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Rapid Smoking of Menthol and Nonmenthol Cigarettes by Black and White Smokers

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**Department of Psychiatry and Biobehavioral Sciences †Department of Psychology and §Department of Public Health, School of Medicine, UCLA, Los Angeles, CA 90073 ‡Veterans Administration Medical Center-West Los Angeles, Brentwood Division, 691/B151D, Los Angeles, California 90073*

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CASKEY, N. H., M. E. JARVIK, W. J. McCARTHY, M. R. ROSENBLATT, T. M. GROSS AND C. L. CARPENTER. *Rapid smoking of menthol and nonmenthol cigarettes by black and white smokers.* PHARMACOL BIOCHEM BEHAV 46(2) 259–263, 1993.—White subjects took significantly more puffs of cigarette smoke before stopping than did black subjects in a modified, controlled-dose rapid smoking procedure. Paradoxically, however, no racial differences were detected for changes in carbon monoxide levels, or changes in cardiovascular variables (systolic and diastolic blood pressure, and heart rate). Due to the cooling and topical anesthetic properties of menthol, it was hypothesized that menthol and regular cigarette smokers would take more puffs from menthol cigarettes than from regular cigarettes before stopping in the controlled-dose rapid smoking procedure. However, no difference was observed for the number of puffs taken from regular as opposed to menthol cigarettes (cigarette type condition) and no differences were found for Cigarette Preference (regular smokers vs. menthol smokers).

Rapid smoking Cigarettes Menthol Carbon monoxide Race Heart rate Blood pressure

THERE is a striking difference between black and white smokers in preference for menthol vs. regular cigarettes in the United States. Approximately 70% of black smokers prefer menthol cigarettes while only approximately 25% of white smokers prefer menthol (3,20). Cigarette flavor preference (menthol vs. regular) is highly associated with race. This observed racial difference in cigarette flavor preference may partly result from or partly cause marked differences in racial targeting of advertising for menthol vs. regular cigarettes (3). Other significant racial differences between black and white smokers have been reported (3,17,18,19,20) with regard to the average number of cigarettes smoked per day and age of onset of smoking. Black smokers smoke fewer cigarettes per day and begin smoking later than white smokers. Paradoxically, black smokers have been reported to have higher cotinine levels than white smokers despite black smokers' self-reported lower daily cigarette consumption relative to white smokers (20).

Menthol is but one of thousands of flavoring agents used by manufacturers in cigarettes, but it is the only one that is used by advertisers and smokers to differentiate between brands. Menthol, a topical anesthetic (1) with cooling effects (5,8), could possibly affect several smoking topography dimensions; for example, puff volume and/or puff duration (16).

The present study is an extension of a previous experiment of aversive thresholds (14) in which smokers smoked their own cigarettes in a modified rapid smoking procedure, inhaling 40 cc of smoke delivered by a controlled-dose smoke delivery system at 15-s intervals. In the previous study, regular and menthol cigarette smokers rapid-smoked their own brand of cigarettes until they could no longer continue in two separate trials conducted at a 1-week interval. In the current study, black and white menthol and regular smokers smoked experimenter-supplied menthol and regular cigarettes in a cross-over design with a "regular" trial (regular cigarettes only) and a "menthol" trial (menthol cigarettes only).

It was hypothesized that both types of smokers (regular and menthol) would take more puffs from menthol cigarettes than from regular cigarettes before reaching their aversive threshold or stopping point in the rapid smoking procedure because of the cooling and anesthetic effects of menthol. The cooling and anesthetic properties of menthol were hypothesized to decrease unpleasant peripheral sensations associated with rapid smoking (6). It was also predicted that menthol smokers would take more menthol puffs than regular smokers

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and similarly that regular smokers would take more regular puffs than would menthol smokers because of their respective cigarette type preferences. The design was constructed to examine possible different responses of black and white smokers to the rapid smoking paradigm employed in this study.

METHOD

Design

A repeated-measures cross-over design was used in which two groups of subjects (regular smokers and menthol smokers) (RS and MS) participated in a modified rapid smoking procedure in two sessions. In one session, subjects smoked regular cigarettes (RC) and in the other, they smoked menthol cigarettes (MC). Order of participation in the RC and MC trials was counterbalanced in both groups of smokers (RS and MS) such that half of each group smoked regular cigarettes in the first trial and the other half smoked menthol cigarettes in the first trial.

