

The impact of flavor descriptors on nonsmoking teens' and adult smokers' interest in electronic cigarettes

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7 **The impact of flavor descriptors on nonsmoking teens' and adult smokers' interest in electronic**
8 **cigarettes**
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Abstract

Introduction:

Smokers switching completely from combustible cigarettes to e-cigarettes are likely to reduce health risk, suggesting that e-cigarettes should be made appealing to adult smokers. However, uptake of e-cigarettes by nonsmoking teens would add risk without benefit and should be avoided. Although e-cigarette flavors may appeal to adult smokers, the concern is that flavors might attract nonsmoking teens.

Methods:

Nonsmoking teens (n=216, ages 13-17, no tobacco in past 6 months) and adult smokers (n=432, ages 19-80, smoking 3+ years; could have used e-cigarettes) were recruited from an Internet research panel. In assessments completed online (May 22 to June 13, 2014), participants indicated their interest (0-10 scale) in e-cigarettes paired with various flavor descriptors. These were mixed (order balanced) with similar flavor offerings for ice cream and bottled water to mask the focus on e-cigarettes and validate the assessment. Mixed models contrasted interest between teens and adults and among adults by e-cigarette history.

Results:

Nonsmoking teens' interest in e-cigarettes was very low (mean 0.41 ± 0.14 [SE] on 0-10 scale). Adult smokers' interest (1.73 ± 0.10), while modest, was significantly higher overall ($p < 0.0001$) and for each flavor (most p -values < 0.0001). Teen interest did not vary by flavor ($p = 0.75$), but adult interest did ($p < 0.0001$). Past-30-day adult e-cigarette users had the greatest interest in e-cigarettes, and their interest was most affected by flavor. Adults who never tried e-cigarettes had the lowest interest, yet still higher than nonsmoking teens' interest ($p < 0.0001$).

Conclusion:

The e-cigarette flavors tested appealed more to adult smokers than to nonsmoking teens, but interest in flavors was low for both groups.

Funding

This work was supported by NJOY, a company that markets electronic cigarettes, but does not make or sell any combustible tobacco products.

Declaration of Interests

All authors work for PinneyAssociates and provide consulting services to GlaxoSmithKline Consumer Healthcare on their stop-smoking medications and to NJOY, Inc. on electronic nicotine delivery systems (ENDS). Dr. Shiffman and Mr. Gitchell also own an interest in a novel nicotine medication in development. The study sponsor was involved in discussion of the study design, but had no role in study execution, data collection, data analysis, or writing of the manuscript, nor did the sponsor review the manuscript prior to submission. The authors have had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analyses.

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INTRODUCTION

The effect of electronic cigarettes (e-cigarettes) on public health is being hotly debated. Although nicotine itself is not harmless, it is known that the harm of smoking overwhelmingly comes from the products of tobacco combustion (U.S. Department of Health and Human Services, 2014). Accordingly, it has been proposed that e-cigarettes have the potential to dramatically decrease the risk to individuals who completely switch to them from smoking combustible cigarettes (Abrams, 2014b; Benowitz, 2014; Cahn & Siegel, 2011; Farsalinos & Polosa, 2014; Polosa, Rodu, Caponnetto, Maglia, & Raciti, 2013). If current smokers switched to nicotine-only products such as e-cigarettes, it is projected that harm would be dramatically reduced (Nutt et al., 2014; Sumner, 2003).

The public health debate, however, centers on the effects on the whole population, which is the standard established in the law that gave the Food and Drug Administration regulatory authority over tobacco (H.R. 1256 -111th Congress, 2009), and this depends heavily on who adopts e-cigarettes (Abrams, 2014b). Uptake of e-cigarettes by individuals who would not otherwise smoke does not decrease risk and could increase it. This could occur if e-cigarette use imposed nicotine-related risks, such as fetal harm during pregnancy (U.S. Department of Health and Human Services, 2014) on individuals not currently subject to them; that is, nonsmokers. A further concern being expressed is that adoption of e-cigarettes by nonsmoking youth who would not otherwise smoke could serve as a “gateway” for them to begin using nicotine and then graduate to smoking of combustible cigarettes (Dutra & Glantz, 2014; Kandel & Kandel, 2014; United States Congress, 2014), though any evidence for gateway effects is highly contested (Abrams, 2014a; Niaura, Glynn, & Abrams, 2014). Nevertheless, there is broad agreement on both sides of e-cigarette issues that it is important to avoid adoption of e-cigarettes by nonsmoking youth (Abrams, 2014b). Thus, the ideal e-cigarette product and promotion would avoid appeal to nonsmoking teens.

At the same time that product features and promotions should avoid appeal to nonsmoking teens, from a public health perspective, an ideal e-cigarette must have high appeal to adult smokers, since its positive impact on public health depends on the extent of its adoption by adult smokers (Sumner, 2003). A product that did not appeal to adult smokers would have little potential for improving public health. The challenge for e-cigarettes is to find a balance between avoiding appeal to nonsmoking teens while appealing to adult smokers, so as to yield a net public health benefit.

