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BRIEF COMMUNICATION

Detection of Vent-Blocking on Light and Ultralight Cigarettes

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PILLITTERI, J. L., A. C. MORSE AND L. T. KOZLOWSKI. *Detection of vent-blocking on light and ultralight cigarettes.* PHARMACOL BIOCHEM BEHAV **48**(2) 539–542, 1994.—Trained raters can reliably identify vent-blocking in ultralight cigarettes based on tar stain patterns, yet detection of this phenomenon has not been previously studied in light cigarettes. This study was conducted to extend the research on vent-blocking in ultralight cigarettes to the much more popular light cigarettes. We wanted to find out if individuals could discriminate among stain patterns on cigarette butts with unblocked (0%), partially blocked (50%), and fully blocked (100%) vents using both light and ultralight cigarettes. Subjects were able to use the stain pattern technique to detect vent-blocking in light cigarettes as well as ultralight cigarettes.

Cigarettes Smoking Tobacco Hole blocking Light cigarettes Ultralight cigarettes

APPROXIMATELY 26% of the adult population in the United States smokes cigarettes regularly (1). For various reasons, including pressure to quit smoking and reduction in health risks, many smokers have turned to "light" (9–12 mg tar) and "ultralight" (1–4 mg tar) cigarettes which have lower tar, nicotine, and carbon monoxide yields than "regular" high-tar (18–20 mg tar) cigarettes. Lower yield cigarettes depend on the presence of air-dilution vents on the filters (rings of small, sometimes invisible perforations around the filter). These vents cause inhaled cigarette smoke to be diluted from 16% to 80% with ambient air (8), thereby decreasing not only the amount of smoke per puff but also the tar, nicotine, and carbon monoxide yields.

Data on cigarette sales indicates that about 2.5 times more smokers use lights than ultralights (2,4). Ultralight cigarettes are diluted with air to a greater extent (i.e., 70% to 80%) than are light cigarettes (16% to 30%), yet changes in smoking behavior can overcome this air-dilution effect for both types of cigarettes. Previous studies have shown that behavioral blocking of the filter vents with the fingers, lips, or tape is a means of overcoming the air-dilution effect and consequently leads to increases in the standard yields of toxic substances (5,6,11). By blocking the filter vents to any degree, inhaled cigarette smoke is less diluted with ambient air as it passes through the filter, thereby increasing the levels of toxins in cigarette smoke.

Vent-blocked cigarette filters produce a characteristic tar stain pattern on the end of the cigarette butt (5,7) which aids in the detection of this behavior. Unblocked cigarettes produce a distinct tar stain in the center of the filter surrounded by unstained white filter. Fully blocked cigarettes produce a uniform tar stain reaching to the edge of the filter. Trained raters can reliably identify vent-blocking in ultralight cigarettes (3,7) based on the scoring procedure described by Kozlowski (3), yet the use of this technique has not been studied in light cigarettes.

Previous research with ultralight cigarettes has demonstrated that some smokers engage in vent-blocking (3,6). To date, no data exists on the prevalence of vent-blocking on light cigarettes. Studies of intentional vent-blocking of ultralight cigarettes have shown that carbon monoxide levels increase significantly as the degree of vent-blocking increases from 0% to 50% to 100% (5,11). Thus, actual smoke exposures from ultralight cigarettes can be equivalent to or even exceed those from high-tar cigarettes.

This study was intended to extend the research on vent-

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blocking to light cigarettes. We wanted to determine if individuals could discriminate among stain patterns on cigarette butts with unblocked (0%), partially blocked (50%), and fully blocked (100%) vents using both light and ultralight cigarettes. This research examines whether the scoring procedure previously discussed is equally applicable for light and ultralight cigarettes.

METHOD

Subjects

Two males and four females volunteered to participate in this study. Subjects were recruited through an advertisement requesting volunteers to participate in a research project involving the visual discrimination of cigarette butts on the basis of tar stain patterns. Subjects were paid $5.00 for participation in the study, which required one hour of time.

Cigarettes

Marlboro Lights® and Winston Ultra lights® were used to study four vent-blocking conditions (0%, 50%, 50–100%, and 100%). Three cigarettes of each brand were used in each condition for a total of 24 total cigarettes. Four additional cigarettes (2 of each brand) were randomly assigned to each of the vent-blocking conditions. These 4 were used as controls to provide examples of the four conditions to the raters prior to the actual rating task.

