Affect, risk perception, and the use of cigarettes and e-cigarettes: a population study of U.S. adults

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Abstract

Background: Tobacco companies argue that the decision to smoke is made by well-informed rational adults who have considered all the risks and benefits of smoking. Yet in promoting their products, the tobacco industry frequently relies on affect, portraying their products as part of a desirable lifestyle. Research examining the roles of affect and perceived risks in smoking has been scant and non-existent for novel tobacco products, such as electronic cigarettes (e-cigarettes).

Methods: We examined the relationship between affect, perceived risk, and current use for cigarettes and e-cigarettes in 2015 in a nationally representative sample of 5398 U.S. adults who were aware of e-cigarettes.

Results: Participants held various affective associations with tobacco products, and affect towards cigarettes was more negative than affect towards e-cigarettes. Using structural equation modeling (SEM), affect towards cigarettes and e-cigarettes was associated with cigarette smoking and e-cigarette use respectively, and these associations were both direct and partially mediated by risk perceptions towards smoking and e-cigarette use. More positive affect towards cigarettes or e-cigarettes was associated with lower perceived risks, which in turn was associated with higher odds of being a current cigarette or e-cigarette user.

Conclusions: In developing models explaining tobacco use behavior, or in creating public communication campaigns aimed at curbing tobacco use, it is useful to focus not only on the reason based predictors, such as perceptions of risks and benefits, but also on affective predictors. Educational efforts aimed at further smoking reductions should highlight and reinforce negative images and associations with cigarettes.

Keywords: Affect, Risk perception, Tobacco, Electronic cigarettes, Cigarettes, Smoking

Background

Despite over 50 years of awareness that smoking causes cancer and premature death, tobacco use remains the leading cause of preventable disease and death in the United States [1, 2]. While the prevalence of smoking has declined in recent years in the United States, over 36 million adults still are current smokers [3]. Why do people start or quit smoking? The answers to this question come from two domains: cognition and affect. Answers from the cognitive domain focus on conscious and deliberate thought processes, such as stated perceptions of risk and benefits [4–6]. In contrast, answers from the affective theories highlight the importance of feelings associated not only to reasons but to all cognitive content, including thoughts and images that influence us in ways that we are not consciously aware of [7]. Affect here is defined as a positive or a negative feeling about an object or a stimulus. Affective reactions can be almost instantaneous and can occur with or without conscious awareness [7].

The decision to start, continue, or stop smoking has sometimes been conceptualized as a decision arrived at by a perfectly or imperfectly rational [8] person who weighs the costs and benefits of the decision and calculates the optimal behavior [9]. This is the view tobacco
companies have long been trying to promulgate. Defend-
ing themselves in court, tobacco companies have denied
that nicotine is addictive [10] and have argued that they
should not be blamed for the deaths and diseases caused
by smoking because the decision to smoke was made by
a rational, well-informed adult who knew and willingly
accepted the risks of smoking [1, 11, 12]. Yet in their
advertising, tobacco companies have employed quite a
different strategy. They focus on affect instead of the
analytic perception of risk.

Tobacco companies have long understood the impor-
tance of affect in promoting smoking [12]. As the grow-
ing scientific knowledge in the 1950s and 1960s led to
increased awareness of the serious health effects of
smoking, tobacco companies started promoting products
aimed at reducing perceptions of risk [13], such as filtered
and low-tar cigarettes [14]. The early advertisements for
low-tar cigarettes focused on reasons and arguments
based on features such as machine yields and amount of
tar [15]. These early advertisements were designed to
appeal to the analytical processing system in smokers
[16, 17]. However, tobacco companies were concerned
that this approach was insufficient to allay the worries of
health-conscious consumers who might quit completely
rather than use low-tar cigarettes [14]. These reason-
based advertisements reminded smokers about health
risks and evoked more negative feelings than they allevi-
ated [14]. Thus, on the advice of their marketing consul-
tants, the companies switched to appealing to positive
feelings instead, generating favorable imagery of smoking
and smokers through use of pictures and associations with
highly desirable places and situations, such as sportiness,
sophistication, style, and relaxation [15].

What tobacco companies have realized is that current
and potential cigarette smokers are driven by affect to a
greater extent than they are driven by calculations of risk
and benefit [18, 19]. More generally, behavioral research
has increasingly recognized the role of affect in decision
making, particularly around risky behavior. There are
several conceptualizations of the role of affect in judging
the risk and acting on it, such as risk-as-feeling hypo-
thesis [20], affect heuristic [21], and somatic markers [22].
All have in common the notion that representations of
objects and events in our minds are inextricably linked
with positive or negative feelings (which are connected
to body or somatic states, as Damasio argued). In mak-
ing a judgment, people refer to these associated feelings,
and they serve as shortcuts for quick decision making.

Research comparing the differential effects of affective
and rational perceptions has found that affect is a better
predictor of smoking compared to reasoned perceptions or
instrumental beliefs [23, 24]. These studies considered
affect and cognitive beliefs as independent predictors
of behavior without examining the (potentially causal)
association between them. However, according to the
affect heuristic [21] and the risk as feeling hypothesis [20],
the affective, largely automatic output of the experiential
system precedes and guides analytical reasoning [25, 26].
Several studies tested a mediated path model and found
that affect predicted smoking intentions and behavior
directly and indirectly through perceptions of risks and
benefits [27, 28]. All of the above studies were limited
to convenience samples and looked exclusively at cigarette
smoking.

With smoking rates declining, tobacco companies have
been looking for ways to reinvigorate their revenues.
Electronic cigarettes (also called “vapes”, “e-cigs”, ENDS,
e-cigarettes) are, according to some researchers, a “dis-
ruptive technology” [29–31] that holds the answer to
eradicating cigarettes or at least reducing harms of
smoking. Other scholars have argued that e-cigarettes
have yet to meet the disruptive technology threshold
since a majority of smokers find them to be a less satis-
fying alternative [32]. Some scholars have expressed con-
cern that e-cigarettes have the potential to renormalize
smoking [33] and might make it harder for smokers to
quit [34]. Evidence from tobacco industry documents
show that tobacco industry has researched nicotine aero-
sol technology similar to modern e-cigarettes since
1990s as a complementary rather than a competing “dis-
ruptive” technology to cigarettes in an effort to deter
health conscious smokers from using nicotine replace-
ment therapy to quit smoking [35]. Today, every major
tobacco company offers an electronic cigarette product
(MarkTen – Altria; Vuse – RJ Reynolds; blu – first pur-
chased by Lorillard, now owned by Imperial Brands) and
the industry is consolidating around these new products
and marketing models [36]. E-cigarettes’ advertising has
spun the gamut of cognitive and emotional appeals,
from portraying e-cigarettes as safer and healthier than
cigarettes, being a “resolution solution” (NJOY) and a
choice recommended by doctors to creating positive im-
ages of rebellious e-cigarette users who “take back” their
freedom (blu) and “rewrite the rules” (Fin) [37, 38].

