A BRIEF ABSTINENCE TEST FOR COLLEGE STUDENT SMOKERS:

TESTING THE UTILITY OF A NOVEL CHOICE TASK

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A BRIEF ABSTINENCE TEST FOR COLLEGE STUDENT SMOKERS: TESTING THE UTILITY OF A NOVEL CHOICE TASK

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DISSERTATION ABSTRACT

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Cigarette smoking among college students is prevalent and correlated with other unhealthy behaviors. Reinforced abstinence (e.g., contingency management) has been demonstrated to be an effective method for reducing substance use in a variety of populations and across a variety of drugs, including cigarettes. Reinforced abstinence has seldom been used with a college student population, in part, because of the costs associated with such programs. Indeed, monetary incentives for abstinence are typically arbitrarily derived and not empirically determined. The current study implemented a choice procedure for empirically assessing optimal incentive levels for brief abstinence among college student smokers and tested the task using a Brief Abstinence Test (BAT).

The choice procedure, called the Reinforcer Preference Task (RPT), posed monetary rewards (e.g., one dollar) of a range of magnitudes and asked participants

(N = 15) whether they would abstain from smoking for some time period (e.g., 1 day) if paid that monetary reward. Dollar amounts ranged from $1 - $1024 and time periods ranged from 1 hour to 1 month. As time periods of proposed abstinence increased, dollar values associated with those time periods increased. The efficacy of this task was tested by using the data from the RPT to determine the monetary value used in a Brief Abstinence Test and to predict participant success in that test. A BAT has been used to effectively reduce cocaine use among methadone maintenance patients (Robles, Silverman, Preston, Cone, Katz, Bigelow, & Stitzer, 2000). However, no published studies have investigated the use of a BAT to reduce the use of cigarettes. The current study found that the BAT is a useful tool for abstinence initiation among some college smokers, as 42% of the sample met abstention criteria during the BAT.

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Cigarette smoking as a Public Health Concern

Cigarette smoking is believed to be the single most preventable cause of death in the U.S. and thus is considered a major public health concern (Center for Disease Control; CDC, 1992). In a recent survey of adults in the United States, about 21% of adults describe themselves as current cigarette smokers despite public awareness campaigns highlighting the negative health effects of smoking (CDC, 2005).

Cigarette Smoking Prevalence among College Students

Cigarette smoking among college students is prevalent and associated with a variety of physically and psychologically unhealthy behaviors. Approximately 80% of smokers try their first cigarette before the age of 18 and among those who initiate smoking, 77% become regular smokers by the age of 20 (CDC, 1998). Thus, for many smokers, the college years are a period of transition from occasional smoking to daily smoking and nicotine dependence (U.S. Department of Health and Human Services, 1994). Surveys of college students confirm that cigarette smoking among college samples is prevalent and correlated with a variety of unhealthy behaviors such as other drug use (Rigotti, Lee, & Wechsler, 2000). An estimated 29% of college students describe themselves as current smokers (Rigotti, et al., 2000; CDC, 1997). Of those who report

currently smokin, an estimated 67.7% have attempted to quit smoking at some point (CDC, 1997).

Current Smoking Cessation Interventions on College Campuses

Smoking prevalence is highest among those aged 18-24 years (CDC, 2005). Colleges and universities enroll more than 12 million individuals, most of whom are aged 18-24 (U.S. Census Bureau, 2005). Thus a college or university setting is an ideal venue for smoking cessation education and interventions. However, in a survey of 393 4-year colleges and universities, only 55.7% offered some type of smoking cessation program on campus (Wechsler, Kelley, Seibring, Kuo, & Rigotti, 2001). Of those offering intervention programs, most reported offering group intervention strategies such as support groups (48.2%). Fewer schools offered individual intervention options such as individual counseling (31%) or medical interventions (28%). Less than 2% of schools offered incentive-based interventions. Nearly all schools with cessation programs (88%) reported that the demand for such programs was low and in some cases insufficient to warrant retaining such services on campus.

Despite the perceived low demand for smoking cessation programs, as noted, more than half of current college cigarette smokers have indicated a quit attempt in the past. The disparity between those who have attempted to quit and the utilization of campus interventions is an important area of concern. Reasons for under-utilization of cessation programs are unknown and may be many, including lack of knowledge about intervention availability, poor efficacy, or unappealing intervention options. The development of appealing and effective smoking cessation programs is needed given the numbers of individuals attempting to quit smoking without success. Operant-based

programs have seldom been implemented to reduce smoking but have been proven effective in the laboratory. A discussion of the operant perspective of substance abuse follows, along with a review of current contingency management research, and finally a critique of CM procedures to reduce substance use.

The Operant View of Substance Use

A fundamental notion of operant conditioning holds that consequences influence behavior *within* the environment in which such behavior and consequences co-occur. In other words, context is important for determining the effectiveness of reinforcers. Just as the context of hunger may result in an increased effort to obtain food, contextual factors may influence similarly the effort put forth to obtain nicotine. In order to understand better the choices related to nicotine intake, one must consider carefully the concurrent presence and availability of nicotine *and* alternative reinforcers in a given environment.

A given environment consisting of nicotine and alternatives will likely have specific contingencies related to access to both nicotine and alternative reinforcers. If the contingencies related to smoking (e.g., smoking that results in increased concentration) are reinforcing, then smoking will be likely to occur again under similar circumstances. If contingencies related to alternative behaviors to smoking are also reinforcing, then a choice between concurrently available reinforcers is likely. Because the contingencies related to both nicotine and alternatives may influence smoking behavior, both must be considered in understanding choice behavior, and as such, may best be characterized through the device of the matching law (Herrnstein, 1974; see McDowell, 1988).

Matching theory states that behavior can be accounted for mathematically such that the number of responses allocated to a behavior (or time allocated to responding) is a

function of both the reinforcement available contingent upon that behavior and the reinforcement available for other alternative responses (McDowell, 1988). Matching theory also characterizes choice behavior as dichotomous: The organism engages in either a target response or all other available responses (i.e., substance use or alternatively available reinforcing behaviors).

Consider substance abuse in terms of the matching law: A person consumes a substance rather than engaging in some alternative behavior based on the reinforcement rate associated with substance use relative to the total reinforcement rate of all other behaviors in the environment. The operant behavioral view suggests that when the history of reinforcement for smoking is of a consistently higher rate than the reinforcement rate for alternative behaviors, substance abuse will occur. Matching theory provides a framework through which one can appreciate choice behavior related to nicotine consumption when competing alternatives to nicotine are available. Contingencies associated with concurrently available substances and alternatives also influence behavior. Operant behavioral interventions for substance abuse, such as contingency management, have been demonstrated to be effective for reducing substance use behaviors. The following section reviews laboratory research that supports the operant view of substance use and provides an empirical foundation for contingency management procedures.

Laboratory Studies of Operant Principles and Smoking Cessation

A variety of laboratory studies have demonstrated that operant principles may be used to understand and manipulate behavior related to substance use. The most prominent principles studied in the substance literature to date are response requirements associated with access to drugs or alternatives and schedules of availability of cigarettes or alternatives to cigarettes. Related to response requirements and schedules of availability, there is also a small but important literature which suggests that abstinence reinforces subsequent abstinence. For such studies, dependent variables for verifying smoking status typically include CO, self-report number of cigarettes smoked, and/or urinalysis tests. The following section summarizes representative laboratory studies.

Response requirement refers to a specific behavioral constraint on access to reinforcers (e.g., lever pressing to meet a response requirement to obtain puffs of a cigarette). Constraints on access to smoking might also include contextual limitations unrelated to behavioral costs (i.e., price of a pack of cigarettes). According to operant theory, increased response requirements associated with cigarette smoking will result in reduced consumption. Similarly, if a person has to work hard (or give up resources) in order to access an alternative reinforcer when cigarettes are readily available to smoke with little or no constraints (behavioral or otherwise) then the individual may be more likely to engage in smoking behavior than if the alternative is easily obtained at a low response requirement.

DeGrandpre, Bickel, Higgins, and Hughes (1994) studied the effects of response requirement manipulations on cigarette smoking in a small sample (N=6) of healthy young adult smokers. Participants responded on an operant console with two plungers.

Each plunger was associated with either cigarette puffs or money and pulling the plunger resulted in access to puffs on a cigarette or money. Availability of cigarette puffs or money was contingent upon completion of a fixed ratio (FR) of plunger pulls ranging from FR 100 to FR 2500. In other words, under an FR 100 schedule, participants would have to pull the plunger 100 times in order to gain access to puffs of a cigarette. As response requirements for access to cigarettes increased, smoking decreased among this sample. This study illustrates the malleability of smoking behaviors as a result of response requirements to gain access to cigarettes. Tidey, Higgens, Bickel, and Steingard (1999) studied the effects of response requirement manipulations on cigarette smoking in a sample of patients diagnosed with schizophrenia or schizoaffective disorder and found similar results. Such information is useful for smoking cessation programs such that interventions might include contingencies for access to cigarettes in order to reduce smoking.

An alternative to increasing response requirements to alter smoking behaviors is to manipulate the schedule of availability of cigarettes or alternatives to cigarettes (e.g., money). For example, Roll, Higgins, and Badger (1996) studied three different schedules of reinforcement availability for drug abstinence. This study included 60 adult community smokers randomly assigned to one of three groups: progressive rate of reinforcement, fixed rate of reinforcement, or yoked-control. Researchers asked participants to abstain (defined as 11 ppm or less) from smoking for 1 week in order to gain access to monetary potential reinforcers. Participants visited the laboratory daily and submitted CO (carbon monoxide) breath samples to verify smoking status. The progressive rate of reinforcement group received $3.00 for the first abstention and an

additional $.50 for each subsequent abstention (as indicated by CO). Additionally, participants could earn bonus payments for consecutive occasions of abstinence. Failure to abstain resulted in withheld payment for the session as well as reset of the progressive rate schedule to $3.00. Participants in the fixed rate of reinforcement group received the same monetary reinforcer on each occasion of abstinence and no bonus payments were available. The yoked control group received the average payment value of the first 10 participants assigned to the progressive rate group. Results revealed that contingent groups demonstrated abstinence 80% more than the yoked control group. The progressive rate of reinforcement group showed fewer participants who resumed smoking following a period of abstinence than the other groups as well as a greater percentage of participants who abstained for the entire week. This study suggests that the schedule of availability of potential abstinent-contingent reinforcers may be directly linked to successful abstinence.

Also related to schedule of availability, Roll, Reilly, and Johanson (2000) investigated the influence of delay on cigarette versus money choices in the laboratory. Participants responded to choices, via operant plungers, between money (ranging from .10 to $2 per choice) available at varied delayed time periods (immediately or 1 to 3 weeks post-session) and cigarette puffs available immediately. Researchers provided vouchers to participants scheduled to receive money at some delay. As expected, longer delays to exchange vouchers for money resulted in increased cigarette puffs. Also, within-session cigarette smoking decreased as the magnitude of the money increase. These data are useful for operant-based interventions in conveying that potential reinforcers will be most effective if available immediately upon completion of contingent

behaviors (e.g., reduced smoking), and that larger magnitude potential reinforcers are more effective than smaller magnitudes.

Finally, laboratory studies have demonstrated that abstinence may actually reinforce subsequent abstinence (Heil, Alessi, Lussier, Badger, & Higgins, 2004). In other words, once abstinence initiation occurs, the experience of abstinence may increase the likelihood that abstinence will occur on a future attempt. A period of abstinence, at least experimentally, results in increased reinforcing efficacy of abstinence while reducing the reinforcing efficacy of cigarette smoking. Heil, et al., (2004) studied otherwise healthy community adult smokers (N = 40) randomly assigned to two conditions. The first condition, C-ALL, engaged in three 5-day periods during which participants could earn money on a progressive rate schedule for abstinence from smoking. The second condition, C-LAST, engaged in two 5-day periods of non-contingent payments regardless of abstinence and one 5-day period during which participants could earn money on a progressive rate schedule. Results revealed that participants in the C-ALL condition experienced significantly more abstinence during the third 5-week period of the study when compared to the C-LAST condition. A greater number of participants in the C-ALL condition achieved complete abstinence during the third 5-day period of the study compared to those in the C-LAST condition. These findings show that abstention history may influence smoking behavior in such a way that abstinence reinforces future abstinence.

In a related study, Lussier, Higgins, and Badger (2005) studied otherwise healthy community adult smokers (N = 63) randomly assigned to one of three conditions: 14-day (abstinence reinforced on a progressive rate schedule for duration of study), 7-day

(abstinence reinforced on a progressive rate schedule for second week of study), and 1-day (abstinence reinforced for last day of the study). Researchers collected CO breath samples to verify abstinence (defined as CO of 4 ppm or less). Following the last session (day 14), all participants were engaged in a choice procedure with a cigarette-associated plunger and a money-associated plunger. Participants responded to twenty choices between cigarettes or money. A response to the cigarette plunger resulted in immediate access to puffs of a cigarette. A response to the money plunger resulted in the immediate increase of a running tally of earned money within the session. Participants initially assigned to the 14-day contingent abstinence group chose fewer cigarette puffs than the 7-day or 1-day contingent groups during the choice session.

A similar study (Roll & Higgins, 2000) used a within-subject comparison to evaluate three different schedules for initiating short-term abstinence from cigarette smoking: a fixed magnitude of reinforcement for cigarette abstinence, a progressive increase in magnitude for abstinence with a reset contingency for cigarette use, and a progressive increase in magnitude for abstinence without a reset contingency. Participants assigned to the progressive ratio schedule with the reset contingency showed greater rates of abstinence than the other conditions. These data suggest that a period of sustained abstinence may influence the reinforcing efficacy of cigarette smoking relative to abstinence.

Together these studies reflect the utility of operant principles and procedures for manipulating abstinence and smoking behaviors and offer suggestions for optimizing conditions for abstinence initiation and maintenance. The following sections outline

research regarding the use of a behavioral intervention, contingency management, for smoking cessation as well as a critique of such research and practice.

Contingency Management of Smoking Cessation

Contingency management (CM), a systematic program of reinforced abstinence, has been shown to be effective for reducing smoking behaviors (e.g., Stitzer & Bigelow, 1982). Stitzer and Bigelow (1982) studied adult smokers (N=11) who reported daily smoking patterns. This study employed a 3-week ABA design consisting of baseline, intervention, and post-intervention weeks to reduce smoking behavior. Participants visited the laboratory once daily for three weeks and provided Carbon Monoxide (CO) readings for monetary reinforcement. During baseline phases payment was non-contingent. During intervention, participants were offered structured payments in exchange for CO readings that met criteria for abstention. Carbon monoxide readings were significantly lower than during intervention than during baseline.

A follow-up study conducted by Stitzer and Bigelow (1983) manipulated the magnitude of available reinforcers for abstinence. Similar results were found in that periods of reinforced abstinence resulted in reduced smoking behaviors. Also, as the value of monetary reinforcers increased, smoking behavior decreased. These results suggest that monetary reinforcers for abstinence can effectively reduce smoking behaviors and higher magnitude reinforcers are more effective than lower magnitude reinforcers. Many other studies have demonstrated the efficacy of CM for use with samples suffering from co-morbid conditions such as methadone-maintained opiate abusers (Schmitz, Rhoades, & Grabowski, 1995; Shoptaw, Jarvik, Ling, & Rawson, 1996), patients with chronic obstructive pulmonary disease (Crowley, Macdonald, &

Walter, 1995), or patients with schizophrenia (Roll, Higgins, Steingard, McGinley, 1998). CM has also been used with otherwise healthy smokers (Stitzer, Rand, Bigelow, & Mead, 1986; Rand, Stitzer, Bigelow, & Mead, 1989) and high school smokers (Corby, Roll, Ledgerwood, & Schuster, 2000).

