statistically significant differences between the scent and no scent condition in regard to attention paid to the smell of cigarettes in the VR rooms. This finding is, perhaps, the most curious in that common sense would dictate that those who are presented with smells would pay more attention to those smells than those who were not presented with smells. Indeed, the subjects who received olfactory stimuli reported higher attention to the smell of cigarettes in the smoking cue rooms, but not at levels found to be statistically significant. There are two reasons why this might have occurred.

First, in the post-VR interview, three of the individuals assigned to the no scent group (30%) mentioned smelling various scents during the VR session and were surprised to learn that no olfactory stimuli had been provided in the VR rooms. Perhaps the environments and the cues within those environments were realistic enough for these participants that they were able to "fill in", or imagine, the smells which would correspond to the visual cues in the VR rooms and, therefore, recorded paying attention to smells which were not existent. This phenomenon has been seen in a previous VR study conducted with adults who abuse or are dependent upon alcohol (P. Bordnick et al., in press). In this study, subjects were presented with alcohol-related visual and olfactory cues in VR environments. In the debriefing interviews, many of the subjects

specifically mention smelling limes that they had seen on a chopping board in a party preparation room. There was no citrus smell of any sort presented to the subjects at any time during the study, but several of the subjects insisted they smelled limes. Future studies may focus on testing this "fill-in" phenomenon by running subjects in VR environments without scent, but asking them questions about attention to scents within the environments to determine to what extent subjects are filling in the missing parts of the environment.

This finding also raises the question of the impact of suggestibility in VR. All subjects filled out the SoSQ before the VR session and, thus, may have had the impression that they would receive scent in the environments. Indeed after finishing the VR session, several subjects noted that they assumed there would be olfactory cues in the environments because they had filled out the SoSQ. This may have led some of those who did not receive scent to perceive "phantom" scents in the environment. This finding may indicate that some young adult smokers are more suggestible in terms of embellishing an existing environmental context and, thus, may be better candidates for VR assessment and treatment modalities than those who are less suggestible. Future studies may consider waiting until after the VR session for subjects to fill out scent questionnaires to avoid providing an expectancy of receiving scent. Additionally, the impact of subject suggestibility should be explored for its potential utility with VR treatments.

Second, of the individuals assigned to the scent condition, in post-VR debriefing sessions four (40%) reported smelling scents, but not smelling cigarettes in the VR rooms. When allowed to smell the scent used for cigarette smoke and raw tobacco, these subjects said that these scents did not correspond with how they felt cigarette smoke and raw tobacco should smell. Thus, subjects receiving scent may have recorded low attention to smell of cigarettes because they did not think the scent they were smelling was that of cigarettes.

Subjects in the scent condition recorded no significant differences from those in the no scent condition in responding to the question about thinking about smoking in the VR rooms. A slight difference was detected between the groups in the party room, but this difference did not achieve statistical significance. Again, use of larger group sizes in future research studies may allow researchers to find differences that this smaller sample size did not have the power to detect and thus provide more information regarding the qualitative experience of young adult smokers in VR environments.

Although no significant differences between the scent condition groups were recorded, this does not necessarily mean that the VR experience was the same for both groups and that VR-presented olfactory stimuli have no impact on subjective reactivity among nicotine dependent young adult smokers. The small sample size employed in this study may not have had the substantial power necessary to detect subtle differences between the scent condition groups. However, differences were detected, suggesting that use of a larger sample size may garner more definitive results.

Limitations

While the results of this study appear to inform social work research and intervention with nicotine dependent young adult smokers, there are several limitations that may have affected the results of this study. First, the generalizability of the results of this study is limited due to the sociodemographic distribution of the sample. While attempts were made to recruit subjects from the entire metro area, many potential subjects did not have transportation to the laboratory site or felt that the site was too far away to merit participation. Thus, the majority of the subjects were students on the college campus that housed the laboratory. This resulted in a sample that favored White students enrolled in a 2-year college program. Therefore, this sample

may not be representative of nicotine dependent young adult smokers of other races or economic, social, or educational statuses, such as 4-year college enrollees or those not currently in school. Additionally, this sample is not necessarily representative of rural young adult smokers or young adult smokers from other geographic regions of the country as these subjects all were recruited in the metropolitan area of a large southeastern city.

