MEASURING THE REINFORCEMENT VALUE OF NICOTINE FOR DEPENDENT SMOKERS UNDER MENTAL MATH, BEHAVIORAL RELAXATION, AND CONTROL CONDITIONS

By

YOLANDA G. QUEVEDO

Bachelor of Arts
Western Washington University
Bellingham, Washington
1988

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1991

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the degree of
DOCTOR OF PHILOSOPHY
December, 1994

MEASURING THE REINFORCEMENT VALUE OF NICOTINE

FOR DEPENDENT SMOKERS UNDER MENTAL MATH,

BEHAVIORAL RELAXATION, AND

CONTROL CONDITIONS

Thesis Approved:

Thesis Adviser

Dean of the Graduate College

PREFACE

Positive reinforcers appear to stimulate drug cravings that lead to continual drug use. It has been suggested that stress may serve a similar role. It may be that when stress is introduced, drugs such as nicotine may become more reinforcing. It was hypothesized that puffs would be more reinforcing to smokers in the stress condition compared to smokers in the relaxation condition. In addition, smokers in the neutral condition would find puffs less reinforcing than smokers in the stress condition and more reinforcing than smokers in the relaxation condition. Forty-five dependent smokers were assigned to one of three groups: 1) Mental Math (stress condition), 2) Behavioral Relaxation (relaxation condition), or 3) Control (neutral condition). Subjects engaged in a concurrent variable ratio (VR) schedule of reinforcement task to earn either cigarette puffs or money. Nine VR schedules ranged from a VR 4 through VR 53 for puffs and from a VR 4 through VR 12 for coins. An ANOVA conducted on the last three VR schedules revealed a significant main effect for schedule and a significant two-way interaction for condition by schedule. These results demonstrated a trend for smokers in both the Mental Math and the Behavioral Relaxation Groups to find nicotine more reinforcing because they worked longer and harder for nicotine.

ACKNOWLEDGMENTS

I would like to express my appreciation to Dr. Frank Collins for his encouragement and guidance. I would also like to thank my committee members, Dr. Don Boswell, Dr. John Chaney, and Dr. Maureen Sullivan for their helpful suggestions and encouragement throughout the study. Many thanks to the American Psychological Association for the 1993 Dissertation Research Award and to the Patricia Roberts Harris Fellowship Program for assisting me through graduate school. The financial assistance provided through these programs have made the completion of this dissertation possible much sooner than would have been possible otherwise.

A special thank you to my colleague and friend, Johnette Clark. Your companionship helped to make the new challenges of graduate school exciting and the difficult days tolerable. I shall always remember the very special memories of graduate school we created and how we came to be called "the twins."

To my daughter, Kim, who genuinely believes that her mom "is smart and will someday be rich" I want to express my deepest appreciation. You always believed that I could do this even when I had my doubts, you encouraged me, you kept the home fires burning while I have been away, and you have completed your transition into a responsible young adult as I have watched from a distance. You always believed in me.

A special thank you to Lauretta Valenti, my undergraduate research assistant, for her continual enthusiasm during the entire academic year we worked together on this project. I appreciated your eagerness to learn research as well as your dedication and hard work. The huge numbers of summary tables you compiled were most helpful to me as I wrote drafts of this dissertation.

TABLE OF CONTENTS

	Page
LITERATURE REVIEW	1
Introduction & Overview	1
Stress	2
Stress and Smoking	3
Initiation of Smoking	3
Maintenance of Smoking	3
Relapse	4
Stimulant Effects of Stress and Smoking	5
Reinforcement Theory of Smoking Maintenance	7
Behavioral Economics Theory	8
Statement of the Problem	9
METHOD	11
Subjects	11
Screening Instruments	12
Physiological Measure	15
Stress Rating	15
Demographic Information Questionnaire	15
Concurrent Schedule Computer Program	16
Procedure	16
RESULTS	18
Demographics	18
Manipulation Check	20
Subjective Measure of Affect	20
Carbon Monoxide (CO) Boost	21
Overall Analysis of Variance for Puffs	22
Analysis of Block 2	24
Analysis of Block 3	24
DISCUSSION	25
REFERENCES	31

Chapter Page

APPENDIXES 37

APPENDIX A - SMOKING RESEARCH QUESTIONNAIRE 38

APPENDIX B - SUBJECTIVE MEASURE OF AFFECT 40

APPENDIX C - DEMOGRAPHIC INFORMATION FORM 42

APPENDIX D - CONSENT FORMS. 44

APPENDIX E - MENTAL ARITHMETIC SCRIPTS. 50

APPENDIX F - BEHAVIORAL RELAXATION TRAINING SCRIPT. . . 52

APPENDIX G - SUMMARIES OF ANOVA TEST CRITERIA 55

LIST OF TABLES

Table		Page
G-1.	Overall Analysis of Variance for Puffs.	56
G-2.	Analysis of Block 2	57
G-3.	Analysis of Block 3	58
1.	Demographic Summary of Subjects	59
2.	Means and Standard Deviations for Number of Puff Reinforcers Earned Per VR Schedule by Condition	60

LIST OF FIGURES

Figure		Page
1.	Mean Stress Rating by Condition for Each Rating Period.	62
2.	Mean Number of Reinforcers Rarned per VR Schedule . . .	63
3.	Mean Number of Reinforcers Earned per VR Schedule in Block 2.	64
4.	Mean Number of Reinforcers Rarned per VR Schedule in Block 3.	65

LITERATURE REVIEW

Introduction and Overview

Both stress and cigarette smoking activate the sympathetic and parasympathetic nervous systems (MacDougall, Dembroski, Slaats, Herd, & Eliot, 1983). However, cigarette smoking appears to reduce stress in addicted smokers. The specific physiological basis for the stress-reducing effects of nicotine is not known, although studies have reported that smokers can regulate nicotine intake to obtain either a depressant or a stimulant effect at will depending on their pre-smoking state (Ashton & Stepney, 1982; Pomerleau & Pomerleau, 1984). Under stress, people smoke more (Pomerleau & Pomerleau, 1987); data are needed to better understand this relationship.

Given that smokers increase their smoking rate under stress, one hypothesis is that nicotine becomes more reinforcing under stress. The present study evaluated changes in the reinforcing properties of nicotine under three conditions: (a) Mental Math, (b) Behavioral Relaxation, and (c) Control. The Mental Math condition involved serial subtraction problems in a time-pressured setting and served as a manipulation of stress (stress condition). The Behavioral Relaxation condition involved instruction in Poppen's (1988) behavioral relaxation procedures (relaxation condition). The Control condition involved reading magazines (neutral condition). In order to demonstrate the reinforcement value of nicotine, each smoker had the opportunity to earn cigarette puffs or coins on a

concurrent schedule computer game. The game was designed to pay off nickels or cigarette puffs as the reinforcers. The amount of work (key presses) to earn puff reinforcers was programmed to gradually increase from a variable ratio (VR) 4 to a VR 53 while coin reinforcers increased from a VR 4 to a VR 12 and then remained constant. A stressed smoker's preference for cigarette puffs over coins regardless of the higher VR schedules would demonstrate that nicotine becomes more reinforcing under stress.

The present paper is organized into several sections. First, definitions of stress are reviewed. Second, the literature on stress and smoking is reviewed in terms of the role of stress on the initiation, maintenance, and relapse of smoking. In addition, a brief discussion of the stimulant effects of stress and smoking is presented. Next, reinforcement theory is reviewed with a focus on positive and negative reinforcement processes. Finally, behavioral economic theory is discussed as a means of studying the reinforcement properties of a substance.

Stress

Stress can be defined in many ways. For example, stress can be understood as an individual's perception that life's demands surpass that person's ability to cope with those demands (Lazarus & Folkman, 1984). Likewise, stress can be defined as the strain resulting from an aversive event or as a set of behavioral or affective responses (Cohen & Lichtenstein, 1990; Lazarus & Folkman, 1984). Furthermore, stress is known to stimulate the body by activating the sympathetic nervous system (SNS) which affects cardiac function. As a result,

the cardiovascular system responds to stress with an increase in heart rate (HR), stroke volume, vascular resistance, and blood pressure (BP; MacDougall et al., 1983). Stress also has been linked to all phases of smoking (eg., initiation, maintenance, and relapse).

Stress and Smoking

Initiation of Smoking. Various stressors have been identified as reasons to initiate smoking. Brunswick and Messeri (1984) found that for black urban adolescent girls, school stress was a causative factor in initiating smoking. However, for black adolescent boys, Brunswick and Messeri (1984) found that those who were pessimistic about their prospects for success by societal norms were equally prone to start smoking. Furthermore, adolescents with fewer psychological resources (low self esteem, high trait anxiety, and an external locus of control) were the most likely to start smoking and to continue smoking as a means of stress management (Penny & Robinson, 1986). The high levels of anxiety indicated by adolescent smokers suggest that smoking serves a stress reduction function or is a stress management technique.

Maintenance of Smoking. Cigarette smokers commonly report that smoking is both stimulating and relaxing depending on the current situation (Epstein & Jennings, 1986). These effects can promote the long-term maintenance of a smoking habit. Pharmacologically, nicotine is a stimulant; however, in stressful situations, smokers claim that nicotine helps them relax (Norton & Howard, 1988). When under stress smokers self-regulate nicotine intake (Ashton &

Stepney, 1982; Pomerleau & Pomerleau, 1984) to achieve a state of relaxation. One method smokers use to regulate nicotine dosage is to adjust each puff volume. Thus, when a larger dose of nicotine is desired, a smoker will inhale more deeply (Pomerleau & Pomerleau, 1987). A second method smokers use to regulate nicotine is to smoke more cigarettes.

There are several possible explanations for a stress-induced increase in cigarette smoking. One such hypothesis is that smokers maintain desired levels of plasma nicotine by regulating nicotine intake (Pomerleau & Pomerleau, 1987).

Another hypothesis is based on the observation that stress causes urine to become acidic. Because nicotine excretion via the kidneys and bladder is the most rapid when the urinary pH remains in the acidic range, Schachter (1978) hypothesized that the process of a rapid excretion rate encouraged further smoking. One final explanation is the anxiolytic effects of nicotine which are supported when subjects' self-reported anxiety levels are lower after smoking (Pomerleau & Pomerleau, 1987).

