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Understanding Craving for Cigarettes: A Multidimensional Assessment Approach

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UNDERSTANDING CRAVING FOR CIGARETTES:

A MULTIDIMENSIONAL ASSESSMENT APPROACH

by

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This Dissertation, submitted by H. Katherine O'Neill in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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This Dissertation meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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Signature H. Katherine O'Neill

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ABSTRACT

Cigarette smoking is a serious health hazard affecting a sizeable proportion of the adult population. The addictive nature of cigarettes has been blamed for the difficulty smokers experience in achieving and maintaining abstinence. Cigarette cravings are frequently cited as a factor contributing to relapse. Addiction theories proposed independently by Wikler, Siegel, and Solomon view cravings as classically conditioned responses to internal or external cues. These responses are presumably multidimensional, having cognitive, emotional, and physiological manifestations.

The current study examined cigarette cravings under controlled laboratory conditions. Forty-six male and female undergraduates served as participants. Stimuli commonly associated with smoking relapse were presented to three groups of subjects: current smokers, recent ex-smokers, and nonsmokers. Both imaginal and in vivo cue exposure were employed.

The findings clearly demonstrated that these laboratory procedures were effective in producing cigarette cravings among former and current smokers, with in vivo

exposure eliciting stronger urges than imaginal cue presentation. As predicted, smokers experienced stronger cravings than ex-smokers, while nonsmokers reported essentially no urges to smoke.

The results also supported the multidimensional nature of cravings. Together, state anxiety, skin conductance, and heart rate accounted for 38% of the variance in craving ratings. Individuals with a history of smoking experienced greater anxiety in response to imaginal and in vivo cues than nonsmokers, but the three groups did not differ on physiological reactions to cue exposure.

Multiple regression analyses examined factors associated with craving strength. Cognitive avoidance of imaginal stimuli was not predictive of craving, but clarity of imagery was positively related to urge level. Other variables associated with craving strength included extraversion, trait anxiety, use of stimulant drugs, use of depressant drugs, and nicotine dependence. These baseline variables accounted for approximately a third of the variance in craving responses to cue exposure.

The results of this study are consistent with theoretical views of cigarette cravings as multidimensional conditioned responses. The implications for assessment of cravings in a laboratory setting are discussed.

INTRODUCTION

Cigarette Smoking

Cigarette smoking is considered the major preventable cause of chronic disease and death in the United States (USDHHS, 1985). Smoking has been linked to coronary heart disease, lung cancer, bronchitis, emphysema, peptic ulcers, and numerous other conditions. A 30-year-old individual smoking two packs a day can expect to die 8 to 9 years sooner than a nonsmoker of the same age (Schwartz, 1987). Despite the considerable evidence that smoking is harmful to health, approximately a quarter of the adult population smokes.

Educational efforts alone have proven insufficient to eliminate smoking-related mortalities. Smokers are well aware of the risks and most desire to quit (Schwartz, 1987). Unfortunately, abstinence is difficult to achieve. Of those who attempt to stop smoking at any point in time, only one in five will succeed (Schwartz, 1987). The majority of smokers make one or more unsuccessful attempts before achieving abstinence (Schacter, 1982).

While smokers usually attempt to quit on their own, some seek professional assistance (Schwartz, 1987). The

most effective smoking cessation programs incorporate behavioral techniques such as setting a target quit date, monitoring progress, obtaining social support, and preparing for high temptation situations (Glasgow and Lichtenstein, 1987). These programs can produce initial cessation rates of 60% to 80%.

Unfortunately, even in the most successful programs, only about 25% of quitters report continued abstinence at long-term follow-up (i.e., 2 to 6 years after treatment). Even among the individuals who are no longer smoking at follow-up, a large proportion report having had one or more "slips", or temporary lapses, during the intervening months (Glasgow and Lichtenstein, 1987).

Given these findings, it has been proposed that the key to helping smokers "beat the habit" lies in developing successful maintenance techniques, rather than in refining existing cessation methods. The U.S. Public Health Service recently named the search for maintenance strategies a top priority for smoking research (Schwartz, 1987).

The pattern of relapse among former smokers is similar to relapse patterns for other psychoactive substance use disorders, such as alcoholism and opiate dependence (Hunt and Matarazzo, 1973). Generally, the greatest proportion of relapse occurs within the first three months of abstinence (Glasgow and Lichtenstein, 1987). With each succeeding month, the percent of individuals who relapse

tends to decline. But there is apparently no "safe point" beyond which ex-smokers need not be concerned about relapse (Brownell, Marlatt, Lichtenstein, and Wilson, 1986).

Theories of Addiction and Craving

Various theorists have attempted to explain why relapse is so common in smoking and other addictive disorders. Among current theories, three give prominence to the role of cravings for tobacco and other substances. These include Siegel's classical conditioning model, Solomon's opponent process theory, and Wikler's conditioned withdrawal theory. All of these views share a basic reliance on the process of classical conditioning to explain both initial drug use and relapse from abstinence. However, they differ in what they consider the most important conditioned stimuli and responses involved.

Siegel (1975) developed his theory of drug use and relapse from his work with opiate addiction, but the theory can also be applied to tobacco dependence. Siegel gives central importance to the psychoactive properties of a drug, including its emotional effects. He proposes that the body's homeostatic mechanisms will attempt to counteract the effects of a drug by producing opposing physiological responses when the drug is present. With repeated administration of the substance, these compensatory responses increase in magnitude to the extent

that they overcome the drug effects (i.e., tolerance develops). Siegel's model further states that these opposing physiological processes may become conditioned responses to various environmental stimuli associated with drug-taking. Once this occurs, the individual will experience effects opposite to those induced by the drug when in the presence of these conditioned stimuli. Since many drugs produce euphoria, relaxation, and other pleasant effects, Siegel believes that the conditioned responses must bring about the opposite feelings (e.g., dysphoria, anxiety). These responses may be manifest cognitively as a craving for the drug.

Siegel's theory explains both maintenance of drug use and relapse following abstinence. In the latter case, he proposes that cravings in response to conditioned environmental stimuli will continue to occur even after regular drug use stops. Although these conditioned responses will eventually become extinguished, many individuals do not wait for this process to occur. Immediate relief from unpleasant states can be achieved by resuming substance use; therefore, relapse is likely.

A similar theoretical view, the opponent process theory, was proposed by Solomon to explain opiate addiction (Solomon and Corbit, 1974). Ternes (1977) then applied this model to smoking behavior. The basic contribution of

Solomon's theory is its greater specification of how conditioned cravings are acquired and maintained.

The "opponent process" named in Solomon's theory is the same homeostatic mechanism described by Siegel (i.e., the response opposite to the action of a particular drug). For example, nicotine has cardiovascular effects that include vasoconstriction. The opponent process theory predicts that one of the body's homeostatic responses to nicotine therefore would be vasodilation. Solomon makes a further distinction between drug effects and opponent responses by referring to their time courses. The drug effect generally tracks the concentration of the substance in the body, while the opposing response is more sluggish (i.e., slower to peak and slower to return to baseline). The relative strengths of the drug-induced and opponent responses determine the physiological state of the individual at any point in time.

During initial administrations, drug effects predominate. Over repeated exposures to the substance, however, the opposing response intensifies. It eventually becomes sufficiently powerful to cancel out the drug effect, producing drug tolerance (i.e., diminished responding to the drug). Like Siegel, Solomon sees the two effects as polar opposites; a drug that induces a pleasant affective state would elicit a homeostatic reaction of dysphoria. Since the drug effect ends sooner than the more

sluggish opponent process, the pleasant state is followed by discomfort, subjectively interpreted as craving. The habitual drug user typically responds by readministering the drug to cancel out the opponent process. Once this cycle is set in motion, it is self-perpetuating.

Solomon's theory explains relapse by referring to classical conditioning processes. Discomfort and craving for the drug may be elicited by a variety of stimuli. Until the conditioned responses are extinguished, cravings will continue to occur, even after an extended period of abstinence.

Ternes (1977) makes an interesting extrapolation from Solomon's theory. Since opponent processes produce negative emotional states, any unpleasant emotion may be interpreted as a signal to take the drug. Thus, aversive states elicited by a variety of environmental events (e.g., anxiety about an upcoming exam) may trigger an urge to smoke. As a result of this generalization process, an abstinent person may frequently feel in need of cigarettes. When coping responses are limited or discomfort is great, the individual experiencing the craving is at high risk for resuming smoking.

A third variation of conditioning theory, Wikler's conditioned withdrawal theory (Ludwig and Wikler, 1974), was developed to explain alcohol abuse, though it may easily be applied to substance abuse in general. The most

important aspect of Wikler's theory for our purposes is the phenomenon labeled "conditioned withdrawal". This term refers to the pairing over time of certain stimuli and withdrawal symptoms, resulting in the development of a conditioned response resembling withdrawal. Thus, Wikler focuses on conditioned stimuli related to the absence rather than presence of the drug. Ludwig and Wikler (1974) argue that the more frequent and severe drug withdrawal symptoms are, the greater the propensity for conditioned withdrawal to develop.

Furthermore, Wikler designates a central role for cravings in motivating drug-seeking behavior. Cravings are defined as the cognitive correlates of the conditioned withdrawal syndrome. Like other theorists, Wikler states that cravings continue to occur during abstinence because they stem from conditioned responses. The cues that give rise to cravings may be either interoceptive (e.g., anxiety, dysphoria) or exteroceptive (e.g., an empty cigarette pack).

Wikler goes even further than the other theorists in giving prominence to the role of drug cravings in relapse. In reference to alcohol addiction, he states that "almost any cognitive construct an alcoholic offers to justify initial relapse...is probably a reflection of underlying craving which, in turn, is an automatic concomitant of a subclinical conditioned withdrawal state of physiological

arousal....Because alcoholics do not spontaneously report craving or because they offer some other reason for drinking does not necessarily mean that they are not experiencing craving or that craving is not an important determinant in the initiation and perpetuation of drinking." (Ludwig and Wikler, 1974, p. 120).

In summary, all of these conditioning theories share a basic mechanism whereby addictive behaviors are maintained. They account for relapse following even long-term abstinence by predicting that, until extinction takes place, conditioned stimuli will continue to elicit unpleasant reactions. Thus, previous users may experience cravings for a drug long after they have given it up.

Research on Cravings

Let us briefly review representative research which addresses conditioning theories of addiction and the concept of craving. Various investigators have tested whether environmental cues established as conditioned stimuli elicit responses different from those produced by the drug itself, as would be predicted by the three theories described above. Laboratory animals have indeed been shown to exhibit drug-opposite physiological responses in the presence of drug-related stimuli. For example, rhesus monkeys exhibited piloerection and yawning, common opiate withdrawal symptoms, when hearing music that had

previously been paired with morphine injections. This effect persisted for months following weaning from the drug (Ternes, 1977). Human laboratory studies produce similar findings for opiates (Eikelboom and Stewart, 1982), cocaine (Childress, Ehrman, McLellan, and O'Brien, 1987; Childress, McLellan, Ehrman, and O'Brien, 1988), alcohol (Monti, Binkoff, Abrams, Zwick, Nirenberg, and Liepman, 1987; Newlin, 1985), and cigarettes (Rickard-Figueroa and Zeichner, 1985).

Ludwig and Wikler (1974) cite evidence for the prevalence of drug cravings under natural conditions. A survey administered to 60 alcoholics revealed that 78% could readily identify cravings to drink in the presence of certain stimuli. For example, approximately half of the respondents reported feeling urges to drink when with other drinkers or in places where alcohol could be found. suggesting that cravings frequently arise in response to environmental cues. When the term "craving" was precisely defined for the subjects, almost all (95%) acknowledged having experienced cravings for alcohol. This finding is consistent with Wikler's assertion that urges to use a drug are commonly experienced by dependent persons.

With reference to cigarettes, there is considerable evidence that smokers and ex-smokers experience urges to smoke in the presence of particular stimuli (presumably conditioned stimuli which elicit conditioned responses

subjectively labelled as "cravings"). One line of research has been to examine cravings during smoking deprivation. Such studies generally find a positive relationship between the length of deprivation and the strength of self-reported cravings (Glassman, Jackson, Walsh, and Roose, 1984), suggesting that smokers are attending to internal cues related to nicotine withdrawal.

Assessment of cravings among nonabstinent smokers reveals a relationship between smoking and mood, such that individuals report a stronger desire to smoke when experiencing negative affective states (Payne, Levis, Colletti, and Schare, 1987). Other researchers have documented variations in the strength of urges to smoke based on environmental cues, such as accessibility of cigarettes (Herman, 1974).

Another area of research relevant to the current study concerns the identification of "high risk" situations associated with relapse among ex-smokers. If a return to drug use is triggered by cravings developed through classical conditioning, then "high risk" situations should be a rich source of conditioned stimuli. Numerous researchers have studied the reasons why former smokers relapse (Lichtenstein and Baer, 1986; Lichtenstein, Weiss, Hitchcock, Leveton, O'Connell, and Prochaska, 1986; O'Connell and Martin, 1987; Shiffman, 1982, 1984; Shiffman, Read, and Jarvik, 1985). In a representative study,

Shiffman (1986) surveyed relapsed smokers and found that about half of the respondents blamed either cravings or withdrawal-like symptoms for their resumption of smoking. The remaining respondents named either specific situational variables (e.g., drinking alcohol) or emotional states (e.g., anxiety) as precipitants of the relapse episode.

Some researchers have attempted to classify types of conditioned stimuli associated with craving and relapse. In one study, a factor analysis identified three basic categories of relapse determinants: negative affective states; positive affective states; and social smoking (Kirscht, Janz, Becker, Eraker, Billi, and Woolliscroft, 1987). Lichtenstein and Baer (1986) identified two major clusters of relapse-related situations, those involving negative affect and/or stress (68% of relapse episodes) and those involving positive mood states and/or consumption of food or alcohol (32% of episodes).