Unaltered cigarettes were used in the unblocked (0%) condition. In the partially blocked (50%) condition, 50% of the cigarette vents were blocked by placing two 6 × 13-mm pieces of cellophane tape opposite to one another over the filter vents. In the condition referred to as the partially–fully blocked condition (50–100%), cigarettes were prepared in a different manner. Initially, these cigarettes were blocked 50% and smoked for 5 puffs. Following these 5 puffs, the cigarettes were then fully blocked and smoked for the final 5 puffs. This vent-blocking condition was included to determine the tar stain pattern that would be produced by this style of blocking and how raters would score these cigarette butts. In the fully blocked (100%) condition, a 30 × 13-mm piece of tape was used to cover all of the filter vents.

All cigarettes were artificially smoked using a 35-cc syringe. Cigarettes were attached to the syringe and smoke was extracted at 30-s intervals for a total of 10 extractions. After all 24 cigarettes had been smoked, the filters were sliced approximately 9 mm above the end of the cigarette butt and fixed in a black rubber holder so that only the end of the tar-stained filter was visible to the raters. Subjects were not aware that two different brands of cigarettes were used or that the filter vents had been artificially blocked with tape.

Scoring Procedure

Cigarette filters were scored using a three-level scale: 0 = little or no tar stain around the outside edge of the filter, yet a distinct tar stain in the center of the filter; 1 = light to moderate tar stain spreading to about 50% of the outside edge of the filter with a noticeably darker center stain; and 2 = uniform tar stain spreading to about 90% or more of the outside edge of the filter. Based on this scoring procedure, unblocked, partially blocked, partially–fully blocked, and fully blocked cigarettes would be correctly scored as 0, 1, 1, and 2, respectively.

Procedure

Subjects were brought into the lab as independent raters and told that their task was to visually examine the 24 random-ordered cigarette butts before them. They were asked to rate each butt on the basis of its tar stain pattern using the scoring procedure previously described. Four sample butts (one representing each of the four vent-blocking conditions) were shown to the subjects and correctly identified by the experimenter prior to the task.

Subjects were provided with rubber gloves to handle the holders containing the butts, a magnifying glass (2× power with 6× power insert) to enhance the image if needed, and a 20-W halogen lamp to improve the lighting. Following trial 1, the 24 cigarette butts were arranged in a second random order and rated again by the subjects. The subjects were told that they were rating the same 24 cigarette butts, although the order of the butts had been changed. Trial 2 was conducted as a reliability check from time 1 to time 2.

RESULTS

Reliability of Ratings

A single butt score was obtained by taking the mean rating or the majority rating of the raters. Using the mean rating, the reliability coefficients for any one rater and all six raters were .73 and .94, respectively [cf. (10)]. For all six raters, the scores were equivalent for lights (.95) and ultralights (.94). The reliability coefficient for the three best raters was .97 (for lights, .98; for ultralights, .96), and for the three worst raters it was .80 (for Lights, .79; for ultralights, .78). For the three best raters, percent agreement was 91.7% for light cigarettes and 77.8% for ultralight cigarettes across both trials. There were no significant differences from trial 1 to trial 2 for any rater.

Validity of Ratings

To evaluate whether this scoring procedure worked differently for lights and ultralights, an analysis of variance (ANOVA) was conducted. The results showed no main effects for brand using either mean scores or majority scores of the three best raters, the three worst raters, or all six raters combined.

Tables 1 and 2 show column percentages for the majority scores of the three best raters for trial 1 as a function of the four vent-blocking conditions. Table 1 represents light cigarettes only, while Table 2 represents ultralight cigarettes.

It can be seen in Table 1 that, overall, light cigarettes were correctly rated, except for one mistake in the unblocked condition. The partially–fully blocked condition was judged to be blocked, but was rated as complete blockade rather than partial blockade. (The tar stain pattern produced by the 50–100% vent-blocking was initially expected to resemble a partially blocked cigarette [i.e., a score of one], but these butts were scored as fully blocked by all raters [i.e., a score of two].) For ultralight cigarettes, Table 2 shows an overall pattern of accurate ratings, with some difficulty rating unblocked and fully blocked cigarette butts. Note that all mistaken ratings were only off by one unit and not grossly in error.