Relapse. Smoking relapse is often attributed to stressful events or negative affective states (Baer & Lichtenstein, 1988; Cummings, Jaen, & Giovino, 1985; Shiffman, 1982). Stressed individuals who smoked high-nicotine cigarettes reported lower levels of anxiety than stressed smokers who used low-nicotine cigarettes. Furthermore, in the same study, reduced right parietal hemisphere activation suggested that the right hemisphere may mediate the antianxiety effects of nicotine (Gilbert, Robinson,

Chamberlin, & Spielberger, 1989). For the stressed smoker, it is the calming, anxiolytic effect of smoking that is sought. Individuals relapse and begin to smoke cigarettes again in order to reduce their anxiety levels.

Stimulant Effects of Stress and Smoking. Stress is a physiological stimulant. The cardiovascular system responds in a similar manner to nicotine, the active agent in cigarette smoke. Nicotine activates sympathetic and parasympathetic nervous systems resulting in an increase in HR, stroke volume, vascular resistance, and BP. In addition, norepinephrine is released from cardiac and smooth muscle while epinephrine is released from the adrenal medulla. Besides these peripheral effects, nicotine also directly affects the central nervous system (CNS) by "desynchronizing cortical electrical activity, releasing neuropeptides such as vasopressin and beta-endorphin, and possibly potentiating central integrative mechanisms influencing SNS activity" (MacDougall et al., 1983, p. 19). Smoking also has been found to raise skin conductance levels (Golding & Mangan, 1982; Russell, Epstein, & Erickson, 1983).

Cigarette smoking combined with stress produces an increase in HR and BP approximately twice the magnitude that results from either smoking or stress alone (Dembroski, MacDougall, Cardozo, Ireland, & Krug-Fite, 1985; MacDougall et al., 1983). However, this effect has not been investigated extensively, and studies have shown mixed results. The HR effect is likely to be additive rather than potentiating (Pomerleau & Pomerleau, 1987). Nevertheless, a substantial increase in HR occurs.

Furthermore, animal studies support the hypothesis that the combination of nicotine and stress result in higher HR and BP readings than either nicotine or stress produces alone. For example, no reduction in SNS activity occurred with rabbits when nicotine and stress were combined as was hypothesized by Morse (1989). Instead, there were significant stress induced elevations observed in corticosterone, epinephrine, and glucose. These findings were consistent with the MacDougall et al. (1983) study in which large increases in HR and BP occurred in stressed smokers.

In summary, nicotine is both a stimulant and a relaxant. These differential effects have been demonstrated with physiological data. For example, smokers in a low arousal condition produced significantly fewer EEG alphas and significant elevations in skin conductance levels (SCL) and HR indicating strong stimulant effects. However, smokers in high arousal situations yield increased EEG alpha activity and HR but only a marginal elevation in SCL, indications of both depressant and stimulant effects (Golding & Mangan, 1982).

In addition to physiological effects, smoking accounts for changes in emotions or affect. The effect of smoking on negative affect has been studied. For example, Cohen & Lichtenstein (1990) found that when smokers remained abstinent for at least six months, they experienced less stress. The authors suggested that increased feelings of personal efficacy and self-esteem accounted for this decrease in perceived stress. These results suggested that the

perceived relaxant effects following cigarette smoking reduced negative affect.

Reinforcement Theory of Smoking Maintenance

There are several operant conditioning processes of tobacco addiction. One process is positive reinforcement. Positive reinforcement suggests that the effect of a drug directly increases drug use. Thus, the pleasurable effect of smoking reinforces and maintains the habit (Levitt, 1971; Newman, Martin, & Irwin, 1973). Nicotine has been identified as the reinforcer in tobacco and the substance that smokers self-regulate (Frith, 1971; Herman, 1974; Russell, Wilson, Patel, Feyerabend, & Cole, 1975; Schachter, 1978).

Some investigators have suggested that triggering the brain's reward system effects a positive mood (Ashton & Stepney, 1982). Activation of the reward mechanism by nicotine results in the release of norepinephrine and dopamine, two neurotransmitters which play a role in the reward system. In addition, a study by Chernick (1983) suggested that endogenous opiates were released by smoking. Endogenous opiates are natural substances thought to alleviate pain and produce pleasure.

A second aspect of conditioning is the negative reinforcement process. Negative reinforcement suggests that the removal of withdrawal symptoms increases drug usage. Thus, the habit is effectively maintained because smoking prevents nicotine's unpleasant withdrawal symptoms such as nicotine craving, irritability, and difficulty concentrating (Ashton & Stepney, 1982; Schachter, 1978). Nicotine also stimulates the brain's reward

system and inhibits punishment (Ashton & Stepney, 1982). Because people tend to relapse under negative affective states, it is difficult to confirm that smokers are experiencing negative withdrawal symptoms when a relapse occurs. Therefore, most current theorists prefer the role of positive reinforcement over negative reinforcement as a mechanism for maintaining the smoking habit (Collins, Epstein, & Caggiula, 1993).

Behavioral Economics Theory

Behavioral economics is an evolving interface between economics and behavior-oriented disciplines. Cost and demand are economic terms applicable to behavior which have an impact on an individual's choice. The relationship between cost and demand can be described as either elastic or inelastic. Elastic demand occurs when there is a small increase in price or cost which produces a large decrease in consumption and thus demand. The reverse, a large increase in price producing a small decrease in consumption, is termed inelastic demand (Hursh, 1984). A comprehension of demand elasticity is important because elasticity predicts the relationship between response rate and reinforcement. For example, increases in a fixed ratio (FR) schedule of reinforcement produce an increase in response rate and a decrease in consumption precisely as the economic concept of inelastic demand would predict (Hursh, 1980).

Behavioral economic theory can be used to study the reinforcement of a substance such as nicotine. According to this theory, the more reinforcing nicotine is, the more it will be chosen over other alternatives. A concurrent schedule paradigm is a

methodology which provides choices of alternative reinforcers. Using a concurrent schedule paradigm, when money is used as an alternative reinforcer for nicotine, deprived smokers initially choose smoking then subsequently show no preference for either reinforcer (Epstein, Bulik, Perkins, Caggiula, & Rodefer, 1991). When food is used as an alternative reinforcer for nicotine, deprived smokers work exclusively for nicotine (Epstein et al., 1991).

In another recent study, low rate and high rate smokers were compared using a concurrent schedule paradigm (Collins, Quevedo, & Epstein, 1992). Smokers chose to work for either cigarette puffs or coins (nickels) as the cost steadily increased on competing VR schedules. The VR schedule for puffs increased from VR 4 to VR 53 in a series of nine steps while the VR schedule for coins increased through the first three steps from VR 4 to VR 12 and then remained constant. There were no differences between low rate and high rate smokers during the first three VR steps; however, as the cost increased, high rate smokers continued to earn more cigarette puffs. Therefore, high rate smokers found nicotine reinforcing under high cost conditions.

Statement of the Problem

Stress exists when life's demands exceed coping ability resulting in SNS stimulation and arousal. Furthermore, stress is a causative factor in the initiation and maintenance of smoking as well as in relapses following quitting. Although both stress and smoking are physiologically stimulating, nicotine alone can

psychologically create either the stimulating or relaxing effect needed by the smoker making it more difficult to resist continual use. Thus, nicotine is a potent positive reinforcer.

The present study was designed to investigate the role of stress on the reinforcement value of nicotine in high rate smokers. The study excluded individuals: (a) already under stress as determined by signs of severe anxiety and/or depression and (b) with low CO levels, less than 10 ppm, typical of nondependent smokers (Lando, McGovern, Kelder, Jeffery, & Forster, 1991). A concurrent schedule paradigm was used with each of the following three conditions: (a) Mental Math (stress group), (b) Behavioral Relaxation (relaxation group), and (c) Control (neutral group). Smokers chose between cigarette puffs and coin reinforcers as the cost for each steadily increased on a concurrent VR schedule for the first three steps (VR 4, VR 8, VR 12). Thereafter, the cost for puffs continued to increase to a VR 53 while the cost for coins remained constant at a VR 12. Groups (stress versus relaxation versus neutral) were compared on the mean number of puffs chosen. It was hypothesized that smokers in the stress condition would choose cigarette puffs regardless of how high the cost became, thus indicating that nicotine had a higher reinforcement value than money under stress. The smokers in the relaxation condition were expected to choose more coins than puffs as the cost differential increased between these two reinforcers, thus suggesting a low reinforcement value for nicotine. It was hypothesized that subjects in the

neutral condition would make choices somewhere in between the other two groups.

METHOD

Subjects

Forty-five volunteers were recruited from the Oklahoma State University campus and local community to serve as subjects. They were recruited from announcements made in Introductory Psychology classes, signs placed on community and campus bulletin boards, and newspaper advertisements. All participants received either extra credit or an honorarium of $20. Subject selection was based on the following smoking history criteria: (a) current cigarette smokers who have smoked 16 or more cigarettes daily on a continuous basis for at least one year, and (b) no use of any other forms of nicotine (i.e., snuff, pipes, or cigars) during the past year.

Three potential subjects who reported smoking 16 or more cigarettes daily were screened out of the study due to CO levels of less than 10 ppm which is not typical for dependent smokers. Twenty-four potential subjects with significant symptoms of anxiety and depression as indicated on Form Y-1 (state only) of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970) and the revised Beck Depression Inventory (BDI; Beck & Steer, 1987) were excluded from the study. They were provided with information for campus and community mental health agencies should they desire to talk with someone about their symptoms. Nine subjects successfully screened into the study but did not return for the second scheduled appointment. Of the nine people, four simply

did not show up (and either had no telephones or had their phone numbers disconnected), three had unanticipated work schedule conflicts, and one was a transplant donor who had been notified that it was now time to prepare for the procedure. One person was asked not to participate because he recently had participated in a similar study.

Forty-five subjects (18 males and 27 females) completed all phases of the study. Subject characteristics are presented in the result section.

Screening Instruments

Screening instruments included a smoking questionnaire, the STAI Form Y-1, and the BDI. These instruments were used to determine which people met the criteria to participate in the study. A smoking research questionnaire was used to collect data about smoking history. Information such as brand smoked, number of cigarettes smoked daily, smoking history, and last quit attempt were requested (See Appendix A).