A specific issue that touches on this delicate balance is the sale of e-cigarettes with characterizing flavors. Sale of tobacco cigarettes with characterizing flavors (except for menthol) were banned under the law (H.R. 1256 -111th Congress, 2009), because such flavors were thought to attract nonsmoking teens to smoking (Food and Drug Administration, 2009). Indeed, tobacco industry documents point to flavorings as methods for increasing the appeal of cigarettes to youth (Carpenter, Wayne, Pauly, Koh, & Connolly, 2005; Dachille, 2009). In a study examining flavored cigarette use, younger cigarette smokers (ages 17-19) were more likely to report use of flavored cigarettes than were older smokers (ages ≥ 25) (Klein et al., 2008), although it is not clear if they initiated their use of tobacco with flavored cigarettes. Similarly, Delnevo and colleagues reported that youth (12-17) and young adults (18-25) were significantly more likely than adults (26+) to report a usual cigar brand that is flavored

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3 (Delnevo, Giovenco, Ambrose, Corey, & Conway, 2014). College students assigned more favorable
4 expectancies to cigarette advertisements portraying flavored cigarettes (Ashare et al., 2007), but later
5 research (Manning, Kelly, & Comello, 2009) found that the appeal of cigarettes was increased by the use
6 of flavor descriptors only among youth classified as high sensation-seeking. Others (Carton, Jouvent, &
7 Widlocher, 1994) independently found that low sensation-seeking youth are less likely to smoke, raising
8 the question of whether flavors would appeal to nonsmokers.
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11 The concern about flavors in combustible tobacco products has been transferred to e-cigarettes,
12 which are increasingly being offered in a proliferation of flavors, including candy, fruit, drink, and food
13 flavors, in addition to tobacco-related flavors (Zhu et al., 2014). Candy and fruit flavors have come under
14 particular scrutiny, on the assumption that they would be particularly appealing to youth and thus might
15 make e-cigarettes appealing to nonsmoking teens. However, since e-cigarettes are a new and unfamiliar
16 product, and one with many novel characteristics besides flavor, it is not clear what role flavor might
17 play in the appeal of e-cigarettes to nonsmoking teens.
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21 The relevance of flavors in e-cigarettes is only just starting to be examined. Pepper et al.
22 reported that adolescent males' interest in e-cigarettes was not affected when they rated a "flavored e-
23 cigarette" versus just an "e-cigarette," but no specific flavors were tested, just the abstract concept, and
24 only among males (Pepper et al., 2013). Farsalinos and colleagues (Farsalinos et al., 2013) found that
25 flavors were an important aspect of e-cigarette appeal among adult e-cigarette users. Additionally, this
26 survey found that adults generally reported starting use with tobacco-flavored e-cigarettes and
27 switching to other flavors as they transitioned from dual use to complete substitution of e-cigarettes for
28 combustible smoking. Without empirical research, there is no obvious way to identify which particular
29 flavors might be appealing primarily to nonsmoking teens and which flavors appeal differentially and
30 primarily to adult smokers. Such information could inform policy and guide selection of appropriate
31 flavor offerings that appeal to the appropriate population segment (i.e., adult smokers) but not
32 nonsmoking teens.
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36 We conducted this study to test and compare the interest in e-cigarettes offered in a range of
37 flavors between two contrasting groups: nonsmoking teens (in whom e-cigarette use should most be
38 avoided) and adult smokers (in whom e-cigarette use is most likely beneficial). The range tested
39 included tobacco flavors, including menthol, which represent the more common flavors of e-cigarettes;
40 candy flavors, such as bubble gum and gummy bear, which have been specifically called out as having
41 special appeal to children; and a range of other flavors (e.g., pomegranate, vanilla bean, double
42 espresso) that are characteristic of e-cigarette offerings. Participants indicated their interest in e-
43 cigarettes characterized by the various flavor descriptors. Consistent with past research that has studied
44 flavors on the basis of flavor descriptors (Carpenter, Wayne, Pauly, Koh, & Connolly, 2005; Manning,
45 Kelly, & Comello, 2009; Zhu et al., 2014), which are thought to be the basis of flavors' marketing appeal,
46 participants in this study indicated their interest in e-cigarettes with various flavor descriptors, but did
47 not sample e-cigarettes or taste any flavors. The analysis compares e-cigarette interest between
48 nonsmoking teens and adult smokers, across flavors and also assesses differences in flavor preferences
49 among adult smokers based on their e-cigarette use history.
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METHODS

Participants

Participants were drawn from an online research panel (Research Now) of 3 million individuals recruited by invitation from companies that invite their customers to join the panel. Those who opt in agree to participate in surveys and are periodically sent email invitations to complete surveys up to 4 times per month. Enrollment by individuals under 18 is done through their parents, who consent to the teen's enrollment. Once enrolled in the panel, parental consent is not required for each survey, and parents are not notified of their teen's participation. Panelists consent/assent to each individual survey in that they decide which surveys to participate in and are free to abandon a survey at any time. A detailed description of the panel methods is available elsewhere (Research Now, 2013). Participants in this survey were compensated with points redeemable for goods from enrollment sponsors (e.g., gift cards, magazines). This study was considered exempt from IRB review in accord with the Code of Federal Regulations 45 Part 46.101.b, which exempts survey research generating de-identified data that does not solicit subject-identified sensitive information that could harm participants.

