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Shedding 'light' on cigarette pack design: color differences in product perceptions, use, and exposure following the U.S. descriptor ban.

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Abstract

Introduction: Many countries removed misleading descriptors (e.g., "light," "mild") from cigarette packaging because they falsely conveyed messages of reduced risk. It is unclear if re-labeled products currently promote misperceptions or differences in product use and toxicant exposure. We compared product perceptions, use, and exposure between a U.S. sample of Marlboro Gold (formerly "light") and Red smokers.

Methods: 240 non-treatment-seeking adult daily Marlboro smokers (70% male, 71% White, mean cigarettes/day = 16.4 [*SD* = 8.3]) completed two laboratory sessions over a 5-day period. During sessions, participants smoked two cigarettes through a topography device to capture their puffing behavior, provided pre- and post-cigarette carbon monoxide (CO) assessments, and completed risk perception and subjective rating questionnaires. Self-reported cigarettes/day were verified via daily filter collection; urine collected at the end of the period was assayed for nicotine metabolites.

Results: Gold (n = 49) smokers were more likely than Red (n = 191) to incorrectly believe their cigarettes had less nicotine and tar than regular cigarettes (*p*'s <.001), and rated them as weaker, less harsh, and mild tasting (p's <.05). Differences between Red and Gold smokers in cigarettes/day and puffing behaviors trended toward significance (*p*'s <.1). Notably, there were no group differences on CO boost or total nicotine equivalents (*p*'s >.2).

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Competing interests

All authors have no conflicts of interest to declare.

Conclusions: Misperceptions about nicotine and tar exist years after rebranding Marlboro Lights as Marlboro Gold. Biological results support that Gold smokers do not have lower toxicant exposure. The U.S. should consider comprehensive packaging or product design regulations to properly inform smokers of product risks.

Keywords

packaging and labeling; advertising and promotion; nicotine; public policy; smoking topography

INTRODUCTION

Although its prevalence is declining,[1] combustible cigarette smoking remains the leading cause of preventable death worldwide.[2] To further reduce tobacco use and related disease, many countries have adopted legislation to enact stronger regulations on tobacco products, including the 2009 Family Smoking Prevention and Tobacco Control Act (FSPTCA) in the U.S.[3] and the World Health Organization's Framework Convention on Tobacco Control (FCTC) in other countries.[4] Provisions of both the FSPTCA and the FCTC allowed for the removal of misleading descriptors (e.g., "light," "mild," "low [tar]") from cigarette packaging and advertising,[3,4] as these terms explicitly and/or implicitly convey inaccurate messages of lower risk.[5] Brands affected by the descriptor ban, however, retained all other marketing and design features. When descriptors were banned in the U.K., perceived benefits of light cigarettes decreased initially, but afterward rebounded slightly.[6] Years after the U.S. enacted a similar ban, it is unknown whether these products mislead consumers about health risks or impact product use and toxicant exposure.

For decades, the tobacco industry used "light," "mild," "low [tar]," and other misleading terms to exploit smokers' health concerns about cigarettes.[5] Cigarettes labeled with these descriptors were marketed as having lower nicotine and tar yield based on a flawed and now abandoned testing method that determined exposure to cigarette constituents using machine-generated puffing behavior, not actual human smoking behavior.[5] In real-world use, design features on light and low-tar products (e.g., ventilation) allow smokers to adjust their puffing behaviors and extract similar or greater levels of nicotine and toxicants compared to "full-flavor" cigarettes, ultimately resulting in similar disease risk.[5,7] As such, nicotine and tar yields stated on cigarette packages and advertisements were poor indicators of actual exposure, yet the industry continued to deceive consumers and maintain sales by marketing these products as healthier alternatives to full-flavored varieties.[8,9]

