

Adolescent Attentional Bias toward Real-world Flavored E-cigarette Marketing

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Objectives: E-cigarettes are now the most commonly-used tobacco product among adolescents; yet, little work has examined how the appealing food and flavor cues used in their marketing might attract adolescents' attention, thereby increasing willingness to try these products. In the present study, we tested whether advertisements for fruit/sweet/savory-flavored ("flavored") e-cigarettes attracted adolescent attention in real-world scenes more than tobacco flavored ("unflavored") e-cigarettes. Additionally, we examined the relationship between adolescent attentional bias and willingness to try flavored e-cigarettes. **Methods:** Participants were 46 adolescents (age range: 16-18 years). All participants took part in an eye-tracking paradigm that examined attentional bias to flavored and unflavored e-cigarette advertisements embedded in pictures of real-world storefront scenes. Afterwards, participants' willingness to try flavored and unflavored e-cigarettes was assessed. **Results:** In support of our primary hypothesis, adolescents looked longer and fixated more frequently on flavored (vs unflavored) e-cigarette advertisements. Moreover, this attentional bias towards flavored e-cigarette advertisements predicted a greater willingness to try flavored vs unflavored e-cigarettes. **Conclusions:** These findings suggest that flavored e-cigarette marketing attracts the attention of adolescents, increases their willingness to try flavored e-cigarette products, and could, therefore, put them at greater risk for tobacco initiation.

Key words: adolescents; e-cigarettes; tobacco marketing; flavors; eye-tracking

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Although cigarette use among adolescents has been in decline, e-cigarette use among adolescents has increased in the past 5 years and is now the most commonly-used tobacco product among youth.¹ Flavored e-cigarettes are particularly popular. Data indicate that 86% of adolescent e-cigarette users currently use flavored products² and 81% of adolescent e-cigarette users report that the first product they used was flavored.³ In recognition of the role of flavors in adolescent tobacco use, in 2009, the Family Smoking Prevention and

Tobacco Control Act required the Food and Drug Administration (FDA) to ban all characterizing flavored cigarettes (apart from menthol).⁴ However, e-cigarettes were not included in this flavor ban, and since then, the availability of flavors has increased steadily. For example, as of 2014, there were an estimated 466 brands and 7764 unique flavors of e-cigarettes and nicotine liquid available on the market.⁵

The use of appetitive food flavor cues (eg, sweet, candy and savory flavors) in e-cigarette marketing

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may be one means by which flavored e-cigarette advertisements attract adolescents. For instance, prior work shows that children and adolescents demonstrate a strong attentional bias towards appetitive food cues and that the strength of this bias prospectively predicts weight gain.⁶ Not only might adolescents be more biased towards such reward cues, but they also may be less able to pull their attention away from these cues as shown in research demonstrating that, when compared to adults, adolescent attention is more prone to being captured by the sight of reward cues (ie, value-based attentional capture⁷). In addition, neuroscience research has demonstrated that adolescents in general appear to be more sensitive to reward cues than adults, exhibiting greater activity in reward-related brain systems when viewing appetitive cues as compared to adults and children.⁸ In the context of flavored e-cigarette advertisements, appetitive food flavor cues may attract an adolescent's attention towards the advertisement, leading to increased processing of the advertisement content and, through repeated exposures, a greater willingness to try the product. Indeed, the influence of attentional biases on consumer choice is well documented. For instance, increased time looking at advertisement images increases brand recall⁹ and is associated with a greater likelihood of purchasing brand-name products.¹⁰

Previous studies have examined the role of flavors in adolescent e-cigarette use by assessing self-reports of product use^{2,3} or product interest,^{11,12} typically in response to verbal descriptions of products and their flavors. However, real-world e-cigarette marketing frequently utilizes appetitive food and flavor cues representing the flavor of the product. Such advertisements consist of color photographs and attractive imagery to convey the food and flavors (eg, chocolate bars, donuts, cotton candy). Thus, the use of verbal labels to measure interest in flavored tobacco products may not accurately reflect how adolescents respond when exposed to real-world marketing for these products.