Recent research has examined how perceptions of risk
and other cognitive factors are associated with initiation,
use, and discontinuation of electronic cigarettes [39–41].
While some studies have looked at the role affect might
play in sparking interest in electronic cigarettes [42],
none examined how affect and risk perceptions of e-
cigarettes are associated in relation to e-cigarette use.

In this paper, we used a nationally representative sam-
ple to examine how current, former, and never users of
cigarettes and e-cigarettes feel about cigarettes and e-
cigarettes and what affective imagery they associate with
each product. We hypothesized that more positive affect
is related to being a current user of the product. We also
evaluated whether the pattern of associations among
affect, risk perceptions, and product use for cigarettes and e-cigarettes is consistent with a mediational model derived from the theoretical framework of the affect heuristic and “risk as feelings” whereby affect has an indirect effect on product use through risk perceptions.

Methods
Data source
We analyzed data from the Tobacco Products and Risk Perceptions Survey (TPRPS) conducted from August to September 2015 by the Georgia State University Tobacco Center of Regulatory Science (TCORS). An annual cross-sectional survey, TPRPS is administered to a probability sample drawn from GfK’s KnowledgePanel, a probability-based web panel designed to be representative of non-institutionalized USA adults. KnowledgePanel only includes adults sampled via address-based sampling. Participants lacking Internet access are provided a computer to facilitate participation. A sample of 6091 qualified completers was obtained from 8135 KnowledgePanel members who were invited to participate in the 2015 survey. The final sample of 6051 cases with a final stage completion rate of 76.0% and a study qualification rate of 98.5% was achieved, after exclusion of 40 cases due to non-response to more than one-half of the survey questions. The analytic sample for this study comprised 5389 participants who reported being aware of any kind of electronic vaporizer product (“Have you ever seen or heard of any type of electronic vapor product, such as e-cigarettes, e-cigars, e-hookahs, e-pipes, vape pens, hookah pens or personal vaporizers/mods before this study?”). Participants who reported not being aware were excluded because they were not asked questions about e-cigarettes. We used an iterative proportional fitting (raking) procedure to adjust for sources of sampling and non-sampling error (such as panel recruitment non-response and panel attrition) to compute a study-specific post-stratification weight. Demographic and geographic distributions from the March 2015 Current Population Survey (CPS) served as benchmarks for adjustment, and included sex, age, race/ethnicity, education, household income, census region, metropolitan area, and internet access. TPRPS was approved by the Georgia State University Institutional Review Board.

Measures
Affect towards cigarettes and e-cigarettes
Participants were asked, “When you hear the word cigarette, what is the first thought or image that comes to mind? Please list just one thought or image.” The same question was used for e-cigarettes, but the word “cigarette” was replaced by the phrase “electronic vapor products, which includes e-cigarettes, e-cigars, e-hookahs, e-pipes, vape pens, hookah pens and personal vaporizers/mods.” (Before any questions about e-cigarettes, the survey provided an explanation of what e-cigarettes are, accompanied by a picture illustrating various e-cigarette types and devices.) Participants were then asked, “How do you feel about this thought or image? Please rate this thought or image and not the word “cigarette” [“electronic vapor product”] itself.” They could rate it on a 5-point scale from −2 (very bad) to +2 (very good) (with 0 being “neither good nor bad”). The same sets of questions were repeated for the second thought or image for both products. In the present study the correlation across participants between the two affect ratings was \( r = .86 \) for cigarette images and \( r = .85 \) for e-cigarette images. We do not differentiate between thoughts or images and refer to them as “images” for the remainder of the paper. This measure of affect has been previously validated by studies showing that the qualitative nature of the images and their valence contribute to an understanding of the meaning of the target concept to an individual and predict a diverse range of judgments, decisions, and behaviors [43, 44].

Risk perceptions of cigarettes and e-cigarettes
To measure perceived risks, participants were asked “Imagine that you just began [smoking cigarettes / using electronic vapor products] every day. What do you think your chances are of having each of the following happen to you if you continue to [smoke cigarettes / use electronic vapor products] every day?” with respect to the following conditions: lung cancer, lung disease other than lung cancer (such as COPD and emphysema), heart disease, and premature death. Response options included a seven-point Likert-type scale ranging from 0 (“No chance”) to 6 (“Very good chance”), and a separate “I don’t know” category, which was treated as missing data in our analyses.

Outcome measures
Behavioral outcomes were: (1) smoking status and (2) e-cigarette use. Smoking status was categorized as never smokers (have not smoked 100 cigarettes in their lifetime), current smokers (smoked 100 cigarettes or more and currently smoking every day or some days), and former smokers (smoked 100 cigarettes or more but currently not smoking). E-cigarette use was categorized as never users (never tried e-cigarettes), current users (currently using e-cigarettes every day, some days, or rarely), and former users (have tried e-cigarettes but not currently using them at all).

Demographics
We measured sex, age, race, and education, categorizing them as shown in Table 5.

Data analytic approach
We conducted the analyses for this study in two stages using Mplus statistical software (v. 7.4) [45]. In the initial
stage, we used ordinal confirmatory factor analysis (CFA) [46] to examine the factorial validity of the measurement models for the affect and risk perceptions constructs, separately for each construct and followed by a correlated factors confirmatory factor model that incorporated factors for each construct (and each product – cigarettes and e-cigarettes). A mean- and variance-adjusted weighted least squares estimator (WLSMV) was used for these CFA models. Model fit was assessed by examination of the chi-square test of exact fit; approximate fit indices (viz., root mean square error of approximation [RMSEA] and comparative fit index [CFI], using criteria suggested by Hu & Bentler) [47]; magnitude and consistency of factor loadings; and modification indices.

In the second stage, we used structural equation modeling (SEM) to estimate the parameters of the hypothesized mediation model of the effect of affect on tobacco product use (cigarettes / e-cigarettes) via perceived risk of the product, while adjusting for covariates (gender, age, race/ethnicity, and education). A logit link function was used to model the multinomial log-odds of product use (current use = referent category) as a function of affect, risk perceptions, and covariates. These analyses employed a robust, full information maximum likelihood estimator (MLR) and adaptive numerical integration (trapezoid; 50 integration points per dimension) with expectation-maximization algorithm.

