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Bidis—hand-rolled, Indian cigarettes: Effects on physiological, biochemical and subjective measures

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Abstract

Bidis, hand-rolled cigarettes imported from India, have become increasingly popular among US teenagers. These cigarettes are perceived as a safer, more natural alternative to conventional cigarette smoking. The present study was conducted to determine whether the acute effects of bidis and conventional cigarettes are similar. Undergraduate cigarette smokers with a history of bidi smoking were tested in two experimental sessions, using a within-subject design. Subjects smoked both a bidi and a conventional cigarette. Physiological and biochemical measures, subjective evaluations, and smoking behavior characteristics were obtained before, during, and after smoking each experimental cigarette. Although time to smoke and puffs per cigarette were significantly higher after the bidi, physiological and biochemical effects of bidi smoking were similar to those of smoking conventional cigarettes. Bidis were rated less satisfying than the conventional cigarette. However, there were no significant differences between the cigarettes in other subjective measures. Our results do not support the belief that bidis are a safe alternative to conventional cigarettes. Furthermore, bidi smoking, like conventional cigarette smoking, may lead to nicotine dependence. © 2002 Elsevier Science Inc. All rights reserved.

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1. Introduction

An estimated 60 million Americans were cigarette smokers in 1998 (U.S. Department of Health and Human Services [DHHS], 1999). Although most US smokers choose to smoke domestically produced, filtered cigarettes, there has been a recent rise in the popularity of bidis, an alternative cigarette imported from India. Bidis are hand-rolled cigarettes consisting of ground tobacco rolled in a tendu leaf, taken from a broad leafed plant native to India (Yadav and Thakur, 2000). Annual consumption of bidis in India accounts for 40% of the country's total tobacco consumption (World Health Organization). In India, bidis contain no flavoring additives. However, manufacturers have recently begun to produce flavored bidis (i.e., root beer, cherry, cinnamon, strawberry, grape, and raspberry) for distribution overseas including the United States (Fisher, 2000). A survey conducted on urban teenagers in the Boston area, indicated that 40% of teenagers had smoked bidis at least once in their lifetime and 16% were current bidi smokers (Centers for Disease Control and Prevention [CDC], 1999). In addition, approximately 13% of the teenagers surveyed said they smoked bidis because they believed them to be safer than commercial cigarettes (CDC, 1999). In a US national sample, 5% of high school students and 2.4% of middle school students reported bidi smoking in the past month (CDC, 2000). Adolescents and teens smoke bidis because they are cheaper, easier to buy, and are perceived to be safer than conventional cigarettes (CDC, 1999; Fisher, 2000).

Although teens may perceive bidis as a safe alternative to conventional cigarettes, there are health risks associated with bidi smoking. Several toxic constituents derived from bidi smoke have been identified. Bidi smoke, like conventional cigarettes, contains phenol, hydrogen cyanide, and

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benzo(*a*)pyrenes (Pakhale et al., 1990) and total particulate matter, a measure directly related to the amount of carcinogenic material (Mishra and Shaikh, 1984). Nair et al. (1989) identified carcinogenic tobacco-specific nitrosomines from the smoke of bidis in concentrations similar to those of conventional cigarettes. In addition, blood carboxy-hemoglobin levels were elevated in bidi smokers (Behera et al., 1991a) and these levels were correlated with the number of bidis smoked (Behera et al., 1991b). These and other factors appear responsible for higher risks of hypertension, coronary heart disease (Gupta et al., 1995), oral (specifically tongue and floor of mouth) (Sankaranarayanan et al., 1989), stomach (Gajalakshmi and Shanta, 1996), and lung (Dikshit and Kanhere, 2000) cancers among bidi smokers. Furthermore, the concentration of nicotine in the tobacco of bidi cigarettes is greater than that of conventional cigarettes. The Massachusetts Department of Health found that although the total amount of nicotine is less, bidis contained concentrations of nicotine three times the amount found in a filtered, conventional cigarette (CDC, 1999). Malson et al. (2001) reported that 11 out of 12 bidis contained higher nicotine concentrations than an unfiltered conventional cigarette.