Other researchers have focused on cravings experienced prior to smoking cessation treatment as predictors of subsequent relapse. In a series of studies, Abrams and his colleagues assessed reactions of smokers to cigarette cues prior to their entry into a standard behavioral smoking cessation program. Craving ratings, as well as changes in heart rate and anxiety levels, predicted outcome at three months (Niaura, Abrams, DeMuth, Monti, and Pinto, 1989) and at six months post-treatment (Abrams, Monti, Carey, Pinto,

and Jacobus, 1988; Pedraza, Zwick, Binkoff, Monti, and Abrams, 1987). Results showed that the individuals who demonstrated the greatest reactivity to smoking-related stimuli prior to treatment were the ones most likely to be unsuccessful in maintaining abstinence from cigarettes at follow-up.

These findings have practical implications for smoking cessation treatment if cravings are viewed as conditioned responses. Techniques which effectively extinguish other types of problematic conditioned responses (e.g., anxiety) may also be applicable to drug cravings. Imaginal or in vivo exposure to smoking cues while preventing actual smoking has been recommended as a method of promoting abstinence from cigarettes (Brownell, Glynn, Glasgow, Lando, Rand, Gottlieb, and Pinney, 1986). Such methods are effective in treating other types of addictions (Cooney, Baker, and Pomerleau, 1983; Wolpe, 1965), so their application to smoking is reasonable.

In fact, controlled evaluations of cue exposure and response prevention specifically for smoking cessation have already appeared in the literature (Corty and McFall, 1984; Raw and Russell, 1980). In the Corty and McFall (1984) study, for instance, smokers handled unlit cigarettes while they listened to audiotaped descriptions of urges to smoke in various common situations (e.g., while drinking coffee). Participants also exposed themselves to environmental cues

between treatment sessions. Results showed clear evidence of extinction of cravings for the targeted situations (that is, after initially increasing, cravings decreased over the course of treatment). However, the strategy was not particularly effective in helping smokers achieve abstinence (i.e., only a third of the subjects had quit smoking by the end of treatment, and only 7% remained abstinent at the 6-month follow-up).

Although its utility as a cessation method is questionable, perhaps extinction of cigarette cravings would be an effective maintenance strategy for individuals already abstinent. In fact, relapse prevention treatments based on cue exposure and response prevention are currently being evaluated (D. Abrams, personal communication, 1989; T. Payne, personal communication, 1989). Before such work can reasonably advance, however, we need valid and reliable methods for assessment of cigarette cravings.

Assessment of Cravings

Although cravings are obviously important to maintenance of cigarette smoking and relapse, research to date has been plagued by incomplete and inadequate assessment of cravings. Brownell and colleagues (Brownell, Glynn, Glasgow, Lando, Rand, Gottlieb, and Pinney, 1986) propose that cigarette cravings be operationally defined as the subjective and physiological components of one's desire

to smoke. Based on this definition, assessment of craving should include cognitive (e.g., urge ratings), affective (e.g., anxiety levels), and psychophysiological measures (e.g., heart rate). This comprehensive definition is preferable to more simple conceptions of craving. It incorporates the elements of craving theoretically important from a classical conditioning perspective. Also, it is consistent with accepted methods for measuring other psychological constructs. Lang (1979) popularized the notion of multichannel assessment by making the observation that synchrony among different response modes may not exist. As with other constructs, cravings may not be easily (or reliably) measured in any one response mode, and may not exhibit concordance among measures (Tiffany and Baker, 1986). However, few investigators of craving thus far have implemented comprehensive assessment procedures.

Much of the work examining the role of cravings in addiction to cigarettes has relied primarily on smokers' self-reports of urges. In relapse studies, urge ratings are typically retrospective (for example, see Shiffman, 1986), but a few prospective studies have been conducted. To illustrate the latter type of research, consider the study described by Kirscht et al. (1987). Smokers rated the frequency with which they encountered fifteen different situations and the estimated difficulty in resisting the urge to smoke in each situation. These two scores were

then multiplied and summed to measure the extent to which smokers anticipated experiencing cigarette cravings following smoking cessation.

Even studies which examine cravings as they occur, a strategy conceivably allowing for precise measurement of the phenomenon, often fail to use a comprehensive assessment strategy. For example, some researchers administer simple questionnaires listing a variety of possible withdrawal symptoms, with craving for cigarettes included along with other symptoms such as appetite changes or irritability (Hatsukami, Hughes, Pickens, and Svikis, 1984).

In the laboratory, researchers have more frequently collected self-reports of craving levels using Likert-type scales. Rickard-Figueroa and Zeichner (1985) used a 5-point rating scale along which smokers indicated their "urge to smoke at this time", while Raw and Russell (1980) employed a 7-point scale assessing subjects' "desire for a smoke". Interesting variations on assessment of the cognitive aspect of craving included the use of a 10-cm visual analog scale along which subjects indicated the strength of their "thoughts about or a wish to smoke" (Glassman et al., 1984), and the employment of a dial which subjects turned to indicate fluctuations in their level of craving (D. Abrams, personal communication, 1989).

Recently, researchers have begun to assess not only the cognitive aspect of cravings, but also their physiological and emotional components. Psychophysiological measures have included heart rate, blood pressure, skin conductance, and temperature, with heart rate being the most commonly-reported measure (Abrams et al., 1988; Glassman et al., 1984; Niaura et al., 1989; Payne et al., 1987). A few researchers have also included assessment of emotional responses, along with self-reported cravings and/or physiological measures. Abrams and his colleagues (Abrams et al., 1988; Niaura et al., 1989) assessed state anxiety and Raw and Russell (1980) measured a variety of emotional responses (e.g., anxiety, aggression).

In order to assess cravings in the lab, one needs an effective means of producing urges to smoke. Theoretically, this could be accomplished by exposing individuals to the relevant conditioned stimuli. Researchers have demonstrated that self-reported cravings can be elicited through either imaginal or in vivo exposure to smoking cues. For example, Corty and McFall (1984) had smokers listen to a tape recording of other smokers discussing their experiences with cigarette cravings. Subjects tracked the strength of their urges to smoke, using a 7-point scale, for the duration of the tape. In another study, Rickard-Figueroa and Zeichner (1985) had

smokers observe a confederate smoke and then rate their desire for a cigarette. Raw and Russell (1980) exposed smokers in vivo to such stimuli as the sight and smell of a lit cigarette, the taste of coffee, and the offer of a cigarette from the experimenter. Herman's (1974) study illustrates still another approach to eliciting cravings. He allowed smokers access to cigarettes under various laboratory conditions (e.g., with or without a nicotine preload, with cigarettes clearly visible or less noticeable) and observed smoking topography variables such as latency to smoke. Thus, cue exposure is a reasonable method of producing cigarette cravings under controlled conditions.

A recent study conducted in Abrams' laboratory is representative of the best research to date on smoking cravings (Abrams et al., 1988). These researchers compared the responses of 42 male smokers, ex-smokers, and nonsmokers to a behavioral role play situation in which subjects conversed with a female confederate who was smoking. Multiple response modes were assessed. Self-report measures consisted of the State-Trait Anxiety Scale (Speilberger, Gorsuch, and Lushene, 1970) and an 11-point Likert scale assessing desire to smoke. Continuous measurement of heart rate was also taken during the role play procedure. The results were in the direction predicted by classical conditioning theories. In the

presence of these smoking cues, smokers scored significantly higher than nonsmokers and ex-smokers on cigarette cravings and anxiety. Smokers also differed from nonsmokers, but not ex-smokers, in heart rate responsivity.

The strengths of this study were its inclusion of multiple measures of craving (cognitive, emotional, and psychophysiological responses) and of subjects with varying smoking histories (smokers, ex-smokers, and nonsmokers). The cue exposure procedures were effective in eliciting cravings among smokers, so that urges to smoke could be examined as they were occurring.

There are several weaknesses in this study, however. First, only men were included in the sample, raising a question of the generalizability of the results to women. Second, the ex-smokers varied widely in their length of abstinence from cigarettes (from 3 months to 5 years; average = 22 months). This makes it difficult to understand the pattern of results; specifically, why ex-smokers and current smokers differed in self-reported craving and anxiety, but not on heart rate responses to smoking cues. Third, subjects were exposed to only one set of smoking-related cues (i.e., seeing a female confederate smoke a cigarette). The literature indicates that a much more diverse set of stimuli is involved in relapse episodes, and thus implies the existence of several other classes of important conditioned stimuli for cravings

(e.g., negative affect). Further, Abrams et al. (1988) required subjects to interact with the smoking confederate, thus introducing considerable variability into the stimulus presentation. A final criticism of the study is its reliance on a single measure of psychophysiological reactivity, heart rate.

Statement of the Problem

The existing literature concerning cigarette cravings is diverse. There are laboratory studies showing that smokers experience craving along with a variety of other symptoms when deprived of cigarettes. There are smoking relapse studies which identify a variety of "high risk" situations associated with increased craving and/or resumption of smoking among abstinent individuals. And, there are a few studies showing that exposure to smoking-related stimuli in the laboratory can produce cognitive, emotional, and/or physiological reactions in current and former smokers. These various lines of evidence converge to suggest that cigarette cravings are multidimensional responses to environmental or internal stimuli which lead to an increased probability of smoking.

However, our understanding of craving as a construct is rudimentary at best. The problem is not a lack of theorizing about the nature of craving, but rather a lack of appropriate methodology for studying it. The existing

research on cigarette cravings is deficient in the following areas: (1) standardization of measurement; (2) standardization of cue exposure procedures; and (3) inclusion of appropriate control groups. There is a clear need for well-controlled laboratory studies to develop valid, reliable, comprehensive methods for assessing cravings (Pomerleau and Pomerleau, 1984; Tiffany, 1990; Tiffany and Baker, 1986).

The purpose of the current study was twofold: (1) to develop simple, easily replicable procedures for eliciting cigarette cravings in the laboratory and (2) to study the nature of these cravings using a multimodal assessment strategy.

In constructing potentially effective and efficient cue exposure procedures, the current study relied heavily upon the existing theoretical and experimental literature. In previous smoking cue exposure research, elaborate role play procedures have frequently been used, as illustrated by the Abrams et al. (1988) study in which subjects interacted with a smoking confederate. In discussing the results of their study, these authors suggested that less expensive, less invasive techniques might be preferable to their cue exposure procedure.

Imaginal cue exposure not only allows for presentation of a wide variety of stimuli, it is also cost-effective. A potential drawback, and perhaps the reason imaginal

exposure has not been widely used by previous researchers, is the artificiality of the procedure. Subjects must create stimuli in their minds and then react as they would if encountering those situations in reality. Imaginal stimuli may be perceived as less intense than in vivo presentation of the same cues. Nevertheless, it makes sense to test the ability of imaginal stimuli to elicit cigarette cravings, and to contrast their effectiveness with in vivo cue exposure.

Another consideration in the selection of smoking cues was the emotional valence of the stimuli. According to the theoretical argument put forth by Ternes (1977), negative mood states can serve as conditioned stimuli for cigarette cravings. There is also considerable experimental evidence linking negative affect with cravings (Payne et al., 1987) and relapse (Kirscht et al., 1987; Lichtenstein and Baer, 1986). One way to evaluate this relationship is to compare the relative strength of cravings elicited by situations involving negative emotions with those involving pleasant affect. Thus, two of the imaginal scenarios used in the present study involved presentation of unpleasant situations with suggestions to experience negative affect (e.g., to become angry when recalling an argument). The other two imaginal exposure trials incorporated positive emotional responses to pleasant stimuli (e.g., comfortably relaxing at home after an enjoyable meal).

The next set of procedural decisions in designing the current study involved the assessment strategy. The first step in developing an assessment is to operationally define the construct one hopes to measure. The definition of craving adopted for the present study is one that has a precedent in the psychological literature and is consistent with classical conditioning theories. Specifically, this definition states that cigarette cravings are the simultaneous cognitive, emotional, and physiological responses associated with one's urge to smoke.

The measures chosen to represent each response channel are those most consistently appearing in the smoking literature to date. For cognitive labelling of the state of "craving", a Likert-type scale rating one's "desire for a cigarette" was constructed. For emotional responsivity, the State-Trait Anxiety Inventory (Speilberger et al., 1970) was employed. And, for physiological responding, heart rate and skin conductance were measured.

A last realm of consideration for the present study concerned the use of experimental controls. Few previous studies have included adequate controls for the general arousal generated by cue exposure procedures. In fact, most research has failed to include control groups of nonsmokers, even though inclusion of individuals lacking a history of smoking is essential to understanding craving.

It is also important to compare current smokers with ex-smokers. Classical conditioning theories predict that former smokers will continue to experience cravings to smoke in the presence of conditioned stimuli until extinction has occurred. Generally, one could predict a negative relationship between length of abstinence from cigarettes and the strength of cravings (although no data on this potential correlation have been reported). If such a relationship exists, it would be important to control for length of abstinence when measuring cravings in former smokers. In the current study, this was accomplished by including only recent quitters (i.e., individuals who had achieved abstinence within the past year) in the sample.

The present study thus proposed to contrast responses to smoking-related cues across three groups of men and women: current smokers; recent quitters; and nonsmokers. Furthermore, care was taken to control for as many potential confounding variables as possible. Such factors as demographic characteristics and smoking histories were carefully assessed, and groups were matched on these variables when possible. Finally, subjects were exposed imaginally and in vivo to stimuli which ought to elicit smoking cravings as well as to supposedly neutral stimuli.

METHOD

Design

The present study was designed to assess the physiological, cognitive, and emotional responses of subjects with different smoking histories to smoking-related stimuli. The types of stimuli chosen for presentation have been strongly associated with relapse among ex-smokers. Cigarette cravings elicited by imaginal and in vivo cue exposure were compared between recent ex-smokers and continuing smokers. A comparison group of nonsmokers was also included to control for the effects of attention and general arousal.

Smoking cues were primarily presented imaginally to allow the testing of responses to a wide variety of events. Subjects formed mental images of four types of situations commonly associated with smoking relapse: (1) social situations involving alcohol consumption (in this case, a party scene); (2) relaxing after a meal (specifically, watching an evening television program); (3) negative interactions with others (here, an argument with a significant other); and (4) frustrating situations (for example, finding out that one's car requires extensive

repairs). A fifth imagined scenario devoid of smoking cues (specifically, being in a movie theater) was included as a control. Subjects were also given a sixth trial consisting of in vivo exposure to an unlit cigarette.