All analyses reported were weighted to account for the complex sampling design and generate estimates generalizable to the subpopulation of U.S. adults who are aware of e-cigarettes. Participants with missing data are included in the analysis if they have at least one non-missing data point under the assumption of missing at random for the full-information MLR estimator and missing at random given observed covariates for the WLSMV estimator [48]. Responses of “don’t know” for the risk perception items were modeled as missing data for all analyses. The amount of missing data for this study was minimal. The median covariance coverage, the proportion of cases that provide complete data for a pair of variables, across all pairs of variables in the models was 91.1%. All statistical tests and confidence intervals were two-tailed with alpha = .05.

Results
Demographic characteristics
Of those aware of e-cigarettes, 50.9% were females, 21.2% were 18–29 years old, 25.3% were 30–44, 27.5% were 45–59, and 26.0% were 60 years and older; 68.1% were White, non-Hispanic, 10.4% were Black, non-Hispanic, 14.6% were Hispanic, and 6.9% other race. Additionally, 10.67% had below high school education, 29.1% had high school diploma, 29.2% had some college education, and 31.1% had bachelor’s degree or higher education. Current smokers comprised an estimated 14.8% of the study population, 28.4% were former smokers, and 57.4% were never smokers. Approximately 8.5% were current e-cigarette users, 11% were former users, and 80.6% had never tried e-cigarettes. As reported elsewhere, 29.8% of current smokers were dual users of e-cigarettes (among current e-cigarette users, 56.9% were current smokers) [49] (see Additional file 1: Table S1).

Risk perceptions
Mean scores for cigarette risk perception ranged from 5.30 (heart disease) to 5.41 (lung disease other than lung cancer), and those of e-cigarette risk perception ranged from 4.17 (premature death) to 4.30 (lung disease other than lung cancer) (see Additional file 2: Table S2).

Affective imagery
Participants provided 9900 images of cigarettes and 9747 images for e-cigarettes. We coded these images by deriving the coding categories inductively from these answers. First, the images were categorized into 36 different categories for cigarettes and 32 for e-cigarettes based on the most frequently occurring images. These categories were further condensed into six categories for cigarettes: synonym, disgust, risky, addiction, satisfaction, and other. The same categories were used for e-cigarettes with addition of “safer/better than cigarettes” and “same/worse than cigarettes” categories. Multiple categories could be assigned to each image; however, use of “other” category was mutually exclusive with the rest of the categories.

The synonym category comprised images dealing with smoke, smoking, physical description of cigarettes and e-cigarettes, brands, and paraphernalia (lighter, ashtray). The disgust category included images and words dealing with repulsed feelings (e.g., “yuck”), negative perceptions of tobacco users, negative feelings (bad and its synonyms), and derogations (stupid, ridiculous).

The risky category was assigned to images mentioning negative health outcomes of using the product (e.g., lung cancer, death), dangerous chemicals (poison, tar), and concerns about others (bystanders, animals). Addiction images dealt with perceptions of dependence and included mentions of nicotine, need, want, and relief of cravings. Satisfication included mentions of relief, enjoyment, pleasure, and other positive sensory associations (good taste). For e-cigarettes, two more categories were used. Safer/better comprised images that favorably compared e-cigarettes to cigarettes in terms of health effects, convenience, or dependence. Same/worse included descriptions of e-cigarettes as same as cigarettes or worse in terms of health effects or satisfaction. The category designated “other” included images that did not fit in any of the preceding categories. Examples include mentions of specific people (“My mom”), places (“outside”),
times (“1980s”), and complementary consumables (“coffee”) associated with these products, cost, personal stories (e.g., “I quit”, “I don’t smoke”), mentions of taste and smell (when they did not have negative or positive connotation), and “don’t know”, “nothing”, etc.

A reliability check was performed by having a second coder independently categorize a randomly selected set of 10% of images. Intercoder reliability was acceptable [50] (Krippendorf’s alpha, for cigarettes: synonym 0.93, disgust 0.90, risky 0.95, addiction 0.79, satisfaction 0.76, other 0.72; for e-cigarettes: synonym 0.91, disgust 0.68, risky 0.92, addiction 0.90, satisfaction 0.80, safer 0.78, same/worse 0.81, other 0.70).

The most frequent images that non-smokers and former smokers envisioned when hearing the word “cigarette” belonged to the category of risky, followed by disgust (Table 1). In contrast, smokers most frequently mentioned synonyms of smoking, followed by the “other” category (which typically included images of specific people or places associated with cigarettes). These two rather bland and non-specific categories accounted for about 59% of the images offered by current smokers.

Images of e-cigarettes were even more extreme in this way. Overall, more than 65% were either synonyms or “other”, the latter being 45.6% (compared to 18.3% for cigarettes). Among current smokers this vacuous imagery was even more pronounced, with 54.7% in the “other” category and 24.5% being synonyms. The most common feelings associated with e-cigarettes were disgust and risky, particularly among former smokers or never smokers, though these two negative images were far less frequent overall (24.5%) than they were for cigarettes (58.4%). For every smoker group, images of e-cigarettes being safer or better than cigarettes were more frequent than images of e-cigarettes being the same or worse than cigarettes.

For the images of cigarettes, offered by current and former e-cigarette users, synonyms were most frequently mentioned, followed by risky (Table 2). For never e-cigarette users, risky and disgust were the most frequent images of cigarettes. For the images of e-cigarettes, regardless of the user status, by far the most frequent images were “other” (45.6%) followed by synonyms (19.6%). Risk as an image was only relatively frequently mentioned by the never users of e-cigarettes (12.7%), while relaxing/satisfaction was mentioned by 6.2% of current e-cigarette users. Regardless of whether participants used e-cigarettes, images of e-cigarettes being safer or better than cigarettes were more frequent than images of e-cigarettes being the same or worse than cigarettes. This was particularly true for current users of e-cigarettes.

Overall, images of cigarettes were valenced more negatively than e-cigarettes, and for both products, current smokers/users had the least negative image, followed by former smokers/users, and never smokers/users had the most negative images (Tables 3 and 4).