Second, availability sampling was used in the selection of study participants. The participants were selected from the individuals responding to an advertisement in a local free paper or flyers handed out on the college campus. Use of availability sampling limits the generalizability of the findings as the individuals responding to the call for subjects may not be representative of all nicotine dependent young adult smokers; therefore, the findings can only be applied to populations closely resembling the sample in this study.

Third, because a small sample size of 20 nicotine dependent young adult smokers was enrolled in this study, generalization of the findings is limited. While a small sample size is appropriate for a pilot study, studies involving much larger samples will be necessary before generalizing results across the population of young adults and employing VR as a treatment modality. Another limitation of this small sample size was its potential impact on the olfactory cue results. Due to the small sample size, only very large differences between the scent and no scent group would have been discernable. While the use of olfactory stimuli may have had some effect on the craving and overall VR experience of the scent group, there was insufficient power to detect these differences.

Fourth, despite utilizing random assignment for the presentation of scent stimuli within the VR environment, the groups were not equivalent on the total score of the Attitudes Towards the Sense of Smell Questionnaire (SoSQ), with the group assigned to receive the VR-presented

scents scoring significantly lower on the SoSQ. Thus, the results regarding the effect of olfactory stimuli should be interpreted with this potential limitation in mind. Additionally, filling out the SoSQ before exposure to the VR environments may have led some subjects to assume they would receive scent while in VR and they may have answered questions regarding attention to scent differently than they would have if they had not made this assumption.

Fifth, self report measures were used to gather all data, including craving. The concept of craving was subject to each participant's interpretation; thus the concept and experience of craving for one subject may have been very different from another subject's interpretation of craving. Because self report measures were utilized, these results may have been affected by reactivity and bias. Subjects may have responded in a manner that reflected an increased awareness of craving feelings as the result of knowing that feelings of subjective craving were being studied. Additionally, participants may have attempted to provide answers that they felt were more socially acceptable or more acceptable to the researcher.

Also, this study quantitatively measured craving and the effect of olfactory stimuli presented in VR on craving among nicotine dependent young adult smokers. While providing important, relevant information, this study did not focus on the qualitative experience of craving or of the VR experience. While no significant differences were found between the group receiving olfactory stimuli and the group not receiving olfactory stimuli in VR, it is unknown how olfactory stimuli contributed to the overall virtual experience of those subjects who received them. Thus, the importance of olfactory stimuli remains unknown until larger studies and qualitative studies can be conducted.

In post-VR debriefing interviews, participants cited some limitations regarding the use of the virtual reality program. Several felt that the environments were not designed with their age

group in mind. In particular, they noted that the party scene was not realistic and that many of the people encountered in the party scene appeared much older than people they normally would associate with at a party. This limitation of the VR system utilized in this study could explain to some extent why craving levels in the smoking cue rooms, while significantly higher than in the neutral cue rooms, was not as high as it has been among older adult samples. Subjects reported feeling uncomfortable smoking around older adults, thus the environmental context provided to these young adult smokers may have limited their craving to an extent.

Other subjects commented on their frustration with the timed path through the rooms. They would have preferred to explore the rooms at their own pace, spending more time interacting with situations and items of interest. Many of the subjects said that they played video games regularly and were accustomed to controlling movement in those games. The inability to control movement within these environments was distracting to these subjects. Subjects also expressed a desire for increased sensory stimuli, stating that the environments would have felt more "real" had the system been equipped with tactile stimuli so they could touch or pick up items in the environments. In addition, some subjects stated that the olfactory stimuli presented to them in the VR environments were not accurate representations of cigarettes and cigarette smoke scents, perhaps causing them to answer questions regarding attention to smells in VR differently than they would have had they accurately perceived the scents.

Implications for Practice

Despite the limitations of this study, it is possible to draw practice implications from the results of this study. Social workers and other mental health providers are uniquely positioned to address issues related to nicotine dependence with young adult smokers from a variety of sociodemographic backgrounds. However, the lack of research available related to young adult

smokers serves as a barrier to providing effective treatment options. This study has demonstrated that when presented with smoking cues within a virtual reality environment, craving levels among young adult smokers increase as opposed to when presented with a neutral cue environment in VR. Additionally, it has demonstrated that presentation of olfactory cues within VR environments does not appear to significantly increase craving levels among nicotine dependent young adult smokers. The implications of the results of this study impact both social work research and practice with young adult smokers.

