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Beliefs About the Direct Comparison of E-Cigarettes and Cigarettes

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Abstract

Background: Recent data suggests that positive beliefs about electronic cigarettes (e-cigs) use can lead to later e-cig use. Considering that many advertisements claim that e-cigs are superior to cigarettes, individuals' likelihood to view e-cigs more favorably than cigarettes can also influence subsequent e-cig use; however, no studies have directly assessed such a comparison.

Objectives: The present study created and validated the Comparing E-Cigarettes and Cigarettes questionnaire (CEAC), which asks individuals to directly compare e-cigs and cigarettes on a number of dimensions, in two independent samples.

Methods: In sample 1 (451 undergraduates; mean age=20.35, SD=5.44, 72.4% female, 73.4% Caucasian) we explored the factor structure of the CEAC and in sample 2 (699 community adults collected via Amazon's Mechanical Turk; mean age=34.04, SD=10.9, 47.7% female, 83.3% Caucasian) we replicated the factor structure.

Results: Exploratory factor analysis suggested a three-factor structure: *General Benefits* ($\alpha=0.80$), *General Effects* ($\alpha=0.86$), and *Health Benefits* ($\alpha=0.88$), which was replicated via confirmatory factor analysis, $\chi^2 = 4.36$; RMSEA= 0.07, 90% CI= 0.06–0.08; TLI = 0.99; CFI = 0.99, and was relatively invariant across product use and gender. Individuals reported viewing e-cigs as safer and more beneficial than cigarettes and these beliefs were higher in e-cig users.

Conclusions: Future work should establish how these comparative beliefs are influenced by e-cig use and/or influence subsequent transition to and increases in e-cig use. Although e-cigs are likely less harmful than cigarettes, and thus these comparative beliefs represent that state of nature, e-cigs are not completely without risk.

Keywords

electronic-cigarettes; cigarettes; public health; smoking; attitudes

Introduction

The prevalence of current electronic cigarette (e-cig) use is 3.7% for adults (Schoenborn & Gindi, 2015). Approximately 9.5% of eighth graders, 14% of 10th graders and 16.2 % of twelfth graders report past month e-cig use (Johnston, et al., 2016). Rates are increasing

despite mixed findings on the health risks and benefits of e-cigs, including that e-cig refill liquid and vapor contain potentially harmful substances (FDA, 2014; Schweitzer, et al., 2015; Sussan, et al., 2015; Lerner, et al., 2015). Considering the high prevalence rate and potentially harmful consequences of e-cig use, a better understanding of the reasons that underlie e-cig use is needed. Further, as e-cigs are often compared to or considered an alternative to cigarettes (Harrell, et al., 2014; Hendricks, et al., 2015; Pepper, et al., 2014; Pokhrel, et al., 2014) a better understanding of such comparative beliefs is warranted. This is key for understanding the developmental trajectory of e-cig use, including ways to intervene upon and prevent use.

Research has established that individuals endorse using e-cigs because they have low health and addiction risks, benefits for smoking cessation (e.g. less severe withdrawal from nicotine use), greater social enhancement, and are as satisfying as cigarettes (Harrell, et al., 2014; Hendricks, et al., 2015; Pepper, et al., 2014; Pokhrel, et al., 2014). These positive beliefs are associated with past 30-day e-cig use, intentions to use e-cigs in the future, and e-cig use one year later (Peters, et al., 2015; Pokhrel, et al., 2014), demonstrating that positive beliefs about e-cigs are related to ultimate use, and further, are often conceptualized as compared to cigarettes.

E-cigs are, in fact, designed to have many similarities with cigarettes, including their look, feel, and drug experience (Dawkins, et al., 2012; Dawkins & Corcoran, 2014; Etter, et al., 2011; Flouris, et al., 2013; Nides, et al., 2014), thus it is not surprising individuals would compare e-cigs to cigarettes. Advertisements for e-cigs often harness such comparisons and purport that e-cigs are safer and more socially acceptable than cigarettes (Grana, et al., 2014; Kim, et al., 2015) despite the fact that empirical research has documented negative health effects of e-cigs (FDA, 2014; Schweitzer, et al., 2015; Sussan, et al., 2015; Lerner, et al., 2015). These comparative beliefs are important because the more that individuals view e-cigs as having benefits over cigarettes, the more likely they may be to transition from cigarettes to e-cigs or to use e-cigs for smoking cessation. Evidence does seem to indicate that e-cigs are safer than cigarettes, thus these comparative beliefs may be accurate (Harrell, et al., 2014), and could positively relate to transitions from cigarettes to less harmful e-cigs. However, evidence is accumulating suggesting negative health effects related to e-cig use (FDA, 2014; Schweitzer, et al., 2015; Sussan, et al., 2015; Lerner, et al., 2015); as such, despite decreases in smoking-related harm, transitioning from cigarettes to e-cigs could be associated with other problems, such as inflammation or reduced immune defenses in the lungs (Schweitzer, et al., 2015; Sussan, et al., 2015). Additionally, such comparative beliefs could be associated with transitioning from non-smoking to e-cig use. This is important because even though e-cigs are likely less harmful than cigarettes, they are likely not completely free from harm.