To be considered nonsmoking teens, participants could have tried combustible cigarettes (8 had done so) but had to report no use of any tobacco product in the past 6 months, and never having used e-cigarettes. We focused on this defined population in order to focus on youth who are less likely to take up smoking combustible cigarettes or other tobacco products, as these nonsmoking youth would be most harmed by taking up e-cigarettes, and in whom adoption of e-cigarettes should be avoided. Adult participants were current some-day or everyday smokers who had been smoking for at least three years. They were subsequently asked about e-cigarette use, but such use was not a criterion for participation.

Invitations were sent to adult panel members with the intention of having survey completers match the age distribution of adult smokers in the US (National Center for Health Statistics, 2013). Nevertheless, the resulting sample over-represented participants 65 and older, so the sample was weighted to match the population age distribution of smokers, following standard procedures for survey data (Kalton, 1983).

Adult smokers ($n=432$) ranged in age from 19 to 80, with average weighted age 43.7 ± 14.5 (standard deviation). A slight majority (55.6%) was female, and 19.0% were non-daily smokers, roughly consistent with population data (Agaku, King, & Dube, 2014). The majority of adult smokers were white (87.8%) and non-Hispanic (95.1%), and 36.3% had graduated college. The mean smoking rate was 11.8 ± 7.6 cigarettes per day. A total of 43.6% of adult smokers had never tried an e-cigarette (never users); 34.6% had tried one but not used one in the past 30 days (past users), and 21.8% had used an e-cigarette in the past 30 days (recent users). (Unweighted demographics are presented in Supplemental Table A). The nonsmoking teens ($n=216$) ranged in age from 13 to 17, with an average age of 15.9 ± 1.1 ; 58.3% were female, 67.6% were white, and 86.6% were non-Hispanic. The larger sample of adult smokers was necessary in order to achieve an adequate representation of ages and also to be able to analyze subgroups that differed by e-cigarette use.

Procedures

A total of 20,235 invitations were sent to adults, with the preponderance (52.8%) sent to 18-24 year olds to compensate for the expected difficulty of recruiting eligible participants in this age group. It is not known how many emails were received or read. The survey was closed when the target sample size was reached; it is not known how many panelists may have tried to enter after this. A total of 1,422 respondents clicked on the survey link. Of these, 93 (6.5%) did not complete the screener, 71 (5.0%) were dropped due to quota restrictions used to balance the age distribution, 817 (57.5%) screened out (543 were not smokers for at least 3 years, 270 used other tobacco, 4 due to age), and 6 (0.4%) started but did not complete the questionnaire, yielding the sample of 432 adult smokers (30.4% of those who responded to the invitation). A total of 14,151 invitations were sent to teens. Of the 398 who clicked on the link, 64 (16.1%) did not complete the screener, 8 (2.0%) were removed due to quota restrictions, 104 (26.1%) screened out (68 due to age out of range, 65 were smokers or used other tobacco, 7 had tried e-cigarettes), and 6 (1.5%) started but did not complete the questionnaire, yielding the sample of 216 teen non-smokers (54.3% of those who responded to the invitation).

Surveys were completed online from May 22 through June 13, 2014. Participants were presented with a screen showing 24 product/flavor combinations. The screen showed written listings of flavor and product combinations (no actual or mock-up of products were shown, in order to focus the assessment on the flavors and not graphics or other characteristics). Ratings of e-cigarette flavors were mixed among ratings of flavored bottled water and ice cream, presented with the same range of non-tobacco flavors (the screener had also included questions about ice cream and bottled water use). A full crossing of flavors and products would have resulted in 39 stimuli to be rated, which was considered too burdensome. Instead, each participant was presented with 24 stimuli, consisting of 8 of the 15 flavors attached to e-cigarettes, plus 8 of the 12 non-tobacco flavors for both bottled water and ice cream. The distribution and order of flavors seen by each participant were assigned using a randomized cyclic incomplete block design with 9 replicates of 24 participants each, while product was randomized and balanced according to a Williams Square design with blocks of size 24 (Williams, 1949). This scheme accommodated 216 participants and was replicated twice for adults. The analysis used random-effects models to account for the "planned missingness" (Neter, Kutner, Nachtsheim, & Wasserman, 1996) of some stimuli from individual participants' stimulus set.