When tobacco manufacturers were prevented from using misleading descriptors in cigarette labeling and advertising, they took several actions to preserve implicit messages about reduced risk. Many brands enacted color-coding schemes, in which "light" or "ultra-light" products were renamed with colors implicitly conveying the same level of health risk, such as blue, gold, or silver (e.g., Marlboro Lights became Marlboro Gold).[10,11] Retailers were provided with flyers detailing these changes to easily redirect consumers to the previous product labeling system.[12] Onserts affixed to packages also reassured smokers that nothing about their brand would change despite forthcoming federally-required packaging changes (although in the U.S., the Food and Drug Administration eventually required that

brands discontinue the use of onserts).[13] Thus, although the intent of removing misleading descriptors was to correct misperceptions, the industry recognized that other components of the cigarette package (e.g., color) could communicate health risk messages[14] and minimize the policy's effects.

Unsurprisingly, studies[6,15,16] conducted soon after misleading terms were banned found little effect on improving smokers' knowledge of product risks. Using four waves of data from the International Tobacco Control Policy Evaluation (ITC) Four-Country Survey, Borland and colleagues found that perceived benefits of light cigarettes in the U.K. decreased immediately following the country's descriptor ban, but only to levels similar to those in the U.S. where no policy change occurred. Further, at a subsequent wave, those perceptions rebounded slightly.[6] Similarly, after the U.S. banned misleading terms, Falcone and colleagues found that fewer than half of light cigarette smokers recruited for an in-person study were aware that any changes had occurred to the packaging of their brand.[15]

Despite having several product lines affected by various countries' descriptor bans over the past 15 years, Marlboro remains the most popular cigarette brand globally and in the U.S. [17] Given that Marlboro Gold (formerly Lights) packaging has changed little aside from removing the word "light," and that the cigarettes themselves have remained unchanged, it is plausible that smokers still choose this sub-brand for perceived health benefits. However, there have been no studies since those conducted immediately after the descriptor ban addressing whether Marlboro Gold cigarettes still mislead consumers about health risks in the absence of the "light" label or previously stated nicotine and tar yields. Further, there is little data objectively characterizing smoking behaviors and toxicant exposure among current Gold smokers. Research on this specific sub-brand is critical, as Marlboro Gold Kings were the top-selling cigarette pack in U.S. convenience stores in 2018 [18]. Additionally, marketing tactics employed by Marlboro to boost sales are likely to be replicated by other brands striving to match Marlboro's popularity.

This study examined differences in product perceptions, smoking behaviors, and exposure between Marlboro Gold and Red smokers participating in a 5-day baseline period of a randomized trial of cigarette packaging. Because Gold cigarettes have retained both their design (i.e., filter ventilation) and packaging features other than the "light" descriptor, we hypothesized that consistent with prior research,[5–7,16,19] Gold smokers would be more likely to: endorse false perceptions of health risks about their cigarettes,[20–22] subjectively rate their cigarettes as lighter/weaker[23]; engage in compensatory smoking behaviors (smoke more cigarettes per day and/or puff more intensively)[24,25]; and have toxicant exposure levels similar to Red smokers.[26]

METHODS

Sample and design

Participants were 240 non-treatment-seeking daily adult smokers who completed a 5-day baseline period of a larger randomized trial of cigarette packaging (ClinicalTrials.gov Identifier: NCT02301351). Smokers were recruited from the Philadelphia area from

October 2014 to February 2019 using digital and print media advertisements and through contacting former participants. Smokers were excluded if they reported: drinking > 25 alcohol-containing drinks/week; using other nicotine-containing products; current/planned cessation program enrollment; a serious/unstable medical condition or substance abuse disorder in the past 12 months; pregnancy and/or lactation; or if they provided a breath alcohol concentration reading > 0 or carbon monoxide (CO) sample < 5 ppm during their initial visit. Those eligible were aged 21–65 and reported smoking ≥ 5 filtered non-menthol cigarettes/day (CPD), smoking regularly for ≥ 5 years, and smoking either Marlboro Gold or Red cigarettes (irrespective of length) > 80% of the time.