While there has been much investigation into the characteristics, needs, and methods of intervention with nicotine dependent smokers, research in this area typically explores adolescent and adult smokers, largely ignoring the population of young adults in between these two groups. This study adds to the existing research focused on young adult smokers, suggesting that utilization of VR systems may be an appropriate method of conducting research with this group.

Smoking assessment and treatment for young adults has received little research attention. Many researchers argue that interventions developed for adults may not be the best approaches for young adults (Lantz, 2003) and that smoking intervention aimed at young adults should be a major public health initiative with a unique set of population specific strategies (Ramsay & Hoffmann, 2004). This study contributes to the literature focusing on young adult smokers and may assist researchers and clinicians in developing strategies targeting this population. In a review of studies conducted on smoking cessation programs for youth and young adults, MacDonald and colleagues (2003) note an absence of programs utilizing emerging technologies for intervention purposes. They argue that technological interventions have great potential to reach young smokers, noting the potential acceptability and appeal of such methods. This study

demonstrates that virtual reality, as an emerging technology, may hold promise as an option for providing both assessment and treatment to nicotine dependent young adult smokers.

This study also speaks to the importance clinicians should place on exploring boredom as a potential cue with clients and on keeping young adults engaged in treatment. The inability of these subjects to return to baseline craving levels in neutral room 2 demonstrates that boredom may serve as a trigger for craving and subsequent smoking behavior in young adults. Clinicians should explore and address this possible trigger with young adult clients. That many in this sample of young adults found neutral room 2 boring also indicates the need to tailor smoking cessation treatment specifically to young adults, focusing on methods that will prevent boredom with treatment regimens.

Interventions targeted toward nicotine dependent young adults are measured using efficacy studies and effectiveness studies (Nathan, Stuart, & Dolan, 2000). Efficacy studies are considered to be laboratory tests, generally conducted in the tradition of classic experimental design (2000). Effectiveness studies emphasize analysis of treatments as applied by a clinician in an uncontrolled, "real world" setting (Seligman, 1995).

There is great debate as to which method is of greater value. Many suggest that research regarding treatment validity should be conducted in a sequential validation process in which treatments found to be valid in efficacy studies would be followed up with effectiveness studies to examine their validity in clinical settings (Kazdin, 2001; Kendall & Hudson, 2001). Thus, this study exploring the ability of a virtual reality craving assessment system to elicit cue reactivity in nicotine dependent young adult smokers can be seen as a beginning step in the above mentioned sequential validation method for demonstrating the clinical validity of VR technology for clinical practice with nicotine dependent young adult smokers. Findings from additional efficacy studies

and, eventually, effectiveness studies of VR assessment systems would contribute both to social workers' understanding of young adult smokers and social workers' abilities to provide young adult smokers with effective intervention strategies.

Additionally, findings suggesting the importance of providing both proximal and distal cues have important clinical ramifications. When exploring cues which lead to smoking behavior with a young adult smoker, clinicians should examine the impact of both types of cues. Cue exposure treatment for young adults should attempt to utilize constellations of complex cues instead of focusing on individual cues in a singular context.

The finding that presentation of olfactory stimuli in VR was not effective in increasing craving levels merits further research, both qualitatively and quantitatively. Future research utilizing a larger sample size may garner results indicating otherwise. Qualitative research to examine the experience of those engaged in VR sessions may also provide more information as to the impact of olfactory stimuli on the overall VR experience. However, the initial implications for social work practice are financially based. Many agency employing social workers and other mental health providers to provide services to young adults are managed under tight budgetary constraints. While components of virtual reality systems are decreasing in price, purchasing a full system may be beyond the financial capability of some agencies. If presentation of olfactory stimuli does not significantly increase craving levels among young adults, the components which deliver such stimuli may be considered to be optional, thus reducing the overall price of the system and potentially improving the likelihood of an agency purchasing a system to utilize with their young adult population. Additionally, this finding may inform social workers who engage young adult smokers in variations of extinction therapy as a means of smoking cessation, as it

suggests that scent is not as important a craving trigger for young adults as are visual and auditory stimuli.

In summary, the virtual reality system explored in this study appears to demonstrate efficacy in eliciting craving among nicotine dependent young adult smokers and VR-provided olfactory cues did not appear to significantly increase craving levels. Social work researchers need to continue rigorous efficacy studies to increase the empirical validity and generalizability of these findings, while social work clinicians should inform themselves of emerging knowledge and prepare to integrate this knowledge into their practice in order to evaluate the clinical effectiveness of such methods.