The goal of the present study was to test whether the use of flavor imagery in e-cigarette advertisements biases adolescents' attention and interest toward flavored (vs unflavored) e-cigarettes in a real-world context. Our study design incorporated several elements to achieve this naturalistic, real-world context. First, we utilized eye-tracking tech-

nology, which presents an unobtrusive means of assessing e-cigarette preference in more naturalistic contexts (eg, real-world retail point-of-sale scenes) that may better approximate adolescent exposure to e-cigarette advertisements in the real-world. Second, in contrast to prior work examining the role of product or advertisement features (eg, health warning labels, price) on tobacco product preferences,¹³ we presented participants with a series of real-world retail point-of-sale scenes of local area storefronts; embedded within these storefront scenes were the real-world advertisements for either an appetitive flavored (eg, sweet, candy, snack) or traditional tobacco-flavored ("unflavored") e-cigarette. As such, our measure of attentional bias was the difference in time spent looking at the flavored versus unflavored advertisements in the cluttered scenes. Third, participants simply were instructed to view the scenes; no mention of e-cigarettes or e-cigarette advertisements was made, thus mitigating any potential task demands such as can occur when participants are asked to report explicit attitudes towards e-cigarette products. We hypothesized that the use of appetitive flavor cues in flavored e-cigarette marketing would bias adolescents' attention towards these advertisement types and lead to increased looking time for flavored versus non-flavored advertisements. In addition, we tested whether this attentional bias towards flavored advertisements predicted an increased willingness to try flavored versus unflavored e-cigarette products.

METHODS

Participants

We recruited 46 individuals between the ages of 16 and 18 years for this study. At the time of recruitment, participants were all non-regular users of tobacco products (ie, non-regular users of cigarettes, e-cigarettes, or other tobacco products) and had no known food allergies that might preclude them from disliking any of the appetitive flavors in the flavored e-cigarette advertisements. Participants were recruited through community postings, emails, and ResearchMatch, a national health volunteer registry that was created by several academic institutions and supported by the US National Institutes of Health as part of the Clinical Translational Science Award (CTSA) program. The sample size of 46 participants in this study was specified

prior to data collection and data collection ceased once we arrived at this number. All participants gave informed consent or assent; a parent provided consent for participants under 18.