Measurement (CFA) models

Results from the CFA models supported the factorial validity of the affect and risk perceptions scales. The affect CFA model was specified with one factor representing affect towards cigarettes and the other factor representing affect towards e-cigarettes. The two affect valence scores for cigarettes and e-cigarettes were loaded separately on the cigarette affect factor and e-cigarette affect factor, respectively. Acceptable model fit was obtained for this model \(\chi^2(1) = 5.1, p = .02\;\text{RMSEA} = .028, 95\% \text{CI} = .008--.055; \text{CFI} = 1.0\), and all standardized factor loadings exceeded .9. More positive feelings towards cigarettes were associated with more positive feelings toward e-cigarettes as reflected by a positive correlation between the factors \((r = .63, 95\% \text{CI} = .60--.66)\). The risk perceptions CFA also fit well by conventional approximate fit standards \(\chi^2(19) = 108.0, p < .001; \text{RMSEA} = .030, 95\% \text{CI} = .025--.036; \text{CFI} = 1.0\), with all standardized factor loadings exceeding .95. Higher perception of risks for cigarettes was strongly correlated with perception of risks for e-cigarettes \((r = .65, 95\% \text{CI} = .63--.68)\). Finally, the combined, correlated

| % who mentioned | Cigarette images | | | E-cigarette images | | |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | Total \((n = 5389)\) | Current smoker \((n = 1184)\) | Former smoker \((n = 1520)\) | Never smoker \((n = 2683)\) | Total | Current smoker | Former smoker | Never smoker |
| Synonym         | 17.5            | 32.8            | 16.4            | 14.2            | 19.6            | 24.5            | 18.7          | 18.8          |
| Disgust         | 23.0            | 6.8             | 21.7            | 27.8            | 13.5            | 6.0             | 13.9          | 15.2          |
| Risky           | 35.4            | 13.7            | 34.6            | 41.4            | 11.0            | 3.5             | 10.9          | 12.9          |
| Addiction       | 4.9             | 9.5             | 5.5             | 3.4             | 3.9             | 2.3             | 4.3           | 4.0           |
| Relaxing/Satisfaction | 2.6   | 12.6            | 2.1             | 0.3             | 1.2             | 2.3             | 0.8           | 1.2           |
| Safer than cigarettes | –        | –               | –               | –               | 5.3             | 6.2             | 4.7           | 5.3           |
| Same/worse than cigarette | –        | –               | –               | –               | 3.8             | 2.4             | 3.2           | 4.4           |
| Other           | 18.3            | 26.1            | 208             | 15.1            | 45.6            | 54.7            | 47.2          | 42.5          |
factors CFA that merged CFA models for affect and risk perceptions for both products also fit the data well by approximate fit standards \(\chi^2(48) = 139.5, p < .001; \) RMSEA = .019, 95% CI = .015–.023; CFI = 1.0]. More positive affect towards cigarettes and towards e-cigarettes was significantly associated with lower perceptions of risk from smoking \( (r_s = -.27 \text{ and } -.19, \text{ respectively}) \) and from using e-cigarettes \( (r = -.18 \text{ and } -.36, \text{ respectively}) \).

Mediation models of affect, risk perceptions, and use Cigarette model

Figure 1 depicts the (partially) standardized coefficient estimates for the paths of focal interest to this study (Table 5 provides the unstandardized path coefficient estimates for all paths of the hypothesized structural model). Results were consistent with our hypothesis that affect towards cigarettes predicts smoking status and that this association is partially mediated by risk perceptions: more positive affect towards cigarettes was associated with lower perceived risks of smoking cigarettes, which in turn was associated with higher odds of being a current smoker. Specifically, a 1 SD difference in affect towards cigarettes was associated with a 0.23 SD difference in perceived risks of smoking after adjustment for the covariates. In turn, a 0.23 SD decrease in perceived risks of smoking was associated with an adjusted 20% higher odds \( \text{(aOR} = e^{-0.23 \cdot 0.80} = 1.20) \) of being a current smoker versus being a never smoker (and a 13% greater adjusted odds of being a current smoker vs. a former smoker). Affect towards cigarettes also had a direct effect on smoking status, independent of risk perceptions and covariates: specifically, more positive affect was directly associated with higher odds of being a current smoker \( (\text{aOR} = 1.91 \text{ vs. never smoker and } \text{aOR} = 1.57 \text{ vs. former smoker for a 1 SD difference in affect}) \).

E-cigarette model

Figure 2 depicts the (partially) standardized coefficient estimates for the paths of focal interest to this study (Table 6 provides the unstandardized path coefficient estimates for all paths of the hypothesized structural model). Similar to the results for the cigarette model, results were consistent with our hypothesis that feelings towards e-cigarettes predict e-cigarette use and that this association

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**Table 2** Proportions of participants reporting various images of cigarettes and electronic cigarettes by e-cigarette user status

| % who mentioned | Cigarette images | E-cigarette images |
|-----------------|------------------|-------------------|
|                 | Total \((n = 5387)\) | Current user \((n = 550)\) | Former user \((n = 655)\) | Never user \((n = 4182)\) | Total | Current user | Former user | Never user |
| Synonym         | 17.5             | 32.4             | 25.8             | 14.8             | 19.6 | 29.0         | 27.2         | 17.6         |
| Disgust         | 23.0             | 15.9             | 18.5             | 24.4             | 13.5 | 2.8          | 9.3          | 15.2         |
| Risky           | 35.4             | 198             | 248             | 38.5             | 11.0 | 3.6          | 4.1          | 12.7         |
| Addiction       | 4.9              | 7.1              | 6.9              | 4.4              | 3.9  | 1.8          | 2.8          | 4.2          |
| Relaxing/ Satisfaction | 2.6          | 8.1              | 6.2              | 1.5              | 1.2  | 6.2          | 1.5          | 0.7          |
| Safer than cigarettes | –              | –                | –                | –                | 5.3  | 7.9          | 5.4          | 5.0          |
| Same/worse than cigarette | –         | –                | –                | –                | 3.8  | 0.6          | 2.6          | 4.3          |
| Other           | 18.3             | 18.5             | 18.5             | 18.3             | 45.6 | 48.4         | 49.2         | 44.8         |