The STAI is a 40-item questionnaire composed of two subscales, the State-Anxiety (S-Anxiety) subscale (Form Y-1) indicating the current level of state anxiety and the Trait-Anxiety (T-Anxiety) subscale (Form Y-2) indicating the general level of trait anxiety. Scores on each subscale range from 20 to 80 with higher scores indicating higher levels of anxiety.

Based on normative data for undergraduates, the mean state score for undergraduate men is 36.35 with a standard deviation (SD) of 9.67, and the mean state score for undergraduate women is 35.12

with a SD of 9.25 (Spielberger et al., 1970). Because 68% of all people lie within one SD of the mean, potential subjects falling above one SD of the mean with a score of 47 or greater were excluded from the study.

Test-retest reliability for the S-Anxiety subscale (Form Y-1) is low with correlations ranging from 0.16 to 0.54 for college students (Spielberger et al., 1970). A low correlation is expected since the test is reflecting the situational anxiety experienced at any given time. Therefore, a measure of internal consistency such as an alpha coefficient is a better indicator of the reliability of the S-Anxiety subscale.

Alpha coefficients for Form Y-1 ranged from 0.90 to 0.94 in adult females and males ages 19-69 indicating a high level of reliability (Spielberger et al., 1970).

Spielberger et al. (1970) provide a summary table for construct validity. For example, mean S-Anxiety scores for military recruits who had just begun their stressful training were higher than non-stressed college students of comparable ages. Furthermore, the male and female recruits scored higher on S-Anxiety subscales than on their own T-Anxiety subscales which suggested that inner turmoil was experienced at the time of the testing. Concurrent validity studies with male and female college students examined the STAI Form X (precursor of Form Y) as a measure of anxiety with the Taylor Manifest Anxiety Scale (TMAS; 1953), IPAT Anxiety Scale (Cattell & Scheier, 1963), and Zuckerman Affect Adjective Checklist (AACL; 1960). High correlations were obtained for the IPAT (0.76 and 0.75,

respectively) and TMAS (0.79 and 0.80, respectively) but the AACL was moderately correlated (0.58 and 0.52, respectively).

The revised BDI is a 21-item self-report questionnaire. Scores on the BDI range from 0-63. For the original BDI Beck designated scores of 0-9 as indicative of no depression, scores of 10-15 indicative of mild depression, 16-23 indicative of moderate depression, and 24-63 indicative of severe depression (cited in Bumberry, Oliver, & McClure, 1978). The manual for the revised BDI suggests the following as score guidelines: ". . . 0 to 9 are considered within the normal range or asymptomatic; . . . 10 to 18 indicate mild-moderate depression; . . . 19 to 29 indicate moderate-severe depression; and . . . 30 to 63 indicate extremely severe depression" (Beck & Steer, 1987, p. 7). Thus, for this study, a score of 16 or above was selected as a reasonable cut-off because symptoms of depression may have interfered with a subject's performance on the experimental tasks.

Test-retest reliability studies have yielded mixed results. For example, in two separate studies of college students, a correlation of 0.90 over a 2-week interval was reported by Lightfoot and Oliver (1985), yet 0.64 over a one-week interval was reported by Zimmerman (1986). However, in clinical populations this measure of stability is meaningless since it is expected that depressed clients will show some improvement in their symptoms due to treatment and/or the mere passage of time. Beck & Steer (1987) report that "for the mixed, single-episode major depression, recurrent-episode major depression, dysthymic, alcoholic, and heroin-addicted patients

[coefficient alphas] are .86, .80, .86, .79, .90, and .88, respectively" (p.9) thus indicating a high level of internal consistency reliability.

Mean correlations for a variety of concurrent validity studies are reported in the BDI manual (Beck & Steer, 1987). For psychiatric populations, the meta-analyses result was a mean correlation of 0.72 and for non-clinical populations, a mean correlation of 0.60.

Physiological Measure

Carbon monoxide (CO) levels were obtained using a Vitalograph CO monitor, Catalog number 29.700. There were two uses for CO levels: to ensure that participants were dependent smokers and to collect CO boost measurements which correlate with the dose of nicotine in cigarette smoking (Frederiksen & Martin, 1979). Individuals with a CO level less than 10 ppm were excluded from the study. This is due to research suggesting that less than 10 ppm is a normal level for nondependent smokers (Lando et al., 1991).

Stress Rating

A Subjective Measure of Affect (SMA) was created using a Likert-type scale. Ratings ranged from 0 to 100 with 0 indicating complete relaxation and 100 maximum tension (see Appendix B).

Demographic Information Questionnaire

A Demographic Information Questionnaire (see Appendix C) was used to obtain general information such as age, gender, ethnicity, education, and income level.

Concurrent Schedule Computer Program

An IBM personal computer was used to execute a computer software program, Monpuf Limit 12 (Collins & Carter, 1991). The Monpuf Limit 12 presents a concurrent VR schedule of reinforcement with a graphic display resembling two slot machines. One slot machine earned pocket change reinforcers while the other machine earned cigarette puff reinforcers. The VR schedule for puff reinforcers advanced from VR 4 through VR 8, VR 12, VR 16, VR 20, VR 25, VR 30, VR 41, and VR 53 while the VR schedule for pocket change reinforcers advanced concurrently from VR 4 through VR 8 and then remained constant at a VR 12. When two reinforcers were earned in each VR schedule (two puffs, two coins, or one coin and one puff), the program automatically advanced to the next VR schedule of reinforcement.

Procedure

Each potential subject was asked to attend a one-hour screening session to complete a smoking research questionnaire, STAI Form Y-1, and BDI. Informed consent (see Appendix D) was obtained for the screening tests. Potential subjects were instructed in the use of the CO monitor and a preliminary CO level was obtained. Subjects meeting the designated criteria for inclusion in the experimental study were introduced to relaxation techniques and serial subtraction. They were then scheduled for a second appointment, the two-hour experimental session.

Initially subjects were assigned to one of three groups in random fashion: (a) Mental Math, (b) Behavioral Relaxation, or

(c) Control. The first subject was assigned to the first (Mental Math) group, the second subject to the second (Behavioral Relaxation) group, the third subject to the third (Control) group, and so on. After half the subjects had been run, the remaining subjects were assigned based on gender to assure an equal number of females and males across groups. Subjects were informed that they would participate in an experiment investigating the reinforcement value of nicotine under a Mental Math, Behavioral Relaxation, or Control condition.

Subjects were instructed to arrive at the laboratory prepared to smoke one cigarette immediately. Upon arrival informed consent for participation in the experimental study was obtained and the subject was asked to smoke one cigarette. A baseline CO level was obtained followed by a twenty-minute rest period. During the rest period the subject once again completed the STAI Form Y-1 and the BDI.

For the following five minutes, the experimental manipulation took place. Subjects in the Mental Math condition performed mental arithmetic (see Appendix E), subjects in the Behavioral Relaxation condition practiced Poppen's (1988) behavioral relaxation techniques (see Appendix F), and subjects in the Control condition read magazines. Each subject then completed a Subjective Measure of Affect (a stress rating) as a manipulation check.

For the next twenty minutes all subjects worked on the concurrent VR schedule of reinforcement on the computer selecting either puff or coin reinforcers ad libitum. Each subject then had a five-minute period to collect the reinforcers earned. For subjects

earning cigarette puffs, CO levels were monitored before and after smoking for the purpose of computing the CO boost (the difference between the pre and post CO levels). This thirty-minute cycle was repeated up to four times in a two-hour period to allow each subject the opportunity to reach and complete one VR 53 schedule. At the conclusion of the study each subject was asked to complete a Demographic Information Questionnaire with the request to "please complete whatever you are comfortable telling me about yourself". Subjects were then debriefed and completed either an extra credit or honorarium form.

RESULTS

Demographics

Demographic information and smoking history were obtained for each subject. These data are summarized in Table 1. All measures were controlled except age. STAI and BDI scores were controlled via cut-off scores; thus there were no overly anxious or depressed participants. Gender was controlled across groups by having nine females and six males in each experimental condition. Nicotine use was controlled for since all subjects used cigarettes as their sole source of nicotine intake. Thus, no one used pipes, cigars, or chewing tobacco. Each subject smoked more than three-fourths of a pack of cigarettes daily for at least one year.

Insert Table 1 about here

Subjects ranged in age from 18 to 63. Mean age for subjects in the Mental Math Group was 33.80 (SD = 14.60), and 30.47 (SD = 11.90) and 30.93 (SD = 11.50) for subjects in the Behavioral Relaxation and Control Groups, respectively. Because age was not controlled for, initial analyses examined differences across the three groups. The ANOVA indicated that the groups did not differ by age (F (2,44) = .30, p>.05).

Initial subject STAI and BDI scores obtained during screening interviews were below cut-off levels. Cut-off score for the STAI Form Y-1 was 47. The mean screening score for subjects in the Mental Math Group was 32.62 (SD = 6.42), and 29.62 (SD = 6.75) and 33.00 (SD = 7.21) for subjects in the Behavioral Relaxation and Control Groups, respectively. A one-way ANOVA examined STAI Form Y-1 screening scores by condition. Results indicated that level of state anxiety was similar across groups (F (2,37) = .98, p> .05).

Individuals with BDI screening scores below 16 were eligible to participate in the study. The mean screening score for subjects in the Mental Math Group was 5.85 (SD = 4.93), and 5.30 (SD = 3.75) and 4.71 (SD = 4.60) for subjects in the Behavioral Relaxation and Control Groups, respectively. A one-way ANOVA conducted on BDI screening scores by group indicated that groups did not differ in terms of level of depression (F (2,37) = .22, p>.05). Mean scores for each group suggested that subjects did not experience any symptoms of depression. STAI and BDI Scores were obtained a second time during the beginning of the experimental session. Two subjects exceeded the STAI cut-off score by one and three points,

respectively. Because these were retest scores and not initial scores, it was decided to allow them to complete the study and their data was used in all analyses.