The present study was designed to compare the acute effects of smoking a bidi (Sher bidi) and a conventional cigarette on physiological, biochemical, subjective measures, and smoking behavior. This study is similar in format to that of Malson et al. (2002); however, recruitment was limited to a population of undergraduate students, more similar in age and smoking history to those of teenage bidi users (DHHS, 1994). This study also extends the existing data on bidi smoking behavior, such as how it is held and how many times it must be relit to continue burning.

2. Methods

2.1. Participants

Volunteers ($N=12$; 9 females and 3 males) responded to advertisements in the college community and by word of mouth. Participants were cigarette smokers who had smoked at least one bidi. Subjects signed an informed consent document, approved by the local Institutional Review Board, indicating their willingness to participate in the study. Demographics on participants were recorded during the first experimental session. The mean age of the volunteers was 22 years (range 19–26 years). Participants had smoked for 5 years (range 1–9) at an average rate of 10 cigarettes per day (range 2–20). Participants were predominately "light" cigarette smokers, with an average FTC yield of 0.8 mg of nicotine and 11.3 mg of tar. The average score on the revised Fagerström Test for Nicotine Dependence (FTND) was 1.6 (range 0–5) out of 10 possible (Heatherton et al., 1991). Non-menthol smokers represented 75% of the sample vs. 25% menthol smokers. Participants were paid US$30.00 for their participation.

2.2. Design

This was an open-label, within-subject design consisting of two conditions: a Sher bidi and a filtered conventional cigarette. The study consisted of two experimental sessions, at least 1 day apart. In each session, subjects smoked a single cigarette ad libitum. The presentation of the experimental cigarettes was counterbalanced. Subjects were asked to abstain from smoking 45 min prior to the experimental sessions.

2.3. Experimental cigarettes

Sher bidi, an unfiltered bidi cigarette with no added flavoring, was used in the present study. The Sher bidi is smaller in length (60 mm) and diameter (5.7 mm) than conventional cigarettes (85 and 7.7 mm, respectively). The average weight of the Sher bidi was 368 mg, of which 166 mg (45%) was tobacco weight (Malson et al., 2001). The rest of the weight resides in the tendu wrapping. The tobacco of the Sher bidi had a nicotine concentration of 24 mg/g and contained approximately 4 mg of nicotine per cigarette rod (Malson et al., 2001). The conventional cigarettes selected were regular strength: Winston or Marlboro (non-menthol) and Newport and Kool (menthol). In general, conventional cigarettes have an approximate weight of 926 mg including 713 mg (77%) of tobacco weight (Malson et al., 2001). The tobacco of conventional cigarettes had an average nicotine concentration of 18 mg/g and contained approximately 13 mg of nicotine per cigarette rod (Malson et al., 2001). Subjects smoked the same type of cigarette (non-menthol or menthol) but not the subject's usual brand. Thus the two experimental cigarettes were less familiar to the subject than their usual brand.

2.4. Dependent measures

2.4.1. Physiological measures

Systolic and diastolic blood pressure (seated) and heart rate were measured using an automated cardiovascular monitor (Datascope, Paramus, NJ).

2.4.2. Biochemical marker

Exhaled carbon monoxide (CO), a biochemical marker of smoke exposure, was measured before and after smoking. Exhaled CO was measured in parts per million (PPM) with a CO monitor (Vitalograph, Lenexa, KS).

2.4.3. Smoking behavior

The time to smoke and the number of puffs per cigarette were recorded while the subject smoked ad libitum. How the subject held the cigarette was recorded as well.

2.4.4. Subjective measures

After smoking, subjects completed two questionnaires on the cigarette smoking experience (the Duke Sensory Questionnaire; Behm and Rose, 1994, the Duke Cigarette Evaluation Scale; Westman et al., 1992). Both questionnaires are based on an anchored, seven-point Likert scale where 1 = *not at all* and 7 = *extremely*. The Duke Sensory Questionnaire (DSQ) measures characteristics of smoking, such as puff liking, satisfaction, nicotine level, similarity to own brand, and evaluation of puff strength on the tongue, nose, mouth and throat, windpipe, and chest (Behm and Rose, 1994). Ratings for puff strength on tongue, nose, mouth and throat, windpipe, and chest were collapsed to determine an overall measure of puff strength (maximum score = 35; range 7–35) (Malson et al., 2002).