**Table 3** Mean valence of cigarette and electronic cigarette image by cigarette smoker status

| Image categories | Cigarette images | E-cigarette images |
|------------------|------------------|-------------------|
|                  | Total | Current smoker | Former smoker | Never smoker | Total | Current smoker | Former smoker | Never smoker |
| Synonym          | −0.62 | 0.01          | −0.72          | −1.02         | −0.27 | 0.19          | −0.19         | −0.47         |
| Disgust          | −0.99 | −0.96         | −0.85          | −1.05         | −0.69 | −0.63         | −0.34         | −0.86         |
| Risky            | −1.40 | −1.42         | −1.32          | −1.43         | −1.22 | −0.66         | −1.11         | −1.30         |
| Addiction        | −0.94 | −0.33         | −1.04          | −1.29         | −0.86 | −0.11         | −0.62         | −1.11         |
| Relaxing/ Satisfaction | 1.10       | 1.30          | 0.77           | 0.28          | 0.96  | 0.85          | 1.15          | 0.94          |
| Safer than cigarettes | –      | –              | –              | –             | 0.82  | 1.12          | 0.72          | 0.78          |
| Same/worse than cigarette | –     | –              | –              | –             | −0.44 | 0.25          | −0.34         | −0.57         |
| Other            | 0.02  | −0.16         | 0.37           | −0.34         | 0.03  | 0.28          | 0.17          | −0.14         |
| Overall          | −0.83 | −0.05         | −0.70          | −1.10         | −0.24 | 0.22          | −0.10         | −0.43         |

*Note: Valence was rated on a 5-point scale from −2 (very bad) to +2 (very good) (with 0 being "neither good nor bad")
is partially mediated by risk perceptions towards e-cigarettes: more positive affect towards e-cigarettes was associated with lower perceived risks of using e-cigarettes daily, which in turn was associated with higher odds of being a current e-cigarettes user. Specifically, a 1 SD difference in affect towards cigarettes was associated with a 0.29 SD difference in perceived risks of e-cigarettes use after adjustment for the covariates. In turn, a 0.29 SD decrease in perceived risks of e-cigarettes use was associated with an adjusted 16% higher odds (aOR = e^{-0.29\cdot-0.52} = 1.16) of being a current e-cigarettes user versus a never user (and a 12% greater adjusted odds of being a current user vs. a former user). Affect towards e-cigarettes also had a direct effect on e-cigarettes use, independent of risk perceptions and covariates: specifically, more positive affect was directly associated with higher odds of being a current e-cigarette user (aOR = 1.62 vs. never user and aOR = 2.03 vs. former user for a 1 SD difference in affect).

**Discussion**

In exploring the question of what predicts initiation, maintenance, or cessation of tobacco use, researchers have most frequently provided a rationalistic explanation, focusing on perceptions of risks and benefits of tobacco use, defining them as reasoned assessments or expectancies [8]. More recently, affect or feelings of risk started gaining a more prominent role. In our study, we used a nationally representative sample of U.S. adults to explore how they feel about cigarettes and e-cigarettes, and what attributes of each product are most prominently featured in their affective imagery for these tobacco products. We tested a model in which feelings about a tobacco product were associated with current use of this product by linking with the behavior directly and indirectly through perceptions of risk.

We found that when asked to describe images that first come to their minds when they hear word “cigarettes” participants’ common images reflect disgust and
Table 5: Unstandardized path coefficients for the mediation model of affect towards cigarettes, risk perceptions, and smoking (n = 5389)

| Direct paths                                                                 | Path coefficient<sup>a</sup> | 95% CI          | p       |
|-------------------------------------------------------------------------------|------------------------------|----------------|---------|
| **Affect → Smoking Status (ref = Current Smoker)**                            |                              |                |         |
| Never Smoker (vs. Current Smoker)                                            | −0.20                        | −0.22 – −0.18   | < 0.001 |
| Former Smoker (vs. Current Smoker)                                           | −0.14                        | −0.16 – −0.12   | < 0.001 |
| **Affect → Risk Perceptions**                                                | −0.66                        | −0.82 – −0.50   | < 0.001 |
| **Risk Perceptions → Smoking Status (ref = Current Smoker)**                 |                              |                |         |
| Never Smoker (vs. Current Smoker)                                            | 0.09                         | 0.08 – 0.09     | < 0.001 |
| Former Smoker (vs. Current Smoker)                                           | 0.06                         | 0.05 – 0.07     | < 0.001 |
| **Covariates → Affect**                                                      |                              |                |         |
| Age (ref = 18–29 years old)                                                  |                              |                |         |
| 30–44 years old                                                              | 0.49                         | 0.10 – 0.88     | 0.013   |
| 45–59 years old                                                              | 0.36                         | −0.02 – 0.74    | 0.065   |
| 60+ years old                                                                | 1.16                         | 0.79 – 1.54     | < 0.001 |
| Race/Ethnicity (ref = White, non-Hispanic)                                   |                              |                |         |
| Black, non-Hispanic                                                          | 0.04                         | −0.42 – 0.49    | 0.872   |
| Hispanic, any race                                                            | 0.07                         | −0.32 – 0.46    | 0.732   |
| Other                                                                         | 0.28                         | −0.30 – 0.87    | 0.343   |
| Education (ref = <High School)                                               |                              |                |         |
| High School                                                                  | −0.37                        | −0.90 – 0.16    | 0.174   |
| Some College                                                                 | −0.72                        | −1.27 – −0.16   | 0.012   |
| Bachelor’s degree or higher                                                  | −1.21                        | −1.79 – −0.64   | < 0.001 |
| Female                                                                        | −0.50                        | −0.78 – −0.22   | < 0.001 |
| **Covariates → Risk Perceptions**                                            |                              |                |         |
| Age (ref = 18–29 years old)                                                  |                              |                |         |
| 30–44 years old                                                              | 0.75                         | −0.45 – 1.94    | 0.221   |
| 45–59 years old                                                              | 1.75                         | 0.57 – 2.92     | 0.004   |
| 60+ years old                                                                | 2.96                         | 1.80 – 4.11     | < 0.001 |
| Race/Ethnicity (ref = White, non-Hispanic)                                   |                              |                |         |
| Black, non-Hispanic                                                          | −0.10                        | −1.66 – 1.47    | 0.902   |
| Hispanic, any race                                                            | 0.71                         | −0.48 – 1.91    | 0.241   |
| Other                                                                         | 0.02                         | −1.86 – 1.91    | 0.980   |
| Education (ref = <High School)                                               |                              |                |         |
| High School                                                                  | 1.55                         | 0.03 – 3.07     | 0.045   |
| Some College                                                                 | 0.88                         | −0.67 – 2.43    | 0.266   |
| Bachelor’s degree or higher                                                  | 2.42                         | 0.92 – 3.91     | 0.002   |
| Female                                                                        | 2.11                         | 1.28 – 2.94     | < 0.001 |
| **Covariates → Never Smoker (vs. Current Smoker)**                           |                              |                |         |
| Age (ref = 18–29 years old)                                                  |                              |                |         |
| 30–44 years old                                                              | −0.68                        | −0.88 – −0.48   | < 0.001 |
| 45–59 years old                                                              | −0.57                        | −0.75 – −0.38   | < 0.001 |
| 60+ years old                                                                | −0.02                        | −0.23 – 0.20    | 0.894   |
| Race/Ethnicity (ref = White, non-Hispanic)                                   |                              |                |         |
| Black, non-Hispanic                                                          | −0.42                        | −0.68 – −0.17   | 0.001   |
| Hispanic, any race                                                            | 0.07                         | −0.15 – 0.29    | 0.560   |
| Other                                                                         | 0.27                         | 0.06 – 0.47     | 0.012   |
risk. This was somewhat less the case for e-cigarettes whose images were primarily just the descriptions or synonyms of the products, as well as associations with specific people, places, and times, or personal stories related to these products.