Thus, the study involved repeated exposure to smoking-related stimuli (within-groups factor) across three different types of subjects: smokers, ex-smokers, and nonsmokers (between-groups factor). Measurements taken at baseline were employed as covariates where appropriate.

Subjects

Students from undergraduate psychology classes at North Dakota State University participated in the study in exchange for extra course credit. To decrease potential confounding of results due to demographic variables, subjects were matched on age and gender across groups. Matching was accomplished by recruiting smokers and nonsmokers of the same gender and age as the ex-smokers who had already agreed to participate.

Within-group homogeneity was sought by limiting the sample to subjects with similar smoking histories. To assure that cigarette smoking had occurred regularly enough to allow for the development of conditioned responses, smokers were required to have at least a one year history of daily smoking and a current smoking rate of at least 20 cigarettes per day. Ex-smokers were those previous regular

smokers (i.e., a pack a day for at least one year) who had quit smoking within the past year. Only persons who had never smoked regularly (defined as weekly smoking for 3 months or longer) comprised the nonsmoker control group. Nonsmokers who indicated an extreme dislike for cigarette use by others were excluded from the sample; it was considered likely that such individuals would experience arousal due to the aversive nature of exposure to smoking cues, potentially confounding the results.

In order to prevent nicotine in the system from influencing responding, smokers abstained from smoking for approximately one hour prior to the assessment. Most nicotine is removed from circulation within 60 minutes after finishing a cigarette (Witters and Venturelli, 1988). Longer periods of abstinence were considered undesirable because of the potential for nicotine withdrawal symptoms. In addition, all subjects avoided ingesting caffeine for an hour prior to the session.

Experimenters

Two female experimenters, a doctoral student and an undergraduate psychology major, conducted the study. They ran 40 and 6 subjects, respectively, distributed in equivalent proportions across conditions. Experimenters followed a script to insure consistency across subjects, and practiced all procedures using pilot subjects prior to actual data collection.

Measures

Sources of data included a variety of questionnaires, craving ratings, and psychophysiological measures. Questionnaires collected general information (e.g., demographics) and smoking histories. The major dependent variables were responses to smoking cue exposure. These measures included: (1) ratings of the strength of cigarette cravings; (2) self-reported anxiety; and (3) psychophysiological responses. The latter involved measurement of heart rate and electrodermal activity (i.e., skin conductance response).

Screening. Screening questionnaires administered to undergraduate psychology classes identified prospective participants. The brief survey assessed age, gender, smoking status (never smoked, currently smoke, used to smoke but quit), history of smoking (years of regular smoking, smoking rate, months of smoking abstinence), and aversion to smoking (7-point scale rating extent to which others' smoking was bothersome).

Recruitment of eligible subjects relied on data from the screening instrument. Specifically, current smokers were recruited if they had smoked a pack a day or more for at least one year. Ex-smokers included in the sample were individuals who had quit within the past 12 months, but who had smoked regularly for at least a year prior to quitting. Nonsmokers were recruited if they had never smoked

regularly and if they reported only a mild to moderate aversion to others' cigarette use (rating of 1 - 4 on the aversion scale).

General information. Several questionnaires assessed demographic information and personality characteristics (see Appendix A). Demographic variables included age and gender of participants. A brief questionnaire assessed intake of central nervous system stimulants and depressants within the past 24 hours and past week. Specifically, participants estimated their consumption of tobacco, caffeine, alcohol, and psychoactive drugs. These data were of interest because differences in intake of these substances could produce differential physiological responding.

Two standardized questionnaires were also included in the assessment. The Eysenck Personality Inventory (Eysenck and Eysenck, 1968), a 57-item self-report instrument, provided scores on the dimensions of extraversion and neuroticism. These scales have been related to physiological responsiveness and to smoking rates in previous samples (Eysenck, 1973). The questionnaire was included in the present study as a potential predictor of individual differences in exposure to smoking cues. The State-Trait Anxiety Inventory (Speilberger et al., 1970) yielded a measure of general anxiety levels, as well as of situational anxiety. The latter served as an indicator of

emotional responsivity to smoking-related stimuli. The questionnaire was administered prior to cue exposure as a baseline measure.

Smoking-related information. Only smokers and ex-smokers completed the smoking-related questionnaires (see Appendix A), which added 15 to 20 minutes to the session duration for these groups. Wording of some items was changed for ex-smokers to reflect their current abstinence from cigarettes; otherwise, items were identical for the two groups. Smoking history, smoking topography, and nicotine dependence were the major areas assessed.

The primary smoking-related measure was the Smoking Patterns Questionnaire (Glasgow, Klesges, Godding, and Gegelman, 1983), which has been demonstrated to be highly correlated with self-monitoring records and objective measures of smoking. This questionnaire includes items assessing smoking rate (e.g., "how many cigarettes do/did you smoke per day?"), brand of cigarettes smoked (for estimation of nicotine dosages), number of years of regular smoking, frequency of use of other forms of tobacco (e.g., cigars, chewing tobacco), and description of cessation attempts (e.g., number of attempts, length of most successful attempt). The Fagerstrom Tolerance Questionnaire (Fagerstrom, 1978) was also included as part of the assessment. This measure yields a score which reflects degree of nicotine dependence, and has been

related to relapse following smoking cessation treatment (Fagerstrom, 1982; Pomerleau, Pomerleau, Majchrzak, Kloska, and Malakuti, 1990). It was incorporated into the present study as a potential predictor of cue reactivity.

Finally, an objective measure of smoking status was collected to corroborate subjects' self-reports. Collection of biochemical measures has been shown to significantly reduce inaccurate reporting of smoking levels (Ossip-Klein, Bigelow, Parker, Curry, Hall, and Kirkland, 1986). Saliva thiocyanate, a chemical which is highly related to smoking patterns over the past 10 - 14 days, was chosen because of its proven validity in other studies (Glasgow, Klesges, and O'Neill, 1986).

Craving. Measures of craving strength, modeled after those used by Abrams (personal communication, 1989), were collected via computer after presentation of each set of smoking-related stimuli. At the end of each trial, subjects rated their current urge level and the maximal craving they had experienced using a 9-point scale, with the extreme responses labeled "no desire" (1) and "extreme desire" (9). The items were worded as follows: (1) "Rate your desire for a cigarette at this moment" and (2) "Rate the strongest desire for a cigarette you experienced while imagining the situation".

Other computer-assisted measures collected at the end of each cue exposure trial included the state anxiety

subscale of the State-Trait Anxiety Inventory (Speilberger et al., 1970), a rating of clarity of imagery (i.e., "Rate how well you were able to imagine yourself in the preceding situation", on a 9-point scale from "not at all" to "extremely well"), and a rating of cognitive avoidance of smoking-related cues (i.e., "To what extent did you find yourself trying not to think about smoking cigarettes?", on a 9-point scale from "not at all" to "a great deal"). The latter two ratings were collected to determine the extent to which cravings elicited solely through imaginal means might be influenced by ongoing cognitive activity. Specifically, it was hypothesized that image clarity would enhance cravings, while cognitive avoidance of cues would diminish cravings.

Psychophysiological measurement. Two psychophysiological measures were collected to further assess subjects' responses to smoking cues. A 4-channel Grass polygraph (Model 79D) was used to obtain data on heart rate and skin conductance response. Two adjacent sound-proof chambers were used in the experiment, one for operating the polygraph and the other for presenting stimuli to subjects. Leads connecting the cardiotachometer and electrodermal electrodes to the polygraph were run through the wall separating the two chambers. The polygraph room was also equipped with a cassette tape player connected to a set of headphones in the adjacent

subjects' chamber. A one-way mirror allowed the experimenter to observe subjects while simultaneously operating the polygraph and audiotape equipment.

The subjects' sound-proof chamber was equipped with a large, comfortable chair and a Zenith personal computer with monitor. The computer was positioned such that the screen was at eye-level for seated subjects and the keyboard was within easy reach of each participant's dominant hand. On a small table beside the chair, there was an inverted plastic box which obscured from view an ashtray, a disposable lighter, and one cigarette.

Procedures

Recruitment. Students enrolled in undergraduate psychology classes were screened to identify potential participants. One of the experimenters visited introductory level psychology classes at the beginning of the spring and summer sessions at North Dakota State University. Students filled out the brief screening instrument in exchange for one point of extra credit towards their course grade. The experimenter explained that she was seeking participants for a study comparing physiological responses of smokers and nonsmokers and that eligible students might be contacted and invited to participate. The response rate of students completing the

screening questionnaire approximated 100% of those present in class on the survey days.

Following identification of appropriate individuals (i.e., those meeting eligibility requirements described above), the experimenter called to give a brief description of the study and invite participation. To prevent subjects from developing expectancies about the purpose of the study which might affect their responses, the experiment was described as "an investigation of people's physical reactions to different kinds of situations". Potential participants learned that the study involved psychophysiological measurement, lasted approximately two hours, and earned them extra credit towards their psychology grade. After obtaining subjects' initial consent to participate, the experimenter scheduled the time of the session and instructed subjects to refrain from ingesting nicotine or caffeine during the hour preceding the experiment since stimulants could alter physiological responses.

When possible, subjects were contacted again the day before the scheduled session. The experimenter reminded participants of their appointment time and of the need to refrain from pre-session nicotine and caffeine consumption.

Questionnaires. Upon reporting to the experiment, subjects were ushered into a small conference room for presentation of written measures. First, individuals read

an informed consent form explaining the basic study procedures (see Appendix A). In obtaining informed consent, the experimenter stressed that the project was approved by the Institutional Review Boards at both North Dakota State University and the University of North Dakota and that participants could withdraw at any time without penalty. (No subjects declined to participate and none requested early dismissal from the experiment.)

After signing the consent form, subjects completed pre-exposure questionnaires. These gathered both general and smoking-related information (see description above). The experimenter assured participants of confidentiality and asked that all questions be answered honestly and completely.

As subjects worked on questionnaires, they also provided a saliva sample for analysis of thiocyanate. In accordance with established procedures (Luepker, Pechacek, Murray, Johnson, Hurd, and Jacobs, 1981), subjects placed cotton dental rolls in their mouths and allowed the rolls to collect saliva for two minutes. When the collection period had elapsed, individuals placed their rolls in test tubes which were subsequently sealed and frozen. Laboratory analysis of thiocyanate levels was supervised by Dr. James Fleeker, an NDSU biochemist familiar with this procedure. The colorimetric method of analysis described by Densen, Davidow, Bass, and Jones (1967) was employed.

While subjects completed pencil-and-paper measures, the experimenter prepared for the cue exposure trials to follow. The order of presentation of imaginal scenes was selected at random, and a cigarette to be used during in vivo exposure was chosen. Where possible, smokers and ex-smokers were given the same brand of cigarette they preferred to smoke. If that brand was not available, a cigarette with a similar nicotine content was selected. Cigarettes for nonsmokers were randomly chosen from among six popular brands (e.g., Camel, Merit).

Cue exposure. After completing the written measures, subjects went into the physiological recording room for the remainder of the experiment. They settled into a comfortable chair and awaited placement of recording sensors. The experimenter described the function of each sensor as it was attached. Subjects were informed that they would feel no sensations from the skin conductance electrodes, but that due to the nature of photoplethysmography, they might feel heat emanating from the heart rate sensor. Participants were asked to refrain from unnecessary movements which might lead to erroneous readings.

To assess heart rate, a photoplethysmograph was attached to the index finger of the nondominant hand, then covered with a black cloth to prevent interference from

ambient light. The cloth was secured in place with adhesive tape.

Skin conductance response required the attachment of two silver - silver chloride electrodes to the thenar and hypothenar eminences of the nondominant hand (Hassett, 1978). The nondominant palm was first cleansed to remove surface dirt and oils and facilitate electrode contact. Electrodes were filled with electrolyte gel and attached with adhesive collars and tape. Once sensors were in place, a rubber strap was draped over the forearm and taped to the chair to discourage arm movements.

After completion of electrode placement, participants sat quietly and relaxed while the experimenter monitored their responses from the adjacent room. Approximately fifteen minutes were allowed for stabilization of physiological responding. The last five minutes of the adjustment period served as the baseline for physiological responses.

At the conclusion of the adjustment phase and baseline assessment, the experimenter returned to the room and instructed subjects in the stimulus exposure procedures. Participants learned that they would listen to audiotaped instructions presented through earphones. They were to follow directions for imagining various scenarios and would respond to questions appearing on the computer screen using the keyboard located next to their dominant hand. The

earphones were then placed in position and the experimenter retired to the adjoining room to activate the audiotaped instructions and resume physiological monitoring.

The cue exposure audiotape presented a series of six situations, lasting from 1.0 minute (the neutral scene) to between 3.0 and 3.5 minutes (the smoking cue scenes). Scenarios adhered to the following format: instructions to pay attention and "imagine the scene as vividly as possible"; an initial description of the situation; four imaginal prompts (i.e., suggestions to conjure up sights, sounds, smells, or feelings associated with that situation); introduction of smoking cues (e.g., seeing someone smoking, noticing a pack of cigarettes); and instructions to "think the same thoughts and feel the same feelings" as if the situation were real. The narrator then paused for 30 seconds to allow the subject to image on his or her own. At the end of this time, the exposure trial terminated and the participant completed a post-trial computerized assessment (craving ratings, state anxiety scale, and ratings of imagery and cognitive avoidance).

Following completion of these measures, subjects relaxed for 5 minutes (specifically, subjects were guided in passive relaxation for 90 seconds, then allowed to relax on their own for 3.5 minutes). The relaxation procedure was included to allow for recovery from any arousal generated by the smoking stimuli. After the relaxation

period, the next exposure trial began. (See Appendix B for sample cue exposure and relaxation scripts.)