The Cigarette Evaluation Scale (CES) is an 11-item questionnaire that evaluates the smoking experience in terms of satisfaction, good taste, and acute effects of smoking, such as dizziness, calming ability, concentration, wakefulness, reduction of hunger, nausea, reduction of irritability, sensations of the smoke in your throat and chest, and reduction of craving (Westman et al., 1992; Rose et al., 2000). Enjoyment of sensation (sensations in throat and chest) and craving reduction items were analyzed separately. Composites of several items were created to measure satisfaction (satisfaction, good taste), psychological reward (calm, concentration, wakefulness, reduction of hunger, irritability), and aversion (dizziness, nausea), using techniques described by Brauer et al. (1999).

2.5. Procedure

This study was conducted at The College of Notre Dame of Maryland. On each study day, resting heart rate (beats per Minute, bpM), blood pressure, and exhaled CO baseline data were collected. Subjects then smoked either the Sher bidi or conventional cigarette ad libitum. As the subject smoked, smoking behavior variables were recorded. Immediately after the cigarette was extinguished, physiological and biochemical measures were collected and subjective questionnaires on the smoking experience were completed. When the subjects completed both sessions, they were asked which cigarette they preferred more.

2.6. Data analyses

Repeated measures analysis of variance (ANOVA) was used for analyses of physiological and biochemical effects (Winer et al., 1991). Main factors included cigarette condition (bidi and conventional) and time (pre and post). Paired *t*-tests with the Bonferroni correction were used to determine post hoc comparisons when the ANOVA indicated a significant main effect of cigarette, time, or cigarette by time interaction (Winer et al.). Subjective and smoking behavior means (specifically time to smoke and puffs per cigarette) were compared using paired *t*-tests. Data are presented as mean ± S.D.

3. Results

3.1. Physiology and biochemical markers

Heart rate was elevated an average of 11.1 and 15.7 bpm after smoking the Sher bidi and the conventional cigarette, respectively. Heart rate was significantly different as a function of cigarette type [$F(1,11) = 7.803$, $P = .017$] and time [$F(1,11) = 29.850$, $P < .001$] but was not significant in the interaction of cigarette by time. Equivalent boosts in heart rate were seen after smoking either cigarette as determined by paired *t* test post hoc comparisons with the Bonferroni correction. Systolic blood pressure increased an average of 6.7 and 5.4 mmHg for the Sher bidi and conventional cigarette, respectively. Systolic blood pressure differed significantly as a function of time [$F(1,11) = 6.974$, $P = .023$], but not cigarette type or interaction of cigarette and time. Paired *t*- test post hoc comparisons with the Bonferroni correction revealed that changes in systolic blood pressure were not significant in either cigarette condition. Diastolic blood pressure increased by an average of 7.5 and 7.3 mmHg after smoking the Sher bidis and conventional cigarettes, respectively. Diastolic blood pressure differed significantly as a function of cigarette [$F(1,11) = 5.140$, $P = .045$] and time [$F(1,11) = 10.804$, $P = .007$], but there was no significant interaction of cigarette and time. Paired *t* test post hoc tests with the Bonferroni correction indicated that conventional cigarette smoking significantly increased diastolic blood pressure ($P < .025$), whereas smoking the Sher bidi did not. Exhaled CO levels increased an average of 6.2 and 5.7 ppm for the Sher bidi and conventional cigarette, respectively. Analysis of exhaled CO showed a significant difference in time only [$F(1,11) = 65.547$, $P < .001$]. Equivalent boosts in exhaled CO were seen after smoking either cigarette as determined by paired *t* test post hoc comparisons with the Bonferroni correction (Fig. 1).

3.2. Subjective evaluations

The cigarettes differed on satisfaction as rated on the Duke Sensory Questionnaire. Participants rated puffs from the conventional cigarette (5.0 ± 1.1) as more satisfying than puffs from the Sher bidi (4.3 ± 1.4) [$t(11) = -3.084$, $P = .010$]. There were no significant differences between the Sher bidi and the conventional cigarette on the Cigarette Evaluation Scale (Table 1).

