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Concurrent use of caffeine and cigarettes in a population of college students

Stephen William Tracy
San Jose State University

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CONCURRENT USE OF CAFFEINE AND CIGARETTES IN A POPULATION OF
COLLEGE STUDENTS

A Thesis

Presented to

The Faculty of the Department of Psychology

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Stephen William Tracy

May 2007

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APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

Dr. Ron Rogers

Dr. Glenn Callaghan

Dr. Jodie Trafton, VA Palo Alto HCS

Stanford University School of Medicine

APPROVED FOR THE UNIVERSITY

ABSTRACT

CONCURRENT USE OF CAFFEINE AND CIGARETTES IN A POPULATION OF COLLEGE STUDENTS

by Stephen W. Tracy

Numerous studies have documented a positive association in the concurrent use of coffee and cigarettes. Furthermore, caffeine is able to alter the behavioral and reinforcing effects of nicotine in animals. Here we examine whether early and regular use of caffeinated beverages moderates the acquisition of cigarette smoking in a sample of 190 college students. Daily use of caffeinated coffee and daily use of caffeinated soda were associated with increased cigarette smoking behavior. Moreover, early and regular use of caffeinated coffee and caffeinated soda moderated the acquisition of later cigarette smoking behavior, suggesting that caffeine may have the ability to alter the addictive potential of cigarettes. The findings presented here should be understood in terms of prevention. If early and regular use of caffeinated beverages facilitates the acquisition of tobacco dependence, then regular caffeine use in youth may be a factor in later acquisition of a cigarette smoking addiction.

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Introduction

The prevalence of coffee drinking and cigarette smoking places caffeine and nicotine among the most frequently self-administered licit psychoactive substances. A number of studies have documented a positive correlation in the concurrent use of caffeine and nicotine (Istvan & Matarazzo, 1984; Swanson et al., 1994). It appears that caffeine is able to alter the behavioral actions of nicotine, not only in terms of nicotine's actions as a stimulant or depressant of motor activity, but more importantly in terms of the subjective and reinforcing effects of nicotine. Thus, caffeine may alter the addictive potential of nicotine.

Research on the etiology of cigarette smoking has primarily focused on the identification of psychosocial predictors of the onset or initiation of smoking. Conrad et al. (1992) summarized findings from 27 studies examining the onset of smoking. All 27 studies reported prospective predictors of the onset or initiation of cigarette smoking. Conrad and colleagues (1992) identified several domains of predictors including social bonding variables, social learning variables, and interpersonal variables. Subsequently, Flay and colleagues (1998) identified four domains of psychosocial variables that predict movement from initiation to advanced stages of cigarette smoking in high school students. Among the predictive domains identified were the use of other substances. Specifically, the use of alcohol and marijuana predicted later use of cigarettes. Unfortunately, few studies have attempted to further clarify additional substances that may predict later smoking habits, especially substances that are licit and readily available to children, such as caffeinated beverages.

Caffeine is the most commonly consumed psychoactive drug in the world (Barone & Roberts, 1984; Gilbert, 1984; Pendergrast, 1999; Fredholm et al., 1999). Worldwide caffeine consumption has been estimated to be around 70 to 76 mg/person/day, while in the United States it is estimated to reach 210 mg/person/day (Gilbert, 1984; Barone & Roberts, 1996). Tolerance can develop readily to some of the behavioral effects of caffeine after chronic ingestion (Holtzman & Finn, 1988). Withdrawal symptoms that ensue after cessation of chronic caffeine consumption are well recognized and physical as well as psychological dependence on caffeine in adult and adolescent populations has been described in the literature (Griffiths & Woodson, 1988; Hale et al., 1995; Hughes et al., 1998; Strain et al., 1994; Bernstein et al., 2002). Caffeine has remained free of regulatory control despite the potential for dependence. This is most likely a result of the large numbers of individuals who use caffeine regularly without showing any significant problems. However, the absence of studies examining the initiation and progression for use of caffeine in youth is alarming considering the prevalence of regular use and potential for addiction.