The first imaginal situation presented was always a control scenario intended to be devoid of smoking cues. It oriented subjects to the procedures and provided a baseline against which reactions to smoking-related scenes could be compared. The format of the neutral scenario followed the general format described above, except that no smoking cues were introduced. The scene chosen was a movie theater, because of the presumed absence of smoking-related stimuli in this setting.

The next four scenarios all featured the combination of specific smoking cues with "high risk" relapse situations. The four scenes were: (1) attending a party and seeing others smoking; (2) relaxing at home and finding a pack of cigarettes; (3) being offered a cigarette by a classmate while fuming over a previous argument; and (4) learning that one's car requires extensive repairs from a mechanic who is smoking. Order of presentation of the four imaginal scenes was counterbalanced across subjects.

The sixth, and always final, exposure trial involved in vivo rather than imaginal exposure. When cued by the tape, subjects turned over the box beside them, revealing a cigarette, lighter, and ashtray. For a duration of one minute, participants handled the cigarette by first putting it between their lips and pretending to light it, then

simply holding the cigarette. (To ensure that subjects did not actually smoke, the lighter was rendered inoperable.) A similar procedure has been used successfullly in Abrams' laboratory to elicit urges to smoke (D. Abrams, personal communication, 1989). At the end of the trial, subjects completed the computerized assessment.

Debriefing. Following completion of all exposure trials, the experimenter returned to the lab room to disconnect the electrodes. Subjects had the opportunity to discuss their reactions to the procedure. Special care was taken to ensure that all ex-smokers were confident in their ability to remain abstinent after leaving the lab. In a few cases, subjects were given advice on how to resist residual cigarette cravings. No subjects expressed serious concerns about potential relapse to smoking due to their participation.

Finally, the experimenter fully debriefed all subjects as to the hypotheses of the study and answered their questions. Participants were asked not to reveal specifics of the experiment or its purpose to classmates. Following calculation of the number of extra class credits earned, subjects were dismissed.

RESULTS

Demographic and Smoking History Variables

Effectiveness of subject selection procedures.

Recruitment of current smokers and nonsmokers proved successful, with 17 and 18 subjects per group, respectively. However, the ex-smoker condition was more difficult to fill. Individuals who had recently stopped smoking comprised only a small percentage of students surveyed. Despite vigorous efforts, only 11 ex-smokers could be recruited to participate. Time constraints prohibited further screening and recruitment of potentially eligible persons.

Thiocyanate, a chemical byproduct of smoking, was collected from all subjects to add credence to their self-reports. Due to unanticipated difficulties with analysis of samples, thiocyanate values were obtained for only 40% of the subjects. A one-way analysis of variance on these data confirmed subjects' self-reported smoking rates. There was a significant effect for Condition, such that smokers produced higher thiocyanate values than either ex-smokers or nonsmokers (means of 257.4, 74.4, and 66.0, respectively; $F(2,18) = 18.35$, $p < .001$), with the latter

two groups not differing significantly. This pattern of means is consistent with the reported smoking status of the three groups.

By definition, nonsmokers reported no current smoking. Seven (39%) of them reported having tried smoking, a rate slightly lower than what would be expected based on national survey data (Ray and Ksir, 1990). Of those with smoking experience, the maximum number of cigarettes reportedly smoked per day averaged only 2.4, suggesting little if any chance for the development of conditioned responses to smoking-related cues. One of the nonsmoking subjects reported current use of smokeless tobacco; none were cigar smokers.

Ex-smokers reported having stopped smoking an average of 5.7 months prior to participating in the study (range from 1 to 10 months). Approximately a third of the group (n = 4) reported having relapsed to occasional smoking since quitting. All four of these subjects had smoked recently, from 3 to 10 cigarettes over the past week (4.5 cigarettes per week on average). Two of the ex-smokers also reported current use of cigars or smokeless tobacco.

On average, smokers reported current smoking rates of slightly more than one pack per day (range = 11 to 40 cigarettes daily). Most had attempted to quit smoking (12 out of 16, or 75%), with the average length of the most successful attempt estimated at 2.3 months (ranging from

less than one month to one year). Three smokers reported current use of cigars or smokeless tobacco.

Comparability of groups. Since groups were matched on age and gender, the three conditions ought not to differ on these variables. A one-way analysis of variance (ANOVA) confirmed comparability among the groups on age ($F(2,43) < 1.0$). The overall age of the sample was 23.6 years, with a range of 18 to 43 years. For gender, a chi-square analysis showed no differences across conditions ($X^2 = 1.66$, $p = .44$). There were 27 men and 19 women in the sample, for a total of 46 subjects. Thus, subject matching procedures were effective in producing groups comparable on age and gender.

Groups were also compared using one-way ANOVAs on personality, attitude, and behavior variables potentially related to craving responses. On both of the Eysenck personality factors, extraversion and neuroticism, the subject groups were comparable (Fs < 1.0). Overall mean scores were 14.78 for extraversion and 11.47 for neuroticism.

Subjects' attitudes toward smoking were assessed by having individuals rate the pleasantness of the sight, smell, and taste of cigarettes when someone else is smoking. Because these three ratings were significantly intercorrelated (rs from .57 to .75), an average attitude score was computed. An analysis of variance on this

measure revealed a significant effect for Condition, $F(2,43) = 15.3$, $p < .001$. Smokers and ex-smokers rated cigarettes as more pleasant than nonsmokers (means of 3.9, 3.5, and 2.3, respectively, on a 7-point scale from "extremely unpleasant" to "extremely pleasant").

Finally, between-group comparisons were made on estimates of recent consumption of substances which alter central nervous system activity. For stimulants, such as caffeine, participants reported having consumed 3.3 food or beverage items within the past 24 hours, with no differences among the three conditions ($F < 1.0$). Intake of central nervous system depressants, including alcohol, was lower than for stimulants (mean of 1.1 items over 24 hours). Again, there were no significant between-groups differences.

Comparisons of smoking histories. Ex-smokers and current smokers were compared on smoking histories with one-way ANOVAs in order to estimate how similar their smoking-related experiences had been. Ex-smokers reported regular smoking for an average of 5.6 years, compared with 9.7 mean years for smokers, a difference which did not meet statistical significance ($F(1,26) = 1.9$, $p = .18$). Smoking rates were also compared, using number of cigarettes per day prior to quitting for ex-smokers and current rate for smokers. These rates were not significantly different, with ex-smokers reporting 18.8 cigarettes per day versus

22.8 per day among smokers ($F(1,26) = 1.1$, $p = .32$). In a similar manner, nicotine content of cigarettes was compared between the two groups. This analysis also failed to identify significant differences ($F(1,26) < 1.0$), with current smokers using cigarettes of about the same potency as former smokers (nicotine values of .74 mg. and .80 mg., respectively; as a frame of reference, cigarettes in this range include Marlboro Lights).

Finally, Fagerstrom Tolerance Questionnaire scores were compared between the two groups. On this measure of nicotine dependence, current smokers averaged 5.2 and ex-smokers averaged 3.4 out of 11 possible points. Of the various smoking history measures, this was the only one to achieve significance ($F(1,26) = 7.7$, $p < .01$). To follow up on this finding, a chi-square analysis was performed on the Fagerstrom Tolerance Questionnaire scores using the recommended cutoff of 7 and above as indicative of a high level of nicotine dependence (Moore, Schneider, and Ryan, 1987). None of the ex-smokers responded in this range, but five (29%) of the current smokers reported strong nicotine dependence ($X^2 = 9.6$, $p < .01$). It was concluded that smokers and ex-smokers were generally comparable on smoking histories, but that smokers evidenced a greater dependence on nicotine (a factor which is negatively related to success in smoking cessation).

Gender differences. Analyses of variance were conducted to compare male and female subjects on general and smoking-related variables. (See Table 1 for means and standard deviations by gender.) There were no significant gender differences on age, extraversion, neuroticism, or anxiety scores (all Fs < 1.3). Similarly, male and female smokers and ex-smokers did not differ on smoking rates or history (all Fs < 1.1).

A nonsignificant trend was seen for thiocyanate values ($F(1,19) = 3.1$, $p = .09$), with men showing higher levels of this smoking-related chemical than women (means = 174.2 vs. 88.9, respectively). Comparisons for two related variables, nicotine content of cigarettes and nicotine dependence, revealed higher scores for men on these variables, but the gender differences failed to reach statistical significance ($F(1,26) = 1.8$, $p = .19$ for nicotine dosage; $F(1,44) = 2.4$, $p = .13$ for nicotine dependence).

Reactivity to Smoking Cue Exposure

Overview of analysis strategy. Between-group differences were examined during five phases of the experiment: at baseline; during the neutral scene; during imaginal smoking scenes involving positive affect (two trials); during imaginal smoking scenes involving negative affect (two trials); and during in vivo exposure. The

Table 1

Means for general and smoking-related variables by gender

General variables	Males (n=26)	Females (n=19)
Age	23.81 (6.6)	23.42 (7.7)
Extraversion	14.92 (4.6)	14.79 (4.2)
Neuroticism	11.42 (4.9)	11.53 (5.4)
Trait anxiety	38.00 (9.3)	41.53 (11.8)
State anxiety (baseline)	36.81 (8.1)	36.53 (9.6)
Smoking history variables[a]	**Males (n=18)**	**Females (n=10)**
Number years smoked	8.48 (8.3)	7.48 (7.7)
Number cigarettes/day	21.33 (7.8)	21.10 (14.0)
Thiocyanate level	174.23 (110.0)	88.89 (104.7)
Nicotine content	0.81 (0.2)	0.68 (0.3)
Nicotine dependence	3.26 (2.8)	2.05 (2.2)

Note: Parenthetical values are standard deviations.

[a]Tabled values include only smokers and ex-smokers.

three classes of dependent variables included craving ratings, anxiety levels, and physiological responses (heart rate and skin conductance).

The two pleasant situations (the party and relaxation scenes) were evaluated together, as were the two unpleasant scenarios (the car repair and argument situations). This was done to test the hypothesis that different levels of craving might be elicited by positive versus negative emotional stimuli. Craving ratings, anxiety, and psychophysiological responses were averaged within each pair of trials.

The general analysis strategy was to contrast the three groups' responses using ANOVAs (or analyses of covariance for psychophysiological measures). Because of the similarity in procedures across cue exposure trials, repeated measures analyses were employed to evaluate these data. Results of the statistical analyses will be discussed separately for each type of dependent variable, first at baseline and then across cue exposure trials.

Baseline comparisons. Cigarette cravings were not assessed prior to the induction of cue exposure, although subjects were tested to determine their baseline levels of anxiety. One-way ANOVAs identified no between-groups differences on either trait or state anxiety ($Fs < 1.0$). See Table 2 for group means and standard deviations on anxiety scores.

Table 2

Means for baseline craving components by condition

Variable	Smokers (n=17)	Ex-smokers (n=11)	Nonsmokers (n=18)
Craving	--	--	--
State anxiety	37.7 (8.4)	37.6 (8.4)	35.2 (9.2)
Heart rate	77.7 (9.2)	73.8 (7.8)	76.5 (9.6)
Skin conductance	4.48 (3.3)	6.35 (4.5)	5.13 (4.3)

Note: Parenthetical values are standard deviations.

To compare the groups on psychophysiological measures, average scores for heart rate and electrodermal activity were calculated for the final 60 seconds of the baseline adaptation) phase. General scoring of heart rate values proceeded as follows: heart rate (recorded as beats per minute) was sampled every 2 seconds, and these values were averaged over every 10 second period to provide a more stable measure. Skin conductance response was calculated by determining the resistance reading every 10 seconds, then converting this value to conductance (Hassett, 1978). The three subject groups did not differ significantly on heart rate or electrodermal responses averaged across the last minute of the baseline period, $F(2,37) < 1.0$ for heart rate and $F(2,39) < 1.0$ for skin conductance. Table 2 presents means and standard deviations for these variables.

Craving responses across exposure trials. Two craving ratings were obtained at the conclusion of each exposure trial: current urge to smoke and the strongest craving experienced during the trial. These two ratings were highly correlated ($rs = .90$ to $.98$ across the six exposure trials), so they were averaged for all analyses. Craving ratings were also averaged across the two positive and the two negative mood imaginal exposure trials.

A repeated measures ANOVA was used to compare the subject groups across four phases of cue exposure: the neutral (control) scene; the pleasant imaginal scenes; the

unpleasant imaginal scenes; and the in vivo exposure trial. Significant main effects for Condition ($F(2,43) = 76.8$, $p < .001$) and Phase ($F(3,129) = 38.2$, $p < .001$) emerged, as well as a Condition X Phase interaction ($F(6,129) = 7.3$, $p < .001$). Figure 1 illustrates these effects, and Appendix C contains ANOVA tables for the analysis.

To determine the source of the interaction, simple main effects for Condition within each Phase were computed. These analyses revealed significant between-groups differences at each phase. Post-hoc Tukey tests showed that, for the neutral exposure trial, current smokers' cravings were significantly elevated above those reported by ex-smokers and nonsmokers, with the latter two groups being statistically equivalent. This finding was contrary to the expectation that the neutral scene would elicit consistently low cravings for all subjects because the scenario lacked explicit smoking cues.