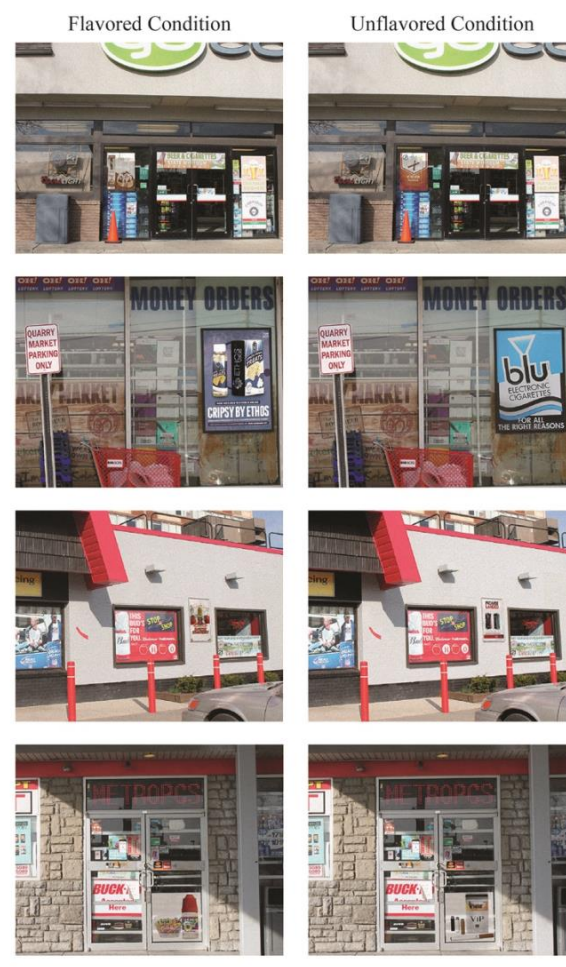
Stimuli

Stimuli consisted of a set of 28 scenes of storefronts from tobacco points-of-sale that were collected in Columbus, OH during the fall and winter of 2015. All storefront scenes contained a variety of marketing advertisements, including those for soda, snacks, and alcohol. Each scene was edited using Adobe Photoshop to include either an appetitive (eg, sweet, candy, snack) flavored (“flavored”) or traditional tobacco-flavored (“unflavored”) e-cigarette advertisement in the same location, thus resulting in 2 versions of each scene. Each manipulated advertisement was edited carefully to match the perspective of the storefront, warping and distortion was applied to the advertisement edges to give the appearance of uneven edges of paper and, finally, glass reflections were superimposed onto the advertisements to give the illusion that they were behind storefront windows consistent with the other advertisements in the scene (see Figure 1 for examples of the stimuli). All other advertisements in the image were left untouched.

As described in the introduction, our goal was to test adolescent responses to e-cigarette advertisements under naturalistic conditions. Therefore, rather than create our own false product advertisements to be inserted into the storefront scenes, we curated a collection of existing, real-world flavored and unflavored advertisements. Criteria for the product advertisements were that the advertisements had a visible image of an e-cigarette product (e-cigarette, e-liquid or vaporizer), and, in the case of flavored advertisements, the advertisement had to contain appetitive food cue imagery representing the flavor (eg, doughnuts for glazed doughnut flavored e-cigarettes).

From this procedure, we generated 2 matched sets of storefront stimuli, each containing 14 scenes with flavored e-cigarette advertising and 14 with unflavored advertising. Both sets were matched such that, if a given point-of-sale scene contained a flavored e-cigarette advertisement in one set, the same point-of-sale scene contained an unflavored e-cigarette advertisement, at the same position

Figure 1
Example of Point-of-Sale Storefront Scenes Edited to Include Either a Flavored (Left) or Unflavored (Right) E-Cigarette Product Advertisement



Note.

Pairs of advertisements were first selected to qualitatively match on visual features (eg, overall color, design, white space and location of products). Quantitative analysis of image saliency as well as luminance and contrast indicated that flavored and unflavored e-cigarette advertisements were well-matched on these features. All other aspects of the scene were untouched.

and size, in the other set. Pairs of advertisements were first selected to qualitatively match on visual features (eg, overall color, design, white space and location of products). Participants were randomly assigned to one of the 2 stimulus sets.

Following stimulus creation, each set was investi-

gated for differences in low-level visual features (eg, contrast, luminance) that may contribute to differences in visual saliency between the flavored and unflavored e-cigarette advertisements that are unrelated to the use of appetitive flavor cues. For this, we used the Matlab based Image Saliency toolbox¹⁴ to calculate an index of visual salience per scene. The Image Saliency toolbox measures the overall visual salience of a scene based on color, luminance, and orientation contrast maps at multiple spatial scales. The resulting saliency maps for each scene highlight regions of the image that would be expected to attract attention and visual fixation based on low-level contrast features of the scene. Upon computing the saliency maps for both versions of each scene (ie, the flavored and unflavored e-cigarette advertisement version), saliency values were extracted from a region of interest encompassing each flavored or unflavored e-cigarette advertisement. Analysis of saliency values within the advertisement region for each scene and advertisement type indicated that there was no difference between flavored and unflavored scene pairs between the 2 stimulus sets ($t(27) = 1.54$, $p = .14$). In addition to saliency, we also calculated luminance and contrast values within each scenes' advertisement region using the Matlab based SHINE toolbox.¹⁵ Across the 2 stimulus sets, there were no significant differences in image luminance ($t(27) = 0.86$, $p = .40$) or contrast ($t(27) = 1.99$, $p = .06$) between flavored and unflavored e-cigarette advertisements. We note that the trend towards a difference in contrast values between the flavored and unflavored advertisements suggests that unflavored advertisements have higher contrast values, which would work against our hypothesis that flavored advertisements attract attention.