Caffeine not only has the potential to cause dependence in chronic users, but it also appears to have the ability to alter the reinforcing and addictive properties of nicotine in animals. Drug self-administration procedures offer an exceptionally useful tool for evaluating the effectiveness of different psychoactive drugs to act as reinforcers of drug-seeking behavior in animals. Shoaib and colleagues (1999) examined caffeine as a potential environmental factor involved in the acquisition and maintenance of nicotine self-administration in rats. Rats were presented with caffeine in their drinking water and

its effects on the acquisition and maintenance of intravenous nicotine self-administration were examined. Chronic consumption of caffeine by rats resulted in striking changes in the reinforcing properties of nicotine. First, the ability of rats to acquire nicotine self-administration was accelerated, requiring fewer sessions to meet acquisition criteria compared to water-drinking controls. Furthermore, a greater percentage of caffeine-drinking rats met the acquisition criteria. Exclusion of caffeine brought levels of nicotine self-administration back to baseline, while adding caffeine to the drinking water of control rats increased responding maintained by nicotine over 90%. These findings strongly suggest that chronic exposure to caffeine can potentiate the reinforcing properties of nicotine.

The neurochemical mechanisms that mediate alterations in the reinforcing properties of nicotine following chronic exposure to caffeine in animals have yet to be determined. Nicotine is an agonist of nicotinic-acetylcholine receptors and the reinforcing effects of nicotine appear to be mediated by activation of these receptors, which can, in turn, facilitate dopamine release in the shell of the nucleus accumbens, an area that plays an important role in the motivational properties of drugs of abuse (Pontieri et al., 1996). Caffeine can also induce dopamine release in the shell of the nucleus accumbens; however, it does so via caffeine's antagonistic actions at adenosine receptors, which are co-localized with dopamine receptors (Ferre et al., 1997). Caffeine inhibits adenosine and adenosine inhibits dopamine release in the shell of the nucleus accumbens (Solinas et al., 2002). It may be that chronic exposure to caffeine results in a "sensitization" of dopamine release in the shell of the nucleus accumbens. Using

microdialysis techniques, Tanda and colleagues (2000) found that in both caffeine-drinking rats and water-drinking control rats, nicotine produced a significant and dose-related increase in dopamine levels in the shell of the nucleus accumbens. This effect was significantly enhanced in the caffeine-drinking rats, compared to water-drinking controls. The authors suggested that chronic exposure to caffeine might interact with the functional responsivity of dopamine in the shell of the nucleus accumbens following exposure to nicotine. In other words, antagonizing the inhibitory tone of adenosine receptors on dopamine may allow more efficient transduction of the dopaminergic signal following nicotine exposure. Although animal studies are useful, there are important differences between experimental studies in animals and the human population.

A number of human studies indicate a strong positive association between caffeine use and cigarette smoking in adult and adolescent populations, regardless of gender (Swanson et al., 1994; Bernstein et al., 2002). In a review of caffeine-tobacco use relationship, Swanson and colleagues (1994) found 15 large (> 1000 participants) epidemiological studies reporting a positive association between coffee drinking and cigarette smoking in adults, regardless of gender. All considered studies reported smokers to drink more coffee, on average about 50% more. There was also a larger proportion of non-smokers who do not consume coffee when compared to smokers. The review also cites several studies demonstrating that the typical desire of smokers to smoke while drinking coffee is independent of the caffeine dose. The positive association between caffeine use and cigarette smoking has been reported in adolescents as well. In a sample of 36 adolescents, Bernstein and colleagues (2002) found a trend

such that teenagers with nicotine dependence consumed more caffeine than those without nicotine dependence, although the authors caution that these findings should be considered preliminary due to the small sample size. Regardless of these findings, several experimental studies have failed to show a correlation between coffee drinking and cigarette smoking. For instance, Kozlowski and colleagues (1976) found that abstinence from caffeine produced an increase in smoking behavior (nicotine consumption), in a population of coffee-drinking smokers. Chait and Griffiths (1983) also showed no increase in the number of cigarettes smoked as coffee dose experimentally increased. However, these studies examined coffee and nicotine consumption over brief (single-dose) intervals and therefore might not be relevant for examining coffee and nicotine consumption, both of which are generally used chronically.