A somewhat different pattern emerged for the exposure trials involving smoking cues. For imaginal stimuli involving positive affect, smokers and ex-smokers showed significantly stronger cravings than nonsmokers. The two smoking groups did not differ during this phase. For the negative affective trials and the in vivo exposure scene, however, all three groups reported significantly different levels of craving. In each case, current smokers reported the strongest urges to smoke, ex-smokers rated their

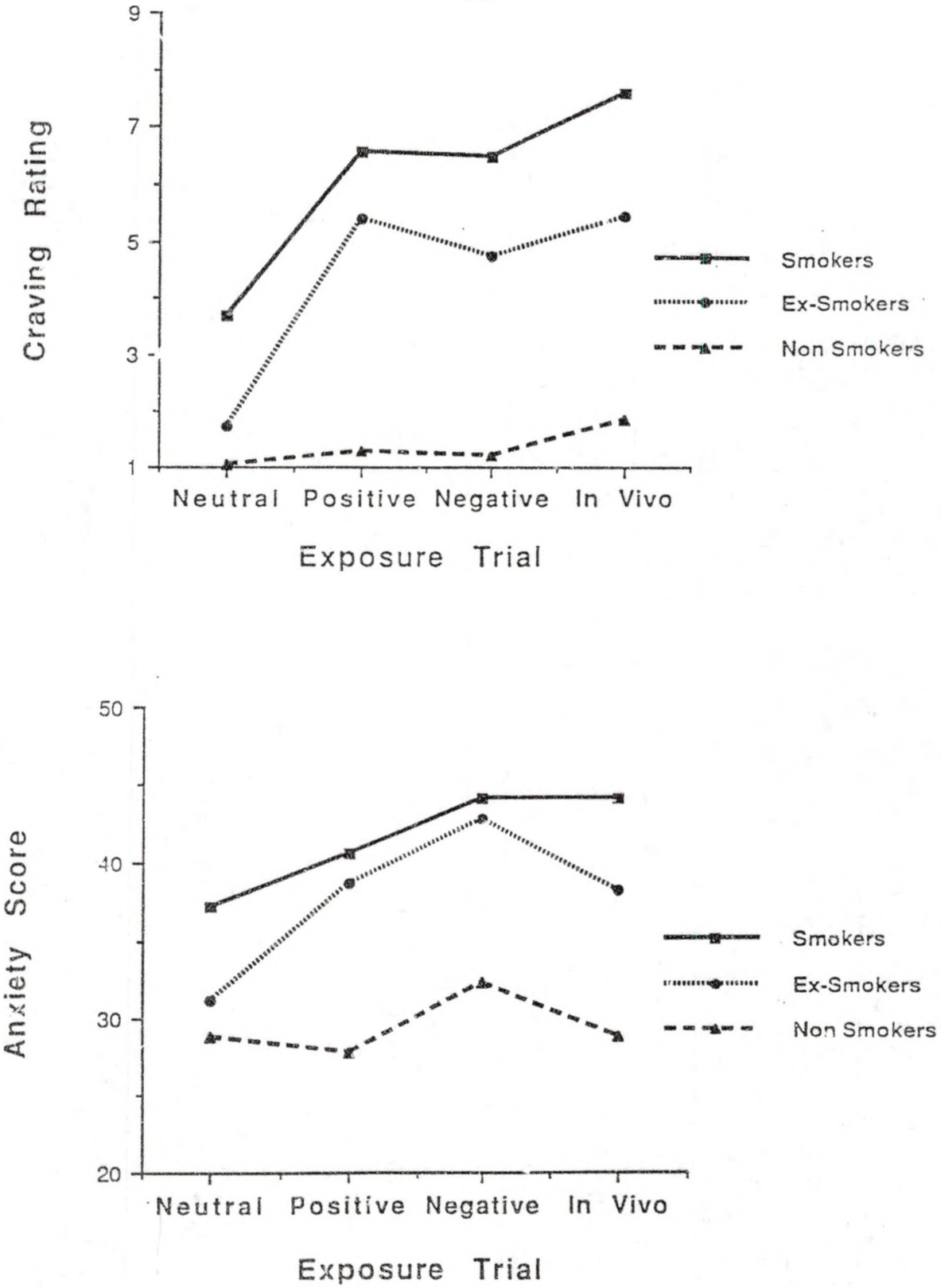


Figure 1. Mean craving ratings and anxiety scores across exposure phases by condition.

cravings more moderate, and nonsmokers reported essentially no desire to smoke.

Main effects for Phase and Condition were also examined. Correlated t-tests performed for each pair of exposure phases, collapsed across conditions, showed that the neutral trial produced weaker urges than all other phases, that positive and negative affective stimuli produced equivalent levels of craving, and that in vivo exposure resulted in stronger cravings than all other phases (all $ps < .05$).

The source of the main effect for Condition was revealed by conducting a Tukey test comparing the groups on craving ratings collapsed across all four phases. All subject groups differed from one another in craving responses to smoking cues. Group means for the overall craving measure were 6.2 for smokers, 4.6 for ex-smokers, and 1.3 for nonsmokers.

Anxiety responses across exposure trials. State anxiety scores served as a measure of emotional responsivity to cue exposure. As was done with craving ratings, anxiety scores were averaged across the two positive and across the two negative imaginal exposure trials. A 3 (Condition) X 4 (Phase) repeated measures ANOVA revealed significant main effects for Condition ($F(2,43) = 13.5$, $p < .001$) and Phase ($F(3,129) = 9.5$, $p < .001$). The interaction between the two factors was not

significant ($F(6,129) = 1.7$, $p = .13$). See Figure 1 for the group means across experimental phases and Appendix C for ANOVA tables.

The main effect for Phase was evaluated by performing correlated *t*-tests between anxiety scores for each pair of exposure phases. These analyses revealed statistically significant differences between the neutral trial and all other trials, with the former producing the weakest anxiety responses (all $ps < .05$). There was also a significant diference between the positive affect and negative affect imaginal scenes, with negative trials associated with greater anxiety ($p < .05$). The two imaginal exposure phases did not differ significantly from the in vivo exposure trial, however.

The source of the main effect for Condition was revealed by conducting a Tukey test comparing the groups on anxiety scores collapsed across all four phases. Smokers and ex-smokers were significantly more anxious than nonsmokers, with the former two conditions not differing significantly from one another. Group means on the overall anxiety measure were 41.8 for smokers, 38.8 for ex-smokers, and 29.7 for never smokers.

Physiological responses across exposure trials. Evaluation of group differences in physiological responding was carried out by comparing heart rate or skin conductance values averaged over a specific sampling period for each

trial. The time period chosen for the neutral exposure trial consisted of the 60 seconds during which the majority of scene-specific imaginal instructions occurred. This specific period was selected because it encompassed the most intensive exposure to standardized imaginal stimuli.

For the imaginal smoking cue exposure trials, two-minute sampling periods were selected for each scene. It was hypothesized that individuals with a history of regular smoking would respond to presentation of stimuli associated with smoking (e.g., social occasions), as well as to more direct suggestions regarding cigarette use (e.g., watching someone else light up). Thus, the 60 seconds directly preceding and directly following the introduction of explicit smoking imagery were chosen. For the in vivo trial, physiological reactions were assessed during the first 60 seconds when subjects actually handled a cigarette.

A separate 3 X 4 repeated measures ANCOVA was conducted for each physiological measure, heart rate and skin conductance. Responses averaged across the last 60 seconds of baseline were used as covariates. Covariance is considered appropriate for analyzing psychophysiological data because of its ability to minimize the error variance introduced by large individual differences.

Results of these analyses revealed main effects for Phase for both variables ($\underline{F}(3,90) = 7.65$, $\underline{p} < .001$ for

heart rate; ($F(3,114) = 23.32$, $p < .001$ for skin conductance). Although no main effects for Condition emerged, there was a statistically significant interaction between Phase and Condition for skin conductance response, $F(6,114) = 2.60$, $p = .02$. No interaction emerged for heart rate ($F < 1.0$). Figure 2 graphically illustrates these results.

Correlated t-tests exploring the Phase effects revealed the same pattern of results for both variables. Physiological responding did not differ significantly among the neutral, positive imaginal, and negative imaginal exposure phases. However, the in vivo trial produced significantly higher skin conductance levels and heart rates relative to the other three phases (all $ps < .05$). Because all subjects showed increased physiological responding during the final exposure trial, it is reasonable to assume that the unique aspects of the trial (e.g., requiring participants to handle a cigarette rather than sit quietly) are primarily responsible for the changes in heart rate and skin conductance reactivity.

Examination of Figure 2 reveals the source of the interaction between Condition and Phase for skin conductance levels. Ex-smokers showed a more dramatic rise on this measure during the in vivo trial than did the other two groups. This finding is difficult to explain in isolation and is probably not meaningful.

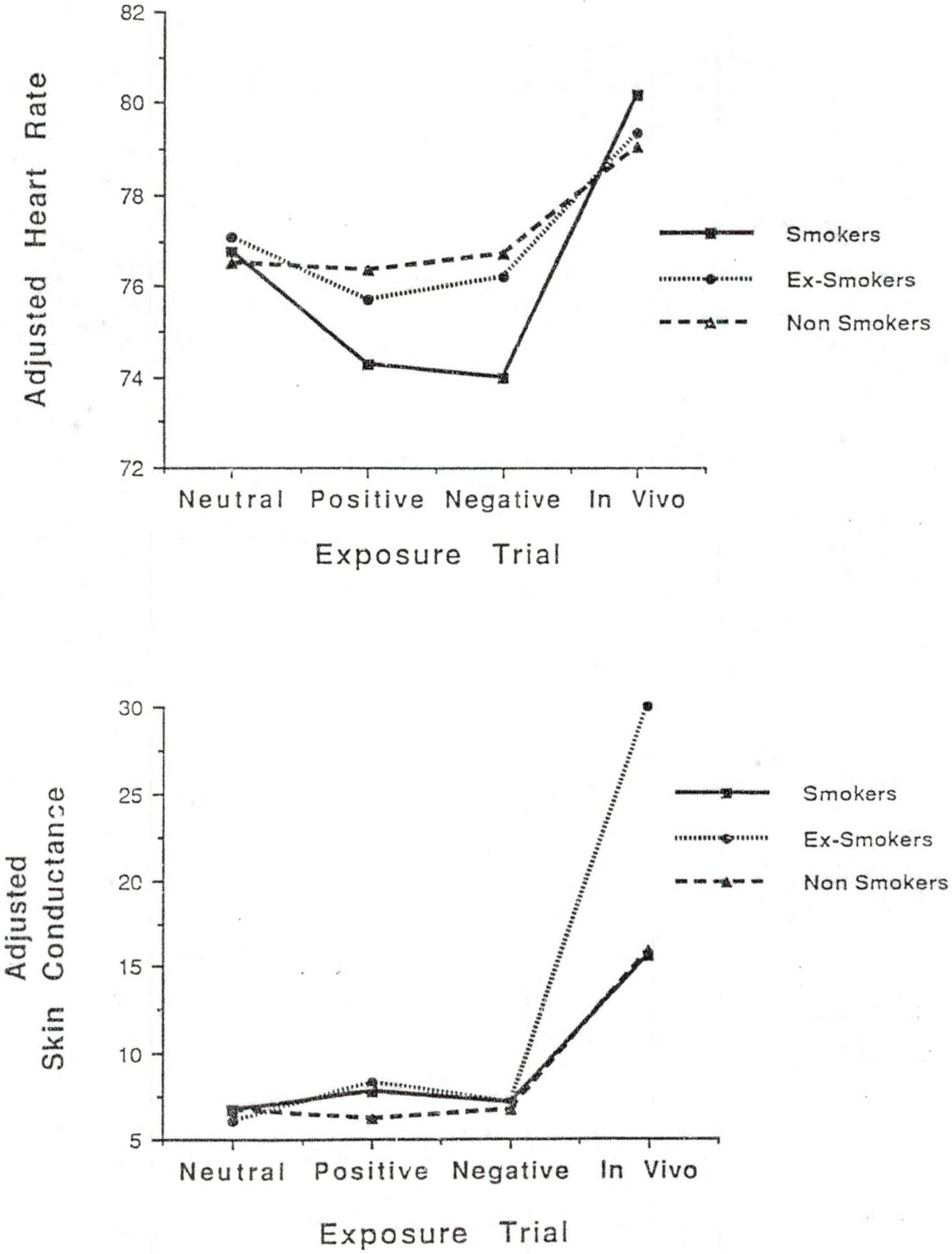
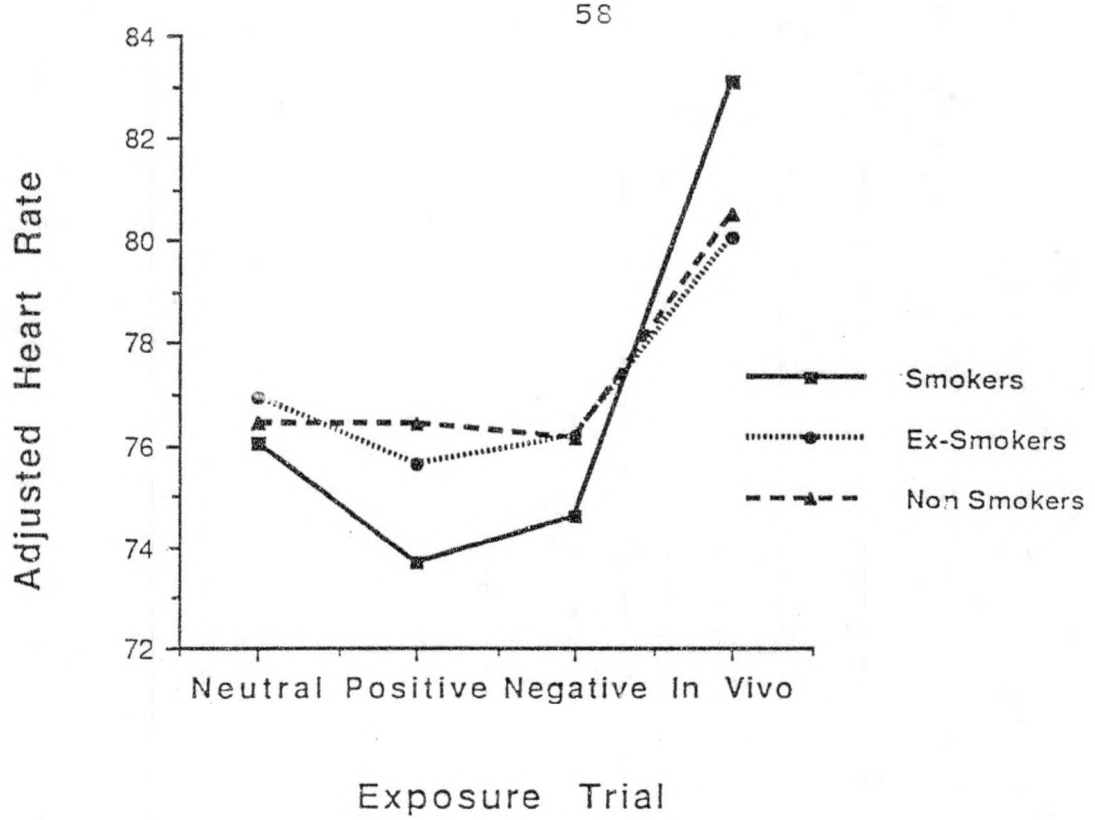


Figure 2. Mean total physiological responses across exposure phases by condition.