Procedure

Eye-tracking procedure. All eye-tracking data were collected from the left eye using an Eye-Link 1000 (SR Research Ltd., Mississauga, Ontario, Canada) desktop mount eye-tracker with a sampling rate of 1000Hz. Participants' heads were stabilized using a chin rest. Scenes were presented on a 1680 by 1050 pixel monitor with a refresh rate of 120Hz and a viewing distance of 40cm. Prior to starting the experiment, participants underwent a calibration procedure consisting of a 9-point fixation sequence. Participants were instructed to

look at each scene as it was presented. We made no mention of the study's hypothesis or of our interest in e-cigarette advertisements, thus ensuring that participants were naïve to the goals of the study. The stimulus set version was counterbalanced across participants so that an equal number of participants saw each of the 2 stimulus sets. As mentioned previously, the 2 stimulus sets were identical except for the type of advertisement inserted into the scene. Storefront scenes were quasi-randomly presented across 3 blocks with the constraint that each block contained an equal number of flavored and unflavored scenes. Between each block, a central drift correction fixation was presented to detect gaze drift between blocks; however, in practice, no participant required correction after any of these periods. Each trial consisted of a 2000ms fixation dot at the center of the screen followed by a 6000ms viewing period where the participant was instructed to view the scene freely.

Eye movement data were analyzed with EyeLink Data Viewer software (SR Research Ltd., Mississauga, Canada). Percent dwell time and number of fixations for areas of interest (ie, flavored or unflavored advertisement) for each scene were identified following the removal of blinks and saccades (defined as eye velocities exceeding 30 degrees/s or eye acceleration exceeding 8000 degrees/s²).

Questionnaires. Following the eye-tracking task, participants' willingness to use e-cigarettes was assessed following the protocol in Gibbons et al,¹⁶ whereby a risk-conducive scenario is presented and individuals are asked to indicate how willing they would be, under those circumstances, to engage in the given behavior. Here, the scenarios described hanging out with a group of friends, and one friend using an e-cigarette and offering the participant a puff. In one scenario, reference was made simply to an e-cigarette without the flavor specified. The second question was modified with the following: "this time one of these friends is using a flavored e-cigarette that is flavored with something you like (eg, apple, chocolate, coca-cola, peach)." After each scenario, willingness was assessed on a 1-7 scale (1 = *not at all willing*, 7 = *very willing*) using 2 questions ("How willing would you be to try a puff [try more than one puff]?"). The 2 items for each willingness scenario were averaged. Next, to capture participants' specific interest in flavored e-cigarettes

(over and above their interest in e-cigarettes), we calculated a difference score between willingness to use a flavored e-cigarette and willingness to use an unflavored e-cigarette. As this index of willingness to try flavored e-cigarette products was highly skewed (skewness = 1.27), we dichotomized scores using the commonly-used cut-offs^{17–20} (≤ 0 = *no willingness* vs >0 = *some willingness*).

Data Analysis

Dwell time was defined as total time in milliseconds spent fixating on the flavored or unflavored advertisement area for each storefront scene. Percent dwell time scores were calculated by dividing advertisement dwell time by the total amount of time viewing the scene (ie, 6 seconds per scene, minus any brief periods of time where fixation was outside the area of the scene) and multiplying by 100. The number of fixations was computed by counting the total number of fixations that fell within the flavored or unflavored advertisement area for each scene. Percent dwell-time and number of fixations were analyzed with a paired-sample t-test and again using a mixed-effects model including advertisement type as a fixed factor and stimulus-set version and participants as random factors for both slope and intercept. We present the results of both analyses for readers who prefer a simple t-test approach as well as those who believe a multi-level model is more appropriate as it allows modeling stimulus as a random factor. Finally, we used logistic regression to test whether an attentional bias towards flavored advertisements predicted willingness to try flavored e-cigarettes (“Flavor Willingness”). Specifically, we calculated the difference between percent dwell time for flavored advertisements versus percent dwell time for unflavored advertisements, and used this difference score as a predictor in a logistic regression on flavor willingness. All analyses were conducted using the R statistical language (R Core Team, 2015). Mixed effect models were conducted using the lme4 package.²¹

RESULTS

Descriptive Statistics

Table 1 provides descriptive statistics. Participant age averaged 17.2 years old, 57% were female, and 67% were Caucasian. Although at the time of recruitment, all participants reported being never