Rand et al. (1989) studied the relative efficacy of CM (combined with frequent monitoring of CO) compared to non-contingent payment (combined with frequent monitoring of CO) and a control group. This research took place in a workplace setting (a hospital) where participants (N = 51) maintained employment. The CM group maintained reduced smoking for significantly longer periods of time than other groups but ultimately experienced similar relapse rates at 6 month follow-up. This study showed that CM can effect change in smoking behavior; however, abstinence criteria included both attendance and only an 11 ppm or less CO reading. The relatively lenient CO criterion combined with a somewhat behaviorally costly participation (frequent CO monitoring) may have reduced the efficacy of CM in general. Rand and colleagues demonstrated the utility of the workplace for CM procedures in that 47 of the initial 51 participants completed the study.

Reinforced abstinence has been demonstrated to be an effective means for reducing substance use behaviors associated with a variety of drugs and among diverse samples (e.g. Petry, Martin, Cooney, & Kranzler, 2000) but few studies have investigated the use of behavioral interventions among college students. A feasibility study conducted by Correia and Benson (2006) demonstrated that CM effectively reduced college student smoking behavior during a 3-week ABA design consisting of baseline, intervention, and post-intervention weeks. This study replicated the methods employed by Corby et al.

(2000). Participants (N= 88) were asked to visit the laboratory twice daily for three weeks and provide breath samples for CO readings for monetary reinforcement. During baseline phases payment was non-contingent. During intervention, participants were offered structured payments in exchange for CO readings that met criteria for abstention. Participants were randomly assigned to receive a high or low magnitude reinforcer value for each period of abstinence.

Carbon monoxide readings were significantly lower during intervention than during either baseline phase. Further, CO readings for those receiving high magnitude reinforcement were significantly lower during intervention than for those receiving low magnitude reinforcement. These results suggest that monetary reinforcers in exchange for periods of abstinence may be effective for reducing smoking behaviors in college student populations. Also, available reinforcers of a higher magnitude may be more effective for reducing smoking behavior than lower magnitude reinforcers. The results of Correia and Benson (2006) are consistent with previous research. However, more laboratory and clinical research is necessary to realize fully the potential utility of behavioral interventions with college student smokers.

Critique of Contingency Management

Although CM interventions have proven useful for reducing substance use, there are a variety of concerns associated with behavioral interventions to date. One such concern involves the cost-effectiveness of CM. A second concern is related to the pattern of continued use associated with failing to make contact with available reinforcement (Lamb, Kirby, Morral, Galbicka, & Iguchi, 2004). In other words, some individuals never initiate abstinence and thus fail to receive reinforcement while undergoing intervention.

In order to address such issues, the parameters involved in abstinence initiation and maintenance need further experimental consideration. In effort to address cost-effectiveness concerns for CM, many researchers have implemented methods for saving money and resources. For example, Petry, et al., (2000) used a fishbowl procedure to reduce CM costs. Participants were randomly assigned to control (usual care) or contingent groups (usual care and CM). Negative Blood Alcohol Content (BAC) obtained from participants resulted in the opportunity to draw a prize from a fishbowl containing 250 slips of paper with prizes designated: 169 were small $1.00 value prizes, 14 were medium $20.00 value prizes, four were large $100 prizes and the rest were worthless. Consecutive days of negative BAC resulted in bonus drawings from the fishbowl, up to 10 drawings per week. Drawings could also be earned for completing specified treatment goals (1 drawing per goal).

Results revealed that the contingent group had a lower percentage of relapse (26%) throughout the 8 weeks of study (4 weeks of treatment and 4 weeks of aftercare) when compared to controls (61%). Retention in treatment was greater (84%) for the CM group than for controls (22%). This study was able to lower costs for contingencies by implementing the fishbowl lottery for prizes. Long term data are not available to date regarding the population in this study.

As noted, many CM participants do not respond to potential reinforcers simply because they fail to make contact with them. In other words, behavior never changes in such a way that participants can earn access to reinforcement. To address this issue, Lamb, et al., (2004) implemented a shaping procedure using percentile schedules to reduce smoking behavior. Adult smokers produced CO breath samples on a daily basis to

verify smoking status. Researchers assigned participants to one of 4 groups: CO parts per million (ppm) at or below the 10^{th}, 30^{th}, 50^{th}, or 70^{th} percentile of his or her own 10 most recent breath samples. For each group criterion needed to be met in order to gain access to monetary reinforcers. Delivery of payments contingent upon reduced CO occurred according to an escalating payment schedule (e.g., Roll, Higgins, & Badger, 1996). Results of this study indicated that shaping is an effective procedure for reducing cigarette smoking. Further, the percentile schedules were effective for early contact with potential reinforcers so that subsequent behavior might be influenced by those consequences.

A potential alternative to shaping is to offer a high magnitude incentive for a low criterion of abstinence (short duration or small reduction). A Brief Abstinence Test (BAT; Robles, Silverman, Preston, Cone, Katz, Bigelow, & Stitzer, 2000) has been developed to experimentally induce abstinence by offering a high magnitude reinforcer for abstinence at a low response cost for obtaining reinforcement. The use of brief abstinence procedures may allow for an effective characterization of the process of abstinence and related phenomena, such as withdrawal, and the efficacy of behavioral interventions might improve with such knowledge (e.g., Heil, Tidey, Holmes, Badger, & Higgins, 2003).

Robels et al. (2000) studied out-patient methadone maintained cocaine users (N=72) to test the efficacy of the BAT for reducing cocaine use. Participants were undergoing 13-week standard care for opioid abuse but cocaine-specific treatment. On Monday of week 9 participants were told that they could earn $100 if they returned to the laboratory on Wednesday of that week and produced a urine sample that indicated

cocaine abstinence. In this population, about 80% of participants initiated abstinence. An initial follow-up study replicated the results (Katz, Robles-Sotelo, Correia, Silverman, Stitzer, & Bigelow, 2002), and a second follow-up study found similar results across multiple BAT occasions within a sample (Sigmon, Correia, & Stitzer, 2004). These results suggest that the BAT is an effective procedure for initiating abstinence among cocaine users. However, no published studies have investigated the use of a BAT to reduce the use of cigarettes or other drugs.

Another concern for behavioral interventions has been cost effectiveness (Petry, 2001). Operant-based programs rely on the malleability of behavior with respect to the arrangement of contingencies within a treatment context. To manipulate contingencies, researchers, and ultimately treatment agencies, must identify reinforcers that influence substance use behavior. Research to date has demonstrated that often the reinforcers that lead to changes in substance use are monetary (e.g., money or vouchers) or worth money (e.g., a wrist watch) and thus incur costs to the intervention programs (e.g. Petry, et al., 2000). More research is necessary to determine the most cost-effective potential reinforcers for different populations in CM procedures. In order to effectively predict the most effective ways to manipulate contingencies related to substance use abstinence, choice procedures may be used.

The Use of Choice Procedures to Inform Selection of Contingency Reinforcers

Reinforcer efficacy has been studied in humans and non-human species using a variety of choice procedures in the laboratory (Bigelow, 2001). Choice procedures generally allow researchers to assess efficiently the reinforcement efficacy of a drug relative to other reinforcers that might be present in an environment for both human

(Bigelow, 2001) and non-human (Katz, 1990) animals. For example, choices made between two or more concurrently available (or immediately versus delayed) reinforcers, where one reinforcer is nicotine, may reflect the relative reinforcer efficacy of nicotine versus other reinforcers.

Monetary incentives for abstinence in contingency management programs are typically arbitrarily derived and a procedure for empirically assessing optimal incentive levels for abstinence is needed (e.g., Stitzer & Bigelow, 1983; Petry et al., 2000). Choice procedures have been used to assess for relative reinforcing efficacy of substances and alternatives to substances (e.g., money) and often produce data that informs behavioral interventions. However, choice procedure data are not currently used to determine the most cost effective reinforcer magnitude to use in behavioral interventions. A novel choice procedure might allow for efficient reinforcer preference testing on either an individual or group level and thus offer a way to maximize cost effectiveness.

Choice procedures have been used to investigate choice behavior related to substance use and data from such procedures may be useful to inform therapeutic interventions. For example, the Multiple Choice Procedure (MCP) developed by Griffiths, Troisi, Silverman and Mumford (1993) effectively (and cheaply) assesses the relative reinforcing efficacy of a drug compared to some alternative potential reinforcer. The MCP involves a questionnaire that presents participants with a series of discrete choices that may consist of drug versus drug or drug versus money (or some other alternative). Through a fishbowl method participants receive one of their chosen preferences. Most often, drug studies use an MCP form with drug versus money choices where the available amount of drug is constant and the available amount of money

progressively increases. The choice point at which a participant indicates that he or she prefers money instead of the drug is termed the "cross-over point" (Griffiths et al., 1993). The higher the cross-over point is for a participant, presumably the higher the reinforcement value of the drug is for that participant relative to the available alternative.

The MCP has been used to confirm that higher magnitude potential reinforcers are preferred over lower magnitudes. Griffith, Rush, and Pahula, (1996) employed the MCP with adult cigarette smokers. Participants (N = 20) were community volunteers who were reportedly habitual smokers. Participants received a form consisting of 10 discrete choices between receiving varied amounts of cigarettes (1 or 2 packs) versus varied money amounts ($.59-$4.91) and one choice between one or two packs of cigarettes. After participants filled out the MCP form, the experimenters randomly selected one of the discrete choices to be fulfilled immediately. The MCP demonstrated the effects of reinforcer magnitude on choice behavior in a single session in that crossover points for two packs of cigarettes were higher than for one pack of cigarettes.

The MCP has also been used to confirm that immediately available potential reinforcers are preferred to those that are delayed. Little and Correia (2006) investigated delay of reinforcement with a college population of heavy and light drinkers (N=21). Using the MCP, they presented participants with a series of reward choices between beer (6 or 12 oz) available immediately or money ($0 - 20) available immediately or at a one week delay. Participants placed a higher value (e.g., indicated higher crossover point) on alcohol (6 and 12 oz) than a delayed alternative reward (M = 2.83, 3.07 respectively), relative to an immediately available alternative (M = 1.60, 2.00 respectively). Further, participants placed a higher value on 12 oz of beer than 6 oz of beer. Thus, participants'

choices were sensitive to both amount of alcohol and the delay associated with delivery of alcohol or money. These results were replicated in a follow-up study (Benson, Little, Henslee, & Correia, 2006).

Data from the MCP, and other choice procedures (e.g., Vuchinich & Tucker, 1983), have been consistent with previous laboratory studies (e.g., Griffiths, Bigelow, and Liebson, 1976), thus suggesting the choice procedures are sensitive to known parameters of reinforcement. The results of MCP studies have also been consistent with CM studies in demonstrating the effects of reinforcer magnitude (e.g., Correia & Benson, 2006) on behavior. MCP studies may then inform CM in that higher magnitude, immediately available potential reinforcers are most likely to be effective for changing behavior. This may seem intuitive, but empirical assessment of such parameters is useful for research design and ultimately therapeutic efficacy. More importantly, the consistency between results generated from choice studies and CM studies suggest that choice procedures might be used to more explicitly model and inform important parameters of CM. For example, choice procedure data are not currently used to determine the most cost effective potential reinforcers to use in behavioral interventions. A novel choice procedure might allow for efficient empirical assessment of adequate incentives on either an individual or group level and thus offer a way to maximize cost effectiveness.

The current project addresses several of the concerns associated with contingency management with a two study endeavor involving both choice procedures and reinforced abstinence. During study I, a novel choice procedure was used to assess the monetary value most likely to serve as an incentive for various lengths of abstinence. Data from

study I was used to generate the monetary reinforcer value used in the BAT procedure (study II). During study II, a within-subjects design will be used to experimentally test the effectiveness of the BAT procedure with a sample of college student cigarette smokers. Our data yield important information regarding empirically assessed reinforcer magnitude, the efficacy of a BAT for abstinence initiation, and the usefulness of this procedure with a population of college smokers. The BAT may also yield results that will increase our understanding of the process of abstinence initiation. The study will also allow the researchers to gather information, in the form of data and procedural knowledge that will facilitate the future implementation of more formal intervention programs for college student smokers.

The primary hypotheses of the study are: 1) In the choice procedure, willingness to abstain from cigarettes for longer periods of time will require increasingly larger monetary reinforcers, and 2) The BAT will yield similar results with smokers as those found for cocaine users by Robels et al. (2000), with indices of drug use (CO levels and urinalysis results) decreasing during the BAT phase relative to either of the baseline phases.

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CHAPTER 2: A NOVEL CHOICE PROCEDURE FOR ASSESSING ADEQUATE INCENTIVE VALUES AMONG COLLEGE STUDENT SMOKERS

Reinforced abstinence has been demonstrated to be an effective means for reducing substance use behaviors associated with a variety of drugs and among diverse populations (e.g. Petry, Martin, Cooney, & Kranzler, 2000). Contingency management (CM), a systematic program of reinforced abstinence, is often designed to increase the frequency or duration of abstinence. CM procedures have been shown to be effective for reducing cigarette smoking behaviors in otherwise healthy adults (Stitzer & Bigelow, 1984, 1985; Stitzer, Rand, Bigelow, & Mead, 1986; Rand, Stitzer, Bigelow, & Mead, 1989), high school (Corby, Roll, Ledgerwood, & Schuster, 2000) and college smokers (Correia & Benson, 2006), as well as methadone-maintained opiate abusers (Schmitz, Rhoades, & Grabowski, 1995; Shoptaw, Jarvik, Ling, & Rawson, 1996), patients with chronic obstructive pulmonary disease (Crowley, Macdonald, & Walter, 1995), and patients with schizophrenia (Roll, Higgins, Steingard, McGinley, 1998).

Addressing Concerns Associated with Contingency Management

Although CM interventions have proven useful for reducing substance use, there are a variety of concerns associated with behavioral interventions to date. One such concern is related to cost-effectiveness of CM procedures. A second major concern is that of a pattern of continued use associated with failing to make contact with available reinforcement (Lamb, Kirby, Morral, Galbicka, & Iguchi, 2004). In other words, some

individuals never initiate abstinence and thus fail to receive reinforcement while undergoing intervention.

Operant-based programs rely on the malleability of behavior with respect to the arrangement of contingencies within a treatment context. To manipulate contingencies, researchers, and ultimately treatment agencies, must identify reinforcers that influence substance use behavior. Research to date has demonstrated that often the reinforcers that lead to changes in substance use are monetary (e.g., money or vouchers) or worth money (e.g., a wrist watch) and thus incur costs to the intervention programs (e.g. Petry, et al., 2000).

In order to address such issues, the parameters involved in abstinence initiation and maintenance need further experimental consideration. In effort to address cost-effectiveness concerns for CM, many researchers have implemented methods for saving money and resources. For example, Petry, et al. (2000) used a fishbowl procedure to reduce CM costs. Participants were randomly assigned to control (usual care) or contingent groups (usual care and CM). Negative Blood Alcohol Content (BAC) obtained from participants resulted in the opportunity to draw a prize from a fishbowl containing 250 slips of paper with prizes designated: 169 were small $1.00 value prizes, 14 were medium $20.00 value prizes, four were large $100 prizes and the rest were not worth a prize. Consecutive days of negative BAC resulted in bonus drawings from the fishbowl, up to 10 drawings per week. Drawings could also be earned for completing specified treatment goals (1 drawing per goal).

Results revealed that the contingent group had a lower percentage of relapse (26%) throughout the 8 weeks of study (4 weeks of treatment and 4 weeks of aftercare)

when compared to controls (61%). Retention in treatment was greater (84%) for the CM group than for controls (22%). This study was able to lower costs for contingencies by implementing the fishbowl lottery for prizes. Long term data are not available to date regarding the population in this study.