It was posited that selection of a more precise time frame for measuring physiological responses (i.e., the first few seconds following the introduction of specific references to smoking) might be more sensitive to between-groups differences in responding. Payne (personal communication, 1990) has found that a 30-second time frame is preferable to longer periods when studying physiological reactivity to smoking cue exposure. Thus, an appropriate 30-second period during each trial was selected for analysis of heart rate and skin conductance in the current study. Specifically, average values for each variable were computed for the 30 seconds immediately following the introduction of explicit smoking cues (e.g., seeing someone light a cigarette). Since the neutral scene contained no explicit references to smoking, the 60-second average values were retained for this trial.

The heart rate and skin conductance averages were analyzed separately by means of repeated measures ANCOVAs, with baseline responses as covariates. Results of these analyses are presented in Figure 3. As can be seen, patterns of results were similar to those obtained using the longer sampling periods for these variables. For heart rate, there was a main effect for Phase ($F(3,87) = 13.34$, $p < .001$), but no significant effects for Condition or the interaction. Analysis of skin conductance also revealed a main effect for Phase ($F(3,114) = 20.77$, $p < .001$), but no



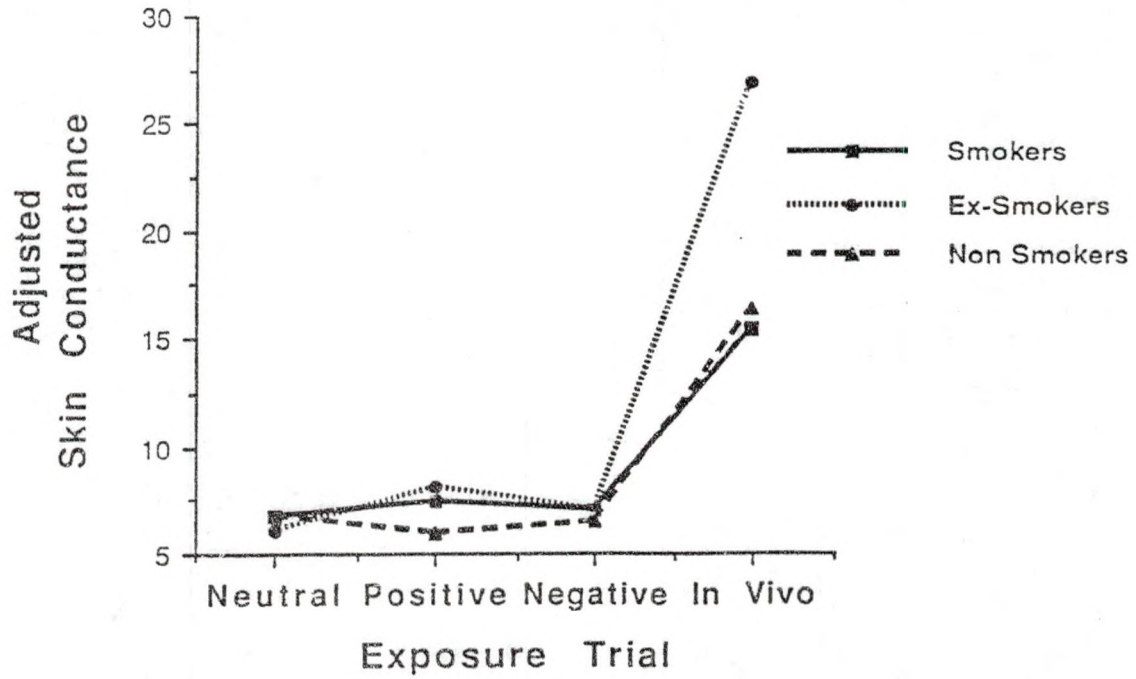


Figure 3. Mean post-cue physiological responses across exposure phases by condition.

other significant effects. Note that the Condition X Phase interaction found for skin conductance values averaged over a longer time period was not replicated in this analysis.

Follow-up correlated *t*-tests using responses averaged across conditions revealed a consistent pattern for both physiological variables. During in vivo exposure, heart rates and skin conductance levels were greater than during any other phase (all *p*s < .05). Physiological responses were statistically equivalent among all other trials. This is the same pattern of results as was observed when physiological readings were averaged across a longer time period (one to two minutes per trial).

Order effects for imaginal cue exposure. As part of the research design, the order of presentation of the four imaginal exposure trials was counterbalanced. From other research, it was anticipated that cravings might increase over the course of the study regardless of the content of specific scenes. To test whether such was the case, separate repeated measures ANOVAs or ANCOVAs were performed on each major dependent variable (using baseline values as covariates for physiological variables). Only the four imaginal exposure trials were included in the analysis; the neutral and in vivo trials were not of interest since their order remained constant for all subjects.

Results of these analyses, as they pertain to order of stimulus presentation, revealed significant main effects

for Trial for four of the six variables tested. These included: anxiety, $F(3,129) = 2.64$, $p = .05$; both skin conductance measures ($F(3,114) = 4.40$, $p = .006$ for total response during each trial and $F(3,108) = 3.48$, $p = .02$ for the 30-second post-cue response); and post-cue heart rate, $F(3,81) = 2.96$, $p = .04$. No Trial effects emerged for the total heart rate measure or craving ratings (both Fs < 1.0). There were no interactions between Trial and Condition. (See Appendix C for ANOVA tables.)

Examination of the means presented in Table 3 reveals that, contrary to theoretical predictions, craving and its associated measures (anxiety, heart rate, and skin conductance) did not systematically increase over the course of cue exposure. The changes in various measures across trials are not systematic and may reflect random variation. In any event, this pattern of results does not give rise to serious concern about order effects.

Variables Associated with Cue Reactivity

Components of craving. A set of regression analyses tested the multidimensional nature of cravings by examining the relationships among cognitive, emotional, and physiological measures. Because nonsmokers reported essentially no cravings, they were excluded from these analyses.

Table 3

Means for craving components by imaginal exposure trial

Variable	Trial 1	Trial 2	Trial 3	Trial 4
Craving rating	4.3	4.2	3.9	4.0
State anxiety	37.0	38.0	35.4	38.4
Total skin conductance	6.9	5.8	6.6	7.6
Post-cue skin conductance	6.9	5.9	6.5	7.5
Total heart rate	77.9	77.4	77.0	76.9
Post-cue heart rate	77.5	76.3	75.5	75.2

An overall craving score was computed by averaging craving ratings across all five of the smoking-related exposure trials. Overall heart rate, skin conductance, and anxiety scores were calculated in the same manner (i.e., averaged across five trials).

A backward multiple regression, with the criterion for removal from the equation set at .10, was conducted using anxiety and the physiological measures to predict self-reported craving. Heart rate was removed from the equation, but skin conductance and anxiety remained as significant correlates. Together, they accounted for approximately 35% of the variance in craving ratings (multiple R = .59). The top panel of Table 4 summarizes results of the analysis.

For subsequent regression analyses, the three craving components of anxiety, skin conductance, and heart rate were all included. Heart rate contributed to the prediction of smoking urge ratings by explaining an additional 3% of the variance, for a total R of .61 (R^2 = .38).

Craving and concurrent cognitive activity. A question of interest in the current study was whether subjects' cognitive activity during exposure trials would affect their experience of craving. To test this notion, a multiple regression analysis predicting craving ratings was performed, forcing in the three craving components first

Table 4

Summary of multiple regression analyses predicting craving

Variable	Beta	Multiple R	R Square
Components of craving			
Skin conductance	-.53	--	--
Anxiety	.33	.59	.35
Craving components and cognitive activity[a]			
Skin conductance Anxiety Heart rate		.61	.38
Clarity of imagery	.54	.80	.64
Craving components and other variables[a]			
Skin conductance Anxiety Heart rate		.61	.38
Extraversion	.49	--	--
Trait anxiety	-.46	--	--
Depressant use	-.38	--	--
Stimulant use	-.36	--	--
Nicotine dependence	.36	.84	.71

[a]The three craving components were entered as a block.

and then entering average imagery clarity and cognitive avoidance scores. If the latter two variables failed to significantly contribute to the prediction of craving ratings ($p = .10$), they would be removed from the equation. Results of the analysis are presented in the middle panel of Table 4. As can be seen, entry of anxiety, heart rate, and skin conductance accounted for 38% of the variance in cravings, and adding clarity of cognitive imagery explained another 26% of the variance, for an overall R^2 of .64. Cognitive avoidance proved not to be significantly related to the strength of cravings. The correlation between craving and imagery clarity was positive, suggesting that individuals who produced more vivid cues experienced stronger urges to smoke.

Craving and other variables. Another multiple regression analysis was performed to test the strength of associations between craving and other variables of interest. The latter comprised four general categories: demographics, smoking history, personality traits, and psychoactive substance use.

The demographic variables consisted of gender and age. Smoking history measures included number of years of smoking, number of cigarettes smoked per day (for ex-smokers, smoking rate prior to quitting), and degree of nicotine dependence (for ex-smokers, dependence prior to cessation). The personality variables believed to be

related to cravings included extraversion, neuroticism, and trait anxiety. One's attitude toward smoking was also included as a trait variable. The final type of variable pertained to intake of substances potentially affecting physiological arousal. Specifically, these were use of stimulants and depressants over the past 24 hours.

The question of interest was whether any of these variables would account for additional variance in craving ratings after anxiety, skin conductance, and heart rate were entered into the regression equation. Thus, the three craving component variables were forced into the equation first, followed by the additional variables. The latter were removed if they failed to contribute significantly to the prediction of craving ratings ($p = .10$).

Results of the analysis are presented in the bottom panel of Table 4. As evident in the table, 38% of the variance in cravings was explained by the three craving components. Five additional variables proved useful in accounting for some of the remaining variance: extraversion, trait anxiety, recent intake of depressants, recent intake of stimulants, and nicotine dependence. These variables produced a change in R^2 of .33, resulting in a total of 71% of variance explained. Examination of correlations revealed that nicotine dependence and extraversion scores were related positively to craving, while trait anxiety and intake of psychoactive substances

were negatively related. To summarize, individuals showing the strongest cravings in response to cue exposure tended to be more dependent upon nicotine, more extraverted, less anxious, and lower in their recent consumption of stimulants and depressants (e.g., caffeine, alcohol).

DISCUSSION

The intent of this study was to evaluate whether cigarette cravings could be reliably elicited in the laboratory, and to determine what the different components of such cravings might be. Specifically, are there cognitive, emotional, and physiological factors which combine to produce the experience smokers and ex-smokers subjectively interpret as "craving"? And can these responses be distinguished from those of persons who do not experience cigarette cravings (i.e., nonsmokers)?

The first major issue to address is whether the participants were properly selected. Specifically, were the subject groups different from one another in the expected ways (e.g., smoking status) and comparable on the remaining variables? Subjects' self-reported smoking rates were verified by thiocyanate analysis. Except for four ex-smokers who reported occasional smoking, the various conditions differed in smoking status as expected according to selection criteria. Overall, within-group homogeneity was high.

On demographic and personality variables, the three subject groups were generally comparable. Matching

procedures were successful in producing groups with equivalent distributions of men and women, and of similar ages. Personality characteristics of extraversion, neuroticism, and trait anxiety were also comparable among conditions. There was a significant between-groups difference in attitudes toward smoking, despite efforts to recruit nonsmokers with only minimal aversion to smoking. All subjects reported somewhat negative attitudes toward cigarettes, which reflects current societal norms. Understandably, nonsmokers viewed smoking in the least favorable light. Noteably, ex-smokers did not rate smoking as significantly more distasteful than did current smokers.

The current study included both male and female participants. There were no significant gender differences on personality, smoking history, or baseline physiological measures. As noted above, male subjects tended towards heavier smoking and produced higher thiocyanate values, but these differences failed to reach statistical significance.

Unfortunately, the small sample size precluded statistical analysis of potential gender effects in reactions to cue exposure. Thus, it was not possible to determine whether the same factors are associated with cigarette cravings for women and men. Results of the regression analysis argue against major differences in cue exposure reactions for men versus women, since gender failed to emerge as a significant predictor of craving

ratings. This finding is far from definitive, however. The question of whether the nature of cigarette cravings differs according to gender simply could not be addressed in the current study.

In general, the sample was appropriate for the research questions being addressed. The three groups of subjects differed little except on the variable of interest, smoking status. Smokers and ex-smokers reported similar histories of cigarette use, suggesting that between-groups differences in cue exposure reactions could be attributed primarily to current smoking status rather than general smoking experience. In other words, differences in levels of craving among ex-smokers relative to current smokers would most likely be due to recent learning experiences (e.g., extinction of smoking urges among ex-smokers).

The remainder of this discussion will review the experimental predictions, then compare them against observed results. According to conditioning theories of craving, certain stimuli become conditioned cues due to their repeated association with smoking. These stimuli are then capable of eliciting conditioned reactions which are subjectively interpreted as cravings.

The stimuli selected for presentation in the current study were of four types: (a) neutral, meaning that they hypothetically would not be associated with smoking;

(b) positive imaginal, or smoking cues involving pleasant affect; (c) negative imaginal, or cues associated with negative emotional states; and (d) in vivo, involving actual exposure to cigarettes and smoking paraphernalia. Among individuals with a history of smoking, it was predicted that:

1. neutral stimuli would produce negligible cravings.
2. smoking-related stimuli would produce greater cravings than neutral stimuli.
3. negative stimuli would produce greater cravings than positive stimuli.
4. in vivo cue presentation would produce greater cravings than imaginal exposure.