Table 1
Study Sample Demographics (Mean or %)

	Total (N = 46)
Demographics	
Sex	
Female	56.5%
Male	43.5%
Mean Age	17.2 (0.77)
Mean Body Mass Index	23.3 (4.35)
Race	
Non-Hispanic white	67.5%
African American	13%
Hispanic	8.7%
Asian	4.3%
Native Hawaiian or Pacific Islander	2.2%
Mixed Race	4.3%
Socioeconomic Status (% middle class)	45.6%
Tobacco Use	
Any Use	26.1%
E-cigarette	23.9%
Cigarette	17.4%

Note.

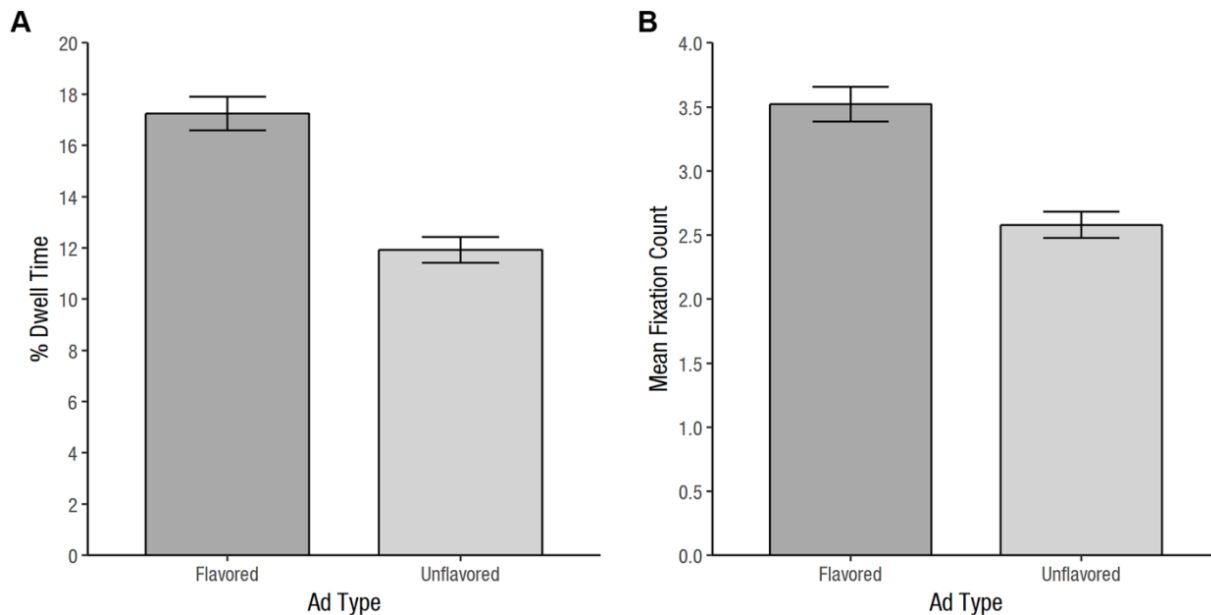
The measure of socioeconomic status asked participants “How would you describe your current social class?” (Response options ranged from 1 = *Working class/lower-middle class* to 4 = *Upper class*).⁴¹ Standard deviations for mean age and mean body mass index are in parentheses.

users of tobacco, when re-assessed after the experiment, 26% (12) of the individuals reported having tried at least one puff of a tobacco product. Specifically, 2% (1) had tried just cigarettes, 9% (4) had tried just e-cigarettes, and 15% (7) had tried both cigarettes and e-cigarettes.

Attentional Bias towards Flavored vs Unflavored E-cigarette Advertisements

When viewing real-world point-of-sale scenes, participants demonstrated an attentional bias towards flavored ($M = 17.23$) vs unflavored ($M = 11.91$) advertisements for both percent dwell time ($t(45) = 7.24$, $p < .001$; Figure 2) and total number of fixations ($t(45) = 6.97$, $p < .001$). The pattern remained in a repeated-measures ANOVA that controlled for ever-use of tobacco ($F(1, 44) = 42.05$, p

Figure 2
Percent Dwell-Time (A) and Mean Number of Fixations (B) for Point-of-Sale Scenes
Containing Flavored or Unflavored E-Cigarette Advertisements



Note.