For each product/flavor combination shown, participants responded to the question "How interested would you be in using a [flavor] [product]?" (e.g., "How interested would you be in using a menthol e-cigarette?"), indicating their interest on a 0-10 scale where 0 indicated "not at all interested" and 10 indicated "very interested." The flavors tested are shown in Figures 1 and 2, and represent the kinds of flavors available in e-cigarettes. Bubble gum, cotton candy, and gummy bear were included to represent flavors expected to be most appealing to youth. The other flavor descriptors represented flavors currently offered in NJOY e-cigarettes (classic tobacco and menthol) or being contemplated for future NJOY offerings at the time of the survey.

Analyses

Analyses included comparisons of teen and adult respondents' ratings by flavor. A sub-analysis compared ratings by flavor within the adult sample by e-cigarette use status (recent user, past user, never user). Analyses were conducted in SAS 9.4 for Windows, using PROC MIXED. All means reported are weighted. Standard errors and significance tests are also model-adjusted, to account for within-subjects correlations and for the "planned missingness" design. A two-tailed p-value <0.05 (with no adjustment for multiplicity) was considered significant.

RESULTS

Adult smokers compared to nonsmoking teens

Figure 1 shows the appeal of individual flavors among adult smokers and nonsmoking teens (see Supplemental Table B). Although neither adults' nor teens' mean ratings were greater than 5 out of 10, adult smokers' ratings (overall mean 1.73 ± 1.0 [SE] on a 0-10 scale) were significantly higher ($p < 0.0001$) than nonsmoking teens' (overall mean 0.41 ± 0.14). There was significant variation by flavor in adult preferences (range of means: 1.01-3.49; $p < 0.0001$), but teen preferences did not vary significantly by flavor (range: 0.16-0.52; $p > 0.75$). For each of the 15 flavors, adult smokers' interest in e-cigarettes was significantly higher than nonsmoking teens' interest (all p-values <0.05, most p-values <0.0001).

E-cigarette use history

Figure 2 shows adult smokers' preferences by their history of e-cigarette use (see Supplemental Table B for full listing of data). Recent (past-30-day) users had the highest overall e-cigarette interest (mean 3.19 ± 0.21), followed by past users (mean 1.62 ± 0.17), and then never-users (mean 1.08 ± 0.15), and comparisons between groups (recent users vs. never users and recent users vs. past users) were all significant (p -values <0.0001). The effect of flavors differed by e-cigarette use history, with recent users making the most differentiation among flavors and displaying a flavor-interest profile different from past users and never users (e-cigarette history x flavor, $p < 0.0001$). As seen in Figure 2, past e-cigarette users' interest was always intermediate between recent users and never users, but for some flavors (e.g., dark tobacco blend, double espresso, pomegranate), their level of interest was closer to that of never users, while for other flavors (e.g., menthol, peach tea) it was closer to recent users' ratings. Across all flavors, all three groups of adult smokers showed significant variation in interest by flavor (p -values <0.0001), in contrast to what was observed for nonsmoking teens. Adults who never tried e-cigarettes had the lowest interest (mean 1.08 ± 0.15), yet higher than nonsmoking teens' interest (mean 0.41 ± 0.14 ; $p < 0.0001$).

Flavor preferences in ice cream and bottled water

Figures 3a and 3b show the interest ratings given by nonsmoking teens and adult smokers for ice cream and bottled water in the flavors assessed for these products (all but the tobacco flavors) (see Supplemental Table C). Interest in these flavored products was much higher than interest in e-cigarettes in the same flavors (adults: all p-values <0.005; teens: all p-values <0.0001), and product interest varied by flavor, even among nonsmoking teens (product x flavor, $p < 0.0001$). These findings also demonstrate that respondents differentiated the flavor descriptors by the product with which they were associated.

DISCUSSION

This study for the first time examined interest in e-cigarettes among nonsmoking teens and adult smokers, and the effect of offering e-cigarettes under various flavor descriptors. Overall, the interest of nonsmoking teens in flavored e-cigarettes was very low, averaging less than 0.5 on a 0-10 scale. Moreover, flavor descriptors had no significant influence on nonsmoking teens' interest in using e-cigarettes. In contrast, although adult smokers' interest was also modest, their interest was significantly higher than that of nonsmoking teens for each flavor. Unlike nonsmoking teens, adult smokers' interest in e-cigarettes varied significantly by flavor – tobacco flavors were most preferred, but non-tobacco flavors such as vanilla bean and raspberry also garnered adult smokers' interest. Interest in non-tobacco flavors was particularly high among recent (past 30-day) e-cigarette users, who rated some novel food and fruit flavors equal to or higher than tobacco flavors.