Subjects

Two independent groups of male cigarettes smokers were recruited from a 21-day inpatient drug and alcohol treatment program at the West Los Angeles Veterans Administration Medical Center. One group (n = 12) characterized themselves as predominantly menthol cigarette smokers and the other group characterized themselves as predominantly nonmentholated (regular) cigarettes smokers (n = 16). Inclusion criteria stipulated that subjects smoke a minimum of 15 cigarettes per day, had smoked for at least 1 year, and had no significant physical health problems; for example, cardiovascular or respiratory disease. Subjects were paid $10/h for study participation.

Eight of the 16 regular smokers were black and 8 were white. Nine of the menthol smokers were black, while only three of the menthol smokers were white. Recruiting white menthol smokers was particularly difficult because of the generally low prevalence of menthol preference among the population of white male smokers (3,12,17,18,19,20) and also because of the predominantly black racial composition of the ward population from which subjects were recruited.

The two cigarette preference (smoker type) groups (RS vs. MS) did not differ significantly with regard to demographic variables, smoking habits, and smoking history. For the total sample (n = 28), the mean age was 39.3 years (s = 6.8), the mean number of years of education was 13.0 (s = 1.8), the mean number of years smoked was 22.1 (s = 7.6), and the mean Fagerstrom Dependence score was 7.2 (s = 1.4). There was no difference between the two smoker groups on self-reported depth of inhalation on a 4-point scale (response range: 1 = "not at all" to 4 = "very deeply") (M = 2.8, s = 0.5).

There was a significant difference between the white and black subjects on the mean number of cigarettes smoked per day ($t(26) = 4.37, p < 0.001$). white subjects reported smoking more cigarettes per day than did black subjects (whites: M = 32.7, s = 12.1; blacks M = 17.4, s = 6.4). This difference is consistent with previously reported racial differences based on either national or larger regional samples (3, 12,17,18,19,20). A significant racial difference was also observed for number of years smoked ($t(26) = 2.84, p < .01$) with white subjects (M = 26.6, s = 4.7) reporting longer smoking careers than black subjects (M = 19.2, s = 7.7). white subjects also had significantly ($t(23) = 2.40, p < 0.05$) higher Fagerstrom Dependence scores than black subjects (M = 8.0, s = 1.3 vs. M = 7.0, s = 0.8). There was a nonsignificant trend ($t(26) = 1.64, p = .11$) for the white subjects to be older than the black subjects (M = 41.8, s = 4.1 vs. M = 37.6, s = 7.7). The significant difference in mean number of years smoked between white and black subjects was maintained when age was used as a covariate.

Procedure

Subjects participated in two experimental sessions, conducted 1 week apart. In the initial session, subjects completed an informed consent form and a questionnaire regarding demographic information and information regarding their physical health, smoking habits, and smoking history. Subjects also completed the Fagerstrom Tolerance Questionnaire (4). After the subjects completed the questionnaires, the experimenters collected a breath sample to determine their baseline carbon monoxide levels. Baseline cardiovascular data (systolic and diastolic blood pressure and heart rate) were then collected three times at 1-min intervals while subjects were seated and were measured with an automated blood pressure and heart rate monitor (IBS Corporation, SD-700A).

After completion of the baseline data collection, subjects underwent a modified rapid smoking procedure using a controlled-dose smoke delivery system described in a previous study (14). In this procedure, subjects were asked to inhale 40 cc of cigarette smoke manually withdrawn from the cigarette via a syringe. Each puff was drawn from the cigarette for 2 s. Subjects were then asked to inhale each puff completely into their lungs. Subjects were given puffs at 15-s intervals and were asked to inhale as many puffs as they could until they could no longer continue. Subjects rated each puff on two dimensions: pleasantness-unpleasantness and the degree to which each puff made them feel weak and/or faint. Immediately after subjects said they wished to terminate the smoking session, their blood pressure and heart rate were measured as in the baseline data collection. An additional breath sample was also obtained to determine postprocedural carbon monoxide levels.