Sample rationale—We recruited Marlboro smokers because Marlboro is the leading cigarette brand worldwide and domestically, commanding 43% of both the U.S. [27] and the greater Philadelphia area markets in 2018 (unpublished analysis of regional Nielson Scan Track data[28]). Limiting recruitment to smokers of one brand helped ensure that observed differences are not attributed to other features that vary between brands, enabling us to conduct a more focused comparison of packaging and marketing effects. Analyzing baseline data collected at the onset of our randomized trial allowed us to comprehensively characterize the perceptions, use behaviors, and exposure of Marlboro Red and Gold smokers when using their own brand.

Procedures—Initial eligibility was determined via telephone interview. Those eligible attended an initial laboratory visit at the University of Pennsylvania to provide written informed consent and confirm eligibility. During this visit, participants were required to physically bring a pack of their own cigarettes to confirm that they were Marlboro Gold or Red smokers. They completed assessments of demographics, medical and smoking history, and product risk perceptions. They also smoked two cigarettes (separated by 45 minutes) through a topography device to capture their puffing behavior, provided CO samples before and after, and provided subjective ratings after smoking each cigarette. Participants returned 5 days later, repeated all but consent and eligibility procedures, and provided a urine sample later analyzed for biomarkers of nicotine exposure. Between visits, participants collected spent cigarette filters in date-labeled re-sealable plastic bags to assist in tracking self-reported daily smoking.[29–32] Those who completed all requirements during the baseline period were compensated up to $75 and continued onto the primary study protocol. The university Institutional Review Board approved all procedures.

Measures

Demographics and smoking history—Demographics included participants' age, gender, race, ethnicity, and highest completed education level. Smoking history included preferred brand characteristics (e.g., variety/strength [referred to hereafter as "brand"], length, mentholation), self-reported CPD assessed using the question "In the past 7 days, how many cigarettes did you smoke per day?," and nicotine dependence assessed using the Fagerström Test for Nicotine Dependence (FTND). [33]

Product perceptions—Perceived risks of using participants' preferred brand relative to "regular" cigarettes were assessed with an 8-item scale.[34–37] Each item was rated on a

5-point response scale: 1 = “definitely not true”, 2 = “not true”, 3 = “unsure”, 4 = “true”, 5 = “definitely true.” Because few smokers endorsed the “definitely true” option, responses were collapsed into three categories: 1 = “not true”, 2 = “unsure, 3 = “true.” Based on extant research,[5] we scored the “not true” and “true” responses, respectively, as “correct” and “incorrect.”

Subjective ratings were assessed using a 14-item, 100 mm visual analog cigarette characteristic rating scale.[36,38,31] Scale anchors were item-specific (e.g., for the “Strength” item: 0 = “Very weak”, 100 = “Very strong”). Lower scores indicated more negative ratings, except for draw and smoke harshness items that were reverse scored.

Smoking behaviors—CPD was assessed via self-report, verified by spent filters collected for all cigarettes smoked throughout the 5-day baseline period.[30–32] Puffing behavior was captured using the handheld, portable Clinical Research Support System (CReSS) topography device (Borgwaldt, KC; Richmond, VA) to provide per cigarette estimates of total puff volume (total amount of smoke inhaled), mean puff volume (average amount of smoke inhaled per puff), puff count (number of puffs taken), duration (average length of each puff), interpuff interval (average length between puffs), and maximum velocity (greatest velocity captured during a puff).[30–32] Consistent with our previous work,[30–32] total puff volume was the primary measure of puffing behavior, as it assesses total smoke intake from a single cigarette while accounting for other behavioral changes (i.e., compensation; e.g., increasing puff number or duration).