Suggestions for Future Research

Because this is the first known study exploring cue reactivity in nicotine dependent young adult smokers using virtual reality technology with enhanced olfactory cues, the limitations of this study are important in that they provide a base for future studies to generate additional information regarding this population and appropriate intervention techniques. Further research in this area is needed to increase generalizability and protect against the inappropriate generalization of findings that may be unique to this study population. The following recommendations may increase the empirical reliability and validity of future studies.

Future studies should employ larger, more diverse samples of nicotine dependent young adult smokers. This study could be replicated with a greater representation of African-American, Hispanic, Asian, and Native American smokers, as well as a greater representation of 4-year college attendees and those either working or currently unemployed. Gender and level of daily cigarette use could be targeted in future studies, as well. While this study was conducted in the greater metropolitan area of a southeastern city, future studies should focus on different

geographic locations, as well as rural and urban populations, with studies taking place in locations that are easily accessed by those of varying economic levels and social classes. The utilization of these recommendations will allow replication studies to demonstrate the effects of virtual reality with expanded olfactory cues on larger, more diverse samples, therefore allowing results to be generalized to a larger population of young adults. In addition, use of larger samples may lead to greater understanding of the impact of olfactory cues presented in VR on craving levels in young adult smokers as it is easier to detect more subtle differences when a larger sample size is employed.

Because of the concerns related to the utilization of self report craving measures, future researchers may want to explore using brain imaging technology and physiological measurements in order to enhance the quality of craving data. As there appears to be a connection between craving and activity in specific areas of the brain, collecting data through use of these technologies may improve the ability of future researchers to gain empirical knowledge of craving and other forms of cue reactivity. In addition, use of physiological measurement and brain imaging technology might provide insight into changes in the brain and body when olfactory stimuli are added to a VR environment. Use of these technologies to collect data regarding olfactory stimuli may provide researchers with useful information regarding the impact of olfactory cues for nicotine dependent young adult smokers.

While the young adults in this study reported no other substance dependence or abuse issues, many young adults who smoke also engage in other substance use. Future researchers may want to explore the use of virtual reality with young adults who abuse or are dependent upon other substances, as well as issues related to cross cue reactivity among this population.

Based on subject comments regarding the inappropriate context of the VR environments and the failure of participants to return to baseline craving levels in neutral room 2, researchers and system designers should work together to develop age appropriate programs for young adult smokers, utilizing younger actors and environmental contexts specifically designed for young adults. Environments in which young adults frequently smoke such as a college campus, car, and club should be developed and tested with young adults. Additionally, research should explore boredom as a condition that prospectively triggers craving in young adults, designing and utilizing smoking and neutral cue rooms with the potential of this possible cue in mind.

Continued research should be conducted into the effects of various stimuli presented in VR situations. While the results of this study did not appear to support the hypothesis regarding presentation of olfactory cues, a study employing a larger sample size may be able to discern effects that were not noticed in this study. In addition, researchers should consider testing the scents they anticipate using to insure they are realistic. Researchers also might look closer at the "fill-in" effect seen in some of the subjects in this study. Exposing subjects to VR environments without olfactory cues and then asking them about their attention to olfactory cues within the environments may garner interesting results about individuals' abilities to experience a VR environment and unconsciously add details that are missing. More detailed exploration of VR provided visual and auditory cues may also be warranted to examine the individual impact of these stimuli on craving levels. Similarly, as technology advances, future researchers should explore the effects of tactile stimuli presented in VR environments.

Of note in this study was the average age of smoking initiation among the participants. The mean age of initiation reported was 14.8 years, with participants reporting that they had been smoking an average of 6 years. This indicates that adolescent years are a critical period for the

establishment of smoking behavior. Future researchers should explore the use of virtual reality technology with this younger age group, focusing on how virtual reality can be used for prevention, as well as assessment and cessation.

In summary, research and intervention strategies specific to young adult smokers are limited. There are calls within the literature for increased activity in these areas, as well as for increased utilization of technology for assessment and treatment. This study has demonstrated that exposure to VR smoking cues appears to increase subjective reactivity in nicotine dependent young adults smokers compared to exposure to VR neutral cues. However, the effect of VR-provided olfactory cues on craving in nicotine dependent young adults smokers remains unclear. While replication studies should be conducted to increase the empirical validity and generalization of these findings, these results appear to indicate that assessment and intervention tools employing virtual reality technology may one day play a role in assisting nicotine dependent young adult smokers to meet their smoking cessation goals.