Manipulation Check

Subjective Measure of Affect. Subjective reports of stressful feelings were obtained immediately following the five-minute manipulation (eg. serial subtraction, behavioral relaxation tape, or magazine reading). Some subjects progressed through the VR schedules at a slower rate than others for a variety of reasons such as a slow rate of keypressing or frequent shifts between coins and puffs before earning a reinforcer. Rate of progress was not controlled for, however, the time interval between breaks (about 30 minutes) was controlled. As a result of this system, all subjects had two breaks while some subjects had three or four breaks. Thus, all subjects completed the first two manipulations and stress ratings (N = 45).

Three one-way ANOVAs were conducted to determine mean differences in the self ratings of stress by condition. A significant main effect for the first stress measure (F (2,42) = 30.60, $p < .001$) was obtained indicating that groups differed based on self-reported stress levels. ANOVA results were also significant for the second rating period (F (2,42) = 18.92, $p < .001$) indicating that differences in stress ratings again varied by group. A third ANOVA was utilized to examine the third stress rating completed by 28 subjects. A significant main effect for condition was obtained (F (2,25) = 9.43, $p < .001$) indicating that groups differences were

evident in tension ratings. Only one subject completed a fourth rating of tension. As shown in Figure 1, the Mental Math (stress) condition had significantly higher ratings than the other two conditions. There is a significant effect for ratings 1, 2, and 3 and in each case, the Mental Math Group demonstrated a higher stress level than the other two groups based on a Tukey HSD ($p < .05$). The Behavioral Relaxation Group and the Control did not differ from one another.

Insert Figure 1 about here

Carbon Monoxide (CO) Boost

Analysis of CO boost looks at the total CO boost per period divided by the number of puffs taken to see if subjects got more nicotine out of each puff. No differences among groups were expected, however, had there been, interpretation of data would have become more difficult with this confounding factor. Thirty-three subjects completed CO levels at Time 1 during the first break. Time 1 means for CO boost per puff by condition were as follows: Mental Math Group = 1.28 (SD = 1.04), Behavioral Relaxation Group = 1.45 (SD = 0.92), and Control Group = 1.94 (SD = 1.08). A one-way ANOVA was conducted to determine CO boost mean differences by condition. No significant effects were obtained for CO boost during Time 1 ($F(2,32) = 1.27$, $p > .05$) indicating that the amount of nicotine per puff did not differ by group.

Thirty subjects completed the CO levels at Time 2 during the second break. Time 2 means for CO boost per puff were as follows:

Mental Math Group = 1.22 (SD = 0.67), Behavioral Relaxation Group = 2.52 (SD = 2.24), and Control Group = 3.59 (SD = 4.66). A one-way ANOVA examined CO boost by condition for Time 2 and resulted in no significant effects (F (2,29) = 1.71 p> .05). Although increases in CO levels were apparent during Time 2 for the Behavioral Relaxation and Control group, the Mental Math group levels remained constant and the nicotine obtained per puff was similar across groups.

Sixteen subjects completed CO levels a total of three times Time 3 during the third break. CO boost per puff means for each group at Time 3 were as follows: Mental Math = 2.14 (SD = 2.02), Behavioral Relaxation = 2.68 (SD = 2.18), and Control = 3.25 (SD =2.60). An ANOVA at Time 3 (F(2,15) = 0.30 p> .05) yielded no significant differences in CO boost among groups, thus amounts of nicotine per puff were similar for subjects in the stress, relaxation, and neutral conditions. One subject completed Time 4, however, CO levels were not collected. Tukey HSD tests were conducted and no two groups during any of the three break periods were significantly different at the .05 level.

Overall Analysis of Variance for Puffs

A two-factor mixed design was utilized with condition (Mental Math, Behavioral Relaxation, and Control) as the between factor and consecutive schedules (VR 4, VR 8, VR 12, VR 16, VR 20, VR 25, VR 30, VR 41, and VR 53) as the within factor. The dependent variable was defined as the number of coin or puff reinforcers earned per experimental schedule. Because the number of puff reinforcers earned is a reflection of the reinforcement value of nicotine, puffs

only were analyzed. The higher the number of puff reinforcers earned, the greater the reinforcement value of nicotine. The means and standard deviations for number of puff reinforcers earned per VR schedule by condition are shown in Table 2.

Insert Table 2 about here

A 3 x 9 (condition x schedules) mixed design ANOVA with repeated measures was conducted. The ANOVA did not yield a significant main effect for condition (F (2,42) = 0.45, $p > .05$) or a condition by schedule interaction (F (16,336) = 1.18, $p > .05$). There was a significant main effect for schedules (F (8,336) = 3.98, $p < .001$) indicating that the VR schedules differed from one another in terms of the number of cigarette puffs earned.

It was expected that the reinforcement value as measured by number of puff reinforcers would be greater for stressed dependent smokers than for the relaxed or control group smokers. As the results indicate, this did not happen. Figure 2 presents mean number of puff reinforcers earned per VR schedule. Visual inspection of Figure 2 shows that the groups did not differ in Blocks 1 and 2. However, further inspection of the graph also suggested that a difference in the number of puff reinforcers earned occurred in Block 3.

Insert Figure 2 about here

A similar phenomenon occurred in an earlier study (Collins et al., 1992). Dependent and nondependent smokers continued to choose an equal number of puffs and coins through the first three VR schedules (Block 1). However, there was a difference in choice of reinforcer at the end of the second set of three VR schedules (Block 2) when dependent smokers switched to puffs. These results suggested that it would be logical to examine possible differences in the last six VR schedules (Blocks 2 and 3). Thus, exploratory post hoc analyses were conducted.

Analysis of Block 2

An ANOVA conducted on Block 2 (puff schedules VR 16, VR 20, VR 25) yielded no significant effects for schedule (F (2,84) = .73, p> .05), condition (F (2,42) = .65, p> .05), or condition by schedule (F(4,84) = .62, p> .05). Thus, dependent smokers in the Mental Math Group did not differ from the Behavioral Relaxation or Control Group in their preference of reinforcer. See Figure 3 for number of reinforcers earned in Block 2.

Insert Figure 3 about here

Analysis of Block 3

An ANOVA was conducted to determine whether the mean number of puff reinforcers earned in each VR schedule of Block 3 (puff schedules VR 30, VR 41, VR 53) differed by condition. There was no main effect for condition (F (2,42) = .89, p> .05). A significant main effect for schedule was obtained (F(2,84) = 11.43, p< .001). In addition, a two-way interaction (condition by schedule) was

significant ($F(4,84) = 2.59$, $p < .04$). Thus, compared to the Control Group, subjects in the Mental Math Group differed in preference for puffs and tended to work harder and longer for nicotine. Likewise, the Behavioral Relaxation Group showed a tendency similar to the Mental Math Group as they earned puffs longer and switched to coins later than did the Control Group. See Figure 4 for the number of reinforcers earned in Block 3.

Insert Figure 4 about here

For all summaries of ANOVA test results see Appendix G.

DISCUSSION

The results of the present study were similar to the pilot study comparing dependent and nondependent smokers (Collins et al., 1992). In the pilot study, dependent smokers appeared to find nicotine more reinforcing than nondependent smokers. In the present study, all smokers were dependent and all appeared to find nicotine quite reinforcing. It was only after the cost difference was a VR 41 for puffs and a VR 12 for coins did any group switch and decrease the number of puff reinforcers earned.

Subjects in the Mental Math condition reported more stress and continued to work for puffs longer than subjects in the Control condition. Thus, compared to the Control Group, there was a trend for subjects in the Mental Math condition to find nicotine more reinforcing.

Because dependent smokers did not show a preference for coins until VR 41, post hoc analysis of data obtained in the final three

schedules was conducted. The significant two-way interaction of condition by trial suggested that emotions play a role in the reinforcement value of nicotine. There was a trend suggesting that nicotine is more reinforcing for smokers in both the stress and the relaxation conditions compared to smokers in the neutral condition.

Analysis of CO boost levels indicated no group difference. Thus, dependent smokers took similar puffs across the study and even though they took fewer puffs toward the end of the study, they probably obtained a similar amount of nicotine from each puff. Alveolar air CO levels did not unduly influence any one group of subject choices of nicotine over a monetary reinforcer.

While it is likely that there are multiple reasons why people smoke, one reason may be stress. Self-report stress ratings served as a manipulation check. The SMA was designed to measure level of stress and ranged from 0 (complete relaxation or no tension) to 100 (maximum tension). The Mental Math Group reported significantly more tension than either the Behavioral Relaxation or Control Group suggesting that the experimental manipulation was effective. Although the results of the SMA were in the desired direction, there are some concerns regarding this instrument. The SMA was face valid and had construct validity due to its Likert-type format. However, no other validity data was obtained. Psychometric properties were not examined thus there is no reliability data. In addition, the SMA was a one-item scale and therefore reliability is probably low.

Future studies might use a well established stress measure as a manipulation check. For example, physiological measures such as HR

and/or BP could be monitored after each experimental manipulation or a psychological paper and pencil instrument with demonstrated psychometric properties could be administered to measure stress.

There was a trend for dependent smokers in the Behavioral Relaxation group to find nicotine more reinforcing than the Control Group. The Behavioral Relaxation Group continued to earn puffs until they reached a VR 53 when their preferences shifted from puffs to coins. In this study, dependent smokers in the Behavioral Relaxation Group consistently found nicotine more reinforcing than Control Group smokers. The Control Group did not find nicotine sufficiently reinforcing at a VR 41 and thus reduced work efforts for puffs.

The Behavioral Relaxation Group and the Control Group demonstrated no significant difference in self-reported tension but there was a difference in their smoking behavior. There are two reasons that may account for this finding: 1) both the Behavioral Relaxation and the Control Groups experienced more stress than they reported, or 2) perhaps they were not stressed but had other emotional experiences such as boredom. If unreported stress were a factor, then listening to a behavioral relaxation training tape was not more relaxing than reading a magazine. Because people report that they smoke to relax (Epstein & Jennings, 1986), it may be that listening to and following the instructions on a BRT (Poppen, 1988) tape was not very relaxing. Those in the Relaxation Group may have reported that they felt more relaxed because they thought they were expected to do so.