As noted, many CM participants do not respond to potential reinforcers simply because they fail to make contact with them. In other words, behavior never changes in such a way that participants can earn access to reinforcement. To address this issue, Lamb, et al. (2004) implemented a shaping procedure using percentile schedules to reduce smoking behavior. Adult smokers produced CO breath samples on a daily basis to verify smoking status. Researchers assigned participants to one of 4 groups: CO parts per million (ppm) at or below the 10^{th}, 30^{th}, 50^{th}, or 70^{th} percentile of his or her own 10 most recent breath samples. For each group criterion needed to be met in order to gain access to monetary reinforcers. Delivery of payments contingent upon reduced CO occurred according to an escalating payment schedule (e.g., Roll, Higgins, & Badger, 1996). Results of this study indicated that shaping is an effective procedure for reducing cigarette smoking. Further, the percentile schedules were effective for early contact with potential reinforcers so that subsequent behavior might be influenced by those consequences.

A potential alternative to shaping for increasing the likelihood that participants will make contact with potential reinforcers is to offer a high magnitude incentive for a low criterion of abstinence (short duration or small reduction). A Brief Abstinence Test (BAT; Robles, Silverman, Preston, Cone, Katz, Bigelow, & Stitzer, 2000) has been developed to experimentally induce abstinence by offering a high magnitude reinforcer

for abstinence at a low response cost for obtaining reinforcement. The BAT may be a useful tool for studying the process of abstinence initiation and related phenomenon, such as withdrawal, and has been used to effectively reduce cocaine use among methadone maintenance patients (Robels et al., 2000). Robels et al. (2000) studied out-patient methadone maintained cocaine users (N=72) to test the efficacy of the BAT for reducing cocaine use. Participants were undergoing 13-week standard care for opioid abuse but not treatment specific to cocaine use. On Monday of week 9 participants were told that they could earn $100 if they returned to the laboratory on Wednesday of that week and produced a urine sample that indicated cocaine abstinence. In this population, about 80% of participants initiated abstinence. An initial follow-up study replicated the results (Katz, Robles-Sotelo, Correia, Silverman, Stitzer, & Bigelow, 2002), and a second follow-up study found similar results across multiple BAT occasions within a sample (Sigmon, Correia, & Stitzer, 2004). These results suggest that the BAT is an effective procedure for initiating abstinence among cocaine users. However, no published studies have investigated the use of a BAT to reduce the use of cigarettes or other drugs.

Although the above studies have demonstrated effective ways to improve the cost-effectiveness of CM as well as likelihood of contact with potential reinforcers, no study or protocol has empirically assessed adequate incentive levels for CM. To date, all contingency management studies and intervention programs have used arbitrarily determined (e.g., based on available resources) potential reinforcers for abstinence. Arbitrarily determined potential reinforcers have been effective but the question remains if lower incentive values could also be effective or if higher incentives are necessary for behavior change.

Choice Procedures

Choice procedures have been used to investigate choice behavior related to substance use and data from such procedures may be useful to inform therapeutic interventions. For example, the Multiple Choice Procedure (MCP) developed by Griffiths, Troisi, Silverman and Mumford (1993) effectively (and cheaply) assesses the relative reinforcing efficacy of a drug compared to some alternative potential reinforcer. The MCP involves a questionnaire that presents participants with a series of discrete choices that may consist of drug versus drug or drug versus money (or some other alternative). Through a fishbowl method participants receive one of their chosen preferences. Most often, drug studies use an MCP form with drug versus money choices where the available amount of drug is constant and the available amount of money progressively increases. The choice point at which a participant indicates that he or she prefers money instead of the drug is termed the "cross-over point" (Griffiths et al., 1993). The higher the cross-over point is for a participant, presumably the higher the reinforcement value of the drug is for that participant relative to the available alternative.

The MCP has been used to confirm that higher magnitude potential reinforcers are preferred over lower magnitudes. Griffiths et al., (1996) employed the MCP with adult cigarette smokers. Participants (N = 20) were community volunteers who were reportedly habitual smokers. Participants received a form consisting of 10 discrete choices between receiving varied amounts of cigarettes (1 or 2 packs) versus varied money amounts ($.59-$4.91) and one choice between one or two packs of cigarettes. After participants filled out the MCP form, the experimenters randomly selected one of the discrete choices to be fulfilled immediately. The MCP demonstrated the effects of reinforcer magnitude on

choice behavior in a single session in that crossover points for two packs of cigarettes were higher than for one pack of cigarettes.

The MCP has also been used to confirm that immediately available potential reinforcers are preferred to those that are delayed. Little and Correia (2006) investigated delay of reinforcement with a college population of heavy and light drinkers (N=21). Using the MCP, they presented participants with a series of reward choices between beer (6 or 12 oz) available immediately or money ($0 - 20) available immediately or at a one week delay. Participants placed a higher value (e.g., indicated higher crossover point) on alcohol (6 and 12 oz) than a delayed alternative reward (M = 2.83, 3.07 respectively), relative to an immediately available alternative (M = 1.60, 2.00 respectively). Further, participants placed a higher value on 12 oz of beer than 6 oz of beer. Thus, participants' choices were sensitive to both amount of alcohol and the delay associated with delivery of alcohol or money. These results were replicated in a follow-up study (Benson, Little, Henslee, & Correia, 2006).

Data from the MCP, and other choice procedures (e.g., Vuchinich & Tucker, 1983), have been consistent with previous laboratory studies (e.g., Griffiths, Bigelow, and Liebson, 1976), thus suggesting the choice procedures are sensitive to known parameters of reinforcement. The results of MCP studies have also been consistent with CM studies in demonstrating the effects of reinforcer magnitude (e.g., Correia & Benson, 2006) on behavior. MCP studies may then inform CM in that higher magnitude, immediately available potential reinforcers are most likely to be effective for changing behavior. This may seem intuitive, but empirical assessment of such parameters is useful for research design and ultimate therapeutic efficacy. More importantly, the consistency

between results generated from choice studies and CM studies suggest that choice procedures might be used to more explicitly model and inform important parameters of CM. For example, choice procedure data are not currently used to determine the most cost effective potential reinforcers to use in behavioral interventions. A novel choice procedure might allow for efficient empirical assessment of adequate incentives on either an individual or group level and thus offer a way to maximize cost effectiveness.

The current project attempted to address several of the concerns associated with contingency management by implementing a novel choice procedure called the Reinforcer Preference Task (RPT). The RPT was used to assess the monetary value most likely to serve as an adequate incentive for various lengths of abstinence. It is hoped that data from this study will be useful for determining adequate incentive levels for abstinence. The extent to which smoking-related variables (e.g., CO reading) are related to RPT choices was also important determination of the present study.

Method

Participants

All participants (N = 15) reported smoking at least 8 cigarettes per day, provided a CO reading of at least 6 ppm, and endorsed not having been involved in active smoking cessation efforts. The sample consisted of undergraduate students (60% female; mean age = 20.8 years) at a large southern land-grant institution. As noted, all participants included in the analyses reported current smoking status. See Table 1 for a summary of smoking-related variables. We recruited for this study via flyers posted in a common area and an on-line recruiting system (Sona Systems). The Institutional Review Board at Auburn University reviewed and approved all procedures.

Measures

Expired breath CO. We used the BreathCO (Vitalograph Inc., Quivira, KS), a portable breath carbon monoxide reader (CO), to verify smoking status for inclusion in the study. Breath CO has been established as a valid index of recent tobacco smoke exposure that directly reflects plasma carboxyhemoglobin levels (Cohen, Perkens, Ury, & Goldsmith, 1971) and correlates highly with plasma nicotine levels (Russell, Wilson, Patel, Feyerabent, & Cole, 1975). Breath CO levels are also correlated with self-reported number of cigarettes smoked per day (Horan, Hackett, & Lindberg, 1978) and within subject changes in smoke exposure (Stitzer & Bigelow, 1982).

Self-report measures. Participants provided information related to age, gender, and race and ethnicity. Participants provided additional information related to their daily smoking habits, use of other tobacco products, smoking history, current motivation to quit smoking, and previous attempts to quit smoking. The Fagerstom Test for Nicotine Dependence (FTND; Radzius, Moolchan, Henningfield, Heishman, and Gallo, 2001), previously used by others to assess tolerance among student populations (e.g., Correia & Benson, 2006), assessed nicotine dependence. The Stage of Change Algorithm assessed motivation to change (Prochaska & DiClimente, 1982) related to cigarette smoking behavior. All self-report measures were collected via the researcher's data collection website in the laboratory.

Reinforcer Preference Task (RPT). The researchers developed this task to empirically assess the value of abstinence across a variety of time periods among smokers. Participants responded to a series of discrete hypothetical choices designed to assess the monetary value most likely to serve as an incentive for periods of abstinence

across a range of time periods. The choice procedure posed monetary rewards (e.g., one dollar) across a range of magnitudes and asked participants whether they would abstain from smoking for some time period (e.g., 1 day) if paid that monetary reward. Dollar amounts ranged from $1 - $1024 and time periods ranged from 1 hour to 1 month. Each of the 102 monetary reward-time period stimuli combinations was presented in random order via SuperLab software. Data points of particular interest include the lowest dollar values for which participants endorse willingness to abstain from smoking for each time period.

Hypothetical Money Choice Task. Participants responded to a series of discrete hypothetical choices between a large fixed amount of hypothetical money ($1,000) available at some time in the future and smaller hypothetical money amounts ($1 - $990) available immediately. Delay intervals ranged from 1 week to 25 years. Each trial consisted of a random combination of a fixed delayed money amount, a smaller immediate money amount and a delay interval. Each of the 188 combinations of immediate and delayed rewards was presented in random order via SuperLab software.

This procedure derives data that are conducive for use with a hyperbolic discounting equation. Research has suggested that a hyperbolic function (as opposed to exponential or linear functions) best describes the discounting rate of reinforcer value related to substance use (e.g., Bickel & Marsch, 2001). In other words, discounting of delayed reinforcers accelerates (value decreases more rapidly) as delay intervals increase.

In research investigating the delay of reinforcer parameter, participants are asked to indicate choices between immediate and delayed rewards that produce an indifference point (equivalence point): the point at which the immediate and delayed rewards are

subjectively equivalent (Bickel & Marsch, 2001). The indifference point also measures the present subjective value of a reward. The indifference point is the data point of interest from which group or individual comparisons of delay discounting rates are made by researchers. This procedure has been used as an index of delay discounting (e.g., Vuchinich & Simpson, 1998).

Procedure

All participants signed an informed consent document prior to the onset of the sessions. Upon obtaining consent, researchers took a breath sample to determine eligibility (i.e., 6 ppm). Participants verbally reported how many cigarettes they smoke on average per day and time since last cigarette smoked. Participants who remained eligible for the study were seated in front of a computer and verbally instructed to fill out demographics and smoking behavior questionnaires via an on-line survey. Upon completion of the self-report measures, the researcher initiated the RPT followed by the HMCT. Verbal instructions were followed by a screen with more specific instructions regarding the RPT:

> This task will involve a series of choices that you will be asked to make. Please consider the choices as you respond to the following question: "Would you be willing to quit smoking for the period of time shown if provided the amount of money shown?" Indicate "Yes" by pressing the 1 key or "No" by pressing the 0 key on the keyboard. Note that all choices are hypothetical (pretend) and will not actually be received. Please respond, however, as though they are real choices.

After the researcher confirmed that these instructions were understood by the participants, two sample choices were presented for practice. The first practice item

asked, “Would you quit for 1 hour if paid $1000?” and the second item asked, “Would you quit for 1 year if paid $1?” If participants responded “Yes” and “No” respectively it was assumed that the task was understood and data collection continued. All items were presented with a reminder that Yes=1 and No=0.

Following the completion of the RPT stimuli, the HMCT initiated automatically. A screen appeared that introduced the participants to the new task, followed by a screen with specific instructions regarding the HMCT:

> This task will involve a series of choices that you will be asked to make. Please consider these choices with this in mind: Which alternative is most appealing to you? Press 0 or 1 on the keyboard to indicate your choice. Note that all choices are hypothetical (pretend) and will not actually be received but please respond as though they are real choices.

After the participant views these instructions two sample choices were presented for practice. The first practice item asked, “Which do you prefer, $1000 today or $1 in a week?” and the second item asked, “Which do you prefer, $10 today or $10 in one year?” A slide prompting participants to ask the researcher for help if needed followed the practice items. The task ended once all items had been viewed and a response recorded for each. The researchers provided extra credit and the participant exited the session.

Results

The mean CO reading for this sample was 16.60 ppm (Min = 6 ppm, Max = 36 ppm). The mean number of cigarettes smoked per day was 12.93 (Min = 9, Max = 20). CO readings were positively correlated (r = .614, p = .01) with the number of cigarettes smoked within the last 24 hours. See Table 1 for a summary of self-report variables.

Reinforcer Preference Task

The RPT was used to determine adequate incentive values for the entire range of abstinence periods. See Table 2 for a summary of RPT data. Quantitatively, the data reflect much individual variability with respect to adequate incentive values. For example, the mean incentive value endorsed for a period of one week of abstinence equaled $99.73 (SD = 86.27) with a range of 226 (Min = $20, Max = $256). However, the data were qualitatively similar in that as time periods of abstinence increased, the dollar values endorsed as adequate incentive for abstinence also increased. For example, the mean endorsed adequate incentive value for one day equaled $19 while the mean value for 1 month equaled $319. Repeated measures ANOVA [F (6, 84) = 17.405, p<.001, partial eta squared = .554] was used to verify that the mean monetary incentive increased across the time periods. Helmert contrasts indicated that each time period differed significantly (p<.01) from the subsequent sequential time period. According to the Helmert contrasts, incentive levels increased across all time periods except the 1 day compared to the 12 hour contrast in which the mean incentive value decreased. Given the wide range of variability within the data (see Table 1), the median appeared to be a better measure of central tendency for the data. The median values also followed a qualitative trend in which median adequate incentive values increased as time periods increased.

See Figure1 for Mean RPT data and Figure 2 for representative individual subject data from the RPT.

Previous studies have shown that choice data related to substance use behaviors do not follow a linear pattern. Curve estimation is important for prediction of choice behavior in other samples or to estimate values across a wide range of parameters. RPT data were tested for best fit within both a linear model and an exponential model. Using a curve estimation procedure, the data were fit to both models (see Figure 3). Although both models produced significant results, the linear model produced a better fit for the data [R^2 = .993, F (1, 5) = 758.79, p<.001] than the exponential model [R^2 = .783, F (1, 5) = 18.04, p = .008].

Hypothetical Money Choice Task

HMCT data were analyzed according to the following equation:

$$v_d = \frac{V}{(1+kd)} \qquad (1)$$

In this equation, v_d represents the indifference point, V represents the value of the delayed reward (e.g., monetary value), k is the discounting rate and d is the duration of delay (Bickel & Marsch, 2001). When indifference points are plotted across a variety of time periods, the data typically produce a hyperbolic curve in which discounting rates increase as delays increase. Figure 4 depicts the indifference curve for this sample and Figure 5 depicts representative individual indifference curves. Using a nonlinear least squares regression, overall k values were computed from raw data for each participant (M = .52 months, SD = .74; Min = .01, Max = 2.52). Higher k values are indicative of more rapid discounting rates in the HMCT, and greater impulsivity.