These data do not support the hypothesis that adding flavors to e-cigarettes will attract interest among nonsmoking teens who had not used e-cigarettes, as flavor descriptors had no significant influence on nonsmoking teens' interest in using e-cigarettes. This was consistent with Pepper and colleagues' findings on adolescent males' response to the concept of flavored e-cigarettes (Pepper et al., 2013). Nonsmoking teens seemed to be expressing a consistent disinterest in e-cigarettes, which was not overcome by offering e-cigarettes in various flavors, even in candy and fruit flavors – flavors that did appeal to them in the other consumer products tested. Among these teens who have thus far rejected cigarette smoking, e-cigarettes seem to have little appeal. Data from the 2012 National Youth Tobacco Survey (NYTS) found some (9.3%) ever-users of e-cigarettes in grades 6-12 had not smoked combustible cigarettes (Corey et al., 2013), indicating there may be subsets of nonsmoking teens where interest in e-cigarettes does occur. Importantly, data from youth surveys, including the NYTS, suggest that nonsmoking teens who have ever used e-cigarettes share characteristics of teen smokers (Rath et al., 2014), such as a higher number of close friends who smoke cigarettes, which suggests they may otherwise have adopted (and might yet still adopt) conventional smoking. The 2013 NYTS reported that only very small percentages of middle (0.4%) and high school (0.6%) students currently use e-cigarettes without also smoking. Strikingly, the data show that rates of smoking combustible cigarettes have dropped among youth, even as experimentation with e-cigarettes has increased (Arrazola, Neff, Kennedy, Holder-Hayes, & Jones, 2014), shedding doubt on the gateway hypothesis (Abrams, 2014a).

With regard to teen interest in flavors, previous research (Manning, Kelly, & Comello, 2009) showed that youth interest in flavors in cigarettes was a function of sensation-seeking: only high sensation-seekers – who are far more predisposed to smoke (Carton, Jouvent, & Widlocher, 1994; Roberti, 2004; Zuckerman, Ball, & Black, 1990) – showed enhanced interest in flavored cigarettes. This may help explain why nonsmoking teens, who are likely to be low on sensation-seeking, showed so little interest in e-cigarette flavors. Additional research is needed to understand the appeal of flavored e-cigarettes to youth based on their experiences with combustible cigarettes and their intentions to use them in the future.

In contrast to nonsmoking teens, adult smokers showed greater interest in e-cigarettes, though even their interest seemed modest and typically lower than their interest in ice cream and bottled

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3 water. Unlike teen nonsmokers, adult smokers' e-cigarette interest varied significantly by flavor, with
4 the strongest interest in tobacco-related flavors, perhaps because such familiar flavors ease the
5 transition for smokers from a familiar product to a less-familiar one (Farsalinos et al., 2013). Even among
6 past and current users of e-cigarettes, tobacco-related flavors attracted the most interest. Not
7 surprisingly, adult smokers who had tried e-cigarettes showed the most interest in them, and history of
8 use also moderated response to flavors. Certain flavors, such as vanilla bean and double espresso, held
9 much more appeal for recent e-cigarette users (which included, but was not limited to, ongoing users)
10 than for past- or never-users. This is consistent with the finding that e-cigarette users gravitate to
11 flavored e-cigarettes over time (Farsalinos et al., 2013), and perhaps reflects a process whereby e-
12 cigarette users seek non-tobacco flavors as part of a transition away from traditional habits and tastes
13 associated with combustible cigarettes towards full substitution of e-cigarettes as a new behavior.
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19 Study participants were queried about their interest in the same flavors in ice cream and bottled
20 water products. The ratings of these other products provided some validation of the methodology by
21 demonstrating higher ratings of interest could be obtained using the one-question assessment of
22 interest and that the methodology could differentiate product and flavors and product-flavor
23 combinations (e.g., ice cream was preferred to bottled water, and butter crunch was rated as a desirable
24 flavor in ice cream, but undesirable in bottled water). The study had limitations and points to additional
25 research needs. We did not survey the full range of groups of interest, but focused on comparing two
26 starkly contrasting groups: nonsmoking teens (in whom it is most important to minimize e-cigarette
27 appeal) and adult smokers (in whom e-cigarette appeal should be maximized). Future research might
28 test e-cigarette interest among smoking or e-cigarette-using teens or nonsmoking (or ex-smoking)
29 adults, whose interest and preferences are also important to understand. Research by Farsalinos et al.
30 (2013) suggests that interest in flavors grows as adult e-cigarette users become more experienced and
31 switch from combustible cigarettes to e-cigarettes, suggesting that longitudinal studies would also be of
32 interest. Other participant characteristics or traits not explored here might moderate e-cigarette
33 interest. It would be useful to know, for example, how e-cigarette interest varies with adult smokers'
34 interest in discontinuing combustible cigarette smoking, and how teen interest varies with amount of
35 experience with combustible cigarettes, and with susceptibility to smoking (Pierce, Choi, Gilpin, Farkas,
36 & Merritt, 1996).
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44 Participants in our study responded to written flavor descriptors and did not taste the actual
45 flavors or see products. Studies of flavors in combustible cigarettes (Ashare et al., 2007) have used
46 similar methods, as it is the descriptors that have generated controversy and are thought to confer the
47 initial appeal to populations of concern, such as nonsmoking teens. Testing of actual experience with
48 flavored e-cigarettes may be valuable, but there are ethical issues in doing such research with
49 nonsmokers. Many other influences on e-cigarette and flavor interest also deserve to be examined:
50 factors such as branding and graphics, advertising and promotion, and peer or social network effects
51 may influence e-cigarette and flavor appeal, and are areas for further inquiry.
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55 Different dimensions and measures of product interest also deserve to be explored. We used a
56 single-item expression of 'interest,' which might have limited response variance, but did capture
57 relevant variability, as demonstrated by the ratings from adult e-cigarette users and by ratings of ice
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3 cream and bottled water. Nevertheless, other measures might provide additional insights. For example,
4 multiple-item assessment of smoking susceptibility (Pierce, Choi, Gilpin, Farkas, & Merritt, 1996), which
5 focuses on respondents' expectations of future product adoption and the role of social influence, might
6 further inform the influence of flavors on e-cigarette appeal. Of course, even those measures are self-
7 reports, and data on how flavors affect actual adoption of e-cigarettes would be useful.
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10 The study tested particular flavor descriptors, and the results may not generalize to other
11 descriptors, though we covered a range of flavors representing the sorts of flavors offered by e-cigarette
12 makers. Importantly, the study sample was drawn from an online panel, and thus may not be
13 representative. The sample over-represented more educated adults, but, in a national sample, Berg et
14 al. found no effect of education on e-cigarette interest (Berg, Haardoerfer, Escoffery, Zheng, & Kegler,
15 2014), and we also saw no effect of education on e-cigarette interest or flavor in this sample (data not
16 shown). Further, many individuals sent an invitation did not respond, which may also undermine the
17 representativeness of the sample.
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24 Conclusion