The interactions between caffeine and nicotine appear to be complex. When attempting to understand environmental factors that may moderate the acquisition of smoking habits and nicotine addiction, it is important to examine interactions among drugs that are commonly used concurrently with nicotine, such as caffeine. Caffeine is the most widely consumed psychotropic drug and is generally considered safe. Moreover, caffeine is the only licit drug regularly ingested by children (Liebman, 1997). From the available literature we cannot discern whether people that start smoking tend to have an intake of caffeine greater than the average, or if they increase their intake of caffeine after starting to smoke. In addition, we do not know whether people who use caffeine regularly before smoking initiation are more likely to become smokers, or if they

tend to progress through the process of acquiring a smoking habit more rapidly than those smokers who did not use caffeine regularly before smoking initiation. Finally, this maybe one of the first studies to examine the concurrent use of caffeinated soda and cigarette smoking: consideration of all sources of caffeine is important, particularly when one considers that caffeinated soda is regularly ingested by children at young ages. These questions highlight a need to examine the extent to which early and regular use of caffeine may facilitate the acquisition of drug-taking behavior, including the use of tobacco. The importance of this issue should be understood in terms of prevention: if caffeine is an important environmental factor in terms of acquisition and subsequent maintenance of drug-taking behavior with nicotine, its heavy use in youth might be a factor in the high incidence of cigarette smoking in youth. Cigarette smoking is the single most preventable cause of premature death in the United States; each year, more than 400,000 Americans die from cigarette smoking. One in every five deaths in the United States is smoking related (Centers for Disease Control and Prevention, 2002).

The primary purpose of this study is twofold. The first aim is to examine whether daily users of caffeinated beverages (e.g., coffee, tea, soda) and high-risk users of caffeinated beverages (i.e., > 6 servings per day) smoke cigarettes more frequently and in greater quantities than those who do not drink caffeinated beverages daily or drink 6 or more servings per day. The second aim is to examine whether early and regular use of caffeinated beverages moderates the acquisition of later cigarette smoking behavior. This study may provide important public health information regarding licit psychoactive

substances (i.e., caffeinated beverages) regularly ingested by children that may influence the acquisition of cigarette smoking and nicotine addiction.

Methods

The following methods were employed to recruit participants, survey and describe the sample, and test the hypotheses of this study.

Participants

Participants were 190 undergraduate psychology students (78% female) who attended San Jose State University (SJSU). SJSU psychology instructors were contacted and asked if they would be willing to reserve the final 5 minutes of class time for completion of a survey to be used for a master's thesis. During the assigned time, students were given the option of either volunteering to complete the survey or leaving the classroom. Volunteers who decided to participate were treated in accordance with university policy for use of human subjects. The participants self-identified their ethnic background as follows: 45% (n=86) White, 18 % (n=34) Hispanic, 20% (n=37) Asian, 5% (n=9) Black, and 12% (n=22) identified themselves as other/mixed ethnic background. Gender of the sample included 78% (n=149) females and 22% (n=41) males. Age of the participants was reported as follows: 4% (n=7) under 20, 34% (n=64) 20-21, 27% (n=51) 22-23, 9% (n=17) 24-25, 7% (n=14) 26-27, 5% (n=9) 28-29, and 14% (n=27) identified themselves as over 30 years of age.

Apparatus

Demographic information was collected from all participants. Participants self-identified gender, age, and ethnic background in a forced-choice response format. These variables were assessed for descriptive purposes in analyses and describing the general sample.

Current use of cigarettes, other tobacco products, caffeinated coffee, tea, and soda was assessed by asking participants about the quantity and frequency of use for these substances over the past month (30 days) according to seven response options (see Table 1).

Table 1.