3.3. Smoking behavior

Time to smoke was significantly longer for bidis (417.1 ± 180.5 s) than for conventional cigarettes (290 ± 72.8 s) [$t(11) = 3.105$, $P = .010$]. More puffs were taken to consume

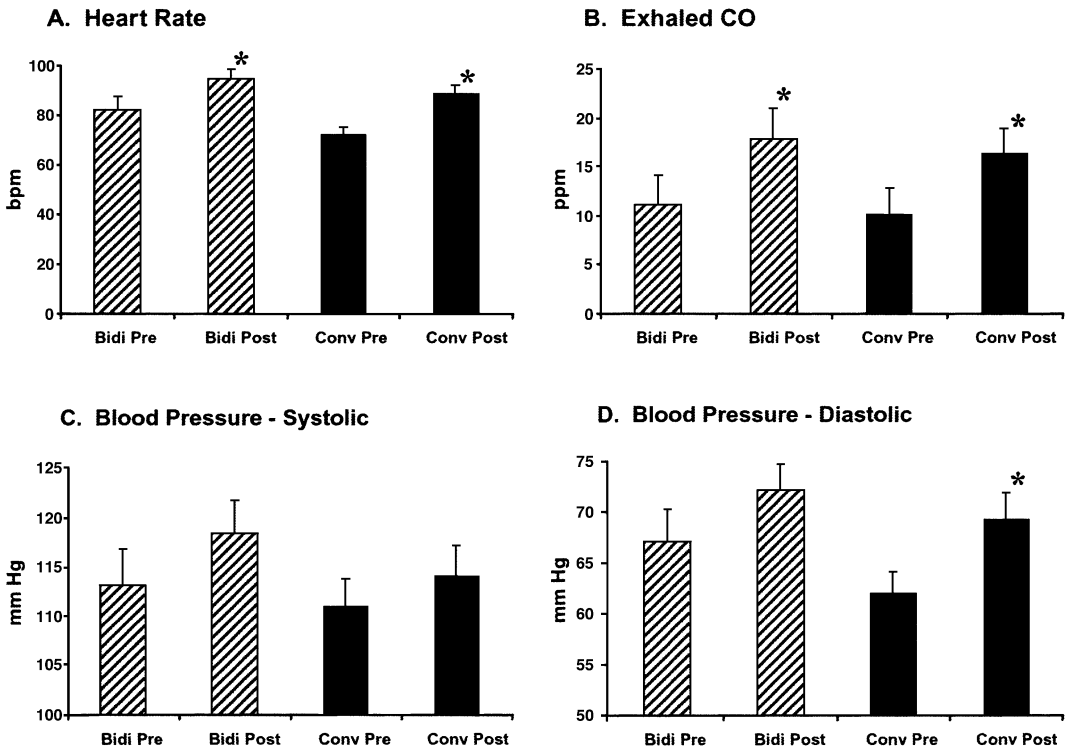

Fig. 1. Physiological and biochemical effects of bidi and conventional cigarette smoking. Paired *t* tests with the Bonferroni correction were used to compare change from baseline within each cigarette condition. * Indicates significant change from baseline ($P < .025$).

the Sher bidi (14.2 ± 5.5) than the conventional cigarettes (9.8 ± 2.7) [$t(11) = 2.252$, $P = .046$]. Several of the participants (5 out of 12) held the bidi between their thumb and index finger, like a marijuana joint is held. Subjects relit the bidis, on average, 1.5 times in order to maintain a lit cigarette (range 0–5).

Table 1
Mean ratings on subjective evaluations of the cigarette smoking experience

		Sher bidi	Conventional cigarette
CES[a]	Satisfaction (maximum score — 14)[b]	8.3 ± 3.4	9.8 ± 2.7
	Enjoyment of sensations	3.3 ± 1.6	3.9 ± 1.6
	Psychological reward (maximum score — 35)[b]	15.1 ± 6.4	17.0 ± 6.3
	Aversion (maximum score — 14)[b]	5.4 ± 3.1	5.5 ± 2.9
	Craving reduction	4.0 ± 2.2	4.4 ± 1.8
DSQ[c]	Liking	4.3 ± 1.4	5.0 ± 1.0
	Satisfaction	4.3 ± 1.6	5.7 ± 0.9 *
	High in nicotine	5.3 ± 1.2	5.4 ± 1.4
	Similar	2.9 ± 1.7	4.2 ± 1.8
	Strength (maximum score — 35)[b]	22.0 ± 8.2	21.0 ± 6.8

Values are mean ± S.D.