It is also possible that the Control Group may have found reading a magazine a familiar, comfortable request and therefore this may have been a more calming task. If this was the case, then the dependent smokers in the Behavioral Relaxation Group may have smoked more than the Control Group in order to induce relaxation. This would also be consistent with Norton and Howard's (1988) report that nicotine helps smokers relax in stressful situations. Nevertheless, it is important to remember that the measure of stress was self-report and therefore subject to demand characteristics. Because demand characteristics can influence all subjects, it is also possible that subjects in the Mental Math Group reported mild stress because they thought they were expected to do so. Although these subjects were not explicitly told that they would be stressed, they may have deduced this because of the nature of the serial subtraction task.

Boredom is yet another reason people tend to prefer nicotine. Smoking is stimulating depending on the smoker's current situation (Epstein & Jennings, 1986) and bored people tend to self-stimulate to stay awake. Visual observation via a two-way mirror during the video game suggested that some subjects became bored. Boredom was evident through behavioral cues such as periodic sighing, occasional finger tapping, and periodic scanning of objects in the room. Thus, some smokers in this study may have preferred nicotine because the repetitive nature of the video game created a boring task.

Future research studies might employ stress and relaxation tasks that would induce stronger responses in subjects making the

choice of reinforcers very distinct from one another. For example, rather than the mild stressor of serial subtraction, math problems or mazes with no solutions could be used. In addition, a relaxation task that involves training sessions to a certain level of expertise might be more effective. Thereafter the subject in a relaxation group could be stressed and then instructed to employ the relaxation training. If indeed boredom is a realistic consideration as visual observation during the video game suggested, then a different task that is more stimulating might be created to present alternative reinforcers.

In summary, behavioral economic theory was used in this study to provide a methodology for studying factors that influence nicotine reinforcement. This framework incorporates the economic concepts of cost and demand which impact an individual's choices. By producing relaxation, stress, or other emotional states such as boredom, we can study and begin to understand the relationship between emotions and smoking.

The present study demonstrated that the Mental Math condition resulted in stress and a tendency for more urges to smoke compared to the Control condition. The Behavioral Relaxation condition induced a similar effect compared to the Control condition. The strength of these findings is tempered by the failure to find an overall significant effect by condition. These results are theoretically consistent with the prediction that nicotine is more reinforcing to dependent smokers under stress and warrants replication.

Caution must be exercised in interpreting the results of this study. These data are promising and indicate that emotions influence urges to smoke; this study does not identify the specific emotions. However, data should not be interpreted to mean that relaxation makes people smoke more. However, the data suggest that some people smoke more when they are not stressed.

References

Ashton, H., & Stepney, R. (1982). Smoking: Psychology and pharmacology. London: Tavistock Publications.

Baer, J. S., & Lichtenstein, E. (1988). Classification of smoking relapse episodes: An exploration of individual differences. Journal of Consulting and Clinical Psychology, 56, 104-110.

Beck, A. T., & Steer, R. A. (1987). Beck depression inventory manual. New York, NY: The Psychological Corporation/Harcourt Brace Jovanovich, Inc.

Brunswick, A. F., & Messeri, P. A. (1984). Origins of cigarette smoking in academic achievement, stress and social expectations: Does gender make a difference? Journal of Early Adolescence, 4(4), 353-370.

Bumberry, W., Oliver, J., & McClure, J. (1978). Validation of the beck depression inventory in a university population using psychiatric estimate as the criterion. Journal of Consulting and Clinical Psychology, 46(1), 150-155.

Cattell, R. B., & Scheier, I. H. (1963). Handbook for the IPAT Anxiety Scale, (2nd Ed.). Champaign, IL: Institute for Personality and Ability Testing.

Chernick, V. (1983). The brain's own morphine and cigarette smoking: The junkie in disguise? Chest, 83(1), 2-4.

Cohen, S., & Lichtenstein, E. (1990). Perceived stress, quitting smoking, and smoking relapse. Health Psychology, 9(4), 466-478.

Collins, F. L., Jr., Epstein, L. H., & Caggiula, A. R. (1993). Behavioral pharmacology of nicotine dependence. Unpublished manuscript.

Collins, F. L., Jr., & Carter, B. (1991). Monpuf limit 12 concurrent VR schedule [Computer program]. Stillwater, OK: Oklahoma State University, Smoking Research Lab in Department of Psychology.

Collins, F. L., Quevedo, Y. G., & Epstein, L. H. (1992). Reinforcing value of nicotine for dependent and nondependent smokers. Unpublished manuscript.

Cummings, V. M., Jaen, C. R., & Giovino, G. (1985). Circumstances surrounding relapse in a group of recent ex-smokers. Preventive Medicine, 14, 195-202.

Dembroski, T. M., MacDougall, J. M., Cardozo, S. R., Ireland, S. K., & Krug-Fite, J. (1985). Selective cardiovascular effects of stress and cigarette smoking in young women. Health Psychology, 4, 153 -167.

Epstein, L. H., Bulik, C. M., Perkins, K. A., Caggiula, A. R., & Rodefer, J. (1991). Behavioral economic analysis of smoking: Money and food as alternatives. Pharmacology, Biochemistry, and Behavior, 38, 715-721.

Epstein, L., & Jennings, J. (1986). Smoking, stress, cardiovascular reactivity, and coronary heart disease. In K. Matthews, S. Weiss, T. Detre, T. Dembroski, B. Falkner, S. Manuck, and R. Williams, Jr. (Eds.) Handbook of stress, reactivity, and cardiovascular disease (pp. 291-309). New York, NY: John Wiley & Sons.

Frederiksen, L. W., & Martin, J. E. (1979). Carbon monoxide and smoking behavior. Addictive Behaviors, 4, 21-30.

Frith, C. D. (1971). The effect of varying the nicotine content of cigarettes on human smoking behavior. Psychopharmacologia, 19, 188-192.

Gilbert, D. G., Robinson, J. H., Chamberlin, C. L., & Spielberger, C. D. (1989). Effects of smoking/nicotine on anxiety, heart rate, and lateralization of EEG during a stressful movie. Psychophysiology, 26(3), 311-320.

Golding, J., & Mangan, G. L. (1982). Arousing and de-arousing effects of cigarette smoking under conditions of stress and mild sensory isolation. Psychophysiology, 19(4), 449-456.

Herman, C. P. (1974). External and internal cues as determinants of the smoking behavior of light and heavy smokers. Journal of Personality and Social Psychology, 30, 664-672.

Hursh, S. R. (1980). Economic concepts for the analysis of behavior. Journal of Applied Behavior Analysis, 34, 219-238.

Hursh, S. R. (1984). Behavioral economics. Journal of the Experimental Analysis of Behavior, 42, 435-452.

Lando, H. A., McGovern, P. G., Kelder, S. H., Jeffery, R. W., & Forster, J. L. (1991). Use of carbon monoxide breath validation in assessing exposure to cigarette smoke in a worksite population. Health Psychology, 10(4), 296-301.

Lazarus, R. S., & Folkman, S. (1984). Stress, appraisal, and coping. New York, NY: Springer Publishing Company.

Levitt, E. E. (1971). Reasons for smoking and not smoking given by school children. Journal of School Health, 41, 101-105.

Lightfoot, S. L., & Oliver, J. M. (1985). The Beck Inventory: Psychometric properties in university students. Journal of Personality Assessment, 49, 434-436.

MacDougall, J. M., Dembroski, T. M., Slaats, S., Herd, J. A., & Eliot, R. S. (1983). Selective cardiovascular effects of stress and cigarette smoking. Journal of Human Stress, 9, 13-21.

Morse, D. E. (1989). Neuroendocrine responses to nicotine and stress: Enhancement of peripheral stress responses by the administration of nicotine. Psychopharmacology, 98, 539-543.

Newman, I. M., Martin, G. L., & Irwin, R. P. (1973). Attitudes of adolescent cigarette smokers. New Zealand Medical Journal, 79, 237-240.

Norton, R., & Howard, R. (1988). Smoking, mood and the contingent negative variation (CNV) in a go-no go avoidance task. Journal of Psychophysiology, 2, 109-118.

Penny, G. N., & Robinson, J. O. (1986). Psychological resources and cigarette smoking in adolescents. British Journal of Psychology, 77, 351-357.

Pomerleau, C. S., & Pomerleau, O. F. (1987). The effects of a psychological stressor on cigarette smoking and subsequent behavioral and physiological responses. Psychophysiology, 24(3), 278-285.

Pomerleau, O. F., & Pomerleau, C. S. (1984). Neuroregulators and the reinforcement of smoking: Towards a biobehavioral explanation. Neuroscience and Biobehavioral Reviews, 18, 503-513.

Poppen, R. (1988). Behavioral relaxation training and assessment. New York, NY: Pergamon Press.

Russell, M. A. H., Wilson, C., Patel, U. A., Feyerabend, C., & Cole, P. V. (1975). Plasma nicotine levels after smoking cigarettes with high, medium, and low nicotine yields. British Medical Journal, 2, 414-416.

Russell, P. O., Epstein, L. H., & Erickson, K. T. (1983). Effects of acute exercise and cigarette smoking on autonomic and neuromuscular responses to a cognitive stressor. Psychological Reports, 53, 199-206.

Schachter, S. (1978). Pharmacological and psychological determinants of smoking. Annals of Internal Medicine, 88(1), 104-114.

Shiffman, C. (1982). Relapse following smoking cessation: A situational analysis. Journal of Consulting and Clinical Psychology, 50, 71-86.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). STAI manual for the state trait anxiety inventory (Self Evaluation Questionnaire). Palo Alto, CA: Consulting Psychologists Press.

Taylor, J. A. (1953). A personality scale of manifest anxiety. Journal of Abnormal and Social Psychology, 48, 285-290.

Zimmerman, M. (1986). The stability of the revised Beck Depression Inventory in college students: Relationship with life events. Cognitive Therapy and Research, 10, 37-43.

Zuckerman, M. (1960). The development of an affect adjective check list for the measurement of anxiety. Journal of Consulting Psychology, 24, 457-462.

APPENDIXES

APPENDIX A

SMOKING RESEARCH QUESTIONNAIRE

Name _____

Phone Number ( )_____ Address_____
Best time(s) to call _____

Psychology 1113 Instructor _____ Section #_____

Semester (circle one): Spring Summer Fall

Please answer the following questions to the best of your ability. All information will remain confidential. Your time is greatly appreciated.