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26 This is the first study to examine how various flavors affected e-cigarette interest in adult
27 smokers and nonsmoking teens. Data suggest that interest in e-cigarettes is very low among
28 nonsmoking teens and is not affected by flavor descriptors. In contrast, while e-cigarette interest among
29 adult smokers was also low, it was significantly higher than among non-smoking teens, and the appeal
30 to adult smokers was affected by flavors. Tobacco-related flavors had the highest appeal among adult
31 smokers, but other flavors demonstrated considerable appeal, especially among those already using e-
32 cigarettes. These findings suggest that certain e-cigarette flavors appeal considerably more to adult
33 smokers than to nonsmoking teens. Further research into the appeal of flavors to these and other
34 populations (i.e., smoking teens and nonsmoking adults) could further examine whether flavored e-
35 cigarettes have differential appeal to adult smokers and whether flavors help adult smokers reduce and
36 eventually eliminate their use of combustible cigarettes.
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Figure Captions

Figure 1. E-cigarette Ratings for Adult Smokers and Nonsmoking Teens by Flavor

Figure 2. E-cigarette Ratings among Adult Smokers by e-Cigarette Use History and Flavor

Figure 3. Flavor Ratings by Product and Flavor among (a) Nonsmoking Teens and (b) Adult Smokers

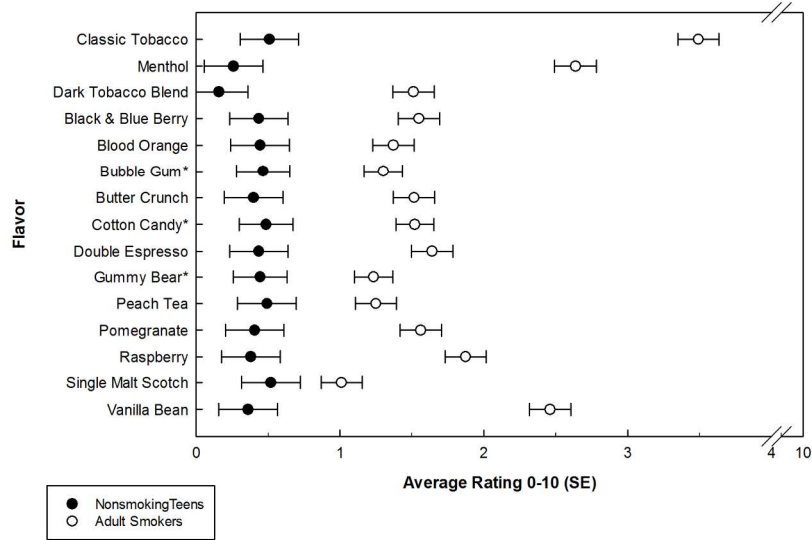
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Bars represent standard errors.
 * Bubble gum, cotton candy, and gummy bear were included to represent flavors expected to be most appealing to youth, but are not being contemplated as flavors for future offerings.