Summary of Measures

		Seven Point Scales				
Variables		Frequency past 30 days	Quantity average day	Age 1st initiated	Age began weekly use	Age began daily use
Nicotine	Cigarettes					
	Other Tobacco		NA			
Caffeine	Coffee					
	Tea					
	Soda					

NA = not measured

In order to assess quantity of cigarette, other tobacco products, caffeinated coffee, tea, and soda use over the prior 30 days, participants were asked to choose the response option that describes their average use of the substance on days that they used the substance. The response options for quantity of cigarette use over the past month assesses the average number of cigarettes smoked on days that the participant engaged in smoking. The response options were as follows: none, 1-5, 6-10, 11-15, 16-20, 21-25, more than 25 cigarettes. For coffee and tea the participant was asked how many 8oz servings were consumed over the past month on an average day in which the individual consumed the substance. The response options were as follows: none, 1, 2, 3, 4, 5, 6 or more servings. For soda the participant was asked how many 12oz servings were

consumed over the past month on an average day in which the individual consumed caffeinated soda. The response options were as follows: none, 1, 2, 3, 4, 5, 6 or more servings. High-risk consumption of caffeinated beverages was defined as 6 or more servings on an average day in which the individual consumed the substance in the past month. Quantity of use for other tobacco products was not assessed.

In order to assess frequency of cigarette, other tobacco products, caffeinated coffee, tea, and soda use over the past month, participants were asked to choose the response option that describes how frequently they used the substance over the prior 30 days. The response options for frequency of use over the past month were as follows: never, once, 2-3 times, 1-2 times a week, 3-4 times a week, 5-6 times a week, daily use.

Lifetime use of cigarettes, other tobacco products, caffeinated coffee, tea and soda was assessed by asking participants at what age they first used the substance, at what age they began using the substance regularly (weekly), and at what age they began using the substance daily. Because this study is concerned with early use of these substances, the response options for these questions were as follows: never, age 12 or before, age 13, age 14, age 15, age 16, age 17 or later.

Procedures

Students participating in this research study were first required to complete a consent form. The consent form states that their responses will be completely anonymous and that strict confidentiality will be maintained. They were also informed that their participation is entirely voluntary, and that they may discontinue participation at any time during the study. They were instructed, in writing, not to put their names on the

survey. Next, the 27-item survey was distributed to students while they remained in their seats. Students completed the survey individually, at the same time as their classmates. The survey took participants approximately 5 minutes to complete. Once complete, students turned in their survey, were thanked for their cooperation and given a written debriefing. The written debriefing consisted of a description of the purpose and methods of the study. Students received no monetary compensation for completing the survey, were not awarded research credit hours or extra credit in exchange for their participation. All materials were kept locked with a key to which only the experimenter has access.

Data Analysis

Summary statistics (i.e., frequencies) were calculated in order to characterize our population's consumption of caffeinated beverages and their use of cigarettes. In order to examine the hypotheses and exploratory analyses in this study, logistic regression models were estimated. Logistic regression allows prediction of group membership by applying the Chi Square statistic when predictors are continuous, discrete, or a combination of the two. Logistic regression allows one to evaluate the odds (or probability) of membership (i.e., odds ratio) of one of the groups based on the combination of values of the predictor variables. The odds ratio (OR) is the values by which the odds of the event change when the independent variable increase by one unit. If the value is greater than 1, the odds are increased; if the value is less than one, the odds are decreased. A value of 1 leaves the odds unchanged. Logistic regression also yields the Nagelkerke R^2 which is an adjusted version of the Cox and Snell R^2 . The Nagelkerke R^2 adjusts the scale of the statistic to cover the full range from 0 to 1.

The hypotheses of this study are as follow:

1. Daily coffee users will smoke cigarettes more frequently than those who do not drink coffee daily. Exploratory analyses will be conducted in order to examine whether daily tea or soda users smoke more frequently than those who do not use tea or soda daily.
2. Daily coffee users will smoke cigarettes in greater quantities than those who do not drink coffee daily. Exploratory analyses will be conducted in order to examine whether daily tea or soda users smoke in greater quantities than those who do not use tea or soda daily.
3. Participants who drink 6 or more servings of coffee in a typical day (high-risk) will smoke cigarettes more frequently than those who do not drink 6 or more cups of coffee in a typical day. Exploratory analyses will be conducted in order to determine whether high-risk tea or soda users smoke cigarettes more frequently than those who do not drink at least 6 servings in a typical day.
4. Participants who drink 6 or more servings of coffee in a typical day (high-risk) will smoke cigarettes in greater quantities than those who do not drink 6 or more cups of coffee in a typical day. Exploratory analyses will be conducted in order to determine whether high-risk tea or soda users smoke cigarettes in greater quantities than those who do not drink at least 6 servings in a typical day.