In this modified rapid smoking procedure, subjects inhaled puffs from commercially available menthol and regular cigarettes selected for near equivalence in 1991 FTC ratings of tar, nicotine, and carbon monoxide delivery (Marlboro king filter soft pack: nicotine delivery = 1.2 mg, tar = 17 mg, CO = 15 mg; Salem king filter menthol soft pack: nicotine delivery = 1.2 mg, tar = 17 mg, CO = 17 mg). Near equivalence in FTC ratings was sought to minimize differences in the two cigarette conditions (RC and MC) which could be attributable to differences in nicotine, tar, and/or carbon monoxide, rather than to mentholated versus. nonmentholated cigarette smoke.

Carbon monoxide ratings/determinations were obtained by having subjects inhale to fill their lungs, hold their breath for 30 s, exhale a small amount of air, and then exhale 500 cc into a Travenol intravenous bag. The breath sample from the Travenol bag was then fed into an Ecolyzer (Energetics Science Inc.), which had been calibrated with carbon monoxide of a known concentration.

RESULTS

Aversive Threshold Reliability

In the total sample (n = 28), the correlation of the total number of puffs taken in the regular trial with the number of

puffs taken in the menthol trial was high ($r = 0.74$, $p < 0.001$) indicating that the subjects had reliable stopping points in the modified rapid smoking procedure across cigarette types. The intertrial correlation in this experiment is significantly lower ($z = 2.03$, $p < 0.05$) than that obtained in a previous study (14) of the same modified rapid smoking procedure ($r = 0.96$). However in that study, all subjects smoked their own preferred brands in both trials.

Stopping Point

A significant racial difference was observed for average number of puffs taken for both trials with white smokers taking significantly more puffs to reach the stopping point than blacks (white smokers: $M = 51.7$, $s = 29.9$; black smokers: $M = 32.6, s = 18.1; t = 2.11, p < 0.05$).

Because of the disproportionately small number of subjects ($n = 3$) in the white menthol cell, this cell was excluded from the analyses. Instead, a series of one-way repeated measures ANOVAs were conducted with three groups: white regular smokers, black regular smokers, and black menthol smokers. To examine possible simple main effects of Race and Cigarette Preference, planned contrasts were conducted. The simple main effect of race was tested by contrasting the white regular and black regular subjects and the simple main effect of Cigarette Preference was tested by contrasting the black regular with the black menthol Subjects. Type of Cigarette (regular vs. menthol) and Pre-Post measures were used as repeated factors and combined with the two between-subjects contrasts in the following analyses.

Using this data analytic approach, the contrast between white and black regular smokers for number of puffs taken before stopping showed a significant "simple main effect" ($F(1, 22) = 8.89$, $p < 0.01$). Using number of puffs to stopping as the dependent variable, no significant effects were obtained using this model for cigarette preference within black smokers, the repeated type of cigarette factor (RC vs. MC), or the interactions of the contrasts with the repeated type of cigarette factor.

A paired comparison t-test yielded no difference between the mean number of puffs taken with regular cigarettes and those taken with menthol cigarettes. The nearly identical means (RC: $M = 40.5$, $s = 27.8$ vs. MC: $M = 39.7$, $s = 25.3$) indicate that the central hypothesis of the experiment was not confirmed. Mentholated cigarette smoke did not allow subjects to take a greater number of puffs in the modified rapid smoking procedure. The observed effect size was miniscule ($d = 0.03$) (2). For this paired comparison, the current study did have adequate power (>0.80) with $n = 28$ to detect a large effect size ($d = 0.74$ one-tailed, 10 puffs) which we had expected based on previous research (15).

Physiological Variables

Increases in carbon monoxide levels, systolic and diastolic blood pressure, and heart rate were expected to result from the modified rapid smoking procedure consistent with previous studies of traditional rapid smoking (9,13,15). The means for subjects' pre- and postcarbon monoxide levels, systolic and diastolic blood pressure, and heart rate are presented in Table 1.

For carbon monoxide, there was a highly significant increase following rapid smoking ($F(1, 22) = 106.19$, $p < .0001$). For the total sample, significant correlations were obtained between number of puffs to stopping and carbon monoxide change scores (postscore minus prescore) for both types of cigarettes (RC: $r = 0.66$; MC; $r = 0.67$). However, the interaction between the simple effect for race and the repeated pre-post effect was not significant despite the fact that the white regular smokers took a significantly greater number of puffs in both the regular cigarette condition ($t(1,14) = 2.42$, $p < .05$) and in the menthol cigarette condition ($t(1, 14 = 2.60$, $p < 0.05$) (see Fig. 1). With carbon monoxide change as the dependent variable, the contrast for cigarette preference within the black subjects was not significant, nor were any other effects in this model.