Nicotine and tobacco exposure—Biomarkers of nicotine exposure were urinary-derived measures that assessed nicotine; its primary metabolite, cotinine; and 3-hydroxy-cotinine, the primary metabolite of cotinine. These measures were summed to provide an estimate total nicotine equivalents (TNE), as recent research indicates the molar sum of these three metabolites predicts nicotine intake as the molar sum of nicotine and its six metabolites.[39]

CO assessed at the onset of each session provided a measure of daily tobacco exposure, while the difference in assessments taken before and after each cigarette smoked in the laboratory, or CO boost, was used to measure smoke exposure from a single cigarette.[30–32]

Data analyses

Analyses were conducted using IBM SPSS Statistics v26. Unpaired t- and χ^2 tests, respectively, compared continuous and categorical variables by study completion status and Marlboro preferred brand group. We used the mean for outcomes assessed repeatedly over the baseline period (e.g., CO, CPD), and included only full study days when computing mean daily cigarette consumption.[30,31] Given unequal group sizes within our sample (i.e., n = 191 vs 49), we report corrected *t*-values for analyses violating Levene’s test for equal variances; χ^2 tests are robust against unequal groups.

RESULTS

Sample characteristics

Participants, on average, were 42.8 years old (*SD* = 10.9), reported smoking 16.4 CPD (*SD* = 8.3) over the past 7 days, and were moderately to heavily nicotine dependent (*M* = 5.4, *SD* = 2.2). The majority were male (68.3%) and non-Hispanic (95.0%); 71.3% identified as White and 43.3% had completed some college or technical training as their highest level of education. The majority smoked Marlboro Red cigarettes (79.6%) and smoked king-sized/regular length (60.8%).

Compared to Gold smokers (n = 49), Red smokers (n = 191) were marginally more likely to be male, χ^2 (1) = 3.6, p = .059, and significantly more likely to have a high school education/GED or less as their highest completed education level, χ^2 (1) = 9.6, p = .002. There were no differences by preferred brand on age [t (238) = −1.2, p = .232], race [χ^2 (1) = .001, p = .975], ethnicity [χ^2 (1) = 0.6, p = .452], CPD [t (238) = 0.1, p = .937], years smoking [t (238) = 1.2, p = .227], or nicotine dependence [t (237) = 0.9, p = .348].

Primary outcomes

Product perceptions—As shown in Table 1, Gold (vs. Red) smokers were more likely to endorse incorrect or unsure responses to perceptions that their cigarettes contained less nicotine [χ^2 (2) = 72.0, p < .001] and less tar [χ^2 (2) = 68.3, p < .001] than regular cigarettes. No other items differed by preferred brand.

As illustrated in Table 2, Gold (vs. Red) smokers rated their cigarettes as weaker [t (86.5) = 3.1, p = .002], less harsh [t (238) = 2.5, p = .014], more mild [t (238) = 2.1, p = .033], having less harsh smoke [t (238) = −2.4, p = .019], and having weaker smoke [t (238) = 2.2, p = .026]. Mean ratings for all other items were not statistically different between groups [t (238)'s = −1.8 to 1.6, p's =.079 to .999].

Smoking behaviors—Although not statistically significant, we observed that Gold smokers smoked marginally more CPD during the baseline period compared to Red smokers [t (238) = −1.7, p = .091]; see Table 2. There were no differences by preferred brand on total puff volume, [t (238) = −0.6, p = .496], the primary puffing behavior measure. However, Gold (vs. Red) smokers had shorter mean interpuff interval [t (238) = 2.1, p = .039] and marginally, but not significantly, shorter mean puff duration [t (238) = 1.8, p = .077]. There were no group differences in mean puff volume [t (238) = 0.7, p = .488], puff number [t (238) = −1.5, p = .152], or peak puff velocity [t (238) = −0.6, p = .538]. Thus, although there were some statistically significant differences between Gold and Red smokers on secondary puffing measures, these did not collectively result in differences in total volume, the primary measure.