Figure 1. E-cigarette Ratings for Adults and Teens by Flavor
 372x287mm (150 x 150 DPI)

Accepted

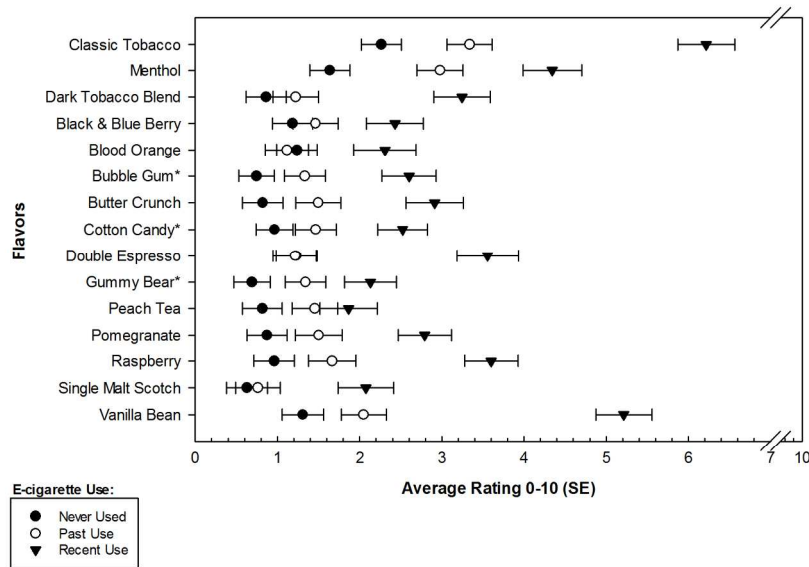


Figure 2. E-cigarette Ratings among Adults by e-Cigarette Use History and Flavor
372x287mm (150 x 150 DPI)

Accepted

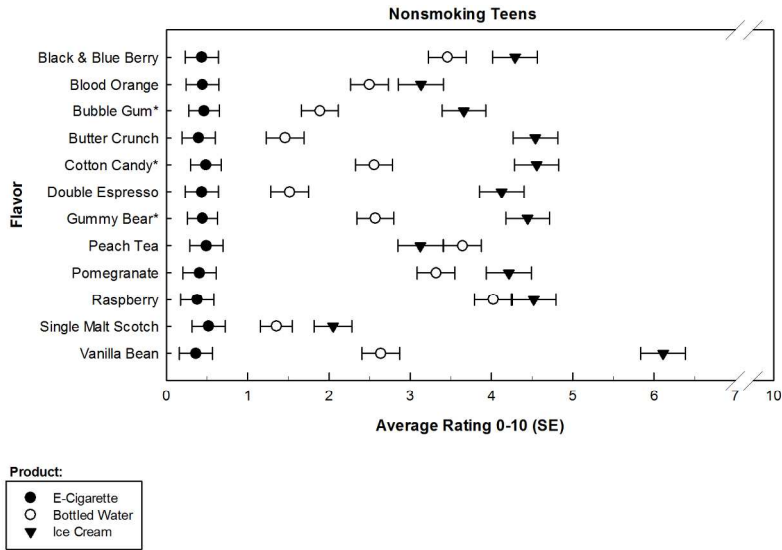


Figure 3a. Flavor Ratings by Product and Flavor among (a) Nonsmoking Teens
 372x287mm (150 x 150 DPI)

Accepted

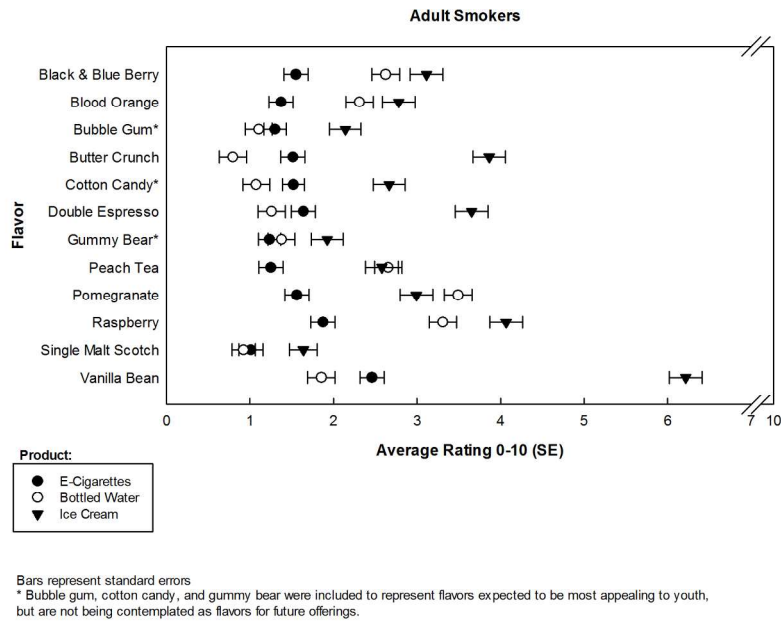


Figure 3b. Flavor Ratings by Product and Flavor among (b) Adult Smokers
372x287mm (150 x 150 DPI)