Exploratory Analyses

Despite a relatively small sample size, exploratory analyses revealed a number of interesting trends. A series of Pearson correlation coefficients were computed to determine the relationships among mean incentive values from the RPT, overall *k* values, and a number of smoking variables. CO readings, number of cigarettes smoked per day, and number of cigarettes smoked in the last 24 hours did not correlate significantly ($p>.05$) with any of the adequate incentive values across time periods. The number of previous quit attempts was negatively correlated with adequate incentive values for all time periods, although conventional significance was achieved only for the 1 month time period ($r=-.620$, $p=.014$). Overall *k* values did not correlate with CO readings, number of cigarettes smoked per day, or number of previous quit attempts. Further, *k* values did not correlate with adequate incentive values from the RPT. See Table 3 for a correlation matrix of smoking-related variables.

We employed regression analysis to determine if a combination of *k* values and several smoking variables were predictive of the adequate incentive values from the RPT. A variety of models were tested but no model produced significant results. The most promising model, $R^2 = .594$, $F(4, 9) = 3.29$, $p = .063$, included the 2 week incentive value as the criterion variable and the number of cigarettes smoked per day, number of quit attempts, CO readings, and *k* values as predictor variables. None of the predictor variables alone was significant contributors to the model; however, the model accounts for a large portion of variance for predicting adequate incentives for 2 weeks of abstinence. A model predicting 1 month incentive value ($R^2 = .550$, $F(4, 9) = 2.75$, p

=.096) also accounted for a large portion of variance using the same predictor variables listed above.

In effort to conserve power in our regression analysis, we tested models with fewer predictor variables. The best model, R^2 = 451, $F(2, 11) = 4.52$, p =.037, included the 2 week incentive value as criterion variable and the number of cigarettes smoked per day (B = .742, p = .015) and k values (B = .559, p = .05). A model predicting 1 month incentive values was not significant (p>.05). See Table 4 for a Regression table of the noted models.

Discussion

This study sought to test the utility of a novel choice task for assessment of the dollar value most likely to serve as an adequate incentive for abstinence among college student smokers. The current study found a qualitative trend in RPT data reflecting an increased adequate incentive value as time of required abstinence increased. Also, quantitatively, the data revealed much individual variability with respect to adequate incentive levels for abstinence. This individual variability may reflect differences in the relative importance or reinforcing value of cigarettes across individuals, and is perhaps important for understanding why some people respond to the intervention approaches and others do not.

Interestingly, although adequate incentive values increased as time periods of abstinence increased, the data revealed a noted exception. The mean adequate incentive value decreased from the time period of 12 hours compared to 1 day. At first consideration, this inconsistency seems counterintuitive; however, several possibilities may account for these data. First, the “12 hour” time period is unambiguous whereas the

descriptor “1 day” may be construed in a variety of ways. Perhaps participants considered 1 day to be daylight hours, or hours during which they are active. Any interpretation other than 24 hours may have influenced choice in the RPT. A second possibility is related to the first in that participants may have considered 1 day as 24 hours but factored in ideas about sleeping (or other competing behaviors to smoking) for much of the time in a 24 hour period. More data are necessary to determine the reliability of this particular finding. Future studies might also use consistent wording across time points (e.g., 24 hours instead of 1 day) to insure that participants are interpreting each stimuli appropriately.

Our data were better fit by a linear model than an exponential model. This trend needs further validation for several reasons. First, our small sample size brings into question the reliability of the finding. Second, an exponential model is often a better fit for choice data and thus more data are needed to confirm these findings in light of previous choice research. The RPT requires further testing to determine which time periods and money values will be most useful for describing the choice behavior and estimating values not included in the choice task.

We used the HMCT to collect data on delay discounting rates among the sample of smokers. Previous research has suggested that delay discounting, a measure of impulsivity, is greater in drug dependent individuals when compared to non-dependent controls (Bickel, Odum, & Madden, 1999). We analyzed our data to determine if the index of impulsivity that the HMCT yields would be related to RPT choices in that those who are more impulsive may be more or less likely to endorse low adequate incentive levels for abstinence. Although the HMCT revealed similar discounting data to previous

studies (e.g., Bickel, Odum, & Madden, 1999), we found that overall *k* values did not correlate significantly with data collected from the RPT. However, regression analysis did reveal that overall k values may be useful as a predictor variable for adequate incentive values (e.g., the incentive value for 2 weeks of abstinence) in the RPT. Another promising predictor variable is the number of cigarettes smoked per day. A larger sample size and a wider range of time periods and money values in the RPT may be needed to investigate the utility of overall *k* values, and other variables, as potential predictors of RPT data. HMCT and RPT data together may provide valuable data for predicting responders and non-responders to CM.

As with any novel task, there are a variety of limitations to consider. The current study constructed the choice task with a clear goal to test subsequently its utility in a brief abstinence test (BAT) of one week of smoking abstinence (Robles, Silverman, Preston, Cone, Katz, Bigelow, & Stitzer, 2000). We derived the range of time periods to include in the task with the one week BAT in mind. A larger range of time periods should be tested to determine if the task is sensitive to longer (or shorter) periods of abstinence. Similarly, the monetary values increased somewhat arbitrarily and a more systematic increase should be considered. Also important, it is possible that participants in this sample responded in such a way that is inconsistent with actual behavior. For example, a participant who endorsed 20 dollar adequate incentive level for one week of abstinence may not actually abstain when offered 20 dollars for one week of abstinence. Research is needed to determine participant accuracy with respect to actual adequate incentive levels.

The current study included a very small sample of light to heavy smokers. A larger sample is necessary to fully elucidate the utility of the task both in general and with

respect to comparisons of adequate incentive levels across light, moderate, and heavy smokers. Also, our sample included only college students and the RPT should be tested with a variety of populations. CM procedures have been used with a variety of samples and differential adequate incentive values (as determined by the RPT) across samples may inform CM procedures. For example, a sample of schizophrenic patients may endorse a consistent and very high adequate incentive level for abstinence while a group of adolescent smokers may have a consistent and somewhat lower adequate incentive level. The utility of the RPT needs to be tested in larger and more diverse samples in order to realize fully its potential.

Another consideration for the RPT is that group data may not be as useful as individual data. Other literatures have described the use of preference assessment on an individual basis for use with Applied Behavior Analysis. For example, Piazza, Fisher, Hagopian, Bowman, and Toole (1996) used a choice assessment procedure to determine which of potential reinforcers would be most effective for with four male patients admitted for destructive behaviors. Each patient's caregiver provided information about preferred stimuli and then a choice assessment procedure paired each choice with every other choice to determine relative efficacy of potential reinforcers. Choice assessments were conducted on an individual basis such that a preferred stimulus for one patient may be a cookie while the preferred stimulus for another patient might be a toy. This process is important because the same stimuli may not serve as reinforcers for different individuals. It is probable that money is not equally reinforcing for all individuals undergoing CM and thus a more individualized assessment of reinforcer efficacy may be necessary. The RPT provides a way to assess individual preferences for those to whom

money is potentially reinforcing. Further research is necessary to determine which parameters of the task are most important and useful for predicting adequate incentive values for CM.

Although the MCP and other choice procedures offer valuable information for predicting and implementing reinforcers in CM, no choice procedure to date has been used to empirically assess the incentive level likely to actually serve as a reinforcer to abstinence. This study is the first to our knowledge to attempt such a task. Prior to the onset of CM studies or programs, knowledge about the efficacy of potential reinforcers has implications for cost effectiveness and therapeutic utility. Those who implement CM want participants to be successful. Similarly, those who participate in CM likely want to be successful. Unfortunately, procedures may not always maximize the likelihood of success. Our task may address this issue by allowing for prediction of effective incentive levels and minimizing the likelihood of offering too little or too much of an incentive. Further our task may inform researchers and others about the likelihood of success for individuals based on the incentive level offered in a CM program. Those not likely to succeed may be encouraged to engage in other treatment alternatives. Ability to predict successful participants may help to reduce costs associated with CM.

The viability of contingency management as a substance use intervention centers on both its therapeutic efficacy and cost-effectiveness. Some participants fail to make contact with potential reinforcers because they fail to meet abstinence requirements because the incentives are not enough to change behavior or because the behavioral requirements are too costly at the onset of the program. Additionally, many participants may not respond to any level of incentive and thus their inclusion in contingency

management programs may be for naught. Petry et al. (2000) used a fishbowl procedure to reduce costs associated with CM and Lamb et al. (2004) addressed failure to contact potential reinforcers. Although methods for saving money within CM procedures are useful and indeed improve costs, these methods do not necessarily improve efficacy of CM (i.e., improve success rate). Empirical assessment of adequate incentive levels, combined with the money-saving techniques (e.g., Petry et al., 2000), and shaping methods (e.g., Lamb et al., 2004) employed by others may lead to an increase in therapeutic efficacy *and* cost-effectiveness. Further research is needed to determine optimal money-saving techniques (e.g., fishbowl procedures), as well as percentile schedules and other individualized approaches for shaping behavior. Further, more research is needed to clarify the utility of empirical assessment of adequate incentives as well as the optimal method for assessment. Also, a variety of variables may contribute to the determination of adequate incentive levels by participants, such as socioeconomic status, polydrug use, or stage of change and further research might consider those variables.

An understanding of variables that contribute to adequate incentive values may improve our understanding of abstinence initiation and maintenance. As noted, there are a variety of parameters which may contribute to adequate incentive values and much research is needed to improve the RPT. If proven reliable and valid, certainly data from the RPT may contribute to CM procedures in the laboratory and in applied settings. CM has been used as a research tool for understanding abstinence initiation and maintenance, as well as the parameters of reinforcement related to behavior change, and phenomena related to abstinence (e.g., withdrawal; Heil, Tidey, Holmes, Badger, & Higgins, 2003).

Although abstinence is a clear goal for participants in CM procedures, studies that employ CM as a research tool may benefit from the RPT by evaluating who might be most likely to engage in abstinence, and thus producing data related to withdrawal and abstinence maintenance. After all, if no one abstains, then no one experiences withdrawal and there are no data.

The RPT might also be used as an index of how difficult abstinence will be for a particular individual or group, regardless of the intervention procedures used. The HMCT and other delay discounting tasks could be used to demonstrate changes in discounting rates as a result of intervention. The RPT might be useful in much the same way. Perhaps individuals who have responded well to CM or other intervention techniques will report lower adequate incentive values as a result of intervention.

Finally, just as CM procedures have been applied to change a variety of substance use behaviors, the RPT may be modified to include those substances. For example, the task might include stimuli which ask a participant is he is willing to abstain from engaging in cocaine use for 1 week or 1 month if paid a specified dollar amount. Similarly, CM procedures have been used to effect behavior change for other problem behaviors and thus the RPT could be modified to reflect those behaviors as well. For example, the RPT might include stimuli which ask a participant if she is willing to exercise for a specified period of time (or frequency) if paid a specified dollar amount. In addition, the task may also include non-monetary incentives as potential reinforcers. For example, vacation time offered in exchange for increased productivity on the job, bonus points offered to students for attendance or punctuality, or vouchers for services or goods offered for wearing sunscreen on a daily basis. The RPT might be useful for empirically

assessing adequate incentive values for a variety of behaviors with a multitude of incentives.

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Figure and Table Captions

Figure 1. Mean adequate incentive values for each time period presented in the Reinforcer Preference Task. Time is plotted in increments of one month. Data points are in sequential order from 1 hour to 1 month.

Figure 2. Representative individual data depicting adequate incentive values for each time period presented in the Reinforcer Preference Task. Time is plotted in increments of one month.

Figure 3. A curve estimation plot depicting both linear and exponential fits of the data.

Figure 4. Mean indifference points for each time period presented in the Hypothetical Money Choice Task. Time is plotted in months.

Figure 5. Representative individual data depicting indifference points for each time period presented in the Hypothetical Money Choice Task. Time is plotted in months.

Table 1. A summary of self-report variables related to smoking.

Table 2. A summary of Reinforcer Preference Task data for all time periods.

Table 3. A correlation matrix of smoking-related variables.

Table 4. A summary of full and reduced regression models for predicting Reinforcer Preference Task adequate incentive values.