Nicotine and tobacco exposure—Importantly, there were no statistically significant differences between Red and Gold smokers on either mean session onset CO [t (61.2) = −1.1, p = .255] or CO boost [t (238) = 1.6, p = .102], as seen in Table 2. There were also no differences on individual nicotine metabolites (i.e., nicotine [t (238) = −0.2, p = .879],

cotinine [t (61.7) = −0.3, p = .734], or 3-hydroxycotinine [t (65.1) = −1.4, p = .186]) or total nicotine equivalents [t (65.9) = −1.0 p = .323].

DISCUSSION

This study compared product perceptions, smoking behaviors, and toxicant exposure among a sample of adult, daily Marlboro Gold and Red smokers to determine if cigarettes no longer labeled as “light” still have the potential to mislead consumers. Our hypothesis that Marlboro Gold (v. Red) smokers would hold more false beliefs about their cigarettes was supported for two items regarding the amount of nicotine and tar in their preferred brand. Gold (v. Red) smokers were more likely to be incorrect or unsure that their cigarettes contained less nicotine and tar than regular cigarettes, but did not differ on other risk perception items. It is encouraging that Gold and Red smokers did not differ on beliefs that their cigarettes were healthier or less likely to cause cancer than regular cigarettes as was demonstrated before the descriptor ban.[21,22] It is possible that rebranding Marlboro Lights as Gold successfully corrected some misperceptions about the product. However, the fact that misperceptions exist specifically about nicotine and tar, the two characteristics that were targeted directly by flawed testing methods and that can be evaluated objectively via biomarker assessment, remains concerning. Because Gold cigarettes are no longer labeled as “light” and do not explicitly display either nicotine or tar yield, these findings suggest that these beliefs persist due to remaining marketing and/or product characteristics of the Gold cigarette (e.g., ventilation, white- (vs. cork-) colored filter). While our data do not support that Gold smokers are misled about explicit health risks of their cigarettes, they clearly show that Gold smokers are misled on nicotine and tar product attributes, which may be connected implicitly with health risk perceptions.

Contrary to our hypothesis that Gold smokers would engage in greater smoking behaviors compared to Red smokers, the greater CPD and secondary puffing measures observed among Gold smokers were not statistically different from Red smokers. It is important to note that our sample was comprised of brand-verified, established Marlboro smokers using their own brand that they provided rather than free preferred brand or novel cigarettes supplied by the study (i.e., not a “switching” or first impression study). Thus, this study design has high external validity and these results represent actual smoking behavior of specific sub-brands when used exclusively for years; differences between Red and Gold smokers may be more subtle than have been previously observed when full-flavored smokers are switched to “light” brands, or provided cigarettes free of charge.[40]

Our hypothesis that Gold and Red smokers would have equivalent toxicant exposure was confirmed, as we found no significant differences between groups on either nicotine exposure (assessed via urinary metabolites) or smoke exposure (assessed via CO). Together with the risk perception findings, we provide critical data showing that Marlboro Gold smokers believe their intake of nicotine and tar to be lower from their preferred brand than regular cigarettes, which is factually incorrect, as objective measurements of biological exposure demonstrate no differences between Gold and Red smokers. Further, because use behaviors were comparable between groups, it is not the case that Gold smokers engaged in compensatory behaviors that offset less exposure per cigarette (e.g., smoking more CPD

but with fewer puffs). This finding is important because it illustrates that beliefs about inhaling lower nicotine and tar from Gold (vs. other) cigarettes are demonstrably false and emphasizes a need for additional regulatory actions to correct these misperceptions.

Finally, as hypothesized, Gold smokers provided subjective ratings of their cigarettes consistent with smoking a “light” or “mild” product. Items related to satisfaction and taste did not differ between groups, but Gold (v. Red) smokers endorsed their cigarettes as being weaker/less harsh and having less harsh/weaker smoke. These results likely reflect responses to greater filter ventilation on the Gold cigarettes creating the sensory perception of “smoother” or “weaker” taste,[41] although the present study is unable to disentangle these effects from other characteristics of Gold smokers and their cigarettes (e.g., packaging differences). Given previous research[20,23,42] demonstrating that subjective experiences of a “weak” or “light” tasting cigarette may reinforce false perceptions of product risks, these results may contribute to the differences in perceptions about nicotine and tar content we observed between brands.