1. What is your sex? (Circle one) Male Female

2. What is your age? _____

3. Are you currently a smoker? Y N

   If you are not a smoker, please skip to question 12.

4. Do you usually smoke only in social situations? (e.g., at parties only or at a bar only) Y N

5. About how many cigarettes do you smoke per day?

   less than 10 10-15 16-20 21-25 more than 25

6. How long have you smoked? (circle one)

   less than 1 year 1 - 2 years more than 2 years

7. What brand of cigarettes do you smoke?_____

8. Have you ever tried to quit before? Y N

9. If yes, when was the last time you tried?_____

10. Are you currently attempting to quit smoking or cut down?

    Y N

11. Do you use any other form of tobacco in addition to cigarettes?

    Y N

12. What is your height (feet,inches)? _____

13. What is your weight? _____

THANK YOU!

APPENDIX B

SUBJECTIVE MEASURE OF AFFECT

PLEASE CIRCLE HOW YOU FEEL RIGHT NOW

TRIAL #1

0	25	50	75	100
Completely relaxed, no tension	very relaxed		very tense	maximum tension

---

PLEASE CIRCLE HOW YOU FEEL RIGHT NOW

TRIAL #2

0	25	50	75	100
Completely relaxed, no tension	very relaxed		very tense	maximum tension

---

PLEASE CIRCLE HOW YOU FEEL RIGHT NOW

TRIAL #3

0	25	50	75	100
Completely relaxed, no tension	very relaxed		very tense	maximum tension

---

PLEASE CIRCLE HOW YOU FEEL RIGHT NOW

TRIAL #4

0	25	50	75	100
Completely relaxed, no tension	very relaxed		very tense	maximum tension

---

APPENDIX C

DEMOGRAPHIC INFORMATION

Age:_____ Sex: Male_____ Female_____

Marital Status: Married_____ Divorced_____
Separated_____ Widowed _____
Never Married _____

If married, how long?_____

If divorced, how long?_____

If widowed, how long?_____

Education: Grade School_____ High School_____
Trade School_____ College_____
Advanced degree_____ Other_____

Occupation: Skilled labor _____ Unskilled labor_____
Professional _____ Not in labor force____

If not in labor force, are you currently looking for employment?
Yes_____ No_____

Job Title: _____

Are you currently a student? Yes_____ No_____

Annual Income: Less than $5,000____ $5,000-$10,000____
$10,000-$20,000____$20,000-$30,000____
$30,000-$40,000____$40,000-$50,000____
$50,000-$60,000____
Greater than $60,000 per year ____

Are you a dependent of your parents, do they claim you for their
Income Tax purposes? Yes_____ No_____

Race: _____

U.S. Citizen? Yes_____ No_____
If U.S. Citizen; Naturalized_____ Natural Born_____

State of residence:_____ State of origin:_____

APPENDIX D

CONSENT FORMS

D-1 Nicotine Reinforcement Project: Screening Interview

Participants should note that neither Oklahoma State University nor its researchers endorse or encourage continuation of smoking; rather, the purpose of this study is to research certain effects upon those who are currently smoking.

I, _____, hereby authorize or direct Dr. Frank Collins and Yoli Quevedo, or assistants of his or her choosing, to perform the following procedure:

You are being asked to participate in a screening interview during which you will be asked to complete three questionnaires. The questionnaires ask about desirable and undesirable life events, your current level of anxiety, and your current level of sadness. The purpose of these questionnaires is to assess the everyday pressures you are experiencing. You may also be instructed in the use of the carbon monoxide monitor and may be asked to provide a preliminary carbon monoxide level by exhaling into a cardboard mouthpiece.

In addition, you may be familiarized with an arithmetic subtraction task and be asked to listen to a five minute relaxation tape. The total time for the screening interview will be approximately one hour.

This is done in preparation for an investigation entitled The Reinforcement Value of Nicotine in Dependent Smokers under Relaxation, Mental Arithmetic and Rest Conditions.

I understand that participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw

my consent and participation in this project at any time without penalty after notifying the researcher.

I may contact Dr. Frank Collins or Yoli Quevedo at (405) 744-6027 should I wish further information about the research. I may also contact University Research Services, 001 Life Sciences East, Oklahoma State University, Stillwater, Oklahoma 74078; Telephone: (405) 744-9992.

I certify that I am 18 years of age or older and that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: _____ Time:_____(a.m./p.m.)

Signed: _____ Age: _____
(Signature of Subject)

I certify that I have personally completed all blanks in this form and explained them to the subject before requesting the subject to sign it.

Signed: _____
(Researcher or designated Representative)

D-2 Nicotine Reinforcement Project: Research Study Participants should note that neither Oklahoma State University nor its researchers endorse or encourage continuation of smoking; rather, the purpose of this study is to research certain effects upon those who are currently smoking.

I, _____, hereby authorize or direct Dr. Frank Collins and Yoli Quevedo, or assistants of his or her choosing, to perform the following procedure:

You are being asked to participate in a research study of the reinforcement value of nicotine. If you agree to participate, you will be asked to do one of the following: 1) answer arithmetic subtraction questions, 2) listen to a relaxation tape, or 3) read some magazines. Then you will be asked to play a video game on the IBM computer. You will have the option of earning either cigarette points or pocket change points during the game. Periodically you will be given the opportunity to cash in your cigarette points for puffs on a cigarette or your pocket change points for nickels. The total time for the study will be about 3 hours. You will not be allowed to smoke except during the 5 minute break period approximately every 30 minutes and then only to cash in the number of puffs you have earned. Should you want to smoke more you may earn more cigarette puffs during the remainder of the game.

Individuals who complete the study will be compensated for their time. If you are in an Introductory Psychology class you have the option of receiving extra credit points or being paid at the

rate of $5 per hour for a total of $20. Other volunteers will be given $5 per hour for a total of $20.

All information obtained during the study will remain confidential. Records will be coded by number and your name will not appear on any forms other than this consent form. The only individuals who will have access to this data are Dr. Frank Collins and the research assistant who is conducting the project with you. His or her name is at the end of this consent form. If the results of the study are reported to a professional group, only average data will be presented, and your records will not be identified.

This is done as part of an investigation entitled The Reinforcement Value of Nicotine in Dependent Smokers under Relaxation, Mental Arithmetic and Rest Conditions.

The purpose of the procedure is to better understand the reinforcement value of nicotine by observing the potential shift to an alternate source of reinforcement as the cost (responses) required to obtain nicotine increases steadily.

I understand that participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty after notifying the researcher.

I may contact Dr. Frank Collins or Yoli Quevedo at (405) 744-6027 should I wish further information about the research. I may also contact University Research Services, 001 Life Sciences East, Oklahoma State University, Stillwater, Oklahoma 74078; Telephone: (405) 744-9992.

I certify that I am 18 years of age or older and that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: _____ Time: _____ (a.m./p.m.)

Signed: _____
(Signature of Subject)

Age: _____

I certify that I have personally completed all blanks in this form and explained them to the subject before requesting the subject to sign it.

Signed: _____
(Researcher or designated Representative)

APPENDIX E

MENTAL ARITHMETIC SCRIPTS

E-1 Screening Interview Script

"In the actual experiment you may be asked to do some mental arithmetic. If so, you would be told to subtract a two digit number from a four digit number until you are asked to stop. For example, please subtract 10 from 2000 (if the ans. = 1990, say 'right, now subtract 10 from 1990,' if the ans. is incorrect say 'no, the correct answer is 1990 because 2000 minus 10 leaves 1990. Now please subtract 10 from 1990'; if the ans. = 1980, say 'right, now continue subtracting 10 from each of your answers until I tell you to stop'; if the ans. is incorrect say 'no, the correct answer is 1980, now continue subtracting 10 from each of your answers until I tell you to stop'). Please stop now."

E-2 Experimental Procedure Script

"I am going to ask you to subtract a two digit number from a four digit number and I want you to continue subtracting until I tell you to stop. Let's begin, please subtract 13 from 4826 and continue to subtract 13 from each of your answers until I tell you to stop."

APPENDIX F

BEHAVIORAL RELAXATION TRAINING SCRIPT

There are ten relaxed postures or activities. The first posture we will focus on is your Back. Your back is relaxed when the spine is perpendicular to the floor, with the shoulder blades and the buttocks touching the back of the chair. A slight lordosis is desirable. Please show me a relaxed back.

The next relaxed posture we will focus on is your Head. Your head is relaxed when it is upright and motionless, with the nose in midline with the body. Please relax your head.

Next, we will focus on your Arms. Your arms are relaxed when they are bent approximately 120 degrees at the elbow with the wrists resting on the thigh, approximately half way between the hip and the knee. Please show me relaxed arms.

The next relaxed posture we will focus on is in your Legs. Your legs are relaxed when they are straight with the feet flat on the floor with approximately 90 degree angle at the knees and ankles. Please relax your legs.

The next posture will focus on your Eyes. Your eyes are relaxed when the lids are closed and smooth. Your eyes are not relaxed when they are tightly shut, or if there is eye movement beneath the lids. Please relax your eyes.

Next we will focus on the posture of your Mouth. Your mouth is relaxed when your teeth are parted and your lips are open in the center. Your mouth is unrelaxed if your lips are closed, or if you smile or lick your lips. Ok, please show me how to relax your mouth.

The next posture will focus on your Throat. Your throat is relaxed when it is quiet and smooth. It is unrelaxed if there is any movement such as muscle twitches or swallowing. Please demonstrate a relaxed throat.

The next relaxed posture we will focus on is your Hands. Your hands are relaxed when you rest them in your lap with the fingers slightly curled into a claw-like position. Your hands are not relaxed if the fingers are flat or curled into a ball. Please show me relaxed hands.

Next, we will focus on being Quiet. You are quiet when you are not making any noise, such as talking, loud sighs, or snores. All right, please demonstrate quiet for the next few moments.

The final relaxed activity is Breathing. Your breathing is relaxed when it is slow and regular. It is not relaxed if it is rapid, or if there are interruptions such as coughing, yawning, sneezing, sniffing, vocalizations, or the like. Please demonstrate relaxed breathing.