Figure 1. Reinforcer Preference Task Mean Incentive Values

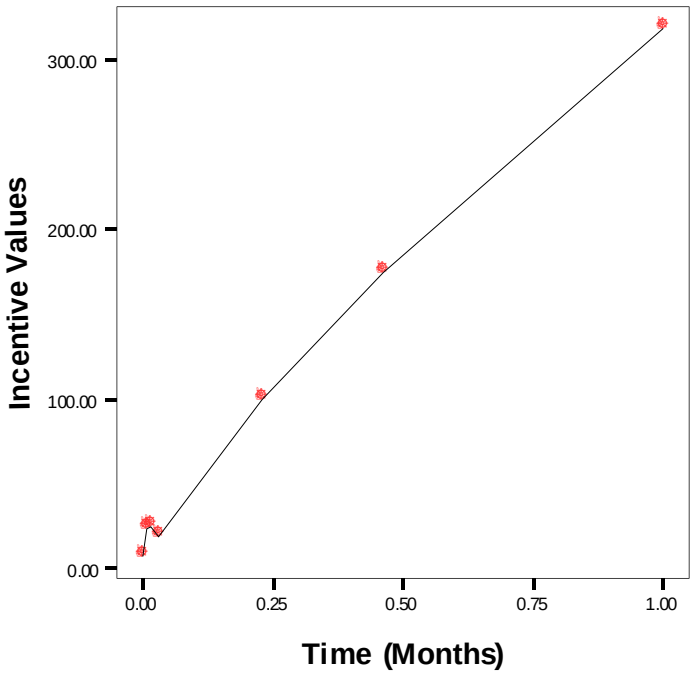

Figure 2. Representative Individual RPT incentive values

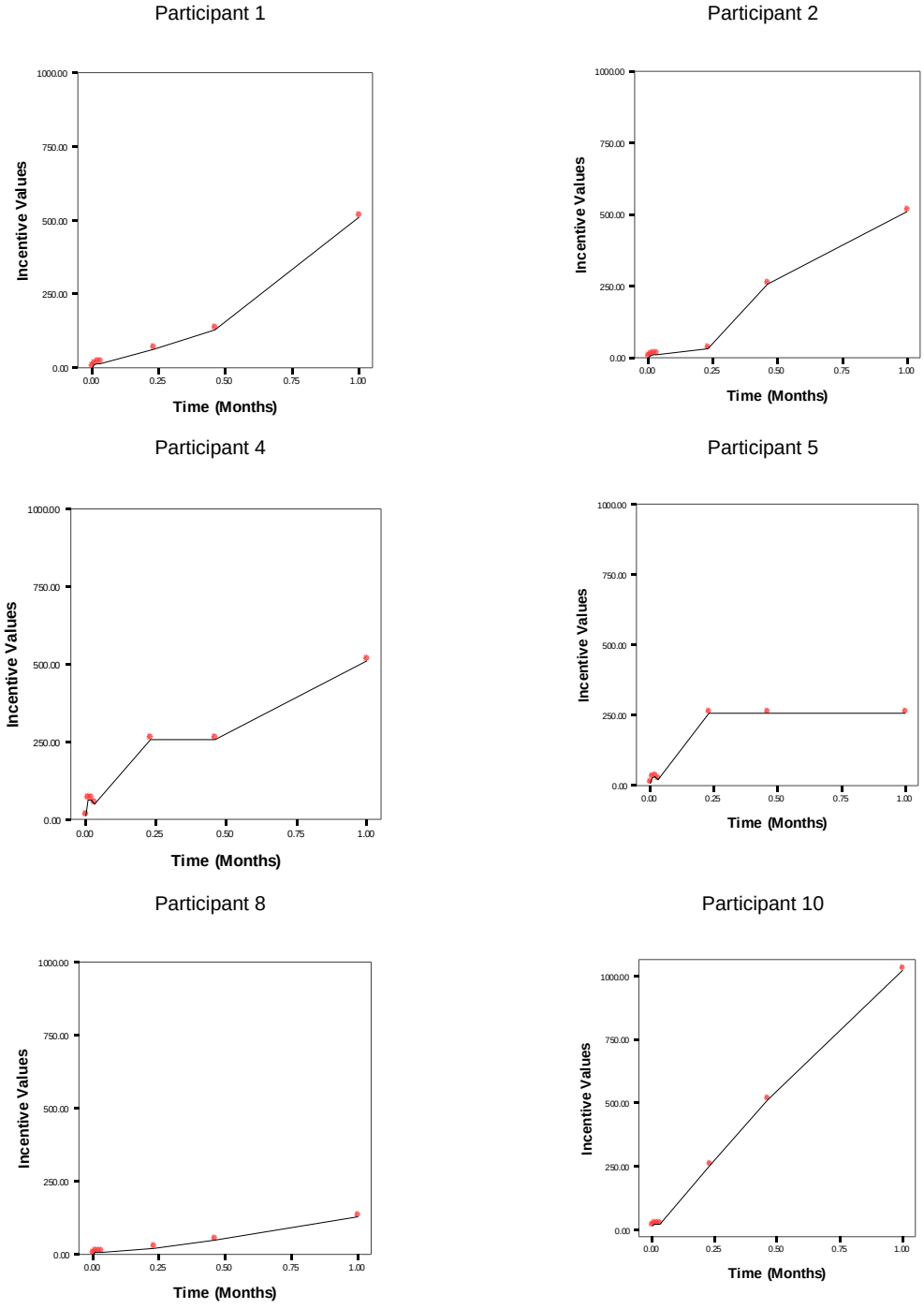

Figure 3. Curve Estimation Plot for Reinforcer Preference Task

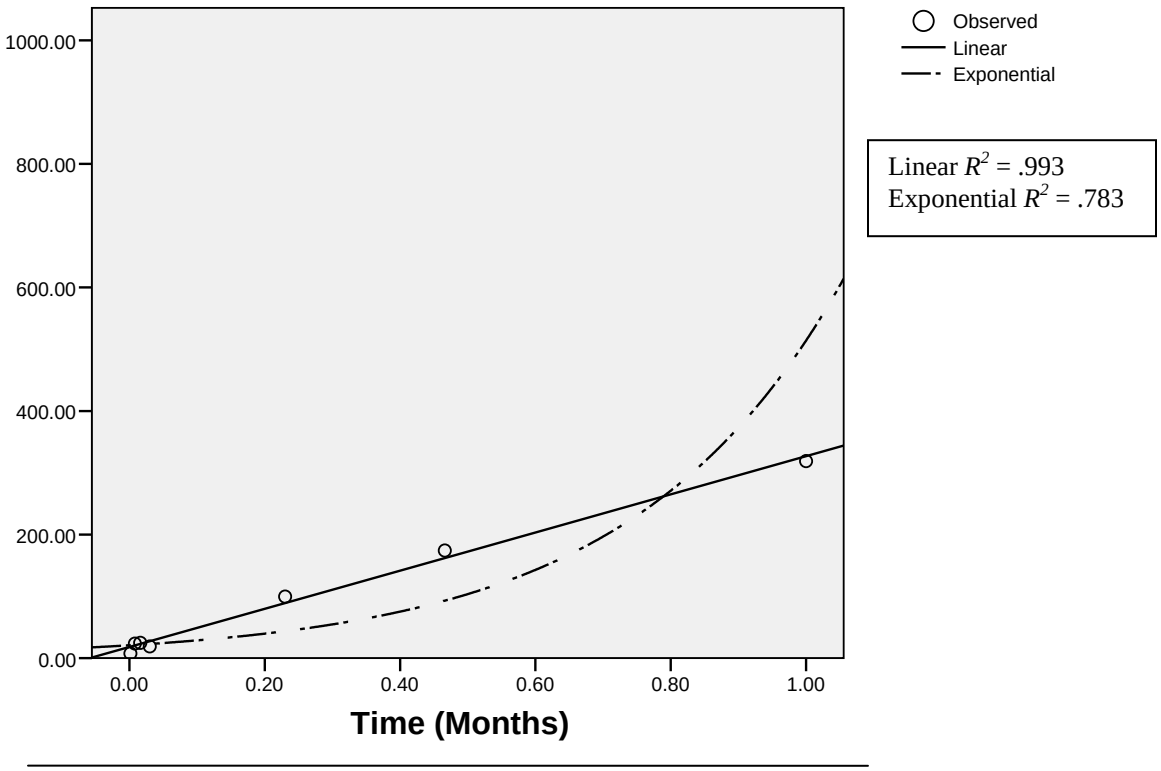

Figure 4.
Mean Subjective Monetary Values for the Hypothetical Money Choice Task

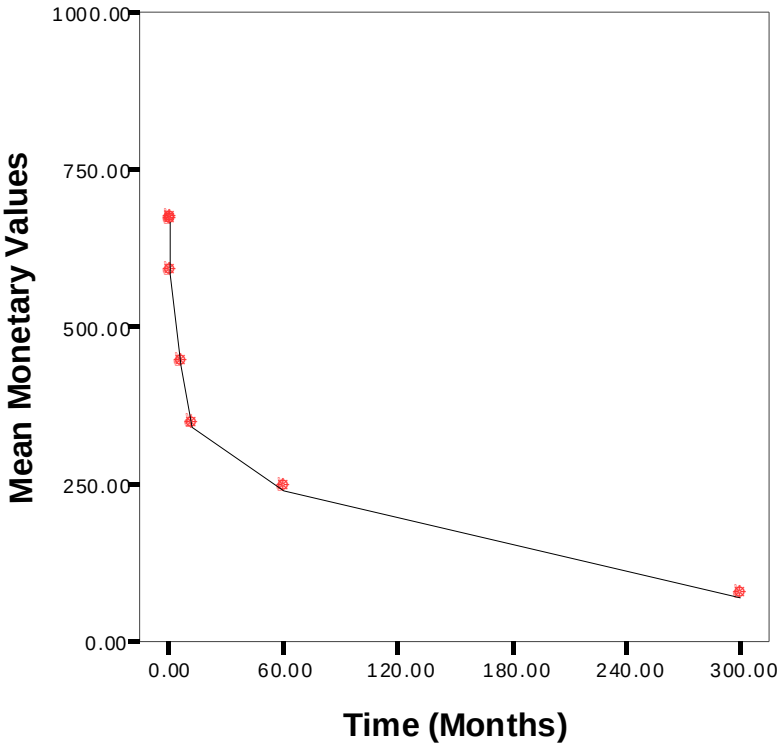

Figure 5. Representative Hypothetical Money Choice Task Indifference Curves

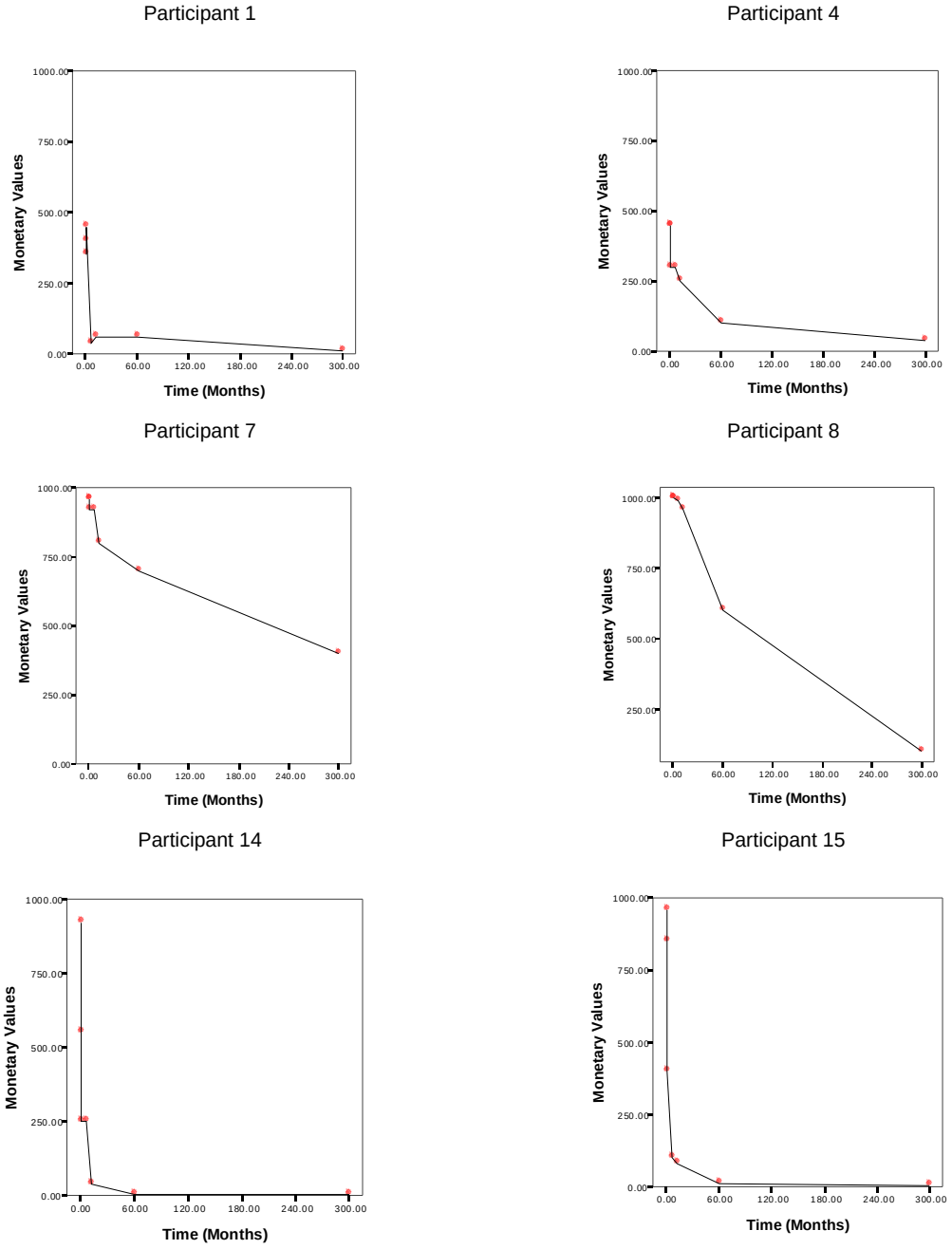

Table 1.
Summary of Self-report Variables

Variables	M	SD	Min	Max
CO reading	16.6	9.74	6	36
Number of cigarettes per day	12.93	3.07	9	20
Age of smoking onset	16.6	1.88	14	22
Previous quit attempts	4.13	3.35	0	10
FTND score	5.38	1.71	2	8

Note. N = 15

Table 2.
Summary of Reinforcer Preference Task Descriptive Data

Time Periods	Median	M	SD	Min	Max
1 hour	8	7.73	7.2	1	28
6 hours	12	23.67	21.65	8	82
12 hours	20	24.93	17.38	8	64
1 day	16	19.07	10.16	8	48
1 week	64	99.73	86.72	20	256
2 weeks	128	174.27	120.79	20	512
1 month	256	319.00	274.63	20	1024

Note. N = 15; numbers reflect dollar values.

Table 3.
Correlation Matrix of Smoking-Related Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. 1 hour incentive	--											
2. 6 hours incentive	.368	--										
3. 12 hours incentive	.377	.975**	--									
4. 1 day incentive	.529*	.803*	.871**	--								
5. 1 week incentive	.376	.340	.449	.645**	--							
6. 2 weeks incentive	.388	.195	.257	.419	.757**	--						
7. 1 month incentive	.132	.081	.112	.367	.581*	.771**	--					
8. Overall *k*	-.088	-.073	.016	.024	-.110	.159	.045	--				
9. CO Reading	.428	.173	.155	.277	.303	.298	.155	-.229	--			
10. Cigarettes smoked per day	.122	-.073	-.115	.026	.400	.464	.415	-.496	.515	--		
11. Number of quit attempts	-.122	-.239	-.193	-.260	-.243	-.459	-.620*	.046	.107	-.186	--	
12. Age of smoking onset	.044	.233	.285	.199	.454	.178	.170	-.186	-.227	-.395	-.341	--

Note. N = 15; * = $p<.05$ and ** = $p<.01$

Table 4.
Summary of Regression Models Predicting RPT Adequate Incentive Values

Variable	β	*SE* β	B	t	R^2
Full Model					
2 week incentive					.594
Overall *k*	84.780	39.579	.525	2.142	
Cigarettes per day	21.974	11.555	.549	1.902	
Quit attempts	-13.762	7.910	-.388	-1.740	
CO Reading	2.467	3.112	.202	.793	
1 month incentive					.550
Overall *k*	102.938	96.310	.276	1.069	
Cigarettes per day	38.362	28.117	.415	1.364	
Quit attempts	-46.627	19.249	-.569	-2.422	
CO Reading	1.744	7.572	.062	.230	
Reduced Model					
2 week incentive					.451*
Overall *k*	90.228	41.529	.559	2.173	
Cigarettes per day	29.701	10.304	.742	2.882*	
1 month incentive					.250
Overall *k*	119.881	112.089	.322	1.070	
Cigarettes per day	53.177	27.811	.575	1.912	

Note. N= 15; * $p<.05$

CHAPTER 3: A BRIEF ABSTINENCE TEST FOR COLLEGE STUDENT SMOKERS

Contingency management (CM), an incentive-based program, has been shown to be effective for reducing a variety of substance use behaviors. For example, CM has been used to decrease use of cocaine, opiates, alcohol, marijuana, methamphetamine, and cigarettes. The basic CM procedure consists of offering incentives for increased frequency or duration of abstinence, decreased substance use (as opposed to abstinence), or increased progress towards treatments goals. CM procedures have consistently been useful for reducing smoking behaviors or initiating smoking abstinence among several different populations including adolescent smokers (Corby, Roll, Ledgerwood, & Schuster, 2000), community adults (Stitzer & Bigelow, 1982, 1983; Stitzer, Rand, Bigelow, & Mead, 1986; Rand, Stitzer, Bigelow, & Mead, 1989), and recently college students (Correia & Benson, 2006). Other studies have demonstrated the efficacy of CM for reducing cigarette smoking with methadone-maintained opiate abusers (Schmitz, Rhoades, & Grabowski, 1995; Shoptaw, Jarvik, Ling, & Rawson, 1996), patients with chronic obstructive pulmonary disease (Crowley, Macdonald, & Walter, 1995), and patients with schizophrenia (Roll, Higgins, Steingard, &McGinley, 1998).

Although effective, more research is needed to improve CM for cigarette smoking. Initial studies demonstrated short term effectiveness with small samples. For example, Stitzer and Bigelow (1982) studied adult smokers (N=11) who reported daily smoking patterns. This study employed a 3-week ABA design consisting of baseline,

intervention, and post-intervention weeks to reduce smoking behavior. Participants visited the laboratory once daily for three weeks and provided Carbon Monoxide (CO) readings for monetary reinforcement. During baseline phases payment was non-contingent. During intervention, participants were offered structured payments in exchange for CO readings that met criteria for abstention. Carbon monoxide readings were significantly lower than during intervention than during baseline. Follow-up studies conducted by Stitzer and Bigelow (1983) manipulated the magnitude of available reinforcers for abstinence. Similar results were found in that periods of reinforced abstinence resulted in reduced smoking behaviors. Also, as the value of monetary reinforcers increased, smoking behavior decreased. These results suggest that monetary reinforcers for abstinence can effectively reduce smoking behaviors, and that higher magnitude reinforcers are more effective than lower magnitude reinforcers.