Taken together, findings suggest that despite no longer being explicitly labeled as “light,” Marlboro Golds are still associated with perceptions of less nicotine and tar, even though users of these products do not inhale lower levels of these constituents. While Gold smokers did not endorse false explicit perceptions that their cigarettes were healthier or less addictive than regular cigarettes, it is clear that the Gold brand conveys that it has “less” of certain constituents (nicotine and tar), which consumers may implicitly associate with some health benefit, perhaps contributing to the enduring popularity of the Gold sub-brand. Years of exposure to deceptive marketing[8,9] by the industry, in conjunction with product design characteristics that share pro-health connotations (e.g., white filters, ventilation that creates a smoother/lighter taste), are likely responsible for the persistence of misperceptions among this sample of inveterate Gold smokers. More restrictive packaging (e.g., plain packaging or warning labels) or design (e.g., removing filter ventilation) regulations and education campaigns may be needed to inform smokers that their nicotine and tar *exposure*, and consequent disease risk, does not differ between products.

Findings from this study should be viewed with consideration of a few limitations. First, data were collected from a convenience sample of smokers of two sub-brand cigarette varieties from a single U.S. city, although this sample is highly representative of the non-menthol smoking population in Philadelphia and greater U.S. (unpublished analysis of regional Nielson Scan Track data[28]). Second, because we compared group differences during a single 5-day period rather than examine changes before and after the descriptor ban, we cannot determine causality between the descriptor ban and our outcomes. However, given that the descriptor ban went into effect in late 2010, and that our sample reported smoking daily for an average of 26 years (range: 3 – 48) with > 85% reporting smoking daily for at least 10 years, a notable strength of this study is that the majority of our sample was smoking their brand pre-descriptor ban and thus essentially participated in a naturalistic experiment during implementation of the ban. Third, because participants were not randomized to a preferred brand condition, we cannot disentangle whether differences in outcomes may be due to specific marketing (e.g., pack color) or product design (e.g., filter ventilation) features, as they share significant overlap and likely interact

to influence outcomes. Future experimental studies are needed to manipulate these features and determine their unique effects on beliefs and behavior. Fourth, it is possible that risk perception items may not have been specific or nuanced enough to detect differences between Red and Gold smokers. For example, asking whether participants' cigarettes had fewer additives or toxicants instead of the broader term of "chemicals" may have yielded different results. Finally, we assessed only urinary nicotine and exhaled breath CO as our measures of toxicant exposure. Future research may consider utilizing a comprehensive panel of biomarkers[43,44] to provide more rigorous product evaluation.

In summary, U.S. Marlboro Gold smokers reported believing that their cigarettes contain less nicotine and tar than regular cigarettes, despite objectively having the same nicotine and toxicant exposure as smokers of "full-flavor" Marlboro Red cigarettes. Actions taken to correct these misperceptions such as removing the "light" descriptor from Gold cigarette packaging and abandoning previous methods of measuring nicotine and tar content are insufficient. Additional packaging (e.g., plain packaging, graphic warning labels) and product regulations (e.g., removing filter ventilation), as well as education campaigns, may be warranted to accurately convey to Gold smokers that their nicotine intake and ultimate disease risk is similar between cigarette sub-brands.

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What this paper adds

- Years after several countries implemented Article 11 of the Framework Convention on Tobacco Control, the U.S. also removed the term of "light" from Marlboro Gold cigarette packaging to correct consumers' misperceptions about these products.
- This study provides recent experimental data demonstrating that despite removing the "light" descriptor in the U.S., Marlboro Gold smokers believe their cigarettes have less nicotine and tar than regular cigarettes, but in fact have carbon monoxide levels and nicotine exposure equivalent to Marlboro Red smokers.
- Our data suggest that additional regulations to cigarette packaging or to the products themselves are needed beyond simply removing the "light" descriptor to address product misperceptions about nicotine and tar in the U.S.