Images of cigarettes were strongly negative for former and never smokers, but sometimes positive (e.g. for relaxing), particularly among current smokers. The negatively valenced categories focused on health risks and disgust were particularly frequent for former and never smokers. Images of addiction were rare, and most frequently brought up by current smokers, perhaps because addiction for them is a more salient and visceral experience.

Comparing cigarettes and e-cigarettes, the images for cigarettes were far more negative. Images related to risk and disgust were frequently associated with cigarettes (35% and 23% respectively), but were much less common for e-cigarettes (11% and 14%). While few participants mentioned images in which e-cigarettes were explicitly compared to cigarettes, most of those comparisons were more favorable towards e-cigarettes, with participants mentioning that e-cigarettes were safer, cleaner, or healthier than cigarettes. Smokers who supplied images of e-cigarettes being worse than cigarettes typically held very positive feelings towards cigarettes. For example, one participant wrote about an e-cigarette “Seems too unnatural. I’ve never really been interested. The thing I like about

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**Table 5** Unstandardized path coefficients for the mediation model of affect towards cigarettes, risk perceptions, and smoking (n = 5389) (Continued)

| Direct paths | Path coefficient$^a$ | 95% CI      | $p$  |
|--------------|----------------------|-------------|------|
| Education (ref = <High School) |                      |             |      |
| High School  | 0.31                 | 0.05 – 0.58 | 0.019|
| Some College | 0.79                 | 0.52 – 1.06 | < 0.001|
| Bachelor’s degree or higher | 1.72                 | 1.46 – 1.99 | < 0.001|
| Female       | 0.02                 | – 0.12 – 0.17 | 0.746|
| Covariates Former smoker (vs. Current Smoker) |                      |             |      |
| Age (ref = 18–29 years old) |                      |             |      |
| 30–44 years old | 0.40                 | 0.15 – 0.65 | 0.002|
| 45–59 years old | 0.75                 | 0.53 – 0.98 | < 0.001|
| 60+ years old | 1.84                 | 1.58 – 2.09 | < 0.001|
| Race/Ethnicity (ref = White, non-Hispanic) |                      |             |      |
| Black, non-Hispanic | – 0.67               | – 0.93 – – 0.41 | < 0.001|
| Hispanic, any race  | – 0.10               | – 0.33 – 0.12 | 0.373|
| Other          | – 0.34               | – 0.64 – – 0.04 | 0.027|
| Education (ref = <High School) |                      |             |      |
| High School  | 0.46                 | 0.16 – 0.76 | 0.003|
| Some College | 0.72                 | 0.41 – 1.03 | < 0.001|
| Bachelor’s degree or higher | 0.88                 | 0.57 – 1.19 | < 0.001|
| Female       | – 0.29               | – 0.45 – – 0.14 | < 0.001|
| Factor Loadings |                      |             |      |
| Risk Perceptions |                      |             |      |
| Lung Cancer | 0.98                 | 0.98 – 0.99 | < 0.001|
| Lung Disease (e.g., COPD) | 0.99                 | 0.98 – 0.99 | < 0.001|
| Heart Disease | 0.97                 | 0.96 – 0.97 | < 0.001|
| Early/Premature Death | 0.96                 | 0.95 – 0.97 | < 0.001|
| Affect |                      |             |      |
| First Image Rating | 0.87                 | 0.86 – 0.89 | < 0.001|
| Second Image Rating | 1.00                 | 1.00 – 1.00 | < 0.001|

Ref = referent group or category. → denotes an estimated model path (for example, “Affect → Smoking Status” signifies the path for the regression of smoking status on affect). $^a$Coefficients are either multinomial logistic coefficients (unstandardized; akin to logistic regression coefficients) if smoking status is the outcome variable (i.e., “→ Smoking Status”, “→ Former smoker”, or “→ Never smoker”), standardized factor loadings or residual correlations for the measurement model paths, or are linear coefficients (akin to regression coefficients) otherwise (i.e., “→ Affect” or “→ Risk Perceptions”)
smoking is that it’s earthy and cozy, like a tiny little campfire... there’s nothing like that about e-stuff.” Our finding that some participants perceived e-cigarettes as worse than cigarettes because e-cigarettes are “unnatural” resonates with findings from other studies where participants thought that e-cigarettes are more dangerous than “natural” tobacco and marijuana products because e-cigarettes and vaporizers contain various “chemicals” [51].

With regard to e-cigarettes, perhaps the most important finding is the high frequency of the “other” category and synonyms. This suggests that the attitudes of our respondents are rather uniformed, cognitively and emotionally, with regard to these new products. This fits with other recent survey data in which questions about risks and other consequences of using e-cigarettes had an unusually high proportion of “don’t know” answers [52].

Campaigns discouraging smoking should reinforce the images focused on risk and disgust, since those were the images that current smokers rated as most negative in valence and they were far less frequent among smokers. This strong negative affect is consistent with findings that most current smokers are miserable and regret having started smoking and want to quit [53, 54]. These findings further support the need to run communication campaigns focused on negative health effects of smoking, such as CDC’s Tips From Former Smokers [55, 56]. Although we did not code for it specifically, quite a few smokers referred to this campaign when they described the first images associated with cigarettes (e.g., “lady on TV with a hole in her throat”). This is in contrast to very few associations with positive images from tobacco advertisements (e.g., “Virginia Slim cigarette ad with the beautiful lady dressed eloquently”). CDC’s Tips campaign has been successful in increasing perceptions of risks and attempts at quitting [56, 57]. However, evaluations of this campaign have not examined to what extent exposure to this campaign has changed smokers’ feelings about smoking and the associated affective imagery, although this might be the mechanism through which it worked. Future studies should explicitly evaluate effects of communication campaigns on affective imagery of tobacco users.