No blocking versus some blocking. To evaluate how accurately the raters could discriminate no blocking (scored as 0)

TABLE 1

COLUMN PERCENTAGES FOR THE MAJORITY SCORES OF THE THREE BEST RATERS FOR TRIAL 1 AS A FUNCTION OF THE FOUR VENT-BLOCKING CONDITIONS: LIGHT CIGARETTES ONLY

		Prepared Cigarettes			
		Unblocked (n = 3)	Half-Blocked (n = 3)	Partially-Fully Blocked (n = 3)	Fully Blocked (n = 3)
Rated score*	0	67%	0%	0%	0%
	1	33%	100%	0%	0%
	2	0%	0%	100%	100%

The percentages based on ns equal to 3 are constrained to only four possible scores (0%, 33%, 67%, and 100%). *Refers to the raters' scores based on the three-level scale described in the Methods section.

from any degree of blocking (scored as 1), partially (n = 6) and fully (n = 12) blocked cigarettes were combined into one group and compared with unblocked (n = 6) cigarettes.

Contingency tables were obtained to calculate percent agreement by blocking condition (i.e., unblocked vs. partially or fully blocked) for the three best raters. All three raters were more accurate in identifying cigarettes blocked to any degree (100% agreement across both trials) compared to unblocked cigarettes (69.5% agreement across both trials).

The majority scores of the three best raters were used to calculate the sensitivity and specificity of the scoring procedure in detecting unblocked versus blocked cigarettes. These results were calculated using 2 × 2 contingency tables which identified four groups of cigarettes: 1) unblocked cigarettes scored as 0 (the true-positives), 2) blocked cigarettes scored as 0 (the false-positives), 3) unblocked cigarettes scored as 1 (the false-negatives), and 4) blocked cigarettes scored as 1 (the true-negatives). The sensitivity and specificity of the scoring procedure were determined for trial 1, trial 2, and both trials combined for the three best raters. The scoring procedure had a sensitivity (or true-positive rate) of 67%, 67%, and 80% for trial 1, trial 2, and both trials combined, respectively. The specificity levels (or true-negative rates) were all 100%. These results, in addition to the percent agreement calculations, indicate that blocked cigarettes were correctly identified more often than unblocked cigarettes.

The majority scores for trial 1 of the three best raters were also used to calculate the sensitivity, specificity, and positive predictive value of the scoring procedure in detecting unblocked versus blocked light and ultralight cigarettes. In the analysis using light cigarettes (n = 12) only, the sensitivity was 67%, specificity was 100%, and positive predictive value was 100%. The same results, respectively, were obtained in the analysis using ultralight cigarettes (n = 12).

DISCUSSION

The results clearly demonstrate that in addition to ultralight cigarettes, the scoring procedure can be used to detect vent-blocking in light cigarettes. The three best raters in this study could reliably distinguish between unblocked and blocked filter vents for both light and ultralight cigarettes. It is reasonable to assume that raters who are specifically trained to detect vent-blocking using this same procedure will perform as well or better than these untrained raters. However, questions may arise concerning whether the accuracy of vent-blocking detection will differ for artificially or machine-smoked cigarettes and human-smoked cigarettes. One study (7) found that accuracy did not differ for machine- and human-smoked cigarettes.

The point of this research was not to demonstrate how well anyone would perform in discriminating among cigarette butt stain patterns, but how well this technique worked with the best raters. Given the small number of cigarette butts in each condition, one mistake in the ratings (e.g., in Tables 1 and 2, one out of three wrong in the unblocked condition) will have

TABLE 2

COLUMN PERCENTAGES FOR THE MAJORITY SCORES OF THE THREE BEST RATERS FOR TRIAL 1 AS A FUNCTION OF THE FOUR VENT-BLOCKING CONDITIONS: ULTRALIGHT CIGARETTES ONLY

		Prepared Cigarettes			
		Unblocked (n = 3)	Half-Blocked (n = 3)	Partially-Fully Blocked (n = 3)	Fully Blocked (n = 3)
Rated score*	0	67%	0%	0%	0%
	1	33%	100%	0%	33%
	2	0%	0%	100%	67%

The percentages based on ns equal to 3 are constrained to only four possible scores (0%, 33%, 67%, and 100%). *Refers to the raters' scores based on the three-level scale described in the Methods section.

a dramatic impact on the percentage correct. Since our sample of butts was small (e.g., only three light and three ultralight butts in each vent-blocking condition), we cannot provide a sensitive estimate of the ultimate accuracy of these ratings with a larger sample of butts.