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APPENDICES

APPENDIX A

MINI INTERNATIONAL NEUROPSYCHIATRIC INTERVIEW

Overview Questions

- Have you been consistently depressed or down, most of the day, nearly every day, for the past two weeks? NO YES
- In the past two weeks, have you been less interested in most things or less able to enjoy the things you used to enjoy most of the time? NO YES
- Have you felt sad, low or depressed most of the time for the last two years? NO YES
- In the past month did you think that you would be better off dead or wish you were dead? NO YES
- Have you ever had a period of time when you were feeling 'up' or 'high' or so full of energy or full of yourself that you got into trouble, or that other people thought you were not your usual self? (Do not consider times when you were intoxicated on drugs or alcohol.) NO YES
- Have you ever been persistently irritable, for several days, so that you had arguments or verbal or physical fights, or shouted at people outside your family? Have you or others noticed that you have been more irritable or over reacted, compared to other people, even in situations that you felt were justified? NO YES
- Have you, on more than one occasion, had spells or attacks when you suddenly felt anxious, frightened, uncomfortable or uneasy, even in situations where most people would not feel that way? Did the spells peak within 10 minutes? CODE YES ONLY IF THE SPELLS PEAK WITHIN 10 MINUTES. NO YES
- Do you feel anxious or uneasy in places or situations where you might have a panic attack or panic-like symptoms, or where help might not be available or escape might be difficult: like being in a crowd, standing in a line (queue), when you are away from home or alone at home, or when crossing a bridge, traveling in a bus, train or car? NO YES
- In the past month were you fearful or embarrassed being watched, being the focus of attention, or fearful of being humiliated? This includes things like speaking in public, eating in public or with others, writing while someone watches, or being in social situations. NO YES
- In the past month have you been bothered by recurrent thoughts, impulses, or images that were unwanted, distasteful, inappropriate, intrusive, or distressing? (e.g., the idea that you were dirty, contaminated or had germs, or fear of contaminating others, or fear of harming someone even though you didn't want to, or fearing you would act on some impulse, or fear or superstition that you would be responsible for things going wrong, or obsession with sexual thoughts, images or impulses, or hoarding, collecting, or religious obsessions.) NO YES
- In the past month, did you do something repeatedly without being able to resist doing it, like washing or cleaning excessively, counting or checking things over and over, or repeating, collecting, or arranging things, or other superstitious rituals? NO YES
- Have you ever experienced or witnessed or had to deal with an extremely traumatic event that included actual or threatened death or serious injury to you or someone else? EXAMPLES OF TRAUMATIC EVENTS INCLUDE SERIOUS ACCIDENTS, SEXUAL OR PHYSICAL ASSAULT, A TERRORIST ATTACK, BEING HELD HOSTAGE, KIDNAPPING, FIRE, DISCOVERING A BODY, SUDDEN DEATH OF NO YES

SOMEONE CLOSE TO YOU, WAR, OR NATURAL DISASTER.

- Did you respond to the trauma with intense fear, helplessness, or horror? NO YES
- During the past month, have you re-experienced the even in a distressing way (such as, dreams, intense recollections, flashbacks or physical reactions)? NO YES
- In the past 12 months, have you had 3 or more alcoholic drinks within a 3 hour period on 3 or more occasions? NO YES
- Now I am going to show you / READ THE LIST BELOW of street drugs or medicines. In the past 12 months, did you take any of these drugs more than once, to get high, to feel better, or to change your mood? NO YES

Amphetamines	Speed	Crystal Meth	Dexedrine	Ritalin, Diet Pills
Cocaine	Crack	Freebase		
Heroin	Morphine, Methadone	Opium	Demerol	Codeine, Percondan, OxyContin
LSD	Mescaline	PCP	MDMA	Ecstasy
Inhalants	Glue	Ether	GHB	Steroids
THC, Marijuana	Cannabis, Hashish	Grass		Barbiturates, Valium, Xanax, Ativan

- How tall are you? ____ inches
- What was your lowest weight in the past 3 months? ____ lbs
- IS PATIENT'S WEIGHT LOWER THAN THE THRESHOLD CORRESPONDING TO HIS/HER HEIGHT? SEE TABLE BELOW NO YES