Results

Consumption of Caffeinated Coffee

As shown in Table 2, almost all of the 190 participants in this study (90.5%, n=172) had consumed caffeinated coffee at least once in their lifetime. Forty percent (n=68) of those who initiated coffee drinking reported doing so at age 12 or before, while 76% (n=131) reported initiating coffee drinking at age 16 or before. Most participants (75.3%, n=143) reported consuming coffee in the past month. Almost half of participants in this study (43.7%, n=83) reported weekly coffee consumption and 16.8% (n=32) reported daily consumption of coffee.

Table 2.

Initiation of Coffee, Tea, Soda, and Cigarettes

Substance Type	% Ever Initiated	Age 12 or Before	Age 16 or Before
Coffee	91%(n=172)	40%	76%
Tea	70%(n=133)	47%	74%
Soda	99%(n=189)	89%	90%
Cigarettes	49%(n=93)	8%	53%

Consumption of Caffeinated Tea

Most of the participants in this study (70%, n=133) reported having consumed caffeinated tea (see Table 2). Forty-seven percent (n=63) of those who had initiated tea drinking reported doing so at age 12 or before, while 74% (n=97) reported initiating tea drinking at age 16 or before. As shown in Table 3, more than half (52.1%, n=99) of the

participants reported tea consumption in the past month, while 21.1% (n=40) reported weekly consumption of tea and 3.7% (n=7) reported daily consumption of tea.

Table 3.

Prevalence of Coffee, Tea, Soda, and Cigarette Use Among College Students

Substance Type	% 30-Day Users	% Weekly Users	% Daily Users
Coffee	75%	44%	17%
Tea	52%	21%	4%
Soda	90%	59%	16%
Cigarettes	21%	14%	8%

Consumption of Caffeinated Soda

All but one participant (99.5%, n=189) reported having consumed caffeinated soda at least once in their lifetime. Most participants (89%, n=168) reported initiating caffeinated soda drinking at age 12 or before; 90% (n=188) reported initiating soda drinking at age 16 or before. Ninety percent (n=171) of participants reported consuming caffeinated soda in the past month and more than half (58.9%, n=112) reported weekly consumption of soda. Sixteen percent of the sample (n=30) reported daily consumption of caffeinated soda beverages.

Cigarette Use

Among college students in this study, almost half (48.9%, n=93) had initiated cigarette smoking. Eight percent (n=7) of those who initiated cigarette smoking did so at age 12 or before, whereas 53% (n=49) reported initiating cigarette smoking at age 16 or before. Twenty-one percent (n=40) of participants had smoked at least once in the past

thirty days and 14% (n=27) reported weekly cigarette smoking. Eight percent (n=15) of the sample reported daily cigarette smoking. Almost one-third of participants (28.9%, n=55) reported ever smoking cigarettes weekly, while 16.3% (n=31) reported ever smoking cigarettes daily. Of those who initiated smoking (n=93), more than half (59.1%, n=55) progressed to weekly use of cigarettes and a comparable number (51.6%, n=48) progressed to daily use of cigarettes.

Concurrent Use of Caffeinated Coffee and Cigarettes

When compared to individuals who have never used caffeinated coffee, individuals who have used (initiated) coffee in their lifetime were 9 times more likely to have also used (initiated) cigarettes in their lifetime ($\chi^2 = 12.89$, OR = 8.99, $P = 0.004$, 95% CI = 2.01-40.29; Nagelkerke $R^2 = 0.09$). As shown in Table 4, those participants who drank coffee daily smoked cigarettes more frequently ($\chi^2 = 6.16$, OR = 1.26, $P = 0.01$, 95% CI = 1.06-1.51; Nagelkerke $R^2 = 0.05$) when compared to those who did not drink coffee daily; moreover, participants who drank coffee daily were 7 times more likely to be current daily cigarette smokers ($\chi^2 = 11.64$, OR = 7.19, $P < 0.001$, 95% CI = 2.39-21.65; Nagelkerke $R^2 = 0.14$). Additionally, daily coffee drinkers smoked cigarettes in greater quantities ($\chi^2 = 7.15$, OR = 2.05, $P = 0.006$, 95% CI = 1.22-3.43; Nagelkerke $R^2 = 0.06$) than those participants who did not drink coffee daily.