Scene and advertisement type were counterbalanced across participants such that for every scene, half of the participants saw a version containing a flavored advertisement whereas the other half saw a version containing an unflavored advertisement in the same location. Error bars indicate +/- 1 standard error of the mean.

< .001). The same effect was obtained when these data were analyzed as a mixed-effects model to account better for any potential stimulus/item effects (percent dwell time: $t(130.9) = 6.12$, $p < .001$; number of fixations: $t(143.4) = 5.28$, $p < .001$). Thus, when accounting for potential item differences across point-of-sale scenes, the attentional bias towards flavored e-cigarette advertisements remains.

Willingness to Use and Attentional Bias

In a logistic regression predicting the Flavor Willingness difference score (ie, the difference between willingness to try flavored e-cigarettes as compared to unflavored ones), attentional bias toward flavored advertisements (ie, the difference in percent dwell time between flavored and unflavored advertisements) was a significant predictor (OR = 1.16; 95% CI, 1.004-1.33, $p = .044$). The effect remained when the regression controlled for ever-

use of tobacco (OR = 1.15; 95% CI, 1.002-1.33, $p = .048$). Thus, for every additional percent dwell time that participants spent looking at flavored versus unflavored advertisements, there was a 16% increase in the odds of having some willingness to try flavored e-cigarettes. Put differently, participants who displayed a greater attentional bias towards flavored versus unflavored e-cigarette advertisements subsequently reported a stronger willingness to try flavored e-cigarettes, over and above the interest in e-cigarettes.

DISCUSSION

In the current study, we used an unobtrusive eye-tracking measure to test whether flavored e-cigarette advertisements attracted adolescents' attention more so than unflavored advertisements. In contrast to prior research using self-report measures,¹² we assessed adolescent preference for e-cigarette advertisements in a reasonably natural-

istic manner by having participants view real-world point-of-sale scenes that had been manipulated to contain flavored or unflavored e-cigarette advertisements. Following this task, we measured willingness to try flavored and unflavored e-cigarettes in a series of risk-conducive scenarios designed to reflect the real-world situations in which adolescents may find themselves (eg, peer use at a party). Consistent with our hypothesis, adolescents demonstrated an attentional bias towards flavored (vs unflavored) e-cigarette advertisements even though participants were naïve to the goals of the experiment and unaware that the scenes had been manipulated. To put these findings in context, over a 6-second visual period, participants spent approximately one second looking at flavored e-cigarette advertisements versus 0.7 seconds for unflavored advertisements when presented in the context of real-world, cluttered visual scenes. Moreover, individual differences in adolescents' attentional bias towards flavored versus unflavored e-cigarette advertisements were subsequently found to predict a greater willingness to try flavored e-cigarettes versus unflavored e-cigarettes.

Exposure to appetitive cues, such as those found in food marketing and imagery, is one of the principal means by which craving can occur.²² Research on the phenomena of cue-reactivity has demonstrated that exposure to drugs, cigarettes, or food cues can elicit a cascade of physiological and psychological responses from increased salivation and reward-related brain activity to heightened craving and consumption.^{23–25} With respect to flavored e-cigarette advertising, it is plausible that a similar mechanism is taking place, whereby the association of appetizing food and flavor cues with e-cigarette products effectively may trick the brain's reward system into viewing the product as an appetitive stimulus, thereby increasing willingness to try flavored e-cigarette products. In support of this notion, we found that attentional biases toward flavored e-cigarette advertisements were subsequently associated with an increased willingness to try flavored versus unflavored e-cigarettes. This finding dovetails nicely with studies of food-cue reactivity demonstrating that individual differences in both eye-tracking and neural measures of food-cue reactivity are associated with increased eating and increased weight gain in adolescents and young adults.^{26–29} Wagner³⁰ provides a relevant review on this subject.