FEMALES	4'10	4'11	5'0	5'1	5'3	5'4	5'5	5'6	5'7	5'8	5'9
Weight (lbs)	85	86	87	89	94	97	99	102	104	107	110
MALES	5'3	5'4	5'5	5'6	5'7	5'8	5'9	5'10	5'11	6'	6'1
Weight (lbs)	108	110	111	113	115	115	118	120	122	125	127

- In the past three months, did you have eating binges or times when you ate a very large amount of food within a 2-hour period? NO YES
- In the last 3 months, did you have eating binges as often as twice a week? NO YES
- Have you worried excessively or been anxious about several things over the past 6 months? NO YES

Non-Alcohol Psychoactive Substance Use Disorders Module

K1 a In the past 12 months, did you take any of these drugs more than once, to get high, to feel better, or to change your mood? NO YES

CIRCLE EACH DRUG TAKEN:

Stimulants: amphetamines, "speed", crystal meth, "rush", Dexedrine, Ritalin, diet pills
Cocaine: snorting, IV, freebase, crack, "speedball"
Narcotics: heroin, morphine, Dilaudid, opium, Demerol, methadone, codeine, Percodan, Darvon, OxyContin
Hallucinogens: LSD ('acid"), mescaline, peyote, PCP ("Angel Dust", "peace pill"), psilocybin, STP, "mushrooms", ecstasy, MDA, or MDMA
Inhalants: "glue", ethyl chloride, nitrous oxide ("laughing gas"), amyl or butyl nitrate ("poppers")
Marijuana: hashish ("hash"), THC, "pot", "grass", "weed", "reefer"
Tranquilizers: Quaalude, Seconal ("reds"), Valium, Xanax, Librium, Ativan, Dalmane, Halcion, barbiturates, Miltown
Miscellaneous: steroids, nonprescription sleep of diet pills, GHB Any others?

SPECIFY MOST USED DRUG(S): _____

	CHECK ONE
ONLY ONE DRUG/ DRUG CLASS HAS BEEN USED	_____
ONLY THE MOST USED DRUG IS INVESTIGATED	_____
EACH DRUG CLASS USED IS EXAMINED SEPARATELY	_____

b SPECIFY WHICH DRUG/ DRUG CLASS WILL BE EXPLORED IN THE INTERVIEW BELOW IF THERE IS CONCURRENT OR SEQUENTIAL POLYSUBSTANCE USE: _____

K2 Considering your use of (drug selected), in the past 12 months:

a	Have you found that you needed to use more (drug selected) to get the same effect that you did when you first started taking it?	NO YES
b	When you reduced or stopped using (drug selected), did you have withdrawal symptoms (aches, shaking, fever, weakness, diarrhea, nausea, sweating, heart pounding, difficulty sleeping, or feeling agitated, anxious, irritable, or depressed)? Did you use any drug(s) to keep yourself from getting sick (withdrawal symptoms) or so that you would feel better? IF YES TO EITHER, CODE YES.	NO YES
c	Have you often found that when you used (drug selected), you ended up taking more than you thought you would?	NO YES
d	Have you tried to reduce or stop taking (drug selected)?	NO YES
e	On the days that you used (drug selected), did you spend substantial time (>2 hours), obtaining, using, or in recovering from the drug, or thinking about the drug?	NO YES
f	Did you spend less time working, enjoying hobbies, or being with family or friends because of your drug use?	NO YES
g	Have you continued to use (drug selected), even though it caused you health or mental health problems?	NO YES

ARE 3 OR MORE K2 ANSWERS CODED YES? NO YES
SPECIFY DRUG: _____ SUBSTANCE DEPENDENCE CURRENT

K3	Considering your use of (drug selected), in the past 12 months:	
a	Have you been intoxicated, high, or hungover from (drug selected) more than once when you had responsibilities at school, at work, or at home? Did this cause any problem? (CODE YES ONLY IF THIS CAUSED PROBLEMS.)	NO YES
b	Have you been high or intoxicated from (drug selected) more than once in any situation where you were physically at-risk (for example, driving a car, riding a motorbike, using machinery, boating, etc.)?	NO YES
c	Did you have legal problems more than once because of your drug use, for example, an arrest or disorderly conduct?	NO YES
d	Did you continue to use (drug selected), even though it caused problems with your family or other people?	NO YES
	ARE 1 OR MORE K3 ANSWERS CODED YES?	NO YES
	SPECIFY DRUG(S):_____	SUBSTANCE ABUSE CURRENT