Table 4.

Concurrent Use: Daily Caffeine Use and Cigarette Smoking Among College Students

	<u>Odds ratios (95% CI)</u>		
	Frequency of cigarettes (0-5)	Daily cigarette smoker	Quantity of cigarettes (0-5)
<i>Daily Use of:</i>			
Coffee	1.26**(1.06-1.51)	7.19*** (2.39-21.65)	2.05**(1.22-3.43)
Tea	---	---	---
Soda	1.23*(1.02-1.47)	5.78** (1.92-17.46)	1.76*(1.05-2.96)

Predictors that were not statistically significant were not presented in table.

* P < 0.05

** P < 0.01

*** P < 0.001

High-risk users of coffee (i.e., participants who drank 6 servings of coffee or more on a typical coffee drinking occasion in the past month) smoked cigarettes more frequently ($\chi^2 = 9.36$, OR = 1.48, P = 0.001, 95% CI = 1.17-1.88; Nagelkerke $R^2 = 0.13$) than participants who drank less than 6 servings of coffee on a typical occasion and were 14 times more likely to be current daily cigarette smokers ($\chi^2 = 12.67$, OR = 14.08, P < 0.001, 95% CI = 3.66-54.18; Nagelkerke $R^2 = 0.18$), as shown in Table 5. Participants who drank 6 servings of coffee or more on a typical occasion also tended to smoke cigarettes in greater quantities ($\chi^2 = 2.99$, OR = 1.92, P = 0.056, 95% CI = 0.99-3.74; Nagelkerke $R^2 = 0.04$) when compared to those participants who did not drink at least 6 servings of coffee on a typical coffee drinking occasion.

Table 5.

Concurrent Use: High Risk Caffeine Use and Cigarette Smoking Among College Students

	Odds ratios (95% CI)		
	Frequency of cigarettes (0-5)	Daily cigarette smoker	Quantity of cigarettes (0-5)
<i>6 or More Servings in Typical Day Using:</i>			
Coffee	1.48**(1.17-1.88)	14.08*** (3.66-54.18)	---
Tea	---	---	---
Soda	---	---	---

Predictors that were not statistically significant were not presented in table.

* P < 0.05

** P < 0.01

*** P < 0.001

Concurrent Use of Caffeinated Tea/Soda and Cigarettes

Examination of the relationship between caffeinated tea use and cigarette smoking revealed no significant differences ($P_s > 0.12$). However, participants who drank caffeinated soda daily smoked more frequently ($\chi^2 = 4.43$, OR = 1.23, $P = 0.028$, 95% CI = 1.02-1.47; Nagelkerke $R^2 = 0.04$) than those participants who did not drink soda daily and were 6 times more likely to be daily cigarette smokers ($\chi^2 = 8.83$, OR = 5.78, $P = 0.002$, 95% CI = 1.92-17.46; Nagelkerke $R^2 = 0.08$). Daily soda drinkers also smoked cigarettes in greater quantities ($\chi^2 = 4.19$, OR = 1.76, $P = 0.033$, 95% CI = 1.05-2.96; Nagelkerke $R^2 = 0.04$) than those participants who did not drink caffeinated soda beverages daily. Examination of the relationship between high risk caffeinated soda

drinking (i.e., 6 or more servings on a typical occasion) and cigarette smoking revealed no significant differences ($p > 0.44$).

Caffeinated Coffee as a Moderator in the Acquisition of Nicotine Dependence

As shown in Table 6, participants who drank coffee daily prior to smoking initiation were not more likely than those who did not drink coffee daily prior to smoking initiation to have progressed to weekly smoking or daily smoking ($P_s > 0.41$).

Table 6.

Effects of Drinking Caffeinated Beverages Daily Prior to Cigarette Smoking Initiation: Moderation in the Likelihood of Progressing to Advanced Stages of Cigarette Smoking

	Odds ratios (95% CI)	
	Likelihood of progressing to weekly smoking	Likelihood of progressing to daily smoking
<i>Caffeinated Beverage:</i>		
Coffee	---	---
Tea	---	---
Soda	2.34*(1.00-5.46)	---

Predictors that were not statistically significant were not presented in table.