The partially-fully blocked cigarettes (50–100%) were used in this study in order to determine the stain pattern that would be produced and how that stain pattern would be scored by raters. In general, all raters detected vent-blocking in those cigarettes which were scored as fully blocked. The stain pattern produced did in fact resemble a fully blocked cigarette, although all vents were blocked for only half the time that the cigarettes were smoked. Other variations on vent-blocking (e.g., blocking half the vents for 7 puffs then all vents for 3 puffs or partially blocking different vents on the cigarette for all 10 puffs) may produce slightly different stain patterns that would be more difficult to categorize as either partially or fully blocked. This finding argues for the use of a two-level blocking scale (no blocking vs. some blocking) [cf. (6)], but the possible advantages of a three-level scale should be explored empirically.

This study demonstrated that the scoring procedure was reliable for light cigarettes. Interestingly, no data exists on the prevalence of vent-blocking on light cigarettes, although more lights are sold than ultralights. According to 1987 Federal Trade Commission (FTC) market share figures, 27.6% of the cigarettes sold were 10–12 mg tar or less (i.e., the light range), while only 10.0% were 6 mg tar or less (2). Therefore, vent-blocking may influence many more smokers than previously thought. If the prevalence of vent-blocking is higher in light than in ultralight cigarettes, then the public health significance would be even greater. The stain pattern technique should be a useful tool in the exploration of how smokers smoke light cigarettes.

Future studies should assess the effects of partial and complete vent-blocking of light cigarettes on tar and nicotine delivery. Using the work by Parker and Montgomery (8), we can estimate standard yields as established by smoking-machine results. Calculations indicate that a light cigarette (9–12 mg tar) can increase in standard yield from 19% (unblocked) to 59% (fully blocked) depending on the extent to which filter ventilation was originally present.

The effects of vent-blocking of light cigarettes on human smoke exposure have not been studied. Estimates of human smoke exposure vary in comparison to estimates of standard yields as established by smoking machines. Human smoke exposure is subject to wide variability due to many factors, including how a cigarette is smoked (i.e., puff volume, velocity, and number of puffs) and individual differences in pharmacokinetics (9). It is hoped that this stain pattern technique will be used in human exposure studies that make use of biochemical indicators of smoke exposure.

REFERENCES

1. Centers for Disease Control. Cigarette smoking among adults—United States, 1990. MMWR 41:354–362; 1990.
2. Federal Trade Commission. Report to Congress: Pursuant to the federal cigarette labelling and advertising act. 1990:50.
3. Kozlowski, L. T. Prevalence of the misuse of ultra-low-tar cigarettes by blocking filter vent. Am. J. Public Health 78:694–695; 1988.
4. Kozlowski, L. T. Evidence for limits on the acceptability of lowest tar cigarettes. Am. J. Public Health 79:198–199; 1989.
5. Kozlowski, L. T.; Frecker, R. C.; Khouw, V.; Pope, M. A. The misuse of 'less hazardous' cigarettes and its detection: Hole-blocking of ventilated filters. Am. J. Public Health 70:1202–1203; 1980.
6. Kozlowski, L. T.; Heatherton, T. F.; Frecker, R. C.; Nolte, H. E. Self-selected blocking of vents on low-yield cigarettes. Pharmacol. Biochem. Behav. 33:815–819; 1989.
7. Lombardo, T.; Davis, C. J.; Prue, D. M. When low tar cigarettes yield high tar: Cigarette filter ventilation hole blocking and its detection. Addict. Behav. 8:67–69; 1983.
8. Parker, J. A.; Montgomery, R. T. Design criteria for ventilated filters. Beitr. Tabakforsch. Int. 10:1–6; 1979.
9. U.S. Department of Health and Human Services. The health consequences of smoking: The changing cigarette. A report of the Surgeon General. U.S. Department of Health and Human Services, Public Health Service, Office on Smoking and Health. DHHS Publication No. (PHS) 81-50156, 1981.
10. Winer, B. J. Statistical principles in experimental design. New York: McGraw-Hill; 1971.
11. Zacny, J. P.; Stitzer, M. L.; Yingling, J. E. Cigarette filter vent blocking: Effects on smoking topography and carbon monoxide exposure. Pharmacol. Biochem. Behav. 25:1245–1252; 1986.