Using the same analytic model (three group one-way ANOVA with planned contrasts to test simple main effects), no significant effects were observed for systolic blood pressure, though there was a nonsignificant trend ($p = 0.08$) for systolic blood pressure to increase with the rapid smoking procedure (pre-post effect). Neither of the contrasts (race with regular subjects and cigarette preference within black subjects) nor the repeated type of cigarette factor were significant. For diastolic blood pressure, a significant repeated pre-post factor effect was obtained ($F(1, 21) = 14.69$, $p = .001$). As with the findings for systolic blood pressure, neither of the contrasts (race with regular subjects and cigarette preference within black subjects) nor the repeated type of cigarette factor were significant.

The results for heart rate also yielded a significant pre-post effect ($F(1, 22) = 56.66$, $p < 0.0001$) indicating that the rapid smoking procedure increased the heart rate. The interaction between the pre-post factor and the contrast for the race effect among the regular smokers showed a trend ($p = 0.06$) for greater increases in heart rate among the black regular smokers than among the white regular smokers. The contrast for the effect of cigarette preference within black subjects interacted significantly ($F(1, 21) = 4.18$, $p < 0.05$) with the pre-post factor reflecting greater increases in heart rate for the black regular smokers than for the black menthol smokers.

The pre-post increases in cardiovascular measures and in carbon monoxide are consistent with previous research on the cardiovascular effects of rapid smoking with the traditional 6-s interval between puffs (9,13,15) indicating that the controlled-dose rapid smoking procedure used here has similar effects despite the longer interpuff interval in this study relative to "traditional rapid smoking" (15 s vs. 6 s).

DISCUSSION

The contrasting findings that the black regular smokers took significantly fewer puffs for both types of cigarettes relative to white regular smokers, but did not have significantly different changes in carbon monoxide, systolic or diastolic blood pressure are intriguing. The lack of difference between the two groups is particularly interesting in light of the high correlation observed between the number of puffs and carbon monoxide change scores. These conflicting findings are consistent with the reported observation (20) of higher cotinine levels among blacks despite self-reported lower amount of daily smoking. Several possible physiologically related pathways for the reported black-white cotinine disparity (20) have been suggested (10); for example, possible differences in lung mixed-function oxidases stemming from dietary differences. It has been suggested (11) that the higher levels of cotinine in black smokers who smoke less per day than white smokers with lower cotinine levels may be an artifact of differences in self-reporting. Self-report bias, however, cannot explain the current experimental data. The volume of smoke obtained by smokers in the rapid smoking procedure in this study was

TABLE 1

MEAN PHYSIOLOGICAL LEVELS PRE- AND POST RAPID SMOKING PROCEDURE FOR REGULAR AND MENTHOL CIGARETTES (TYPE CIGARETTE) BY RACE (BLACK VS. WHITE) AND CIGARETTE PREFERENCE (REGULAR VS. MENTHOL)