These findings also have implications for the FDA regulations on warning labels. The Congress mandated the FDA to create pictorial warning labels for cigarettes [58]. Pictorial warning labels on cigarettes are required by law in at least 105 countries [59], and extensive research shows that large pictorial warning labels are effective in informing consumers about the harms of smoking and motivating smokers to quit [60–62]. The first set of the pictorial warning labels proposed by the FDA was struck down in court, partially because the court concluded that there was no evidence that the emotional labels selected by the FDA have an effect on reducing smoking [63]. When the FDA proposes its next set of pictorial warning labels, the agency can argue that pictorial warning labels are instrumental in helping achieve the substantial governmental goal of reducing smoking (assuming the case again will be held up to the test of Central Hudson) [64], because affect is central to smokers’ decisions to start or quit smoking and that affective messages are needed to break the positive associations smokers have of cigarettes. The association between affect and smoking provides additional evidence to use pictorial warning labels on cigarettes that evoke strong negative emotions.

Over the past several years, comparative perceptions of risks of e-cigarettes in relation to cigarettes have been
Table 6 Unstandardized path coefficients for mediation model of affect towards e-cigarettes, risk perceptions, and e-cigarettes use ($n = 5389$)

| Direct paths                                      | Path coefficient* | 95% CI               | $p$     |
|--------------------------------------------------|-------------------|----------------------|---------|
| Affect $\rightarrow$ E-cigarette use status (ref = Current e-cigarette user) |                   |                      |         |
| Never user (vs. Current e-cigarette user)        | −0.24             | −0.27 -- 0.21        | <0.001  |
| Former user (vs. Current e-cigarette user)       | −0.17             | −0.20 -- 0.14        | <0.001  |
| Affect $\rightarrow$ Risk Perceptions             | −1.05             | −1.28 -- 0.83        | <0.001  |
| Risk Perceptions $\rightarrow$ E-cigarette use status (ref = Current e-cigarette user) |                   |                      |         |
| Never user (vs. Current e-cigarette user)        | 0.07              | 0.06 -- 0.08         | <0.001  |
| Former user (vs. Current e-cigarette user)       | 0.03              | 0.02 -- 0.04         | <0.001  |
| Covariates $\rightarrow$ Affect                   |                   |                      |         |
| Age (ref = 18–29 years old)                       |                   |                      |         |
| 30–44 years old                                  | −0.04             | −0.39 -- 0.31        | 0.818   |
| 45–59 years old                                  | −0.27             | −0.62 -- 0.07        | 0.119   |
| 60+ years old                                    | 0.14              | −0.19 -- 0.48        | 0.401   |
| Race/Ethnicity (ref = White, non-Hispanic)       |                   |                      |         |
| Black, non-Hispanic                              | 0.00              | −0.45 -- 0.45        | 0.994   |
| Hispanic, any race                               | −0.39             | −0.75 -- 0.02        | 0.036   |
| Other                                            | −0.03             | −0.49 -- 0.43        | 0.899   |
| Education (ref = <High School)                   |                   |                      |         |
| High School                                      | −0.18             | −0.62 -- 0.25        | 0.408   |
| Some College                                     | −0.57             | −1.02 -- 0.13        | 0.012   |
| Bachelor’s degree or higher                      | −0.84             | −1.28 -- 0.40        | <0.001  |
| Female                                           | −0.26             | −0.50 -- 0.02        | 0.035   |
| Covariates $\rightarrow$ Risk Perceptions         |                   |                      |         |
| Age (ref = 18–29 years old)                       |                   |                      |         |
| 30–44 years old                                  | 1.98              | 0.71 -- 3.25         | 0.002   |
| 45–59 years old                                  | 3.39              | 2.09 -- 4.70         | <0.001  |
| 60+ years old                                    | 5.76              | 4.36 -- 7.16         | <0.001  |
| Race/Ethnicity (ref = White, non-Hispanic)       |                   |                      |         |
| Black, non-Hispanic                              | 0.86              | −0.91 -- 2.63        | 0.339   |
| Hispanic, any race                               | −0.24             | −1.62 -- 1.14        | 0.736   |
| Other                                            | 1.13              | −0.57 -- 2.82        | 0.193   |
| Education (ref = <High School)                   |                   |                      |         |
| High School                                      | −0.03             | −1.66 -- 1.60        | 0.969   |
| Some College                                     | 0.28              | −1.29 -- 1.86        | 0.723   |
| Bachelor’s degree or higher                      | 0.58              | −0.91 -- 2.06        | 0.446   |
| Female                                           | 1.96              | 1.02 -- 2.91         | <0.001  |
| Covariates $\rightarrow$ Never user (ref = Current e-cigarette user) |   |                      |         |
| Age (ref = 18–29 years old)                       |                   |                      |         |
| 30–44 years old                                  | 0.33              | 0.07 -- 0.58         | 0.011   |
| 45–59 years old                                  | 0.90              | 0.68 -- 1.12         | <0.001  |
| 60+ years old                                    | 1.86              | 1.61 -- 2.11         | <0.001  |
| Race/Ethnicity (ref = White, non-Hispanic)       |                   |                      |         |
| Black, non-Hispanic                              | 0.12              | −0.21 -- 0.44        | 0.476   |
| Hispanic, any race                               | −0.48             | −0.71 -- 0.24        | <0.001  |
increasing among adults in the U.S. [52] At the same time, the rates of use of e-cigarettes have been increasing [65, 66]. This is counterintuitive, since perceived risk is usually negatively related to behavior, as described by various health behavior theories [5, 67, 68] and shown empirically for variety of substance use, from marijuana to cigarettes [69, 70]. Our findings provide one possible explanation for this discrepancy—while perceived risk plays a role in e-cigarette use, affect towards e-cigarettes explains current e-cigarette use above and beyond perceptions of risk. We found that on average, adults have more negative affect towards cigarettes than e-cigarettes.

**Limitations**

This study employed only two images for each product, in contrast to past studies that used 5–6 images [27, 44, 71]. This might have restricted the pool of affective cues. However, in past studies [44, 71] and this study, the affective valences of the subsequent images were highly correlated, indicating that the first two images might be enough to capture the central affect towards the product.