Previous studies have identified some beliefs about e-cigs through various scales and single items. One study adapted the 25-item Brief Smoking Consequences Questionnaire (BASQ-A) to assess beliefs about e-cig consequences (e.g. health risks, craving/addiction), which produced adequate fit and reliability, but did not provide direct comparisons of e-cigs and cigarettes and only sampled hospitalized smokers, limiting the generalizability of the scale (Hendricks, et al., 2015). An e-cig expectancy questionnaire was developed using 40 items

with 7 scales (e.g. social enhancement, affect regulation, negative health outcomes), although scales varied in their predictive validity as related to e-cig use intent, and no comparisons were made to cigarettes (Pokhrel, et al., 2014). Additionally, recent research validated the Short-Form Vaping Consequences Questionnaire (Morean & L'Insalata, 2016) which examines expectancies of e-cigarette use, and though comparisons were made between smoking and e-cigarette use expectancies, the comparisons were assessed statistically and not through direct questions.

To our knowledge, 1) there is no cohesive measure of e-cigs beliefs as directly compared to cigarette beliefs across product-use status, 2) research has yet to fully examine invariance of these comparative beliefs across gender, e-cig use status, and cigarette use status.

The goal of the present pair of studies was to create the Comparing E-cigarettes and Cigarettes questionnaire (CEAC) to directly assess how individuals view e-cigs as compared to cigarettes. Though individual items do not typically contain comparative language in the literature, valid measures, particularly related to attitude documentation, have examined comparisons within the scale items (Dijkstra, et al., 2007; Menninga, et al., 2011; Nakar & Viker, 2010). This has been done to answer research questions about comparative attitudes, which is in line with the goal of the present studies.

This paper collected two independent samples in order to: 1) assess comparative beliefs of e-cig use and cigarette smoking across multiple domains, 2) establish initial reliability and validity data for the CEAC, 3) examine measurement invariance of the CEAC across gender, e-cig use status, and cigarette use status, and 4) compare e-cig and cigarette users on the CEAC.

Methods

Because studies were of minimal risk and identifiable information was not collected, the present studies were exempted from review by the University Institutional Review Board. Participants were given a study information sheet prior to completing the questionnaires.

Sample 1 participants and procedures

Sample 1 participants were undergraduate students who were over the age of 18 and who were enrolled in an introduction to psychology course at a large Midwestern University. They chose to take part in this online study in exchange for course credit. The study was posted on the online university research management system. After reading a description of the study, participants were given a link to an online survey, where they responded to demographic items, the CEAC, and other measures not relevant to the current study (the results for which have not been reported elsewhere). Upon completion, participants received research credit towards their psychology course.

Sample 2 participants and procedures

Sample 2 participants were recruited through Amazon's Mechanical Turk (www.mturk.com) as part of a larger research study. Mechanical Turk (MTurk) is an online web service that connects researchers ("requesters") with individuals willing to complete tasks for a wage

(“workers”). This method of data collection has been validated in psychological research (Adams, et al., 2014; Andover, et al., 2014; Boynton, et al., 2014; Hershberger, et al., 2016; Holden, et al., 2013; Horton, et al., 2011; Papa, et al., 2014). The inclusion criteria for participants were: 21 years or older, able to read and understand questions in English, live in the United States, and drink alcohol. Workers on Amazon’s MTurk self-selected to take part in this study, which was listed as “E-cig, Cigarette, and Alcohol Use Study.” Participants received \$0.75, which is in line with the average hourly wage of \$1.40 for MTurk workers (Horton, et al., 2011). After reading the description of the study and signing up for the study, participants were given a link to the online survey. Participants completed the study questionnaires (see Measures) and other measures not relevant to the present study. Participants were compensated following completion in line with MTurk procedures.