APPENDIX B

SMOKING HISTORY

SMOKING HISTORY

How many cigarettes do you smoke per day: _____ (specify amount, 10, 12)

How long have you smoked at this rate: _____ (years)

What age did you first start smoking: _____

Did you ever quit smoking for a period longer than a few days: _____ (Y or N)

If yes, how many past quit attempts have you had: _____

What methods have you tried in the past and how many times (0, 1, 2, 3, etc.):

_____ Nicotine gum or lozenge

_____ Patch

_____ Medication (specify medication i.e., Zyban, herbal remedy, etc.)

_____ Talk therapy (individual or group)

_____ On your own (cold turkey, other)

Describe some situations where you smoke:

_____

_____

_____

Are there any situations that make you think about or crave cigarettes:

_____

_____

_____

List any objects (food, drinks, ash trays, etc.) that make you crave or want to smoke:

_____

_____

_____

Do you ever anticipate smoking: _____

If yes, when (describe): _____

APPENDIX C

NICOTINE DEPENDENCE QUESTIONNAIRE

Nicotine Dependence Questionnaire (modified from FTND)

1. How soon after you wake up do you smoke your first cigarette?
   [ ] Within 5 minutes (3)
   [ ] 6-30 minutes (2)
   [ ] 31-60 minutes (1)
   [ ] After 60 minutes (0)

2. Do you find it difficult to refrain from smoking in places where it is forbidden?
   [ ] Yes (1)
   [ ] No (0)

3. Which cigarette would you hate most to give up?
   [ ] The first one in the morning (1)
   [ ] All others (0)

4. How many cigarettes/day do you smoke?
   [ ] 10 or less (0)
   [ ] 11-20 (1)
   [ ] 21-30 (2)
   [ ] 31 or more (3)

5. Do you smoke more frequently during the first hours after waking than during the rest of the day?
   [ ] Yes (1)
   [ ] No (0)

6. Do you smoke if you are so ill that you are in bed most of the day?
   [ ] Yes (1)
   [ ] No (0)

7. How often do you inhale the smoke from your cigarette?
   [ ] Never (0)
   [ ] Sometimes (1)
   [ ] Always (2)

8. What type of cigarette do you smoke?
   [ ] Low nicotine (0.9 mg or less) (1)
   [ ] Medium nicotine (1.0-1.2 mg) (2)
   [ ] High nicotine (1.3 mg or more) (3)

APPENDIX D

QUESTIONNAIRE OF SMOKING URGE

QSU-BRIEF FORM

Indicate how much you agree or disagree with each of the following statements by placing a single checkmark (like this ✓) along each line between STRONGLY DISAGREE AND STRONGLY AGREE. The closer you place your checkmark 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.

1. I have a desire for a cigarette right now.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

2. Nothing would be better than smoking a cigarette right now.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

3. If it were possible, I probably would smoke now.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

4. I could control things better right now if I could smoke.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

5. All I want right now is a cigarette.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

6. I have an urge for a cigarette.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

7. A cigarette would taste good now.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

8. I would do almost anything for a cigarette now.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

9. Smoking would make me less depressed.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

10. I am going to smoke as soon as possible.

STRONGLY DISAGREE_____:_____:_____:_____:_____:_____:_____:STRONGLY AGREE

APPENDIX E

ATTITUDES TOWARDS THE SENSE OF SMELL QUESTIONNAIRE

Attitudes Towards the Sense of Smell Questionnaire

Please read the following statements and mark your responses on the scales provided.