	Race					
	White			Black		
	Mean	SD	Change	Mean	SD	Change
Carbon monoxide*						
Regular smokers						
Regular cigarette pre	28.5	(10.2)		20.9	(7.1)	
Regular cigarette post	43.3	(10.6)	14.8	31.9	(7.0)	11.0
Menthol cigarette pre	24.9	(10.0)		22.9	(6.9)	
Menthol cigarette post	41.9	(10.6)	17.0	33.0	(9.2)	10.1
Menthol smokers						
Regular cigarette pre				22.2	(6.4)	
Regular cigarette post				33.8	(7.6)	11.6
Menthol cigarette pre				22.7	(5.7)	
Menthol cigarette post				41.1	(9.0)	18.4
Systolic Blood Pressure†						
Regular Smokers						
Regular cigarette pre	120.1	(10.4)		119.9	(13.9)	
Regular cigarette post	123.0	(6.9)	2.9	124.1	(11.7)	4.2
Menthol cigarette pre	121.2	(13.3)		122.8	(14.3)	
Menthol cigarette post	123.9	(15.3)	2.7	125.3	(10.0)	2.5
Menthol smokers						
Regular cigarette pre				119.2	(7.5)	
Regular cigarette post				120.5	(6.8)	1.3
Menthol cigarette pre				119.9	(8.7)	
Menthol cigarette post				122.2	(8.6)	2.3
Diastolic Blood Pressure†						
Regular smokers						
Regular cigarette pre	77.7	(8.4)		78.5	(10.7)	
Regular cigarette post	83.6	(6.6)	5.9	82.0	(6.3)	3.5
Menthol cigarette pre	78.4	(8.8)		79.0	(10.2)	
Menthol cigarette post	81.9	(8.3)	3.5	84.9	(11.6)	5.9
Menthol smokers						
Regular cigarette pre				75.7	(11.8)	
Regular cigarette post				77.7	(7.1)	2.0
Menthol cigarette pre				72.9	(12.9)	
Menthol cigarette post				77.4	(9.7)	4.5
Heart Rate†						
Regular smokers						
Regular cigarette pre	78.2	(10.1)		78.8	(12.0)	
Regular cigarette post	83.7	(12.1)	5.5	85.1	(11.9)	6.3
Menthol cigarette pre	76.8	(11.4)		75.5	(7.8)	
Menthol cigarette post	82.0	(12.3)	5.2	87.7	(11.8)	12.2
Menthol smokers						
Regular cigarette pre				78.4	(10.8)	
Regular cigarette post				81.5	(13.3)	3.1
Menthol cigarette pre				79.6	(11.4)	
Menthol cigarette post				84.0	(10.2)	4.4

*White regular smokers: $n = 8$; Black regular smokers: $n = 8$; Black menthol smokers: $n = 9$.
†White regular smokers: $n = 8$; Black regular smokers: $n = 8$; Black menthol smokers: $n = 8$.

verifiable by the experimenters and not dependent on self-report.

Contrary to our hypothesis, type of cigarette (menthol vs. regular) had no discernible effect on the number of puffs that subjects took before they stopped in the rapid smoking procedure. The rapid smoking procedure used here may account for the lack of difference between number of puffs to stopping with regular and menthol cigarettes for the entire sample. Rapid exposure to repeated doses of menthol via rapid smoking may have cumulative effects, which may then attenuate

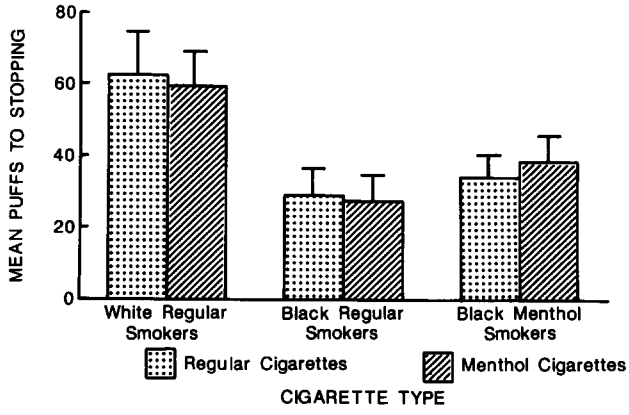

FIG. 1. Number of puffs to stopping by cigarette type, cigarette preference, and race.

menthol's cooling and anesthetic properties. The 15-s interval between puffs here is considerably shorter than the typical 40-s interval (19) observed in topographical studies of subject paced smoking.

Green's (7) work indicates the complexity of the oral perceptual effects of menthol. In one experiment (7), he reported that mentholated solutions above oral temperature felt significantly warmer than a control solution of deionized water when sipped and held in the mouth for 5 s. In the same experiment, mentholated solutions below oral temperature enhanced sensations of coolness. In a follow-up experiment (7), pretreatment with a mentholated solution for 5 min increased cold enhancement, but "attenuated sensations of warmth", while pretreatment for 10 min resulted in cold enhancement and disattenuation of sensations of warmth. Green later (8) reported that prolonged exposure to menthol ("several min") inhibits the perception of warmth "over the range of temperatures between the threshold for warmth and the threshold for heat pain" (p. 837). He also noted (8) that exposing subjects to high concentrations of menthol resulted in marked burning sensations as well as cooling. The shorter interpuff interval in the current study may have raised buccal temperatures in this study thereby reducing the cooling effect of menthol, resulting in no difference between the regular and menthol cigarette conditions in the number of puffs to stopping.

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