Measures

Demographics and product use status.—Participants reported the following items: 1) age, gender, and ethnicity (White/Caucasian, African American, Asian/Pacific Islander, American Indian/Alaskan Native, Hispanic, Other); 2) e-cig use (“Do you use electronic-cigarettes currently”, with responses including either “Yes” or “No”); and 3) cigarette use (“Do you smoke cigarettes currently?”, with responses including either “Yes” or “No”). Participants’ product use status was determined by their responses to the e-cig and cigarette use items. Those responding “Yes” to the e-cig item only were designated as “e-cig users”, while those responding “Yes” to the cigarette item only were designated as “cigarette users”, and those responding “No” to the e-cig and cigarette items were designated as “non-users.”

Construction of the Comparing E-cigarettes and Cigarettes questionnaire (CEAC).

Development of the CEAC was the overarching goal of the current study. Specifically, we aimed to assess comparative beliefs of e-cig use and cigarette smoking across multiple domains. In line with the social cognitive Theory of Planned Behavior (TPB), which posits that beliefs are predictive of behavioral intent and ultimate behavior (Ajzen & Fishbein, 1988), we developed items that 1) addressed domains previously found to be predictive of use or intent to use e-cigs (e.g. Dawkins, et al., 2014; Pokhrel, et al., 2014; Hendricks, et al., 2015), 2) assess beliefs that are targeted in e-cig advertisements that shape intent and e-cig use (Grana, et al., 2014; Kim, et al., 2015), 3) had the potential to be used in college and community based samples of individuals of varying product use statuses, as e-cig advertisements appeal to both cigarette users and non-smokers (Grana, et al., 2014), and 4) were worded to compare e-cigs to cigarettes. These beliefs that were drawn and adapted from the e-cig literature were then compiled, excluding any overlapping items (e.g. many scales contain items assessing beliefs that “E-cigs are good for your health;” Pokhrel, et al., 2014; Hendricks, et al., 2015), resulting in an initial 17 item scale.

The initial version of the CEAC was comprised of 17 items, with response items ranging from 1 (strongly agree) to 5 (strongly disagree). All items were reverse coded so that higher values corresponded with more positive beliefs about e-cigs as compared to cigarettes. Though the scale was presented in a reverse order than is typical, the visual aid was in line with other research, running visually from agree to disagree (e.g., the UPPS Impulsive Behavior Scale; Lynam et al., 2007).

The initial 17 items of the CEAC were pretested on a sample of 118 college students (mean age=23.85, SD=6.25, 73.6% Caucasian, 86% female, 5.1% e-cig users, 8.3% cigarette users). The overall reliability of the CEAC in the pilot sample was excellent (Cronbach's $\alpha=0.94$). Analyses indicated that the removal of any items would not improve overall Cronbach's α . The overall mean score for each individual item was 3.09 (SD=0.64) and scores were approximately normally distributed. All 17 items were thus retained at this stage for subsequent testing in the undergraduate sample.

Statistical Analysis Plan

Sample 1.—First, data were examined for random or careless responding and for missing data. Four “bogus items” (e.g., “I never brush my teeth”, “I do not understand a word of English”; Meade & Craig, 2013) were included and failure of 2 or more of these items resulted in excluding the data from that participant from further analysis. Missing data was examined for randomness and was imputed using multiple imputation (Schlomer, et al., 2010) using the MICE package in R3.0.1 (Beaujean, 2014). Next, we conducted a principal component analysis using the *factanal* command in the Psych package in R3.0.1 in order to determine the best number of factors to extract. Factors were retained that had eigenvalues >1 and were supported both by scree plot evaluation and parallel analysis. We then ran a series of exploratory factor analyses using oblimin rotation (to allow for the intercorrelation of factors). Items had to have factor loadings >0.50 on its own factor with loadings $<0.0.30$ on other factors to be retained on the scale.

Sample 2.—First, careless and missing data were handled as in Sample 1. Second, we conducted a confirmatory factor analysis via structural equation modeling using the *lavaan* package in R3.0.1 to examine the robustness of the model supported in Sample 1. Third, we examined measurement invariance of the model across product use status (e-cig user and cigarette user) and gender. Fourth, we created scale scores by summing items included on each factor and means and standard deviations on these scores were examined across demographics, as able depending on the measurement invariance findings. Last, we conducted a structural path analysis examining how scores on the CEAC subscales vary across e-cig use and cig use, after controlling for age and gender.