All measures were self-reported; however, self-report of behavior in surveys has been a reliable measure [72]. Since this was a cross-sectional survey, all data are correlational and, therefore, casual inference is limited. We are limited to concluding only that our data were

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**Table 6** Unstandardized path coefficients for mediation model of affect towards e-cigarettes, risk perceptions, and e-cigarettes use (n = 5389) (Continued)

| Direct paths                          | Path coefficient | 95% CI       | p      |
|--------------------------------------|------------------|--------------|--------|
| Other                                | −0.29            | −0.66 – 0.08 | 0.124  |
| Education (ref = <High School)       |                  |              |        |
| High School                          | 0.31             | 0.04 – 0.57  | 0.023  |
| Some College                         | 0.48             | 0.21 – 0.75  | < 0.001|
| Bachelor’s degree or higher          | 1.15             | 0.84 – 1.47  | < 0.001|
| Female                               | −0.05            | −0.23 – 0.13 | 0.589  |
| Covariates Former user (ref = Current e-cigarette user) |                  |              |        |
| Age (ref = 18–29 years old)          |                  |              |        |
| 30–44 years old                      | 0.14             | −0.14 – 0.42 | 0.338  |
| 45–59 years old                      | 0.20             | −0.04 – 0.45 | 0.107  |
| 60+ years old                        | 0.45             | 0.16 – 0.74  | 0.002  |
| Race/Ethnicity (ref = White, non-Hispanic) |              |              |        |
| Black, non-Hispanic                  | 0.26             | −0.07 – 0.59 | 0.119  |
| Hispanic, any race                   | −0.18            | −0.46 – 0.10 | 0.200  |
| Other                                | −0.29            | −0.72 – 0.14 | 0.182  |
| Education (ref = <High School)       |                  |              |        |
| High School                          | −0.01            | −0.30 – 0.28 | 0.966  |
| Some College                         | 0.31             | 0.01 – 0.62  | 0.045  |
| Bachelor’s degree or higher          | 0.39             | 0.05 – 0.74  | 0.027  |
| Female                               | 0.08             | −0.12 – 0.28 | 0.432  |
| Factor Loadings                      |                  |              |        |
| Risk Perceptions                     |                  |              |        |
| Lung Cancer                          | 0.99             | 0.99 – 0.99  | < 0.001|
| Lung Disease (e.g., COPD)            | 0.99             | 0.98 – 0.99  | < 0.001|
| Heart Disease                        | 0.97             | 0.97 – 0.98  | < 0.001|
| Early/Premature Death                | 0.96             | 0.96 – 0.97  | < 0.001|
| Affect                               |                  |              |        |
| First Image Rating                   | 0.87             | 0.85 – 0.88  | < 0.001|
| Second Image Rating                  | 1.00             | 1.00 – 1.00  | < 0.001|

Ref = referent group or category. → denotes an estimated model path (for example, “Affect → E-cigarette use status” signifies the path for the regression of e-cigarette use status on affect). *Coefficients are either multinomial logistic coefficients (unstandardized; akin to logistic regression coefficients) if e-cigarette use status is the outcome variable (i.e., “→E-cigarette use status”, “→Former user”, or “→Never user”), standardized factor loadings or residual correlations for the measurement model paths, or are linear coefficients (akin to regression coefficients) otherwise (i.e., “→Affect” or “→ Risk Perceptions”)
consistent with our hypothesized and theory-guided mediational model, and acknowledge that alternative models with different causal assumptions (e.g., bi-directional relationships) may also fit the data equally as well. Our study design cannot evaluate which among the current and many alternative models is the correct or best fitting model. Future studies should explore longitudinal effects of affect on behavior or manipulate affect directly as was done by Finucane et al. [26] There could be dynamic feedback loops whereby the experience of tobacco use influences subsequent affect, perceptions of risk, and future tobacco use (e.g., affect→perceptions→product use→affect→…). However, our study was not designed to test dynamic feedback loops. Future intensive longitudinal studies, for example, using ecological momentary assessment (EMA), can evaluate such recursive models. Our study provides initial support to justify these more resource-intensive EMA studies, which would be able to better test and compare the alternative models.

Affect was measured by asking participants to write down an image that comes to mind when they hear the word “cigarettes” or “EVPs”. This open-ended measure provided in-depth insight into visceral feelings participants associate with tobacco products. However, for many participants, the images were not very informative and consisted of the image of the product themselves (i.e., synonyms). To more systematically study affect, future studies should use a more structured approach to soliciting images. Instead of asking participants to write down the first few images of tobacco products, studies should give participants a list of images and ask to what extent they associate these images with each tobacco product and the image’s valence. Although the solicitation of images might appear to be visually focused, the instructions did not discourage participants from providing responses related to senses of smell, taste, and touch.

Conclusion
Our work adds to the limited literature on the association between affect, risk perceptions, and tobacco use by evaluating them for the first time in the nationally representative sample of the U.S. adults. Consistent with the affect heuristic [21], affect towards cigarettes and e-cigarettes was associated with cigarette smoking and e-cigarettes use respectively, and these associations were both direct and partially mediated by risk perceptions towards smoking and e-cigarettes. More positive affect towards tobacco products was associated with lower perceived risks, which in turn was associated with higher odds of being a current tobacco user. The overall relationships between affect, risk perceptions, and current use were similar for cigarettes and e-cigarettes. In developing models explaining tobacco use behavior, or in creating public communication campaigns aimed at curbing tobacco use, it is useful to focus not only on the reason based predictors, such as perceptions of risks and benefits, but also on affective predictors. The former may be very useful in providing a part of the answer, but including affect in the models and looking at the combined effects of reason and affect will enable researchers and regulatory agencies to better understand predictors of use and to design effective communication campaigns.

Additional files

Additional file 1: Table S1. Prevalence of cigarette smoking and e-cigarette use. (DOCX 14 kb)

Additional file 2: Table S2. Means of risk rating scores. (DOCX 13 kb)

Abbreviations
aOR: adjusted odds ratio; CFA: Confirmatory factor analysis; e-cigarettes: electronic cigarettes; EVP: Electronic vapor product; RMSEA: Root mean square error of approximation; SEM: Structural equation modelling; TRRPS: Tobacco Products and Risk Perceptions Survey; WLSMV: mean- and variance-adjusted weighted least squares estimator

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Availability of data and materials
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Authors’ contributions
SW, CM, TP, and PS designed the study. LP wrote the first draft. SW and DO conducted the analyses. All authors contributed to writing, revising, and approved the final manuscript.

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Ethics approval and consent to participate
The study on which these data analyses are based was approved by the Georgia State University Institutional Review Board (Reference number 341154). Participants were provided information about the study and consented by proceeding to take the survey; this implied consent was approved by the Georgia State University Institutional Review Board.

Consent for publication
Not applicable.

Competing interests
The authors have no conflicts of interest.
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