* $P < 0.05$

As shown in Table 7, among participants who progressed to weekly smoking, drinking coffee daily prior to smoking initiation predicted a more rapid progression from initiation to weekly cigarette smoking ($\chi^2 = 5.98$, $OR = 0.53$, $P = 0.026$, $95\% CI = 0.297-0.927$; Nagelkerke $R^2 = 0.14$). Regarding participants who progressed to daily smoking, drinking coffee daily prior to smoking initiation predicted a more rapid progression from

initiation to daily smoking ($\chi^2 = 4.93$, OR = 0.561, P = 0.04, 95% CI = 0.323-0.974; Nagelkerke $R^2 = 0.13$).

Table 7.

Effects of Drinking Caffeinated Beverages Daily Prior to Cigarette Smoking Initiation:

Time of Progression from Initiation to Advanced Stages of Cigarette Smoking

	Odds ratios (95% CI)	
	Time of progression to weekly smoking	Time of progression to daily smoking
<i>Caffeinated Beverage:</i>		
Coffee	0.53*(0.30-0.93)	0.56*(0.32-0.97)
Tea	---	---
Soda	---	---

Predictors that were not statistically significant were not presented in table.

* P < 0.05

Caffeinated Tea/Soda as a Moderator in the Acquisition of Nicotine Dependence

As shown in Table 6, participants who drank caffeinated soda daily prior to smoking initiation were more than twice as likely as those who did not drink caffeinated soda daily prior to smoking initiation to have progressed to weekly cigarette smoking ($\chi^2 = 3.94$, OR = 2.34, P = 0.049, 95% CI = 1.00-5.46; Nagelkerke $R^2 = 0.06$); however, they were not more likely to have progressed to daily smoking (Ps > 0.41). Participants who drank caffeinated soda daily prior to smoking initiation did not progress through the process of acquiring a smoking habit more rapidly than those who did not drink soda daily prior to smoking initiation (Ps > 0.22). Participants who drank caffeinated tea daily prior to smoking initiation were not more likely than those who did not drink tea daily

prior to smoking initiation to have progressed to weekly smoking or daily smoking ($P_s > 0.15$). Furthermore, participants who drank tea daily prior to smoking initiation did not progress through the process of acquiring a smoking habit more rapidly than those who did not drink tea daily prior to smoking initiation ($P_s > 0.35$).

Discussion

The present study is one of the first to examine patterns of caffeine and tobacco use concurrently in a sample of college students. Results from this study provide important new information concerning the timing of initiation, prevalence, and concurrent use for two of the most frequently consumed licit psychoactive substances. Use of caffeinated coffee and caffeinated soda was highly prevalent in the present sample. Daily users of caffeinated coffee and daily users of caffeinated soda smoked cigarettes more frequently, were more likely to be daily cigarette smokers, and smoked cigarettes in greater quantities than those who did not consume caffeinated coffee or caffeinated soda daily. We found that daily use of caffeinated coffee prior to smoking initiation predicted a more rapid progression from smoking initiation to more advanced stages of cigarette smoking. Additionally, participants who drank caffeinated soda daily prior to smoking initiation were more likely to have progressed to advanced stages of cigarette smoking. To our knowledge, this is the first study to find a relationship between cigarette smoking and drinking caffeinated soda beverages. This study may also be the first to find that early and regular use of caffeinated beverages moderates the acquisition of tobacco dependence in humans. The findings reported here should be understood in terms of prevention because caffeinated beverages are the only licit psychoactive substances available to children and adolescents.

We found significant differences in cigarette smoking behavior for participants who used caffeinated coffee daily. As predicted, we found that daily users of caffeinated coffee smoked cigarettes more frequently and in greater quantities than those who did not