Results

Sample 1 Participant Characteristics

Nineteen participants were removed from the study prior to data analysis for not completing the CEAC, resulting in a final sample size of 451 (mean age=20.35, SD=5.44, 72.4% female, 73.4% Caucasian). Product use status for this sample was as follows: Non-smokers $n=86.92\%$, E-cig users $n=6.87\%$, Cigarette users $n=7.09\%$, Dual users $n=3.55\%$. Product use status did not vary by gender ($\chi^2=4.00$, $p=0.26$) or age (p 's .12 to .86). Participants included in the final sample did not differ from excluded participants on any study variables. There was 0.33% (37 data points/11328 total data points) data that was missing at random, determined by intraocular inspection of missing data patterns. The majority of individuals ($n=444$) had complete data; most individuals with missing data were only missing 1 item and there was no pattern to the missingness. Individuals with missing data did not vary from

the rest of the sample in age ($p=0.52$) gender ($p=0.57$), or product use status ($p=0.68$). Therefore, missing data was imputed using multiple imputation; resulting imputed values fell within the expected distribution of data and means and standard deviations in the new data set did not differ significantly from non-imputed data values.

Sample 1 exploratory factor analysis

The principal component analysis suggested that no more than three factors are likely and the scree plot strongly suggested leveling off after factor 3. We conducted a parallel analysis on this data and found that the eigenvalues for the three factors were larger than the average eigenvalue produced from 100 factor analyses of random data and larger than the eigenvalue at the 95th percentile of eigenvalues produced from random data, thus supporting a three-factor solution. We then ran a series of exploratory factor analyses using oblimin rotation (to allow for the intercorrelation of factors). We set the following guidelines to determine how items loaded onto factors: the item must load > 0.50 on a factor and < 0.30 on any other factor. These solutions suggested that items 8, 9, 10, 11, 12, 14, and 15 did not meet the retention criteria; therefore we removed these items from subsequent analyses. We conducted a second factor analysis after removing these items, which suggested three factors (original item numbers shown): 1) *General Benefits* (explaining 22.6% of the variance; items 1–5; example item: “Electronic cigarettes can be used to quit or cut down on smoking traditional cigarettes”); 2) *General Effects* (explaining 21.8% of the variance; items 13, 16 & 17; example item: “Compared to traditional cigarettes, electronic cigarettes can improve health”); and 3) *Health Benefits* (explaining 16.3% of the variance; items 6 and 7; example item: “Electronic cigarettes are less harmful to the user’s health than traditional cigarettes”; see Table 1)¹. Items were then renumbered to reflect the 10 rather than the 17-item scale length (Factor 1: items 1–5; Factor 2: items 8–10; Factor 3: items 6 and 7), which will be used in the rest of the manuscript.

Sample 1 CEAC Scores Across Demographics And Product Use Status

Individual subscale descriptive information for the CEAC was as follows: 1) *General Benefits* mean item score=3.38 (SD=0.83, range=1 to 5, $\alpha=0.80$); 2) *General Effects* mean item score=2.84 (SD=0.98, range=1 to 5, $\alpha=0.86$); and 3) *Health Benefits* mean item score=2.93 (SD=1.08, range=1 to 5, $\alpha=0.88$). The three factors were significantly and moderately intercorrelated (r ’s=0.42 to 0.47, all p ’s<0.001). Table 2 presents differences in CEAC scores by gender and product use status.

Sample 2 Participant Characteristics

Eighty-eight participants were removed for failing two or more careless responding items and 37 participants were removed because they did not complete the CEAC (missing more than 3 items), resulting in a final sample size of 699 (mean age=34.04, SD=10.9, 47.7% female, 83.3% Caucasian). Product use status for this sample was as follows: Non-smokers=47.64%, E-cig users=10.44%, Cigarette users=22.03%, Dual Users=19.89 Product

¹We also conducted two and four factor analyses to examine alternative possible solutions. The two-factor solution created a large amount of cross-loadings between the two factors and did not result in meaningful factors. The four-factor solution did not result in a meaningful fourth factor (either in factor loadings or in variance explained).

use status did not vary by gender ($\chi^2=2.75$, $p=.43$) or age (p 's .34 to .63). Participants included in the final sample did not differ from excluded participants on any study variables. There was 0.50% (84 data points/16077 total data points) data missing which was missing at random, determined by intraocular inspection for patterns. The majority of individuals ($n=639$) had complete data; most individuals with missing data were only missing 1 item and there was no pattern to the missingness. Individuals with missing data did not vary from the rest of the sample in age, gender, or product use status (p 's $> .05$). Therefore, missing data was imputed using multiple imputation; resulting imputed values fell within the expected distribution of data and means and standard deviations in the new data set did not differ significantly from non-imputed data values.