Accepted

Supplemental Table A

Unweighted and Weighted Demographics of the Sample

	Adult Smokers		Nonsmoking Teens
	Unweighted	Weighted	Unweighted ¹
<u>Sex:</u>			
Male	45.14%	44.37%	41.67%
Female	54.86%	55.63%	58.33%
<u>Age:</u>			
13	—	—	3.70%
14	—	—	6.02%
15	—	—	25.46%
16	—	—	25.46%
17	—	—	39.35%
18-24	11.11%	12.32%	—
25-34	21.76%	23.00%	—
35-44	14.81%	18.11%	—
45-54	18.29%	22.04%	—
55-64	13.43%	15.74%	—
65+ ²	20.60%	8.79%	—
Mean (SD)	46.7 (16.4)	43.7 (14.5)	15.9 (1.1)
<u>Education:</u>			
< H.S.	0.23%	0.10%	—
H.S. graduate/GED	15.97%	16.01%	—
Some college/Associate degree	45.83%	47.57%	—
College graduate	26.62%	26.26%	—
Graduate/Professional degree	11.34%	10.05%	—
<u>Race:</u>			
White	88.43%	87.84%	67.59%
Black	3.70%	3.90%	10.65%
Other	7.87%	8.26%	15.74%
Unknown	—	—	6.02%
<u>Ethnicity:</u>			
Hispanic	4.40%	4.87%	13.43%
Non-Hispanic	95.60%	95.13%	86.57%

¹ Teen data were not weighted² This age stratum was the most distant from the population profile in the unweighted data

Supplemental Table B
Mean ratings for electronic cigarette flavors (0-10 scale)

Flavor	Nonsmoking Teens	All Adult Smokers	Adult Smokers Recent ¹ e-cigarette users	Adult Smokers Past ¹ e-cigarette users	Adult Smokers Never ¹ e-cigarette users
Black & Blue Berry	0.44***	1.55	2.43	1.46	1.18
Blood Orange	0.44***	1.37	2.31	1.12	1.24
Bubble Gum	0.47***	1.30	2.60	1.34	0.75
Butter Crunch	0.40***	1.51	2.91	1.50	0.82
Classic Tobacco	0.51****	3.49	6.22	3.34	2.26
Cotton Candy	0.49****	1.52	2.52	1.47	0.96
Dark Tobacco Blend	0.16****	1.51	3.25	1.22	0.86
Double Espresso	0.44****	1.64	3.56	1.22	1.23
Gummy Bear	0.44***	1.23	2.13	1.34	0.69
Menthol	0.26****	2.64	4.34	2.98	1.64
Peach Tea	0.49**	1.25	1.87	1.46	0.82
Pomegranate	0.41****	1.56	2.79	1.50	0.87
Raspberry	0.38****	1.87	3.60	1.67	0.96
Single Malt Scotch	0.52*	1.01	2.08	0.76	0.63
Vanilla Bean	0.36****	2.46	5.21	2.05	1.31
Overall mean	0.41****	1.73	3.19 ⁺⁺⁺⁺	1.62 ^{++++,§§§§}	1.08 ^{++++,§§§§}
p-value for variation among flavors	0.7543	<0.0001	<0.0001	<0.0001	<0.0001
¹ Definition: Recent e-cigarette user: Used in the past 30 days; Past e-cigarette user: Used but not within the past 30 days; Never e-cigarette user: Never tried e-cigarettes					
Comparison vs. all adult smokers: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$					
Comparison vs. nonsmoking teens: † $p < 0.05$, †† $p < 0.01$, ††† $p < 0.001$, †††† $p < 0.0001$					
Comparison vs. adult recent e-cigarette users: § $p < 0.05$, §§ $p < 0.01$, §§§ $p < 0.001$, §§§§ $p < 0.0001$					

Supplemental Table C

Mean ratings of bottled water and ice cream flavors (0-10 scale) and comparison to ratings of flavored electronic cigarettes among nonsmoking teens and adult smokers

Flavor	Nonsmoking Teens		Adult Smokers	
	Bottled water mean	Ice cream mean	Bottled water mean	Ice cream mean
Black & Blue Berry	3.46****	4.29****	2.63****	3.11****
Blood Orange	2.50****	3.13****	2.31****	2.78****
Bubble Gum	1.89****	3.66****	1.10	2.14****
Butter Crunch	1.46****	4.54****	0.80**	3.86****
Cotton Candy	2.56****	4.56****	1.07	2.67****
Double Espresso	1.52**	4.13****	1.26*	3.65****
Gummy Bear	2.57****	4.44****	1.38	1.92****
Peach Tea	3.64****	3.13****	2.66****	2.58****
Pomegranate	3.32****	4.21****	3.49****	2.99****
Raspberry	4.02****	4.52****	3.31****	4.07****
Single Malt Scotch	1.35****	2.05****	0.92	1.64****
Vanilla Bean	2.64****	6.11****	1.86*	6.22****
Overall mean	2.58****	4.06****	1.90*	3.14****
p-value: Variation among flavors	<0.0001	<0.0001	<0.0001	<0.0001
p-value: Product ^a × Flavor interaction	<0.0001		<0.0001	
^a Product refers to e-cigarettes, bottled water, and ice cream				
Comparison vs. e-cigarette means (see Supplemental Table B for e-cigarette means): * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$				