Behavioral interventions have been well studied with respect to cigarette use but few studies have investigated the use of behavioral interventions among college students. College students are of particular concern because smoking prevalence is highest among those aged 18-24 years (Centers for Disease Control; CDC, 2005). Colleges and universities enroll more than 12 million individuals, most of whom are aged 18-24 (U.S. Census Bureau, 2005). Most cigarette smokers (80%) have tried their first cigarette by age 18 and become regular smokers by age 20 (77%; CDC, 1998). This pattern of smoking initiation and maintenance suggests that the college years are developmentally important with respect to smoking behaviors and dependence (U.S. Department of Health and Human Services, 1994). Surveys of college students confirm that cigarette smoking among college samples is prevalent and correlated with a variety of unhealthy behaviors

such as other drug use (Rigotti, Lee, & Wechsler, 2000). An estimated 29% of college students describe themselves as current smokers (Rigotti, et al., 2000; CDC, 1997). Of those reporting current smoking status, an estimated 67.7% have attempted to quit smoking at some point (CDC, 1997).

To date, only one study has addressed the use of CM procedures with college students. A feasibility study conducted by Correia and Benson (2006) demonstrated that CM effectively reduced college student smoking behavior during a 3-week ABA design consisting of baseline, intervention, and post-intervention weeks. Participants (N= 88) were asked to visit the laboratory twice daily for three weeks and provide breath samples for CO readings for monetary reinforcement. During baseline phases payment was non-contingent. During intervention, participants were offered structured payments in exchange for CO readings that met criteria for abstention. Participants were randomly assigned to receive a high or low magnitude reinforcer value for each period of abstinence.

Carbon monoxide readings were significantly lower during intervention than during either baseline phase. Further, CO readings for those receiving high magnitude reinforcement were significantly lower during intervention than for those receiving low magnitude reinforcement. These results suggest that monetary reinforcers in exchange for periods of abstinence may be effective for reducing smoking behaviors in college student populations. Also, available reinforcers of a higher magnitude may be more effective for reducing smoking behavior than lower magnitude reinforcers. The results of Correia and Benson (2006) are consistent with previous research. However, more laboratory and

clinical research is necessary to realize fully the potential utility of behavioral interventions with college student smokers.

A seemingly significant barrier to CM with college students, as evidenced by Correia and Benson (2006), is an issue of attrition. Of the 88 participants enrolled in the study, 57 (64%) completed the first baseline and intervention weeks, and 39 (44%) completed the three week study. Although Correia and Benson (2006) present compelling results to indicate the utility of CM with college student smokers, methods for improving attrition rates are necessary. Two potential influences on attrition include the high behavioral costs of attending laboratory sessions twice daily and the possible lack of abstinence initiation to make contact with potential reinforcers. Correia and Benson required their participants to visit their laboratory twice per day, five days per week, for the duration of the three week study. Previous studies (e.g., Stitzer & Bigelow, 1982) did not report issues with attrition; however, those studies also employed smaller sample sizes and, in some cases, required fewer laboratory visits. For example, Stitzer and Bigelow (1982) required only one daily visit and studied only 11 participants. Further, Stitzer and Bigelow (1982) provided participants with free cigarettes throughout the duration of the study so that attendance was potentially reinforced even if abstinence did not occur.

In addition to the number of required sessions, several features of the college environment and lifestyle may have contributed to the high attrition rates reported in Correia & Benson (2006). College students function in a very dynamic environment in which class and work schedules changes, and campus events are scheduled throughout the day and evening, resulting in a multitude of obligations and reinforcers that may

compete with the demands of a research study. CM procedures for college students should consider ways to improve attrition rates. One such consideration is the frequency of laboratory visits in previous research. The high frequency of visits is linked to a practical issue related to the use of CO breath samples to verify smoking status. CO levels are indicative of recent exposure to carbon monoxide so that frequent measurement is necessary to track smoking behaviors across longer periods of time (e.g., days, weeks).

The most intuitive way to cut down on the behavioral costs of participating in CM to reduce smoking is to use a biological marker that is sensitive to smoking across longer periods of time than CO samples. An option that has been explored in the literature is the use of urine cotinine (a metabolite of nicotine) measures (Bernaards, Twisk, Mechelen, Snel, & Kemper, 2004). Using urine testing potentially allows for participants to visit the laboratory only once or twice a week as opposed to five to ten times per week. A concern related to urine testing is that of accuracy. Semi-quantitative tests are not without false positives and negatives so that use of these tests as a lone criterion for abstinence may be premature at this point (Bernaards, et al., 2004). Quantitative tests are more accurate but are more costly and time consuming. Research is needed to clarify the utility of urine tests versus CO samples with respect to attrition and accuracy.

As noted above, in addition to issues of attrition with college students involved in CM procedures, problems with abstinence initiation may also contribute to participant drop-out. If participants never reduce smoking to criterion then reinforcers are never available and thus cannot influence behavior. Ways to improve abstinence initiation are needed to improve the therapeutic utility of CM but also to improve the use of CM as a research tool. Several studies have addressed this issue and offer sound alternatives

including the use of percentile schedules to shape abstinence and start-up bonuses for initial instances of abstinence. Percentile schedule studies to date have used CO breath samples to verify smoking status so that while effective for abstinence initiation, shaping requires frequent laboratory visits to verify smoking status. More research is needed to determine if less frequent visits would allow for continued success of percentile schedules or if the utility of the shaping procedures is related to frequent potential availability of reinforcers. Similar to percentile schedules, escalating payment schedules have also been used in CM procedures. Start-up bonuses entail providing a high magnitude incentive for initial abstinence and have seldom been used or studied. One study found that start-up bonuses ($50) for cocaine abstinence initiation did not improve CM outcomes beyond the effects of an escalating payment schedule (Silverman, Wong, Umbricht-Schneiter, Montoya, Schuster, & Preston, 1998). More research is needed to determine under what conditions start-up bonuses may be effective, if at all.

A potential alternative to both shaping and start-up bonuses is to offer a high magnitude incentive for a low criterion of abstinence (short duration or small reduction). This has been referred to as a brief abstinence test (BAT; Robles et al., 2000). The BAT is useful to study the process of abstinence initiation and related phenomenon, such as withdrawal. Robels et al. (2000) studied out-patient methadone maintained cocaine users (N=72) to test the efficacy of the BAT for reducing cocaine use. Participants were undergoing 13-week standard care for opioid abuse but not cocaine-specific treatment. On Monday of week 9 participants were told that they could earn $100 if they returned to the laboratory on Wednesday of that week and produced a urine sample that indicated cocaine abstinence. In this population, about 80% of participants initiated abstinence.

An initial follow-up study replicated the results (Katz, Robles-Sotelo, Correia, Silverman, Stitzer, & Bigelow, 2002), and a second follow-up study found similar results across multiple BAT occasions within a sample (Sigmon, Correia, & Stitzer, 2004). These results suggest that the BAT is an effective procedure for initiating abstinence among cocaine users. However, no published studies have investigated the use of a BAT to reduce the use of cigarettes or other drugs.

The primary goal of the current investigation is to test the feasibility and effectiveness of a BAT in initiating abstinence among college student smokers. A second goal is to improve on the attrition rates reported in the Correia and Benson (2006) study. The current study differed from previous research in at least three ways. First, we tested the BAT with cigarette smokers as opposed to illicit drug consumers (i.e., cocaine). Second, the sample included college student smokers whereas previous BAT studies have utilized an out-patient methadone maintained sample. Third, while Correia and Benson required their participants to visit the lab twice per day for three weeks, the current study required only 3 visits over a three week period. Finally, we employed the use of a three-prong test for abstinence including a urine test, a CO breath sample, and self-report. Secondary goals of the study include the examination of relations between and among self-report measures of dependence and withdrawal and measures of smoking status.

Method

Participants

Recruiting for this study was conducted via flyers posted in a common area and an on-line recruiting system (Sona Systems). Of 68 volunteers who completed the initial screener, 26 individuals qualified for entry into the study. Of those qualified and invited

to participate in the study, 12 individuals enrolled, and all 12 completed the three week study. All recruiting and study procedures were approved by the Institutional Review Board at Auburn University.

All participants (N = 12) met the inclusion criteria; they reported smoking at least 10 cigarettes per day (11.5; Min = 8, Max = 20), provided a CO reading of at least 12 ppm (21.25 ppm; Min = 12 ppm, Max = 37 ppm), confirmed smoking status via urinalysis (3.33; Min = 1, Max = 7), and endorsed not having been involved in active smoking cessation efforts. The sample consisted of undergraduate students (58.3% female, mean age = 21) at a large southern land-grant institution.

Biological Measures

Expired breath CO. We used the BreathCO (Vitalograph Inc., Quivira, KS), a portable breath carbon monoxide reader (CO), to verify smoking status for inclusion in the study. Breath CO has been established as a valid index of recent tobacco smoke exposure that directly reflects plasma carboxyhemoglobin levels (Cohen, Perkens, Ury, & Goldsmith, 1971) and correlates highly with plasma nicotine levels (Russell, Wilson, Patel, Feyerabent, & Cole, 1975). Breath CO levels are also correlated with self-reported number of cigarettes smoked per day (Horan, Hackett, & Lindberg, 1978) and within subject changes in smoke exposure (Stitzer & Bigelow, 1982). Recent clinical applications of CO readings include distinguishing between smokers and nonsmokers (Jarvis, Tunstall-Pedeo,Feyerabent, Vesey, & Saloojee, 1987), detecting smoking following smoking cessation treatment (Gariti et al, 2002), and establishing periods of abstinence as part of contingency management studies (Corby et al., 2000). Nonsmokers generally have breath CO levels below 8 ppm (Jarvis et al., 1987; Vogt, Selvin,

Widdowson, & Hulley, 1977), a light to moderate smoker has levels between 8 and 15, and a heavy smoker typically has levels between 15 and 40 ppm, depending on the amount of recent smoke exposure. Correia and Benson (2006) utilized breath CO to detect recent cigarette smoking with college students undergoing a contingency management smoking cessation intervention.

Urinalysis. We collected urine samples during each session and analyzed the samples with a semiquantitative test of urine cotinine (immunoassay test strips, or ITS). This procedure identified smokers who abstained from smoking over a period of a week and those who did not abstain. ITS provide immediate results (15 minutes), and do not require special equipment or technical personnel. We used NicCheck (Mossman Associates, Blackstone, MA) to measure the presence of cotinine. The use of NicCheck has been tested and validated in several studies (Bernaards, et al, 2004; Leischow, Merikle, Cook, Newman, & Muramoto, 1999). NicCheck urinalysis scores range from 0 – 14 where zero indicates no smoking over the last 5-7 days, and 14 indicates very heavy smoking. Each possible score corresponds to a shade of pink (a color card is provided by Mossman Associates) to which participant ITS can be compared to determine a score. For this study, at least three study personnel examined the ITS and discussed the score to consensus. To meet criteria for abstinence participants must have produced a score of zero.

Self-Report Measures

Demographics. A questionnaire assessed for sample description including participant's age, gender, and ethnicity. The questionnaire also asked about the number of years participants have been in school, fraternity/sorority affiliation, and current place of

residence. Finally, participants disclosed information about current medical or psychiatric conditions.

Reinforcer Preference Task (RPT). The researchers developed this task to empirically assess the value of abstinence across a variety of time periods among smokers. Participants responded to a series of discrete hypothetical choices designed to assess the monetary value most likely to serve as an incentive for periods of abstinence across a range of time periods. The choice procedure posed monetary rewards (e.g., one dollar) across a range of magnitudes and asked participants whether they would abstain from smoking for some time period (e.g., 1 day) if paid that monetary reward. Dollar amounts ranged from $1 - $1024 and time periods ranged from 1 hour to 1 month. Each of the 102 monetary reward-time period stimuli combinations was presented in random order via SuperLab software. For the current study we used data from a previous study with a similar sample and determined the median dollar value for which participants endorsed willingness to abstain from smoking for one week.

Smoking Behavior Questionnaire (SBQ). Participants provided information on their smoking history, current motivation to quit smoking, and previous attempts to quit smoking. Participants also reported whether or not they were actively engaged in, or have immediate plans to engage in, an active smoking cessation treatment program.

Daily Tobacco Report (DTR). During each laboratory visit, participants reported on the use of cigarettes and other tobacco products they have had over the last seven days, including specific questions about the last 24 hours.

Nicotine Dependence. The Fagerstrom Tolerance Questionnaire (FTQ; Fagerstrom & Schneider, 1989), an 8-item measure, assessed nicotine dependence.

Scores range from 0-11, with higher scores indicating more severe levels of dependence. Recent studies support the use of the FTQ with student populations (e.g., Chalmers, Seuire, & Brown, 2000).

Addiction Level. The Hooked on Nicotine Checklist (HONC) measured dependence level for smokers (O'Laughlin, Kishchuk, DiFranza, Tremblay, & Paradis, 2002). The HONC is a 10-item "yes" or "no" checklist. A "yes" endorsement of one or more items indicates some level of dependence and more items endorsed indicate greater levels of dependence. Previous research has demonstrated that the HONC is predictive of smoking status at 6-month and 1-year follow-up points and has also been shown to be both a reliable and valid measure of dependence (Wellman et al., 2006).

Nicotine Withdrawal. The Wisconsin Smoking Withdrawal Scale, a 28-item self report measure, assessed symptoms of nicotine withdrawal (WSWS; Welsch, Smith, Wetter, Jorenby, Fiore, & Baker, 1999). Items are rated on a 5-point scale ranging from (0) strongly disagree to (4) strongly agree. The WSWS provides an overall withdrawal score and seven factorally derived subscale scores that reflect the severity of common symptom clusters (e.g., anxiety, concentration, hunger). Previous research has shown that the WSWS has adequate internal consistency, and is predictive of smoking cessation outcomes (Welsch et al., 1999).

Stage of Change. The Stage of Change Algorithm assessed stage of change within the transtheoretical model (Prochaska & DiClimente, 1982). The transtheoretical model suggests that individuals progress through several stages of change with respect to negative health behaviors. Stages of change include precontemplation, contemplation,

preparation, action, and maintenance. A series of "yes" or "no" questions is used to determine stage of change.

Procedure

Screening. All potential participants completed an initial on-line screener to determine eligibility for the study. This web-based questionnaire asked participants their age and for permission for our research team to verify current enrollment at Auburn University. Participants were also asked to indicate how many cigarettes they smoke per day, and whether or not they are currently engaged in any structured smoking cessation programs. Currently enrolled students between the ages of 18-24, who self reported smoking at least 10 cigarettes a day, and denied engagement in active smoking cessation were invited to participate.

Intake/Baseline 1. During the first week (Baseline 1), participants visited the laboratory on either Monday or Tuesday in the afternoon (5 p.m. to 7 p.m.). At the onset of the first scheduled session, participants provided informed consent permitting researchers to obtain a breath sample and urine sample to verify smoking status and eligibility for the study. Participants produced the samples and, if they qualified, enrolled in the study by signing a second informed consent document. All qualifying participants generated a unique code name used to identify them for the duration of the study. Participants completed the following self-report measures: Demographics, DTR, FTQ, HONC, and the WSWS.

During this visit researchers informed participants that if they return one week from the present date and produce a urinalysis sample and breath sample indicative of recent abstinence that they would receive monetary compensation ($65.00). Researchers

disclosed that the urinalysis test is sensitive for a period of roughly 5-7 days so that at least 5 days of abstinence will be required to produce a clean sample but that the only guaranteed methods to earn money would be to abstain for 7 days.

Brief Abstinence Test. During the second week (BAT), participants returned to the laboratory one week following their initial visit (e.g., if the initial visit was on a Monday then all visits occurred on a Monday) in the afternoon (5 p.m. to 7 p.m.). At this visit researchers collected an expired breath sample for CO analysis, a urine sample, and all self-report measures listed above. During this visit participants received monetary reinforcement ($65.00) if both the CO (< 4ppm) and the urinalysis sample (NicCheck score = 0) met criteria for brief abstinence and they verbally reported having abstained for at least last 5 days. Participants received no payment if the breath sample, urine sample, or verbal report indicated the presence of nicotine. All participants scheduled visits to return to the laboratory one week after the BAT for a final visit at which time a $5 completion bonus payment would be available.