[a] The Cigarette Evaluation Scale.

[b] Indicates collapsed values. Unless otherwise indicated, maximum score was 7.

[c] The Duke Sensory Questionnaire.

* Indicates significant difference from conventional brand ($P = .01$).

4. Discussion

The purpose of this study was to compare the physiologic, biochemical, subjective effects, and smoking behavior of bidi and conventional cigarettes in a sample of college-aged smokers. Although the bidis were smoked differently (increased time to smoke and more puffs per cigarette), there were no differences in heart rate, systolic blood pressure, or exhaled CO between the two experimental cigarettes. In addition, bidis have been shown to deliver equal or higher concentrations of nicotine, on average, than conventional cigarettes (Malson et al., 2002). Bidi smoking was expected to equal or increase physiologic and subjective measures of cigarette strength above those found after conventional cigarette smoking. Our findings support the hypothesis that bidi smoking produces effects similar to commercial cigarette smoking.

In general, the smoking experience of the Sher bidi was comparable to the conventional cigarette on both subjective questionnaires, except participants were more satisfied with puffs from the conventional cigarette than the Sher bidi. However, when participants were asked at the end on the study which experimental cigarette they preferred, nearly half of the smokers preferred the bidi to the conventional cigarette. Among US teenagers, the choice to smoke a bidi, as opposed to a conventional cigarette, may rely on factors other than satisfaction. For example, young people may be attracted to the cheaper price, the flavor additives, or the aesthetics of the bidi, which is similar in appearance to a

marijuana joint (Fisher, 2000). Indeed, almost half of the participants of the present study held the bidi like a joint (hand-rolled marijuana cigarette), with the index finger and thumb.

The smoking history of the current sample of young adults is similar to that of adolescents: both groups smoked approximately 10 cigarettes per day, compared to 19 cigarettes per day in the adult population (DHHS, 1994). Although adolescents smoke less than adults, symptoms of tobacco dependence can occur within weeks of occasional use (Kandel and Chen, 2000; DiFranza et al., 2000). Current research has speculated that nicotine dependence occurs during the adolescent years due in part to increased sensitivity to nicotine (Zack et al., 2001; DiFranza et al., 2000; Corrigall et al., 2001). Exposure to bidi smoke, differences in smoking behavior (longer smoking time, more puffs), and increased sensitivity to nicotine may lead to an increased risk of dependence among adolescents.

Results from the present study are consistent with previous research where the effects of bidi smoking in older, more experienced smokers were assessed (Malson et al., 2002). In spite of different smoking profiles of the subjects (i.e., dependence levels, smoking history), acute effects of bidis were similar. For example, the increases in heart rate, systolic blood pressure, and exhaled CO levels were equivalent after bidi smoking or conventional cigarette smoking. Therefore, we can infer that our findings may generalize to effects of bidi smoking in adolescents and teenagers.

Even though the time to smoke and the number of puffs taken were higher for consumption of the Sher bidi, bidi smoking has physiologic and biochemical effects similar to those of conventional cigarette smoking. These findings suggest that bidi cigarettes are not a safe alternative to conventional cigarettes. Because smokers often become dependent in their teenage years, it is important to correct the popular notion among some adolescents that bidis are a safe alternative to conventional cigarette smoking.

References

Behera D, Dash S, Dinakar M. Blood carboxy-hemoglobin levels in Indian bidi and cigarette smokers. Respiration 1991a;58:26–8.

Behera D, Dash S, Dinakar M. Correlation of smoking behavior and blood carboxy-hemoglobin in bidi and cigarette smokers. Indian J Chest Dis Allied Sci 1991b;33:43–6.

Behm FM, Rose JE. Reducing craving for cigarettes while decreasing smoke intake using capsaicin-enhanced low-tar cigarettes. Exp Clin Psychopharmacol 1994;2:143–53.

Brauer LH, Behm FM, Westman EC, Patel P, Rose JE. Naltrexone blockade of nicotine effects in cigarette smokers. Psychopharmacology 1999;143: 339–46.