APPENDIX G

SUMMARIES OF ANOVA TEST CRITERIA

Table G-1

Overall Analysis of Variance for Puffs

Effect	F	df	Significance level
BETWEEN			
Condition	0.45	(2,42)	n.s.
WITHIN			
Schedules	3.98	(8,336)	<0.001
Cond. x Schedules	1.18	(16,336)	n.s.

Table G-2

Analysis of Block 2

Effect	F	df	Significance level
BETWEEN			
Condition	0.65	(2,42)	n.s.
WITHIN			
Schedules	0.73	(2,84)	n.s.
Condition x Sched.	0.62	(4,84)	n.s.

Table G-3

Analysis of Block 3

Effect	F	df	Significance level
BETWEEN			
Condition	0.89	(2,42)	n.s.
WITHIN			
Schedules	11.43	(2,84)	<0.000
Condition x Sched.	2.59	(4,84)	<0.043

Table 1

Demographic Summary of Subjects

Characteristics		Condition		
		Mental Math	Relaxation	Control
Gender	Female	9	9	9
	Male	6	6	6
Age	Mean	33.8	30.5	30.9
	SD	14.6	11.9	11.5
Ethnicity	Caucasian	15	13	15
	Native American	0	2	0
# Cigs. Smoked daily	16-20	8	8	5
	21-25	1	4	6
	>25	6	3	4
# Years Smoked	1-2	1	2	0
	>2	14	13	15
Last Quit Attempt	Never	6	5	5
	>1 yr. ago	7	7	5
	<1 yr. ago	2	3	4
	?	-	-	1

Table 2

Means and Standard Deviations for the Number of Puff Reinforcers Earned per VR Schedule by Condition

VR Schedule	Condition					
	Mental Math		Relaxation		Control	
	M	SD	M	SD	M	SD
4	0.933	(0.961)	0.867	(0.915)	1.000	(0.926)
8	0.867	(0.915)	1.067	(0.884)	0.867	(0.834)
12	1.267	(0.884)	1.067	(0.799)	0.867	(0.743)
16	0.600	(0.632)	1.067	(0.799)	0.800	(0.676)
20	0.800	(0.862)	1.067	(0.704)	0.733	(0.799)
25	1.000	(0.926)	1.000	(0.926)	0.933	(1.033)
30	1.000	(0.926)	0.933	(0.961)	0.867	(0.743)
41	0.867	(0.915)	1.133	(0.915)	0.400	(0.632)
53	0.333	(0.724)	0.667	(0.816)	0.400	(0.737)

Note: M = Mean
SD = Standard Deviation

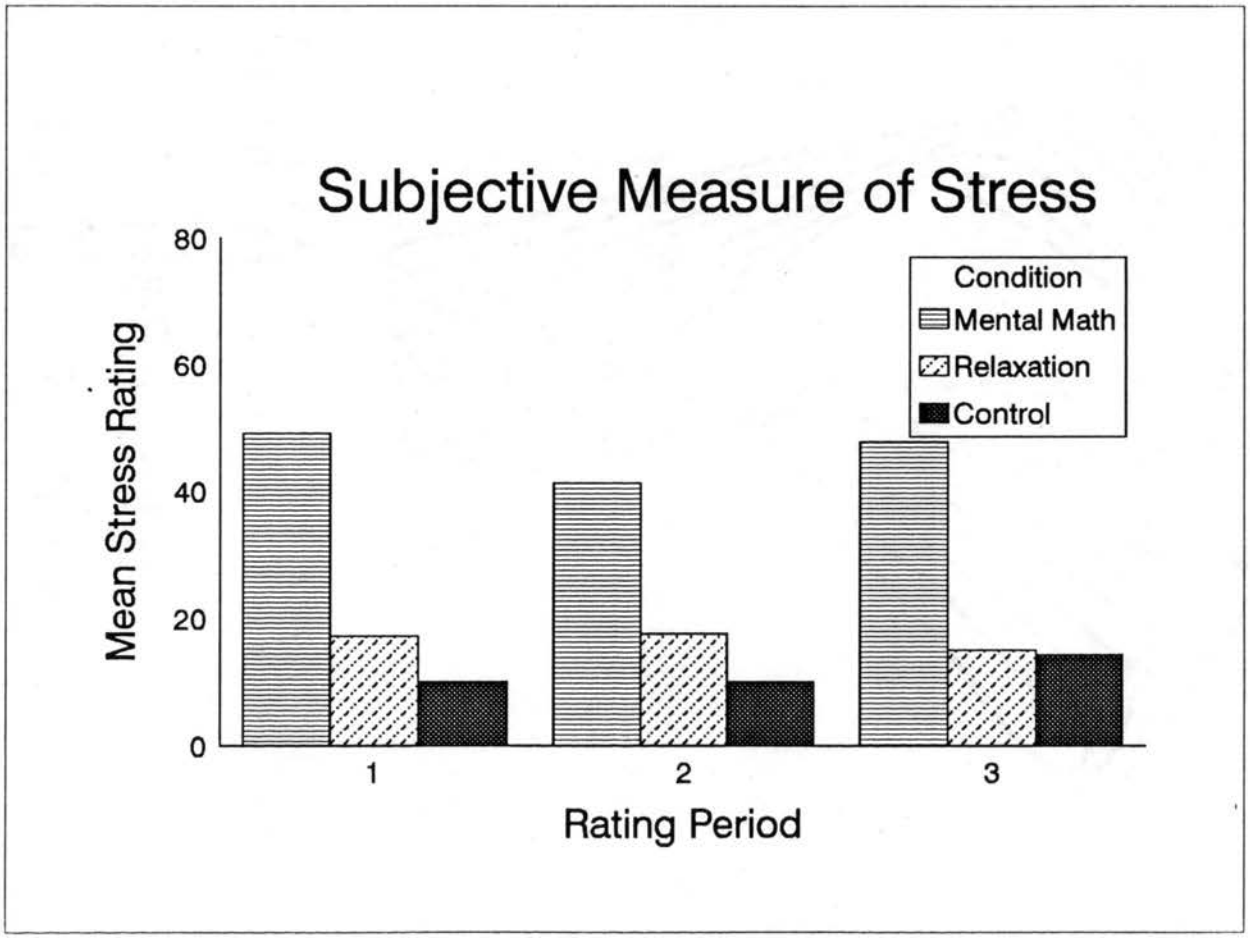
Figure Captions

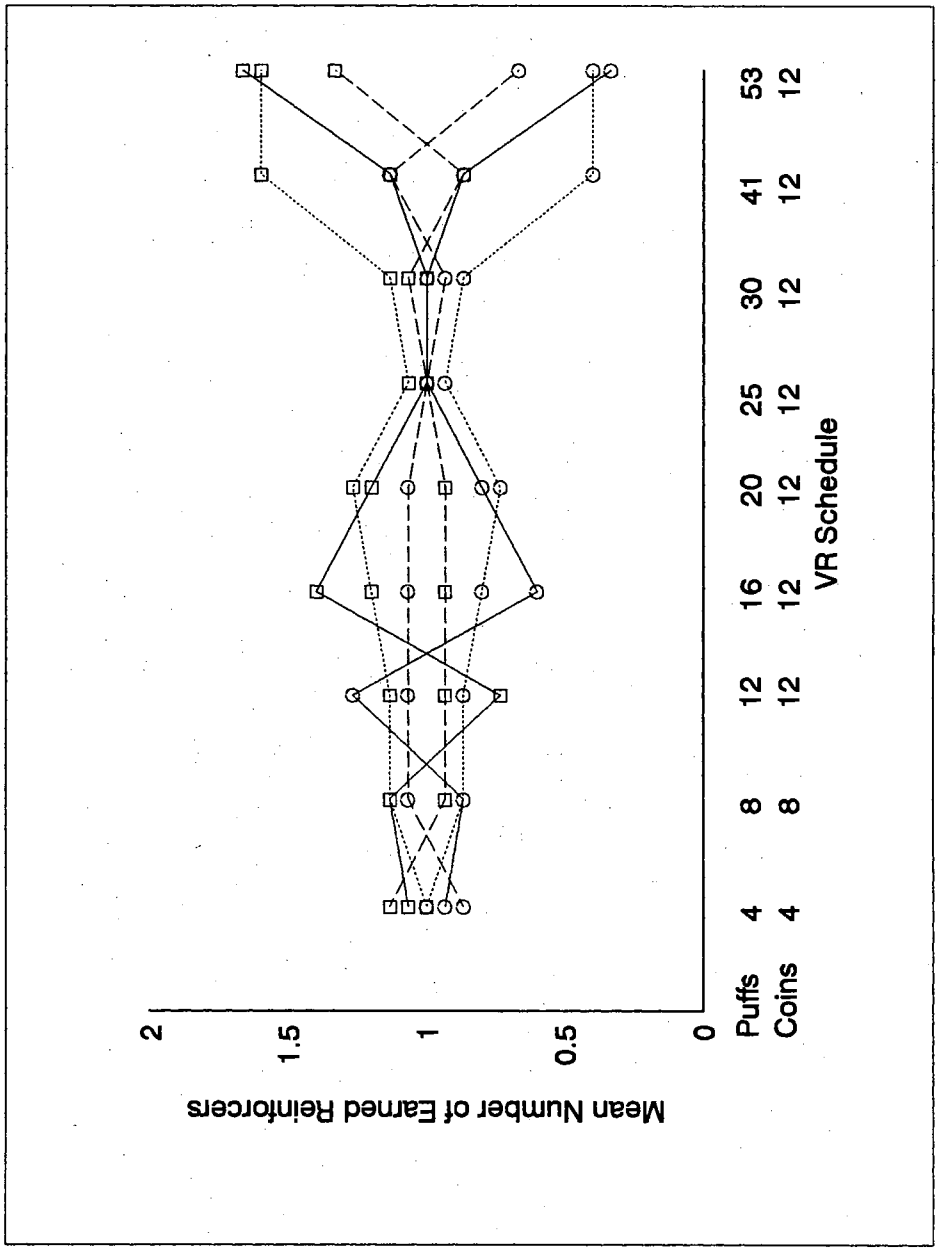
Figure 1. Mean stress rating by condition for each rating period.