Baseline 2. The third week (Baseline 2) replicated the first week (Baseline 1). Participants who attended all three visits received a bonus payment of $5.

Results

All participants produced completed data sets and no attrition occurred. Mean FTQ at Baseline 1 was 9.25 (SD = 1.4) and the mean HONC score at Baseline 1was 7.17 (SD= 2.89). According to the Stage of Change algorithm, 1 participant met criteria for preparation, 8 for contemplation, and 3 for precontemplation. See Table 1 for a summary of self-report variables.

During each stage of the study, abstinence was defined as a 0 on the urinalysis test, a CO sample reading less than 4 ppm, and a self-report of 0 cigarettes smoked over the last five days. Of the 12 participants who completed the study, 5 (41.7%) passed the test of abstention during the BAT, and 1 (8%) passed the test during Baseline 2. During the BAT, seven participants produced a CO breath sample below criterion (<4 ppm) but endorsed having smoked at least once during the abstinence test (i.e., last 5 days) or produced at least a score of 1 on the urinalysis test. All participants who self-reported smoking during the BAT produced CO and urinalysis scores indicative of smoking. Ten of the 12 participants reduced CO levels and 8 of 12 reduced urinalysis scores from Baseline 1 to BAT phase.

Repeated measures ANOVAs revealed that CO levels [F (2, 22) = 9.08, p=.001, partial eta squared = .542] and urinalysis scores [F (2, 22) = 8.12, p=.002, partial eta squared = .425] changed across phases of the study. Contrasts indicated that both CO (p=.007) and urinalysis scores (p=.006) decreased significantly from Baseline 1 to the BAT phase; however, CO and urinalysis scores did not differ significantly from BAT to Baseline 2. Contrasts also revealed significantly higher CO at Baseline 1 than CO at Baseline 2 (p<.001) but not significantly different urinalysis scores (p = .082). See Figure 1 for mean CO and urinalysis data. See Figure 2 for representative individual CO and Figure 3 for representative urinalysis data.

Repeated measures ANOVAs also revealed that number of cigarettes smoked per day [F (2, 22) = 23.31, p<.001, partial eta squared = .679] and time since last cigarette smoked [F (2, 22) = 8.96, p=.001, partial eta squared = .449] changed across phases of the study. Contrasts indicated that both number of cigarettes smoked per day (p=.007)

and time since last cigarette smoked (p=.006) decreased significantly from Baseline 1 to the BAT phase and increased significantly from BAT to Baseline 2. Contrasts also revealed significantly higher cigarettes smoked per day (p = .001) at Baseline 1 than Baseline 2 but not significantly different time since last cigarette smoked (p = .229). See Figure 4 for mean number of cigarettes smoked per day and time since last cigarette data. Repeated measures ANOVA revealed that withdrawal symptoms did not vary significantly as a function of the phase of study.

A series of independent t-tests revealed no significant differences among those who met the abstinence criteria during the BAT phase and those who did not abstain on self-report measures of smoking-related variables. Secondary goals of the study included examination of self-report measures of dependence (HONC) and withdrawal (WSWS) and their relationships to measures BAT smoking status. Pearson correlations indicated a significant positive correlation between HONC total scores and urinalysis scores during the BAT phase (r = .602, p = .038) such that higher levels of dependence corresponded to higher urinalysis scores. Also, HONC total scores and the number of previous quit attempts correlated positively (r = .720, p = .019) for the BAT phase. Finally, urinalysis and the concentration subscale (but not total score) of the WSWS correlated positively (r = .691, p = .013). See Table 2 for a correlation matrix of smoking-related variables.

Discussion

The current investigation sought to test the feasibility and effectiveness of the BAT with college student smokers, and to improve attrition rates associated with college students engaging in CM procedures. Our findings suggest that the BAT could be a useful tool for abstinence initiation among college student smokers. A significant portion

of the sample met the abstinence criteria, and the majority of participants at least cut down on smoking (i.e., reduced CO, urinalysis score, and/or cigarettes smoked per day) during the BAT. The addition of a urinalysis criterion to verify smoking status, and the associated reduction in the required number of sessions, seemingly improved participant retention in that attrition did not occur in this sample. Both biomarkers (CO and urinalysis scores) and self-report measures of smoking (cigarettes smoked per day and time since last cigarette) varied as a function of phases of the study. In general, CO, urinalysis scores, and number of cigarettes smoked per day were reduced during BAT when compared to Baseline 1 and increased towards Baseline 1 levels during Baseline 2. Similarly, time since last cigarette increased during BAT when compared to Baseline 1 and decreased toward Baseline 1 levels during Baseline 2. These results are consistent with previous research in that contingent monetary payment resulted in periods of abstinence or reduced smoking among college student smokers (Correia & Benson, 2006).

We employed a novel choice procedure, the RPT, to empirically assess the monetary value used as incentive for abstinence. For the present study, we offered the median ($65) value endorsed by participants in a previous study as an adequate incentive for one week of abstinence. The sample used to derive this value did not include participants from the current study, but instead from a similar sample of college student smokers (see Chapter 2 of this dissertation). It remains to be seen if the RPT will be a useful contributor to CM procedures and more research is needed to develop further this task.

Self-report measures of dependence (HONC) and withdrawal (WSWS) appeared to be only peripherally related to measures of smoking status during the BAT phase of the study. The HONC correlated positively with BAT urinalysis scores. The relationship between dependence as measured by the HONC and failure to abstain (higher urinalysis scores) follows the logic that greater dependence would render abstention more difficult. The HONC also correlated positively with previous number of quit attempts which also follows the logic that greater dependence reduces likelihood of success in quitting so that multiple attempts may have been met with failure to abstain for long periods of time. Surprisingly, the WSWS total score did not correlate with any smoking status measure; however, the concentration subscale of the WSWS correlated positively with urinalysis scores indicating that those who reduced smoking during the BAT experienced reduced concentration during that time, presumably as a result of withdrawal. Given that some withdrawal symptoms from smoking cessation may subside in less than a week (Julien, 2005), perhaps symptoms of withdrawal were not present at the time of data collection after the BAT phase. More likely is that most of our participants did not truly abstain and thus withdrawal did not occur. More data are needed to clarify these findings.

Interestingly, measures of smoking taken at Baseline 2 did not fully return to Baseline 1 levels. Our data suggest that participants cut down on smoking or abstained during the BAT and continued a reduced pattern of smoking (but not complete abstention) during Baseline 2. Previous research has demonstrated that the ABA reversal design results in a reversal towards initial baseline (e.g., Stitzer & Bigelow, 1982); however, Corby et al. (2000) found similar results to the current study at Baseline 2 and a return to initial baseline levels of smoking did not occur until a two-week follow-up.

Several phenomena may explain this pattern of behavior. First, the participants who abstained or reduced their smoking during the BAT may have viewed the procedure as an opportunity to initiate more prolonged changes in behavior.

The second possible explanation is related to stages of motivation for change. The transtheoretical model suggests that that smokers progress through a series of stages (precontemplation, contemplation, preparation, action, and maintenance) when moving towards behavioral changes to reduce smoking. Research has shown that these stages of change are linked to motivation to reduce or quit smoking and one's stage may be linked to treatment outcome (Prochaska & DiClemente, 1992). For example individuals in a precontemplation stage of change have not considered quitting and have no plans to do so and thus may respond poorly to treatment efforts according to the model. Individuals who are classified in the contemplation stage of change have considered quitting but have no immediate plans to do so and treatment may or may not be effective for such people. Individuals in a preparation stage of change are thinking about quitting in the near future such that an intervention is likely to be successful at this stage. The action stage refers to those people who have initiated abstinence and the maintenance stage refers to those who have maintained abstinence over a long period of time. In the current study, most participants were classified in preparation or contemplation stages of change with respect to smoking according to the Stage of Change algorithm. Perhaps those participants in the contemplation or preparation stage of change utilized the BAT as an impetus to quit smoking. In other words, it is possible that the procedure used during the BAT induced marginally motivated participants to reduce their smoking, and the increased motivation led to prolonged reductions even after the contingent payment was no longer available.

Finally, the current sample's pattern of behavior, at least clinically, is promising and suggests that perhaps the BAT may have therapeutic utility. In contrast, the failure to return to baseline may suggest that the change in smoking behavior during the BAT can not be fully accounted for by the experimental contingencies. Thus, it is possible that the pattern of smoking behavior in this sample resulted from natural fluctuations in smoking that might have occurred without a contingency condition. Given the encouraging results of this initial within-subject design, further research might consider the addition of a follow-up phase and/or a non-contingent group with which to compare contingent groups.

Although a high-magnitude potential reinforcer may have been effective incentive for some participants to reduce smoking, not all individuals responded to gain access to money. Perhaps some participants needed money more than others, and thus the monetary incentives functioned to reinforce abstinence behavior while for others money did not influence behavior. Also, data collection for this study took place across one academic semester such that some participants enrolled early in the term while others enrolled closer to finals (although not during finals). Successful abstinence may have been hindered by competing stressors such as studying. Alternatively, successful abstinence may have been challenged by competing reinforcers to the monetary incentives such as social occasions (e.g., parties) during which peers are smoking. Although this study successfully initiated and in some cases maintained reductions, abstinence and smoking reduction did not occur for all participants. Given the small and homogenous sample, more research is needed to clarify the utility of the BAT for abstinence initiation among college student smokers.

The current study results differed from the initial BAT study in two primary ways. First, a reversal to initial baseline levels of substance use was more evident with cocaine use (Robles et al., 2000) than with cigarette use. Second, the present study produced lower rates of abstinence among participants. The more prominent reversal for cocaine use may be a function of several study differences. For example, the participants in the Robles et al. (2000) study were polysubstance consumers who were undergoing methadone maintenance who also used cocaine. The BAT for cocaine took place during an opiate treatment program such that cocaine may have served as a substitute drug for opiates. For the present study, no other drug use was targeted.

With respect to lower abstinence rates in the current study, several possibilities deserve consideration. Robles et al. (2000) had two possible criteria to earn payment for abstinence: benzoylecgonine (metabolite of cocaine) concentrations reduced by 50% during contingent periods *or* benzoylecgonine concentrations fell below 300 ng/ml. The current study relied upon three criteria (CO>4 ppm, urinalysis score=0, and self-report) to earn payment for abstinence. Further, our study required at least 5 days of smoking abstinence while Robles et al. required 2 days of cocaine abstinence. The more stringent test of abstinence, employed in the current study may have influenced results. Also, the magnitude of potential reinforcer was larger ($100) for cocaine abstinence than for smoking abstinence.

Despite limitations, the current investigation suggests that the BAT is indeed a useful tool for inducing short-term abstinence and reductions among college student smokers. The ability to induce abstinence, even for short periods of time, is necessary for studying the process of abstinence initiation and maintenance (Heil, Tidey, Holmes,

Badger, & Higgins, 2003). A full understanding of the variables that prevent and facilitate abstinence may be possible through the systematic use of the BAT in the laboratory. A number of processes related to abstinence may also be better understood through the use of the BAT. For example, withdrawal and craving might be secondary phenomena observed as a result of abstinence initiation. Further, research has shown that a period of smoking abstinence may reduce the reinforcing efficacy of cigarette smoking such that even a short period of abstinence might increase the likelihood of sustained abstinence at a later date (Lussier, Higgins, & Badger, 2005). In other words, the experience of abstinence may be more reinforcing relative to smoking after abstinence has been initiated and maintained for some time. Given these results, the BAT may be an effective tool for the onset of abstinence both experimentally and therapeutically. More research is necessary to determine the full utility of the BAT in research and intervention contexts.

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Figure and Table Captions

Figure 1. Mean (and standard error) CO and urinalysis data plotted across study phase.

Figure 2. Representative individual CO readings plotted across study phases. Participants 1, 4, and 9 did not pass abstention test during the BAT; participants 2, 5, and 8 passed test of abstention during the BAT.

Figure 3. Representative individual CO readings plotted across study phases. Participants 1, 4, and 9 did not pass abstention test during the BAT; participants 2, 5, and 8 passed test of abstention during the BAT.

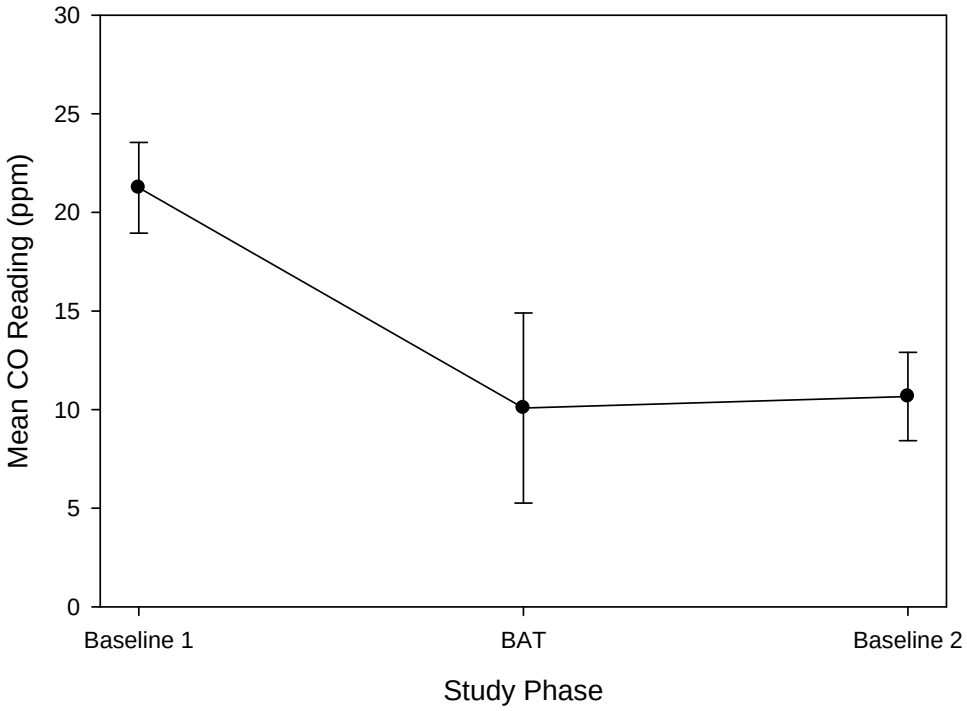
Figure 4. Mean (and standard error) number of cigarettes smoked per day and time since last cigarette smoked data plotted across study phase.

Table 1. Summary of smoking-related variables for each study phase.

Table 2. Correlation matrix of smoking-related variables during the BAT

Figure 1.