Centers for Disease Control and Prevention. Bidi use among urban youth — Massachusetts, March–April, 1999. MMWR 1999;48:796–7.

Centers for Disease Control and Prevention. Tobacco use among middle and high school students — United States, 1999. MMWR 2000;49:49–53.

Corrigall WA, Zack M, Eissenburg T, Belsito L, Scher R. Acute subjective and physiological responses to smoking in adolescents. Addiction 2001;96:1409–17.

DiFranza JR, Rigotti NA, McNeill AD, Ockene JK, Savangeau DS, Coleman M. Initial symptoms of nicotine dependence in adolescents. Tob Control 2000;9:313–9.

Dikshit RP, Kanhere S. Tobacco habits and risk of lung, oropharyngeal and oral cavity cancer: a population-based case-control study in Bhopal, India. Int J Epidemiol 2000;29:609–14.

Fisher L. Bidis- the latest trend in US teen tobacco use. Cancer Causes Control. 2000;11:577-8.

Gajalakshmi CK, Shanta K. Lifestyle and risk of stomach cancer: a hospital based case-control study. Int J Epidemiol 1996;25:1146–53.

Gupta R, Sharma S, Gupta VP, Gupta KD. Smoking and alcohol intake in a rural Indian population and correlation with hypertension and coronary heart disease prevalence. J Assoc Physicians India 1995;43:253–8.

Heatherton TF, Koslowski LT, Frecker RC, Fagerström KO. The Fagerström Test for Nicotine Dependence: a revision of the Fagerström Tolerance Questionnaire. Br J Addict 1991;86:1119–27.

Kandel DB, Chen K. Extent of smoking and nicotine dependence in the United States: 1991–1993. Nicotine Tob Res 2000;2:263–74.

Malson JL, Pickworth WB, Murty R, Sims K, Mangena M. Comparison of the nicotine content of tobacco used in bidis and conventional cigarettes. Tob Control 2001;10:181–3.

Malson JL, Lee EM, Moolchan ET, Pickworth WB. Nicotine delivery from smoking bidis and an additive-free cigarette. Nicotine Tob Res 2002 (in press).

Mishra UC, Shaikh GN. Total particulate matter in cigarette and bidi smoke. Sci Total Environ 1984;37:213–22.

Nair J, Pakhale SS, Bhide SV. Carginogenic tobacco-specific nitrosomines in Indian tobacco products. Food Chem Toxicol 1989;27:751–3.

Pakhale SS, Jayant K, Bhide SV. Chemical analysis of smoke of Indian cigarettes, bidis and other indigenous forms of smoking — levels of steam — volatile phenol, hydrogen cyanide and benzo(*a*)pyrene. Indian J Chest Dis Allied Sci 1990;2:75–81.

Rose JE, Behm FM, Westman EC, Johnson M. Dissociating nicotine and non-nicotine components of cigarette smoke. Pharmacol, Biochem Behav 2000;67:71–81.

Sankaranarayanan R, Duffy SW, Day NE, Nair MK, Padamakumary GA. Case-control investigation of cancer of the oral, tongue and the floor of mouth in southern India. Int J Cancer 1989;44:617–21.

U.S. Department of Health and Human Services, 1994. Preventing tobacco use among young people: a report of the surgeon general. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

U.S. Department of Health and Human Services, 1999. 1998 National Household Survey on Drug Abuse [on-line]. www.samhsa.gov/PRESS/99/990 18fs.htm.

Westman EC, Levin ED, Rose JE. Smoking while wearing the nicotine patch: is smoking satisfying or harmful? Clin Res 1992;40:871–80.

Winer BJ, Brown DR, Michels KM. Statistical Principles in Experimental Design. 3rd ed. Boston, MA: McGraw Hill, 1991.

World Health Organization. Tobacco or health: a global status report. Centers for Disease Control and Prevention. www.cdc.gov/tobacco/who/india.htm.

Yadav JS, Thakur S. Cytogenic damage in bidi smokers. Nicotine and Tobacco Research 2000;2:97-103.

Zack M, Belsito L, Scher R, Eissenburg T, Corrigall W. Effects of abstinence and smoking on information processing in adolescent smokers. Psychopharmacology 2001;153:249–57.