1. I may come to like a perfume solely because it is associated with someone I like.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

2. I may come to like an odor solely because it is associated with someone I like.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

3. When I like a new place, it is partly because I like the odors.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

4. I am more likely to spend time in a shop if it has a pleasant smell.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

5. I am more likely to enjoy a meal if I like the way it smells.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

6. I may dislike an odor solely because it is associated with someone I don't like.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

7. I may dislike a perfume solely because it is associated with someone I don't like.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

8. When I like a food, it is partly because of the smell.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

9. If I don't like a new/cosmetic/health product, it is partly because of the smell.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

10. When I don't like a new food, it is partly because of the smell.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

11. When I like a new person, it is partly because of their smell.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

12. The smell of food may make me hungry, even if I have just eaten.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

13. If I don't like a person I've just met, it is partly because I don't like their smell.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

14. I use differently scented products according to the mood I am in.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

15. When I don't like a new place, it is partly because I don't like the odors there.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

16. Certain smells can evoke pleasant memories.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

17. Certain smells can evoke unpleasant memories.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

18. Smells can evoke feelings of happiness and joy.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

19. Smells can evoke feelings of sadness.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

20. Some smells can increase feelings of well-being.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

21. Some smells can reduce stress levels.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

22. Aromatherapy can be used to induce relaxation or energy.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

23. Aromatherapy can be used to treat specific illnesses.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

24. Some smells remind me of my childhood.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

25. I would rather lose my ability to smell than my ability to hear.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

26. I would rather lose my ability to smell than my ability to feel.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

27. I would rather lose my ability to smell than my sight in one eye.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

28. I would rather lose my ability to smell than my ability to see.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

29. I would rather lose my ability to smell than my hearing in one ear.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

30. I would rather lose my ability to smell than my ability to taste.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

31. My sense of smell is just as important as my other senses.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

32. Smell is an important part of my life.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

33. Certain smells affect productivity in the workplace.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

34. My ability to appreciate food flavor relies mainly on the sense of smell.

1	2	3	4	5	6	7
Strongly disagree			Neither agree nor disagree			Strongly agree

APPENDIX F

TELEPHONE SCREENING FORM

TELEPHONE SCREEN : UGA VR SMOKING 2007

APPOINTMENT DATE:	TIME:

DATE OF CONTACT:

Date: _____

Male (1) _____ Female (2) _____

Height: _____inches Weight: _____lb.

Age: _____ Race: _____ (1 = White)
(2 = African American)
(3 = Hispanic)
(4 = other)

Occupation: _____
If student, where: _____
2-year or 4-year program: _____

Referred to Study via: _____

MEDICAL STATUS	YES	NO
1. Do you have any problems with your health? If yes: _____	□	□
2. Are you pregnant?	□	□
3. Are you on any regular medication? If yes: _____ Are any of these administered nasally?	□ □	□ □
4. Do you have asthma or other chronic respiratory illnesses?	□	□
5. Do you have any type of smell disorder?	□	□
6. Do you currently have a cold or other respiratory infection?	□	□

7. Do you have problems viewing computer or television screens? ☐ ☐
8. Do you have any current or past history of seizure or seizure disorder? ☐ ☐
   If yes: _____

9. Do you have a fear of closed spaces or know of anything that would prevent you from wearing a VR helmet? ☐ ☐

CURRENT USE OF TOBACCO PRODUCTS YES NO

6. Do you use tobacco products? ☐ ☐

7. If yes:
   a) ___ Cigarettes (a1) Usual brand name: _____

   (a2) ___ Regular (1) (a3) ___ Filtered (1) (a4) ___ Menthol (1)
   ___ Lights (2) ___ Non-filtered (2) ___ Non-menthol (2)

   (a5) ___ Regulars (1) ___ Kings (2) ___ 100's (3) ___ 120's (4)

   (a6) Approximately how many cigarettes per day? _____

   b) ___ Cigars (b1) Approximately how many units per day? _____
   c) ___ Pipe (c1) Approximately how many units per day? _____
   d) ___ Chewing tobacco (d1) Approximately how many units per day? _____

SMOKING PATTERN

8. How many cigarettes, on average, do you smoke each day? _____

9. How many cigarettes, on average, do you smoke each week? _____

10. Approximately how many cigarettes have you had in the past month? _____

PRESENT DRUG USAGE

11. Are you using or have you used any legal or illegal drugs like*(opiates, cocaine, amphetamines, barbiturates, benzodiazepines, marijuana, prescription drugs, or non-prescription drugs) in the past month?

YES NO
☐ ☐

PAST/PRESENT PSYCHIATRIC PROBLEMS	YES	NO
12. Have you ever been treated for psychiatric problems?	□	□

Any current problems? If yes, _____

OTHER ENROLLMENT FACTORS	YES	NO
13. Can you read and write in the English language?	□	□
14. Can you arrange transportation to Gwinnett University Center?	□	□
15. Have you participated in a study trial in the past month?	□	□