use caffeinated coffee daily. Participants who used coffee daily were 7 times more likely to be daily cigarette smokers. These findings lend support to previous studies showing an association between coffee drinking and cigarette smoking (Matarazzo, 1984; Swanson et al., 1994; Bernstein et al., 2002). We also found that daily drinkers of caffeinated soda smoked cigarettes more frequently and in greater quantities than those who did not use caffeinated soda daily. Daily users of caffeinated soda beverages were 6 times more likely to be daily cigarette smokers. To our knowledge, this is the first study to report an association between soda drinking and cigarette smoking. We found no relationship between daily caffeinated tea drinking and cigarette smoking. Although associations between tea drinking and cigarette smoking have been investigated with mixed results in prior studies (e.g., Gilbert, 1979; Prineas et al., 1980), the lack of effect reported here may be due to the very small number of participants in this sample who used caffeinated tea daily (4%). We cannot imply causation from the associations found between caffeinated coffee/soda drinking and cigarette smoking behavior; however, the findings reported here highlight a need to further examine whether caffeinated beverages moderate the acquisition of nicotine dependence, particularly soda, due to the large number of children and adolescents who regularly consume caffeinated soda beverages.

Our examination of caffeinated beverages as potential moderators in the acquisition of a cigarette smoking habit yielded significant findings. We found that daily use of caffeinated coffee prior to smoking initiation predicted a more rapid progression from smoking initiation to more advanced stages of cigarette smoking. Furthermore, we found that participants who drank caffeinated soda daily prior to smoking initiation were

more than twice as likely to have progressed to advanced stages of cigarette smoking. Together, our findings suggest that *early and regular use of caffeinated coffee and soda may put one at risk of progressing to advanced stages of cigarette smoking.*

The present study extends previous animal and human research suggesting that daily caffeine use potentiates the reinforcing effects of nicotine. Shaoib and colleagues (1999) utilized animal models and demonstrated that consumption of caffeine by rats resulted in striking changes in the reinforcing properties of nicotine. First, the ability of rats to acquire nicotine self-administration was accelerated, thereby requiring fewer sessions to meet criteria when compared to water-drinking controls. Second, a greater percentage of caffeine-drinking rats met the acquisition criteria when compared to water-drinking controls. Indeed, we found in this human sample that consuming caffeinated beverages daily accelerated the acquisition of a cigarette smoking habit and predicted a greater likelihood of progressing to advanced stages of cigarette smoking. Human studies also suggest that caffeine can potentiate the reinforcing effects of nicotine. Jones and Griffiths (2003) found that in a drug versus money measure of reinforcement participants were willing to pay significantly more money to receive a dose of intravenous nicotine in the caffeine maintenance phase than in the caffeine abstinence phase. Furthermore, during caffeine maintenance, intravenous nicotine produced significantly higher ratings of drug effect, stimulated, rush, liking, and good effect when compared to intravenous nicotine during caffeine abstinence, the direction of these effects suggesting enhancement of positive effects of nicotine. Finally, compared to caffeine abstinence, intravenous nicotine during caffeine maintenance significantly decreased

ratings of bad effects. Our results taken in combination with the aforementioned animal and human research studies suggest that caffeine has the ability to potentiate the reinforcing properties of nicotine and may influence the trajectory (i.e., acquisition) of nicotine dependence in humans. Elucidating the possible neurochemical changes that may be responsible for caffeine's apparent ability to potentiate the reinforcing properties of nicotine is beyond the scope of this study, however, animal studies suggest an increased sensitivity of mesolimbic dopamine transmission following chronic exposure to caffeine (see Tanda & Goldberg, 2000; Horger, 1991).

Although the findings presented here are consistent with theory and previous studies, and have important public health implications, some limitations should be noted. Few participants in this study smoked cigarettes daily (8%). Some associations that did not reach statistical significance may have reached significance if the sample had a greater prevalence of daily cigarette smokers. The fact that our sample was derived from a cohort of college students may limit the generalizability of the findings presented here. A further limitation of this study is that it was retrospective.

This study offers new and valuable information on the concurrent use of caffeinated beverages and cigarettes. Regular use of caffeinated coffee and regular use of caffeinated soda was associated with increased cigarette smoking behavior. Moreover, early and regular use of caffeinated coffee and caffeinated soda moderated the acquisition of later cigarette smoking behavior. Our findings suggest that caffeine may have the ability to alter the addictive potential of cigarettes, thereby highlighting a need to further examine this possibility. If early and regular use of caffeine facilitates the acquisition of

tobacco dependence, then regular caffeine use in youth may be a factor in later acquisition of a cigarette smoking addiction.

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