Another set of predictions concerns differences among conditions. Specifically, it was expected that:

1. smokers and ex-smokers would experience cigarette cravings, but nonsmokers would not.
2. current smokers would experience greater cravings than ex-smokers.

A final set of expectations concerned the nature of cigarette cravings. These predictions were that:

1. craving ratings would be associated with concurrent emotional and physiological responses.
2. individual differences in cravings could be explained by smoking history, personality, and behavioral factors.

What do the data suggest about the accuracy of the first set of predictions regarding cigarette cravings among smokers and ex-smokers? If these expectations were confirmed, we can conclude that, not only were experimental procedures successful in eliciting cravings in the laboratory, but that manipulation of stimulus content produced results consistent with theoretical predictions.

The expectation that the neutral exposure scene would not produce urges to smoke was only partially supported by the data. Ex-smokers showed little response to the movie theater scene, but smokers acknowledged experiencing moderate levels of craving (means of 1.7 and 3.7, respectively).

It is not clear why current smokers evidenced significantly greater cravings during this scene relative to former smokers. One explanation is that the smoking-related questionnaires administered prior to cue exposure may have activated urges to smoke. Other researchers have found that reactivity to neutral stimuli is enhanced when such stimuli are embedded in the context of smoking cues (Baker, Cannon, Tiffany, and Gino, 1984). Smokers may have been expecting to encounter smoking cues during imaginal exposure, and may have been experiencing anticipatory cravings. However, the plausibility of this explanation is weakened by its inability to account for the finding that former smokers did <u>not</u> experience cravings in response to

the neutral stimuli after completing the same smoking questionnaires.

Another possible reason for smokers' elevated cravings during the neutral scene is that smokers were entering nicotine withdrawal; by this point in the study, they had been abstinent from nicotine for at least 90 minutes. In support of this view, previous research has found that smokers' cravings increase as the time period since the last cigarette lengthens (Glassman et al., 1984). In the current study, there was a weak positive relationship between craving during the neutral scene and the number of minutes since the subject had last smoked (r = .39, p = .12). Ex-smokers, who were not experiencing acute nicotine withdrawal, did not appear to be craving cigarettes prior to the introduction of explicit smoking-related cues.

A final proposition is that, for smokers, the neutral scene was not actually devoid of smoking cues. Perhaps these subjects had associated being in a movie theater with symptoms of nicotine withdrawal. The mean rate of cigarette consumption by current smokers was approximately 22 per day, suggesting that persons were averaging one to two cigarettes per hour. Thus, sitting in a theater for a couple of hours could well be associated with low-level nicotine withdrawal. This explanation for smokers' cravings to the imaginal scene is consistent with Wikler's

theoretical view of craving as "conditioned withdrawal" (Ludwig and Wikler, 1974). Since ex-smokers had been abstinent from cigarettes for several weeks or months, they may have already lost their reactivity to withdrawal-related cues.

In summary, it is not clear why smokers exhibited urges to smoke in response to supposedly neutral stimuli. Further research is needed to replicate this finding and evaluate the accuracy of the alternative explanations described above.

The next three predictions pertained to hypothetical differences in craving responses to various types of stimuli. One expectation was that exposure to explicit smoking-related cues would result in greater urges to smoke than exposure to a neutral image. This expectation was well-supported by the data; craving levels doubled for smokers and tripled for ex-smokers when smoking cues were incorporated into the imaginal scenes.

Comparisons of reactions to positive imaginal scenes (i.e., attending a party and relaxing at home) with those resulting from presentation of negative stimuli (i.e., discovering that one's car needs expensive repairs and recalling an upsetting argument) failed to reveal anticipated differences. Contrary to theoretical predictions (Siegel, 1975; Solomon and Corbit, 1974), negative affective states were not associated with stronger

cigarette cravings than were positive emotions. Anxiety scores were higher for negative than for positive scenes, but this effect was not specific to individuals with a smoking history. Together, these findings suggest that subjects could discriminate between the two types of scenes and in fact experienced greater emotional discomfort during negative affective trials, but that this did not lead to stronger urges to smoke.

The final prediction concerning differences among various types of stimuli was that in vivo exposure would produce the most intense cravings. The data clearly support this assertion. Cravings increased significantly for smokers and ex-smokers when subjects shifted from imagining smoking-relevant scenes to actually handling a cigarette.

In summary, two of the four predictions concerning differential reactions to various types of smoking cues were supported. These were the expectation that smoking-related stimuli would produce cravings, and the idea that in vivo exposure to cigarettes would elicit stronger urges than imaginal exposure. The two experimental hypotheses not consistent with actual findings concerned a predicted lack of responsivity of smokers to neutral cues and a tendency for negative affective scenes to produce stronger cravings than pleasant stimuli.

Implications from these results are that both imaginal and in vivo exposure can be effectively used to elicit cigarette cravings in the laboratory. Both types of exposure, as used in the current study, are simple to administer and low in cost. Presenting subjects with an unlit cigarette produced the most powerful cravings, while imaginal trials exposed participants to a wider range of stimuli purported to be related to relapse and craving. Thus, each method has its advantages and the selection of a particular procedure would depend on the research question of interest.

The next set of predictions concerned hypothesized differences among smokers, ex-smokers, and nonsmokers. The first of these expectations was that only individuals with a smoking history would experience cravings. The findings addressing this prediction are unequivocal. Nonsmokers' reports of cravings approximated 1.0, indicating no desire to smoke, while smokers and ex-smokers consistently rated their urges at a higher level.

It was also hypothesized that ex-smokers would show less reactivity to conditioned stimuli than current smokers. The rationale for this prediction was that abstinent individuals would have experienced many more extinction trials than continuing smokers.

Generally, the data support this assertion. Overall, smokers rated their cravings stronger than did ex-smokers

(means = 6.2 and 4.6, respectively). There was some variation among trials, though. For one type of cue exposure, positive imaginal stimuli, the difference between smokers and ex-smokers failed to achieve significance. For all other trials, current smokers rated their urges to smoke significantly higher than did former smokers.

The lack of a difference between current and former smokers in response to pleasant stimuli is counter to what one might expect from the relapse literature. Relapsed smokers cite negative affective stimuli twice as often as positive cues when explaining their resumption of smoking (Lichtenstein and Baer, 1986). Assuming that craving strength is highly related to risk of relapse, one would expect to find strong smoking urges in ex-smokers exposed to unpleasant situations (that is, ex-smokers should most resemble smokers under these circumstances). However, in the current study, it was when ex-smokers were experiencing positive affective states that they were craving cigarettes to the same extent as current smokers.

The overall difference in urge levels between former and current smokers was consistent with classical conditioning explanations of craving. Abstinent persons ought to experience reductions in craving as these conditioned responses become extinguished.

A specific prediction one might make is that former smokers who had been abstinent longer would have weaker

responses to smoking cues. Results of this study showed, however, that the length of abstinence was not related to overall craving (r = -.11, p = .75). It is useful to remember in interpreting this finding that the length of abstinence is at best an inprecise measure of one's opportunities for exposure to smoking cues. Further research is needed to explore whether an extinction process is responsible for reduced cravings following smoking cessation.

A general difficulty in interpreting between-groups differences in the current study arises from the fact that a sizeable proportion of the ex-smoking group reported having had an occasional cigarette since quitting. Such practices would theoretically interfere with extinction of craving. A comparison of overall cravings for successful versus unsuccessful abstainers showed that the latter individuals did tend to report stronger cravings (means of 5.4 versus 4.9, respectively). Since the sample was too small to allow statistical analysis of this difference, it must be interpreted with caution. But, it does suggest that the responses of smokers and ex-smokers to cue exposure would have been even more divergent had the latter condition included only successfully abstinent persons.

Although the reductions in craving levels among ex-smokers relative to continuing smokers were statistically significant, the clinical relevance of these differences

are less impressive. Ex-smokers showed considerable reactivity to smoking-related stimuli, and most likely were experiencing cravings to smoke when exposed to similar situations in real life. Since cravings are presumed to be important in relapse, these data are consistent with the conclusion reached by Brownell, Marlatt, Lichtenstein, and Wilson (1986) that former smokers remain susceptible to relapse for a considerable period of time after achieving abstinence.

The final pair of hypotheses addressed in the current study concerned relationships among craving ratings and other variables. First, it was proposed that the subjective label of "craving" is only one part of a multidimensional conditioned response. A backward multiple regression analysis revealed that anxiety and electrodermal activity accounted for over a third of the variance in craving ratings. This finding is consistent with theoretical predictions that smokers and ex-smokers will report having a craving for nicotine when they experience emotional and physiological arousal occuring in response to smoking cues.

Another way to examine the contribution of various measures of craving is to evaluate the consistency of results across measures. To summarize the findings discussed previously, all three variables, anxiety, skin conductance, and heart rate, varied significantly across

exposure trials. Physiological responses were relatively stable across all imaginal trials but increased during in vivo exposure. Anxiety, on the other hand, was lowest during the neutral scene and highest during exposure to negative affective stimuli. Of the three craving components, state anxiety was the only one to consistently discriminate among types of subjects, with the pattern being similar to between-groups differences in craving ratings. Skin conductance levels differed by condition only during the in vivo trial, and heart rates were equivalent among the groups throughout the experiment.

Other researchers have had similar difficulties pinning down the physiological component of cigarette cravings. A perusal of the relevant literature revealed inconsistent results for electrodermal activity and heart rate in cue exposure paradigms. Across studies, skin conductance responses to smoking cues did not reliably occur. Similar problems arose for investigators assessing heart rate. Sometimes heart rate increased, sometimes it decreased, sometimes it did not change during cue exposure. Abrams (personal communication, 1989) attempted to deal with this problem by focusing upon the magnitude of heart rate fluctuations, regardless of the direction. Using this approach with the current data, however, still failed to reveal significant between-groups effects ($\underline{F}$s < 1.0).

The elusiveness of consistent physiological reactions to cue exposure may be due to a variety of factors. Lang (1979) argued for the relative independence of various response modes, and proposed that it is reasonable not to expect high concordance among cognitive, emotional, and physiological measures of the same construct. If this is the case for craving, then researchers are advised to use multiple measures of urges to smoke and to predict only moderate relationships among these measures. From this point of view, the findings of the current study provide adequate support for the multidimensional nature of cigarette cravings.

A second consideration in the failure to find consistency across measures is the wide range of individual differences typically observed in physiological responding. The use of covariance to analyze such data is one way to control for baseline differences. Other statistical methods, such as response pattern analysis, might be useful in evaluating reactions to smoking cue exposure. Future work, incorporating larger numbers of subjects than were available in the current study, could test the value of alternative statistical approaches.

In the current study, the greatest barriers to evaluating the contributions of physiological responses to our understanding of craving were the small sample size and the difficulties in obtaining complete data on subjects.

In the ex-smoking condition, for instance, only eight subjects had sufficient physiological data to allow them to be included in repeated measures analyses. The small cell sizes and the large variances in skin conductance and heart rate made it unlikely that significant findings would emerge for these measures. Since some intriguing results were found, such as the contribution of electrodermal responses in explaining variations in craving ratings, replication with a larger sample will be important.

The final hypothesis to be examined here concerns the association between craving and its presumed predictor variables. Backward multiple regression analyses addressed two specific aspects of this hypothesis: first, that concurrent cognitive activity would influence cravings and second, that certain baseline variables would explain individual differences in responses to cue exposure.

Analysis of the association between cognitive variables and craving ratings revealed that persons with clearer images tended to experience stronger urges to smoke. Although causative statements cannot be made, it is reasonable to assume that generating vivid, realistic imaginal stimuli allows one to experience stronger reactions. Interestingly, subjects' attempts to avoid thinking about smoking were not predictive of craving levels. Specifically, participants did not appear to be "turning off" imaginal stimuli in order to minimize their

urges to smoke. These findings have practical implications for designing future studies. For example, a researcher desiring to produce cravings through imaginal exposure might first train subjects in imagery-enhancing techniques.

The search for other variables associated with craving responses identified five significant predictors. Two of these were personality variables (extraversion and trait anxiety), two were behavioral measures (intake of depressants and stimulants), and only one was related to smoking per se (nicotine dependence).

Examination of the variables significantly associated with craving reveals a fairly consistent pattern. Individuals who showed the strongest smoking urges seemed to share a propensity for chronic underarousal. High extraversion scores (Eysenck and Eysenck, 1968), low trait anxiety levels, and below average intake of depressant drugs are all consistent with chronically low central nervous system activity.

Although the exploratory nature of these data does not allow for definitive explanations, a possible mechanism to explain the association between craving and underarousal will be outlined. Chronically underaroused persons might well depend upon stimulant drugs such as nicotine to bring their arousal up to more optimal levels. Since nicotine has a relatively short half-life, repeated doses would be needed to maintain adequate arousal throughout the day.

Frequent smoking might then lead to greater physical dependence upon nicotine, which would explain why this factor is also predictive of craving levels. The only predictor variable that does not nicely fit this model is stimulant use; individuals with strong cravings reported lower intake of stimulant drugs than subjects with less craving.

Overall, there is enough consistency in the pattern of results to propose that persons who smoke primarily to increase autonomic arousal experience stronger cigarette cravings than individuals who smoke mainly to achieve other nicotine effects. Because of the connection between craving and relapse, we might also presume that chronically underaroused persons would have more difficulty quitting smoking and remaining abstinent than other smokers. Additional research to explore this potentially important relationship between arousal and craving is clearly warranted.

In summary, the current study demonstrated that cigarette cravings can be elicited in the laboratory through simple imaginal and in vivo cue exposure techniques. The findings underscore the importance of including appropriate control groups of smokers and nonsmokers when evaluating cravings as a potential factor in relapse among ex-smokers. Finally, there is evidence to

support theoretical views of cigarette cravings as multidimensional conditioned responses.

Much additional work in this area is required in order to gain an adequate understanding of craving. To meet this goal, researchers need to agree on a standardized methodology for eliciting and assessing cigarette cravings. This study provides a model for an effective methodology which could easily be adopted by other laboratories. But, although these results are promising, there is a clear need for replication with a larger sample before the findings can be accepted with confidence.