Mean CO and Urinalysis Data



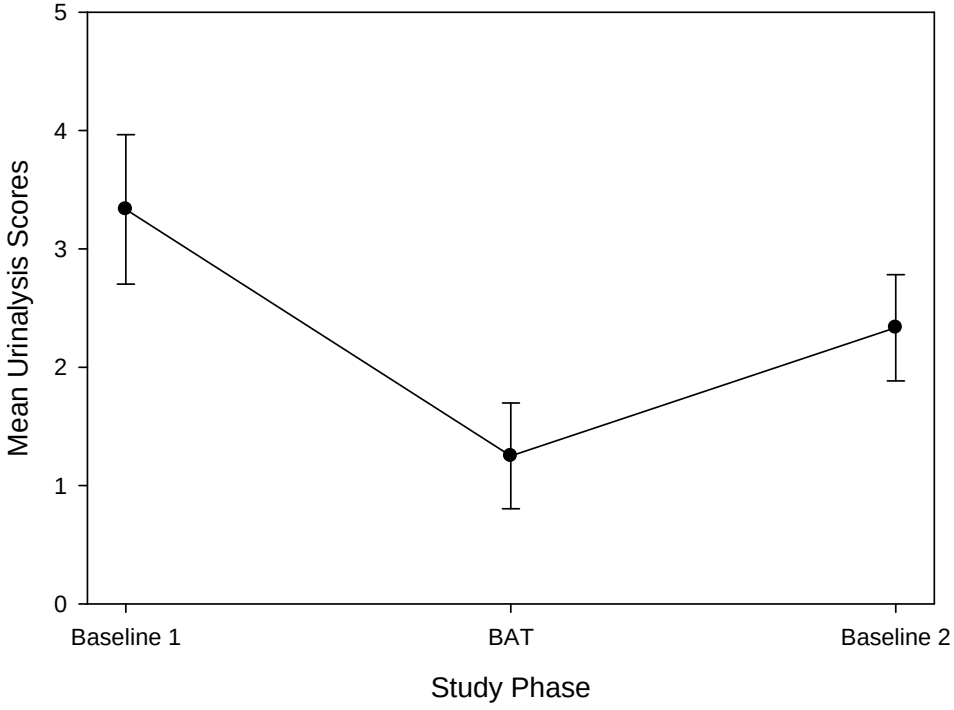


Figure 2.
Representative Individual CO Readings Across Study Phase

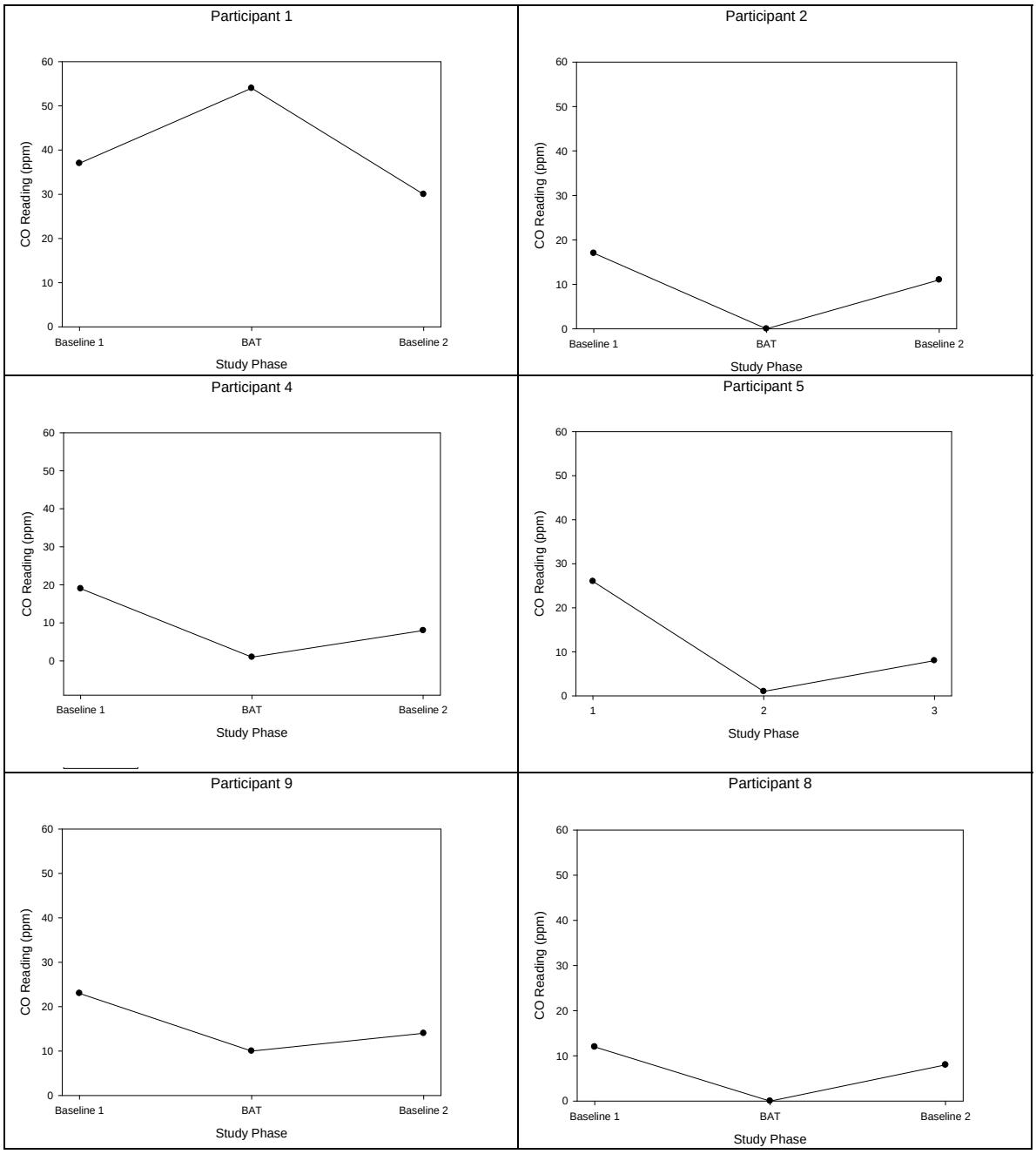


Figure 3.
Representative Individual Urinalysis Scores Across Study Phase

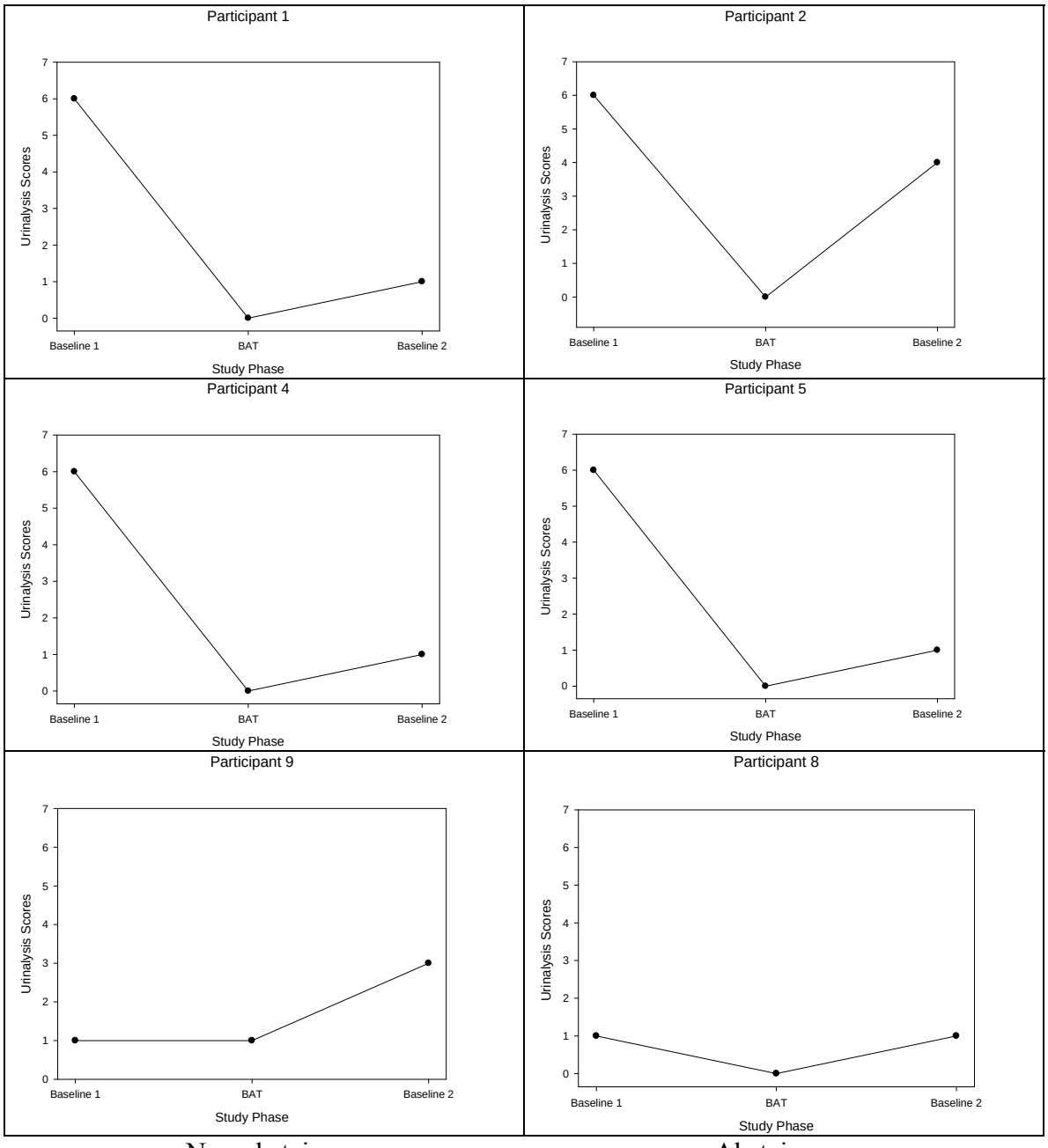
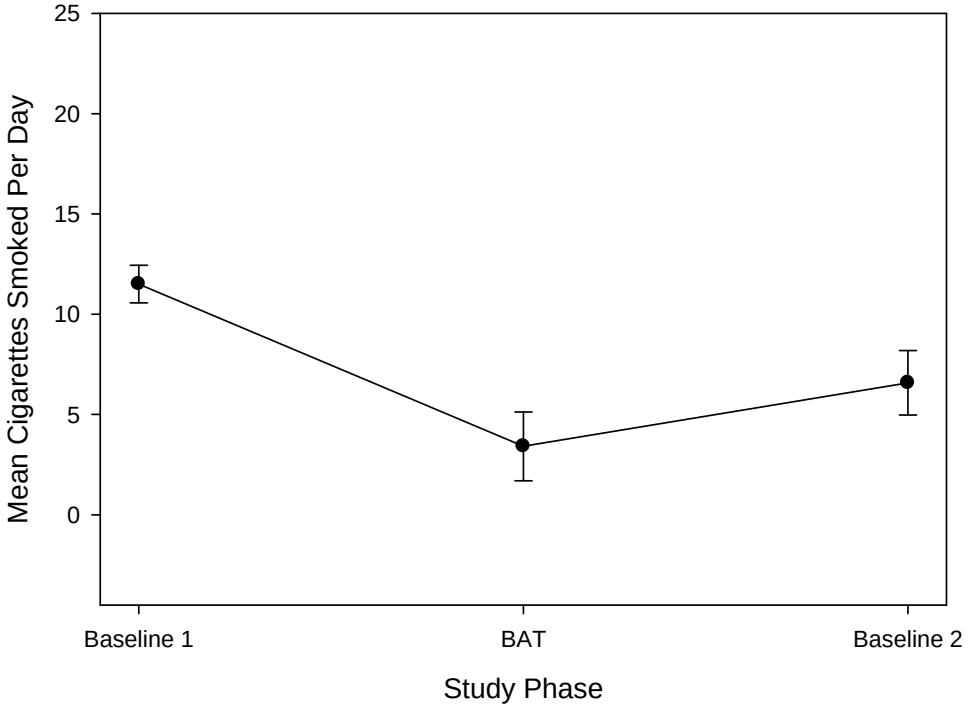


Figure 4.
Mean Number of Cigarettes Smoked Per Day and Time Since Last Cigarette



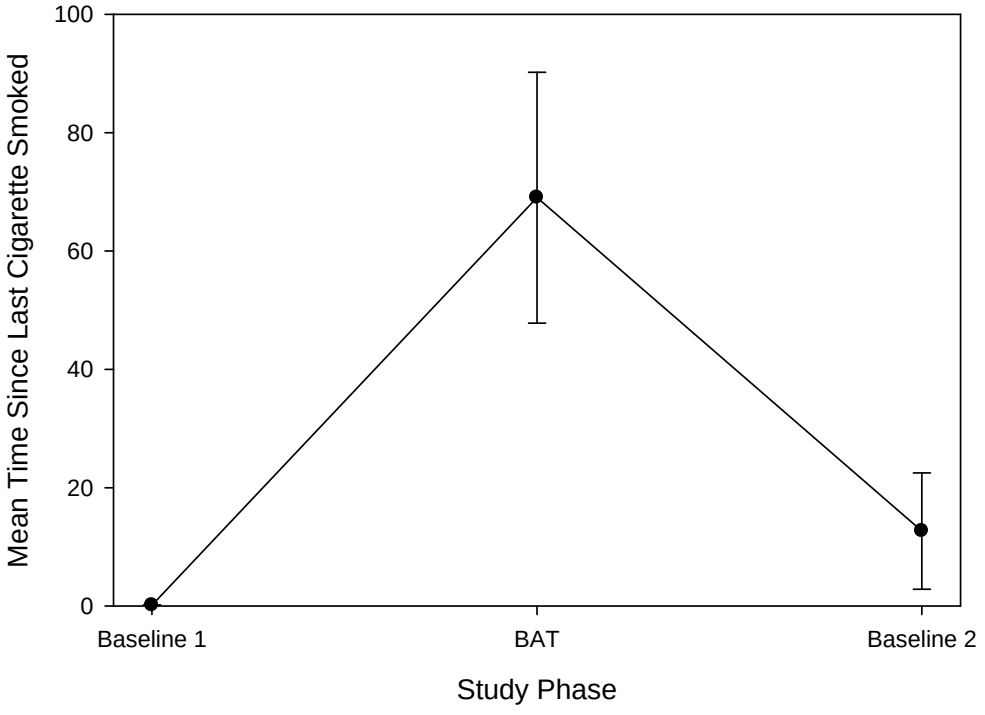


Table 1.
Summary of Smoking-related Variables

	Baseline 1		BAT		Baseline 2	
Variables	M	SD	M	SD	M	SD
CO reading (ppm)	21.25	7.96	10.08*	16.68	10.66*	7.76
Urinalysis score	3.33	2.18	1.25*	1.54	2.33	1.56
Number of cigarettes per day	11.50	3.23	3.40*	5.95	6.50*	5.55
Time since last cigarette (hours)	.14	.14	69.00*	73.40	12.67	34.05
HONC score	7.16	2.28	6.67	2.64	6.75	2.59
WSWS score	53.58	12.47	59.33	14.49	56.00	15.79

Note. N = 12. * indicates significant difference from Baseline.

Table 2.
Correlation Matrix of Smoking-Related Variables During the BAT

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. BAT CO	--												
2. Time since last cigarette	-.541	--											
3.Cigarettes smoked per day	.310	-.564	--										
4. Urinalysis score	.101	-.752**	.819**	--									
5. HONC total score	.250	-.554	.490	.602*	--								
6. WSWS total score	-.127	-.054	.377	.345	.153	--							
7. WSWS Anger	-.123	.011	.333	.325	.094	.663*	--						
8. WSWS Anxiety	.009	-.231	.140	.185	-.079	.737*	.571	--					
9. WSWS Concentration	-.118	-.379	.458	.691*	.308	.553	.255	.347	--				
10. WSWS Craving	-.166	.327	.138	-.026	.102	.564	.541	.213	.179	--			
11. WSWS Hunger	-.269	.341	.028	-.184	.229	.426	.042	.198	-.108	.311	--		
12. WSWS Sadness	.179	.-.478	.269	.484	.189	.693*	.478	.630*	.528	.009	-.117	--	
13. WSWS Sleep	-.006	-.052	.339	.239	-.134	.811**	.354	.528	.394	.237	.227	.723**	--

Note. N = 12; * = $p<.05$ and ** = $p<.01$