Compared to other age groups, adolescents may be particularly susceptible to food and flavor cues. Research examining the neurobiology of adolescent development suggests that adolescence is a period associated with enhanced reward sensitivity to food, nicotine, and other types of appetitive cues.^{8,31,32} Some authorities argue that adolescents may be more sensitive to appetitive reward cues^{7,8} and exhibit a stronger preference for sweet flavors than adults.³³ Furthermore, research indicates that adolescents perceive fruit and candy-flavored e-cigarettes as being less harmful than generic e-cigarettes.^{13,34} Among the many reasons provided for this heightened adolescent reward response are models of development that suggest that the relatively late maturation of the prefrontal cortex in adolescents leads to an imbalance between brain regions involved in reward and emotional processes and the prefrontal cortex involved in self-control.³⁵ Other mechanisms unique to adolescents are no doubt also at play (eg, increased sensation seeking, novelty seeking, peer influence, and environmental exploration).

It is worth noting a few key strengths and limitations to this study. To begin, the present study employed eye-tracking as an unobtrusive measure of attentional bias. This allowed us to sidestep potential experimenter demand effects, such as can occur when participants can infer that a study concerns e-cigarette use given the stimulus materials as in eye-tracking studies using more standard forced choice paradigms (eg, viewing a flavored and unflavored e-cigarette product simultaneously) as well as avoid social desirability biases that could lead to an under-reporting of preferences for e-cigarette products.

Moreover, the use of real-world point-of-sale storefront scenes with embedded real-world advertisements provided a reasonably ecologically valid context for measuring the impact of flavored e-cigarette marketing. One limitation to using real-world advertisements, however, is that this placed limited control on our ability to match flavored and unflavored e-cigarette advertisements on features related to colorfulness or image complexity. Our finding that there were no significant differences in the low-level visual features of the flavored versus unflavored stimulus sets, as well as finding no differences in attentional salience between im-

age types based on a computational model of visual salience (as described in the methods section) assuages some of these concerns. When navigating the trade-off between well-controlled paradigms and ecological validity, our goal was to emphasize ecological validity. This approach stands in contrast to prior work that has focused solely on isolated images of product packages¹³ or that used only verbal labels to indicate flavored and unflavored e-cigarettes.¹² Although such studies are useful for assessing the impact of specific product features (eg, warning labels), we argue that the real-world scenes used in the present study more closely approximate the context in which teens are exposed to marketing in the real world.

Conclusions

Using a naturalistic eye-tracking paradigm, the present study found that adolescents demonstrated an attentional bias towards flavored versus unflavored e-cigarette advertisements when viewing real-world scenes and that this difference in attention subsequently predicted an increased willingness to try flavored versus unflavored e-cigarettes. Additional analyses showed that this effect could not be attributed to differences in the low-level visual features or visual salience between flavored and unflavored advertisement types. Overall, these findings suggest that flavored e-cigarette advertising could put adolescents at risk for tobacco initiation and underscore the need for further tobacco regulation to protect youth.

IMPLICATIONS FOR TOBACCO REGULATION

The sensitivity to flavored e-cigarette advertising demonstrated by adolescents in the present study suggests that flavored e-cigarettes may place adolescents at greater risk for e-cigarette experimentation. These findings are consistent with research that exposure to food advertising in children and adolescents can influence food preferences, purchasing, and consumption.^{22,24} Findings are also consistent with older research with cigarettes, which show tobacco companies used flavoring to appeal to youth and encouraged smoking initiation.³⁶ Such findings ultimately led to the ban on all characterizing flavored cigarettes, other than menthol.⁴ A few localities, such as San Francisco, California, have

extended this effort by restricting the sale of all flavored tobacco products, including flavored e-cigarettes.³⁷ The FDA should consider implementing similar regulations at the national level to prevent the sale and marketing of flavored e-cigarettes and protect youth. The importance of these types of policies is supported not only by the present study, but additionally by evidence that adolescent e-cigarette users are at risk for transitioning to regular cigarette use.³⁸⁻⁴⁰

Human Subjects Approval Statement

The study protocol was approved by The Ohio State University IRB as protocol 2015C0138.

Conflict of Interest Disclosure Statement

All authors of this article declare they have no conflicts of interest.

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