In conclusion, the study of cigarette cravings has great potential for easing the struggle of the many individuals who desire to achieve long-term abstinence from smoking. Since it is possible to manipulate cravings within a controlled laboratory setting, there is reason for much optimism about our ability to understand and ultimately control this important factor in addiction to cigarettes.

APPENDICES

APPENDIX A

QUESTIONNAIRE MEASURES

Smoking Research Consent Form

What is the study about? This study investigates how and why people who smoke sometimes crave cigarettes. We are interested in learning what kinds of events trigger urges to smoke and how these urges are experienced. We will study current smokers, those who used to smoke but quit, and people who have never smoked.

What will I be asked to do? The study will last from 90 - 120 minutes. We will collect information from you by means of questionnaires, ratings, and physiological monitoring equipment. The main portion of the study involves imagining yourself being in several different situations for brief periods of time. Afterwards, you will describe your reactions to each situation. We will also measure your physiological responses to each scene. These measurements are simple to obtain and should produce no discomfort whatsoever. In addition, you will complete several questionnaires covering such topics as your smoking history. Finally, you will be asked to provide breath and saliva samples to verify your smoking status.

What will be done with the information? All information provided by participants will be kept confidential. Only research personnel will have access to your data. If the study is published in a scientific journal, results will be presented in summary form so that it would be impossible to identify individual participants.

What are the risks? If you have ever smoked, it is possible that you will experience urges to smoke during some of the procedures. However, it is unlikely that these urges will last very long. Should you find yourself feeling too uncomfortable, you may stop at any time.

What are the benefits? For your participation, you will receive 6-8 extra credit points toward your psychology grade or a monetary payment. If you are a current smoker or ex-smoker, participation in this experiment may be beneficial in another way. It has been shown that when you feel an urge to smoke but do not have a cigarette, future cravings to smoke may be reduced. You will also be making a valuable contribution to scientific knowledge about smoking. Since cravings are important in the maintenance of smoking, gaining greater understanding of cravings will aid people in their efforts to control their smoking.

Statement of consent. I have read the description above and have had the study explained to my satisfaction. By signing below, I indicate that I freely and willingly choose to participate in this research. I understand that I may withdraw my participation at any time without penalty.

Signed _____ Date _____

If you have any questions or concerns, contact Dr. Charles Peterson, Chair, Human Subjects Review Committee, 237-7609.

NAME: _____ DATE: _____

SMOKING HISTORY QUESTIONNAIRE
(CURRENT SMOKERS)

This survey contains questions about your history of smoking and current smoking patterns. It is important that you answer every item carefully and honestly. If you have any questions, please ask for assistance.

1. Your age: _____

2. Your sex: Male ___ Female ___

3. Your occupation: _____

4. How many years have you regularly smoked cigarettes? _____

5. How many cigarettes do you currently smoke per day? _____

6. What brand do you usually smoke? _____

7. What kind of cigarettes are they? (Check one alternative from each pair)

   a. filter ___ or non-filter ___

   b. plain ___ or menthol ___

   c. hard pack ___ or soft pack ___

   d. king (85 mm) ___ or long (100 mm) ___ or 120 mm ___

8. What other brands do you smoke? (please describe using categories above)

   _____

9. What percent of the time do you smoke these other brands? _____

10. When you typically put your cigarette out, how much of it is left?

    None ___ 1/6 ___ 1/3 ___ 1/2 ___ 2/3 ___ 5/6 ___

11. While your cigarette is burning, what percent of the time are you typically smoking it, rather than holding it or letting it burn in an ashtray?

    90-100% ___ 70-80% ___ 50-60% ___ 30-40% ___ 10-20% ___

12. How deeply do you usually inhale when you smoke cigarettes?

    just into the mouth ___ down into the throat ___

    partly into the chest ___ deeply into the chest ___

13. Do you typically smoke more in the morning than during the rest of the day? Yes ___ No ___

14. How soon after you wake up do you smoke your first cigarette? _____ minutes

15. Of all your cigarettes during the day,
which one would you most hate to give up? _____

16. Do you typically find it difficult to refrain
from smoking in places where it is forbidden? Yes ___ No ___

17. Do you smoke when you are so ill
that you are in bed most of the day? Yes ___ No ___

18. When smoking, how often do you inhale? always ___ sometimes ___ never ___

19. Do you smoke cigars, pipes, or cigarillos? Yes ___ No ___

a. What brand? _____

b. How many times per week? _____

20. Do you use chewing tobacco or snuff? Yes ___ No ___

a. Which brand? _____

b. How long does a can or pouch last? _____

21. Have you ever seriously tried to stop smoking? Yes ___ No ___

a. How many times have you tried to quit? _____

b. How long did you quit on your most successful attempt? _____

22. When you are with someone who is smoking, while you are not, how do you find the smell of the cigarette smoke? (Circle one number)

1	2	3	4	5	6	7
extremely unpleasant			neither pleasant nor unpleasant			extremely pleasant

23. When you are with someone who is smoking, while you are not, how do you find the taste of the cigarette smoke? (Circle one number)

1	2	3	4	5	6	7
extremely unpleasant			neither pleasant nor unpleasant			extremely pleasant

24. When you are with someone who is smoking, while you are not, how do you find the sight of the cigarette smoke? (Circle one number)

1	2	3	4	5	6	7
extremely unpleasant			neither pleasant nor unpleasant			extremely pleasant

Name _____ Date _____

Intake Questionnaire

Instructions: Some foods, beverages, and drugs may affect physiological responding. Please indicate your intake of such substances by answering the questions below. Remember that your answers are strictly confidential.

Tobacco consumption.

1. How many cigarettes have you smoked during the past week? _____
2. How many cigarettes have you smoked within the past 24 hours? _____
3. How long ago did you finish your last cigarette? ____ hours, ____ minutes
4. How much chewing tobacco or snuff did you use this past week? _____

Caffeine consumption. Estimate how many servings of the following caffeinated foods and beverages you have consumed within the past 24 hours and past 7 days.

	past 24 hours	past 7 days
cups of coffee	_____	_____
cups/glasses of tea	_____	_____
cans/glasses of soft drinks	_____	_____
chocolate bars	_____	_____

Alcohol consumption. Estimate how many servings of the following alcoholic beverages you have consumed with the past 24 hours and past 7 days.

	past 24 hours	past 7 days
cans/glasses of beer	_____	_____
glasses of wine	_____	_____
drinks containing liquor	_____	_____

Drug consumption. Put a checkmark beside any of the following drugs you have taken within the past 24 hours.

___ prescription drugs; describe: _____

___ nonprescription drugs; describe: _____

___ recreational stimulants (e.g., cocaine, speed)

___ recreational depressants (e.g., marijuana)

APPENDIX B

REPRESENTATIVE SCRIPTS FOR CUE EXPOSURE AND RELAXATION

Imaginal Exposure: Neutral Trial (Movie Scene)

In a moment you are going to hear a description of a situation. I'd like you to close your eyes, and try to imagine that situation as vividly as possible: the sights, sounds, smells and feelings. To help you get a clear image, I will ask you some questions that you can answer in your mind. As you listen, try to imagine yourself actually experiencing the situation.

Let's begin. Imagine that you are sitting in a theater with some friends enjoying a movie. It is a light-hearted comedy staring some of your favorite actors. Notice which of your friends is sitting to your left. Who is to your right? Can you smell the popcorn? What other smells do you notice?

Pay attention to the way your chair feels. Notice the stickiness under your feet. You are feeling good and really enjoying the movie. Take a moment to imagine this situation as vividly as you can. Think the same thoughts and feel the same feeling as if you were actually there.

(Pause) Now stop imagining the situation. Open your eyes and look at the computer screen. Press the space bar on the keyboard to reveal the first question. Answer each question by typing your response on the keyboard. When you have finished all the questions, the technician will return.

Imaginal Exposure: Positive Affect Trial (Party Scene)

Now, get ready to hear the next situation. As before, close your eyes, and try to imagine the scene as vividly as possible. Put yourself into the situation and allow yourself to experience it. As much as you can, think the same thoughts and feel the same feelings you would if the events were really happening. Imagine that you are at a party at a friend's place. A lot of people you know are there. Refreshments have been served and you are holding a drink in your hand. Look around you. What does the room look like? Who else is there? What do you hear? Music? Conversation? What have you been drinking? Notice the appearance, the aroma of the beverage you are holding.

The party is getting noisier. Everyone seems to be enjoying themselves. You notice that someone near you is smoking a cigarette. Picture this person as clearly as you can. See the smoker inhale, and the end of the cigarette glows brightly. Now the smoker exhales and the smoke hangs

in the air. Now you can see the smoke drifting towards you, closer and closer until you can smell it. You watch the smoker offering someone else a cigarette, and that person lights up too. Take a moment to imagine this situation as vividly as you can.

(Pause) Now, stop imagining the situation. As before, answer the questions as they appear on the computer screen. After answering all the questions, just relax for a few minutes.

Relaxation Instructions

Now, I would like you to relax for a few minutes. Make yourself comfortable in your chair and close your eyes. Now, place one hand on your lower stomach. Make believe you have a balloon in your lower stomach and that as you breathe in you are going to fill up that balloon so that your stomach muscles will go out. Your hand will actually rise. Try that. Breathe in deeply, and feel your hand rise. Now, exhale, and feel your hand go down again. What you are doing is sending air deep into your lungs. Try that again. Breath deep and fill up the balloon. Now breath out and feel your hand go back down. Continue to breathe deeply and slowly. As you breathe, say this phrase to yourself: "I feel calm." As you breathe in you might say, "I feel ..." and as you breathe out, "calm." Take a few more of these slow, deep breaths while saying to yourself, "I feel calm."

(Pause) You may stop your deep breathing now if you wish. Just clear your mind and relax for a few more minutes.

APPENDIX C

SUMMARIES OF STATISTICAL ANALYSES

I. Condition by Exposure Phase Analyses of (Co)Variance.

Craving Ratings.

Source	df	Sum of Squares	Mean Square	F	p
Condition(C)	2	803.31	401.65	76.85	.000
Error	43	224.75	5.23		
Phase(P)	3	195.36	65.12	38.21	.000
C X P	6	74.60	12.43	7.30	.000
Error	129	219.82	1.70		

Anxiety Scores.

Condition(C)	2	5250.60	2625.30	13.46	.000
Error	43	8389.67	195.11		
Phase(P)	3	1243.14	414.38	9.50	.000
C X P	6	441.86	73.64	1.69	.129
Error	129	5627.62	43.62		

Total Heart Rate Responses.

Covariate	1	8327.60	8327.60	138.60	.000
Condition(C)	2	19.14	9.57	0.16	.853
Error	29	1742.40	60.08		
Phase(P)	3	334.17	111.39	7.65	.000
C X P	6	52.25	8.71	0.60	.731
Error	90	1310.45	14.56		

Total Skin Conductance Responses.

Covariate	1	2412.76	2412.76	20.16	.000
Condition(C)	2	422.08	211.04	1.76	.186
Error	37	4428.35	119.69		
Phase(P)	3	5208.00	1736.00	23.32	.000
C X P	6	1162.48	193.75	2.60	.021
Error	114	8486.96	74.45		

Post-cue Heart Rate Responses.

Source	df	Sum of Squares	Mean Square	F	p
Covariate	1	7724.88	7724.88	97.36	.000
Condition(C)	2	6.29	3.14	0.04	.961
Error	28	2221.64	79.34		
Phase(P)	3	699.61	233.20	13.34	.000
C X P	6	78.48	13.08	0.75	.612
Error	87	1520.85	17.48		

Post-cue Skin Conductance Responses.

Covariate	1	2786.60	2786.60	24.97	.000
Condition(C)	2	235.12	117.56	1.05	.359
Error	37	4128.30	111.58		
Phase(P)	3	4471.66	1490.55	20.77	.000
C X P	6	707.56	117.93	1.64	.142
Error	114	8180.38	71.76		

II. Condition by Trial Order Analyses of (Co)Variance.

Craving Ratings.

Source	df	Sum of Squares	Mean Square	F	p
Condition(C)	2	1037.45	518.72	88.23	.000
Error	43	252.80	5.88		
Trial(T)	3	5.25	1.75	1.16	.327
C X T	6	8.72	1.45	.96	.452
Error	129	194.30	1.51		

Anxiety Scores.

Condition(C)	2	6016.44	3008.22	9.69	.000
Error	43	13350.87	310.49		
Trial(T)	3	323.89	107.96	2.64	.053
C X T	6	303.06	50.51	1.23	.294
Error	129	5283.70	40.96		

Total Heart Rate Responses.

Source	df	Sum of Squares	Mean Square	F	p
Covariate	1	8895.05	8895.05	130.18	.000
Condition(C)	2	221.92	110.96	1.62	.214
Error	30	2049.92	68.33		
Trial(T)	3	30.33	10.11	.97	.409
C X T	6	38.41	6.40	.62	.716
Error	93	965.35	10.38		

Total Skin Conductance Responses.

Covariate	1	1917.93	1917.93	33.58	.000
Condition(C)	2	38.50	19.25	.34	.716
Error	37	2113.23	57.11		
Trial(T)	3	80.39	26.80	4.40	.006
C X T	6	44.37	7.39	1.21	.304
Error	114	694.52	6.09		

Post-cue Heart Rate Responses.

Covariate	1	8111.35	8111.35	107.72	.000
Condition(C)	2	248.52	124.26	1.65	.211
Error	26	1957.81	75.30		
Trial(T)	3	115.32	38.44	2.96	.037
C X T	6	99.32	16.64	1.28	.274
Error	81	1050.18	12.97		

Post-cue Skin Conductance Responses.

Covariate	1	1651.14	1651.14	27.95	.000
Condition(C)	2	44.56	22.28	.38	.689
Error	35	2067.81	59.08		
Trial(T)	3	65.93	21.98	3.48	.018
C X T	6	39.03	6.50	1.03	.410
Error	108	681.65	6.31		

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