Table 1.

Participant responses for risk perception items by preferred brand groups.

	Preferred Marlboro Brand					
	Red (n = 191)			Gold (n = 49)		
Risk perception items	Correct (%)	Unsure (%)	Incorrect (%)	Correct (%)	Unsure (%)	Incorrect (%)
1. Your current cigarettes are ***lower in nicotine*** than regular cigarettes.***	69.6	29.8	0.5	24.5	42.9	32.7
2. Your current cigarettes are ***lower in tar*** than regular cigarettes.***	65.4	34.0	0.5	18.4	53.1	28.6
3. Your current cigarettes are ***less addictive*** than regular cigarettes.	79.1	17.3	3.7	71.4	24.5	4.1
4. Your current cigarettes are ***less likely to cause cancer*** than regular cigarettes.	81.7	13.6	4.7	85.7	12.2	2.0
5. Your current cigarettes ***have fewer chemicals*** than regular cigarettes.	71.7	25.1	3.1	65.3	34.7	0.0
6. Your current cigarettes are ***healthier*** than regular cigarettes.	82.2	17.3	0.5	79.6	18.4	2.0
7. Your current cigarettes ***make smoking safer***.	86.9	9.4	3.7	87.8	12.2	0.0
8. Your current cigarettes ***help people quit smoking***.	92.1	7.3	0.5	93.9	6.1	0.0

Note:

* indicates significant χ^2 comparison at p-level < .05,

** = p < .01,

*** p < .001

Table 2.

Mean (± standard error) outcome measures by preferred brand groups.

	Preferred Marlboro Brand	
	Red (n = 191)	**Gold (n = 49)**
Subjective ratings		
Strength **	62.9 (1.4)	54.5 (2.3)
Harshness *	47.1 (1.3)	39.8 (2.6)
Heat	34.7 (1.5)	31.2 (2.9)
Draw	32.7 (1.4)	35.8 (3.0)
Taste (bad/good)	61.9 (1.4)	61.4 (2.3)
Satisfaction	67.7 (1.5)	68.0 (2.9)
Burn rate	54.9 (1.5)	60.7 (2.6)
Taste (mild/not mild) *	47.7 (1.4)	41.2 (2.5)
Too mild	64.7 (1.5)	64.0 (2.8)
Smoke harshness *	62.4 (1.4)	69.7 (2.5)
Aftertaste	49.9 (1.7)	50.8 (3.0)
Staleness	70.9 (1.6)	76.4 (2.5)
Smoke strength *	57.6 (1.5)	50.5 (2.4)
Smoke smell	55.4 (1.6)	55.4 (3.1)
Smoking behaviors		
Daily cigarette consumption	13.1 (0.5)	15.1 (1.2)
Total puff volume (ml)	844.7 (21.6)	878.3 (49.1)
Mean puff volume (ml)	63.2 (1.4)	61.0 (3.2)
Puff number	13.9 (0.3)	15.0 (0.6)
Puff duration (sec)	2.2 (0.0)	2.0 (0.1)
Interpuff interval (sec) *	21.9 (0.6)	19.0 (1.0)
Peak velocity (ml/sec)	47.0 (1.0)	48.4 (2.0)
Biomarkers of exposure		
Nicotine (μg/ml)	2.5 (0.1)	2.5 (0.2)
Cotinine (μg/ml)	4.0 (0.5)	4.2 (0.5)
3-hydroxy-cotinine (μg/ml)	9.5 (0.6)	11.6 (1.4)
Total nicotine equivalents (μg/ml)	15.9 (0.8)	18.0 (2.0)
Onset CO (ppm)	18.3 (0.6)	20.2 (1.6)
CO boost (ppm)	4.8 (0.2)	4.2 (0.3)

Note:

* indicates significant t-test comparison at p-level < .05,

** = p < .01,

*** p < .001