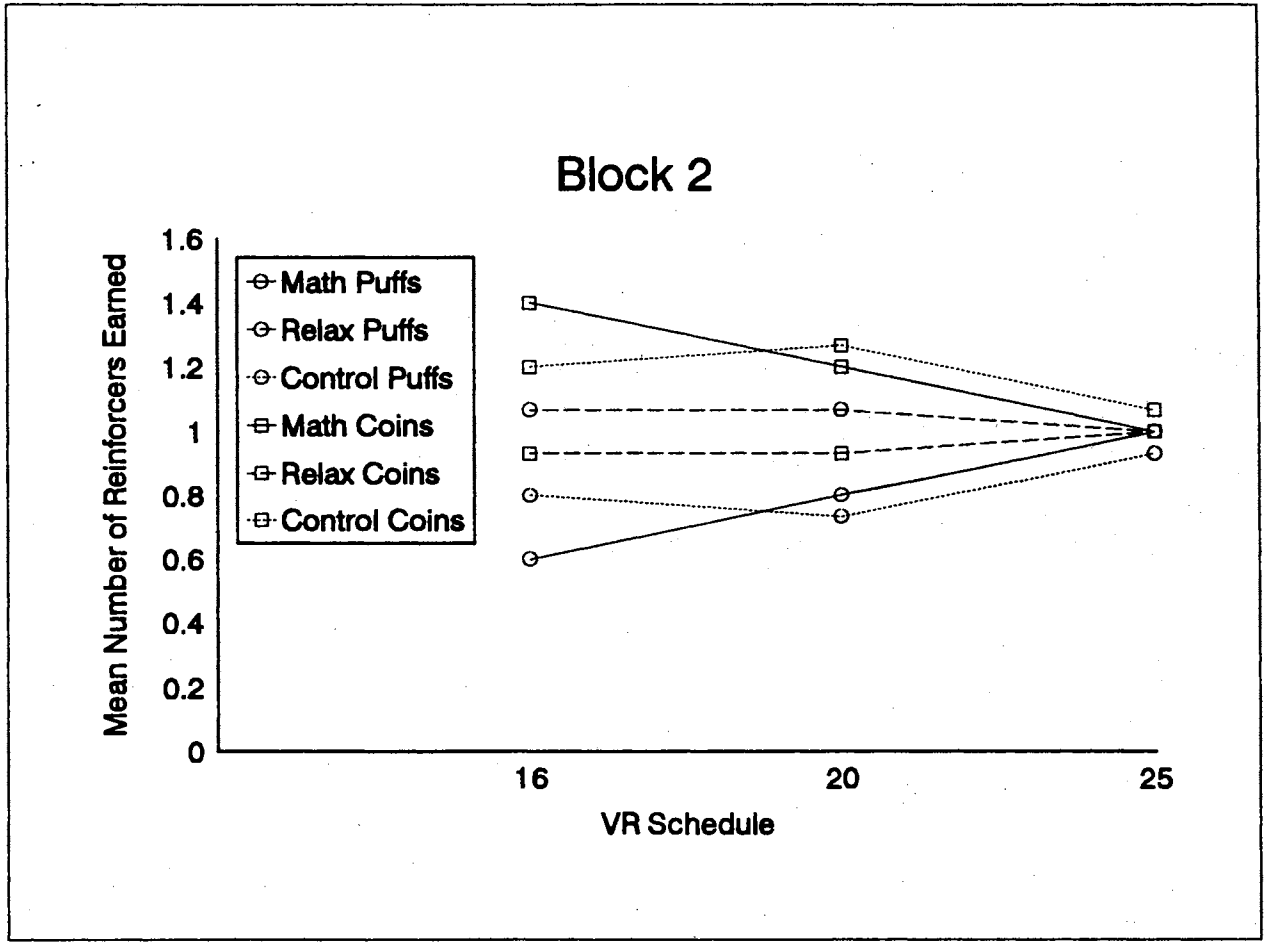
Figure 2. Mean number of puff reinforcers earned per VR schedule. Puffs are represented by a circle and coins by a square. The Mental Math condition is indicated by a solid line, Behavioral Relaxation condition by a broken line, and Control condition by a series of dots.

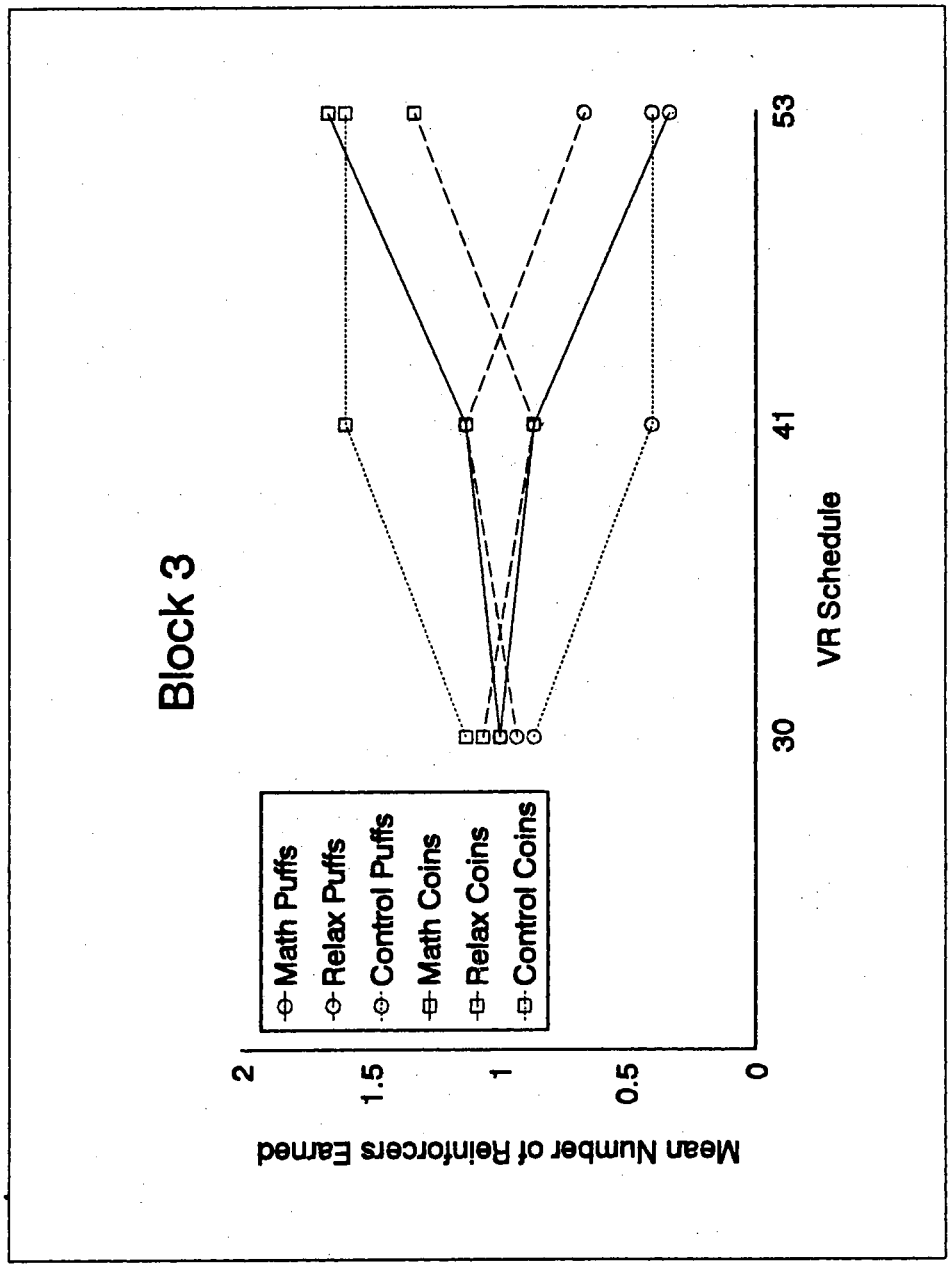
Figure 3. Mean number of reinforcers earned per VR schedule in Block 2.

Figure 4. Mean number of reinforcers earned per VR schedule in Block 3.


Subjective Measure of Stress
Mean Stress Rating
80
60
40
20
0
1
2
3
Rating Period
Condition
Mental Math
Relaxation
Control


Mean Number of Earned Reinforcers
2
1.5
1
0.5
0
Puffs 4 8 12 16 20 25 30 41 53
Coins 4 8 12 12 12 12 12 12 12
VR Schedule


Block 2
Mean Number of Reinforcers Earned
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Math Puffs
Relax Puffs
Control Puffs
Math Coins
Relax Coins
Control Coins
16
20
25
VR Schedule


Block 3
Mean Number of Reinforcers Earned
2
1.5
1
0.5
0
30
41
53
VR Schedule
Math Puffs
Relax Puffs
Control Puffs
Math Coins
Relax Coins
Control Coins

VITA

Yolanda G. Quevedo

Candidate for the Degree of

Doctor of Philosophy

Thesis: MEASURING THE REINFORCEMENT VALUE OF NICOTINE FOR DEPENDENT SMOKERS UNDER MENTAL MATH, BEHAVIORAL RELAXATION, AND CONTROL CONDITIONS

Major Field: Clinical Psychology

Personal Data: Born in Los Angeles, California, December 10, 1946, the daughter of Eduardo Quevedo and Eloisa Grado Quevedo.

Education: Graduated from Providence High School in June, 1964, Burbank, California; graduated from Los Angeles County General Hospital School of Nursing in June, 1967; received Associate of Arts for University Transfer Degree from Skagit Valley College, Mount Vernon, Washington, in August, 1986; received Bachelor of Arts Degree in Psychology from Western Washington University, Bellingham, Washington, in June, 1988; received Master of Science Degree in Psychology from Oklahoma State University in July, 1991; completed requirements for the Doctor of Philosophy Degree at Oklahoma State University in December, 1994.

Honors and Awards: American Psychological Association Science Directorate Dissertation Research Award, 1993; Sigma Phi Omega, National Academic Honor and Professional Society in Gerontology, 1992; Patricia Roberts Harris Academic Fellowship, 1988-1991; Psi Chi, National Psychology Honor Society, 1987; National Hispanic Scholar, 1987 and 1989-93.