Sample 2 Confirmatory Factor Analysis and Measurement Invariance

We conducted a confirmatory factor analysis using the lavaan package in R3.0.1 (Beaujean, 2014). For the model tested, we analyzed the covariance matrix. We fixed the scale by setting the variance of each latent variable to itself equal to 1. Because each item used a Likert scale, each item was treated as an ordinal variable. To assess the degree of fit, we used the following indices with fit recommendations: χ^2/df (< 3.0); Root Mean Square Error of Approximation (RMSEA < 0.05); Tucker Lewis Index (TLI > 0.95); and Comparative Fit Index (CFI > 0.95 ; Hu & Bentler, 1998; Steiger, 2007). The model tested was the same as that from the EFA (see Figure 1), which consisted of items 1–5 loading onto the *General Benefits* factor, items 6–7 loading onto the *Health Benefits* factor, and items 8–10 loading onto the *General Effects* factor. Fit indices for the model indicated adequate, although not ideal, fit: $\chi^2/df = 4.36$; RMSEA = 0.07, 90% CI = 0.06–0.08; TLI = 0.99; CFI = 0.99. Modification indices were reviewed for suggestions to improve model fit. The top four modification indices were to allow the following correlations between the error terms for the following item pairs: items 9 and 10, items 3 and 5, items 2 and 3, and items 3 and 4. After allowing these intercorrelations, fit was much improved: $\chi^2/df = 1.20$; RMSEA = 0.03, 90% CI = 0.02–0.05; TLI = 0.99; CFI = 0.99. Therefore, this model was retained for subsequent analyses.

Measurement invariance across product use status and gender was computed using the SEMTools package (see Table 3). Measurement invariance was tested against the following cutoffs: CFI and TLI > 0.95 , RMSEA < 0.05 . Across cigarette users and non-cigarette users, models assessing configural and metric invariance (constraining loadings to be equal across groups), demonstrated adequate fit, whereas models assessing scalar invariance (constraining loadings and intercepts, to be equal across groups) met the CFI criteria, but not the RMSEA criteria (see Table 3). Across e-cig users and non-e-cig users, the models assessing configural, metric, and scalar invariance demonstrated adequate fit; although constraining loadings and intercepts to be equal across groups resulted in a worse fitting model ($\chi^2 p < 0.001$ in each case; see Table 3). Across men and women, models assessing configural, metric, and scalar invariance all demonstrated adequate fit (see Table 3). Although full measurement invariance is not reached across all groups, configural and metric invariance are reached, thus allowing for comparisons between groups on the CEAC scales. Table 4 provides factor loadings for each CEAC subscale by product use status and gender.

Sample 2 CEAC Scores Across Demographics And Product Use Status

As in sample 1, three subscales were computed: 1) *General Benefits* (mean item score=3.48, SD=0.79, range=1 to 5, α =0.82); 2) *General Effects* (mean item score=3.25, SD=1.05, range=1 to 5, α =0.85); and 3) *Health Benefits* (mean item score=2.87, SD=1.10, range=1 to 5, α =0.90). These three subscales were significantly intercorrelated (r 's=0.43 to 0.58, all p 's<0.001). Table 2 presents differences in CEAC scores by gender and product use status.

Path Analysis of CEAC scores across Cigarette and E-Cig Users

We conducted a path analysis using the lavaan package in R3.0.1 First, product use status was identified as a measured dichotomous variable (e-cig user or cigarette user). Age, gender, and ethnicity were included as covariates for product use status. We included pathways from product use status to each of the three CEAC scales (*General Benefits*, *General Effects*, *Health Benefits*). We defined each CEAC scale as latent factors with individual CEAC item indicators by fixing the loading of the first item on each factor to 1. To assess the degree of fit, we used the following indices with fit recommendations in parentheses as suggested by Hu & Bentler (1998): Root Mean Square Error of Approximation (RMSEA < 0.05); Tucker Lewis Index (TLI > 0.95); and Comparative Fit Index (CFI > 0.95).

Overall, this model demonstrated adequate fit: CFI = 0.99, TLI = 0.98, RMSEA = 0.05 (0.05 – 0.06, 90% confidence interval; see Figure 2). E-cig use was significantly related to *General Benefits* (loading=0.51, p <.001), *General Effects* (loading=0.43, p <.001), and *Health Benefits* (loading=0.27, p <.001). Cigarette use was only significantly related to *General Effects* (loading=0.15, p <.001).

General Discussion

The relative benefits of e-cigs as compared to traditional cigarettes are often targeted by e-cig advertisements. Endorsement of such beliefs is likely a powerful predictor of later e-cig use (Choi, et al., 2014) – both in transitioning from non-use to e-cig use and from cigarette use to e-cig use. The current study integrated the growing body of e-cig belief literature to create a novel standardized measure directly comparing beliefs concerning e-cigs and cigarettes (CEAC).

Across two independent samples, the initial data from the CEAC showed adequate reliability and validity. Exploratory factor analysis suggested three separate, though related, factors (*General Benefits*, *General Effects*, and *Health Benefits*). These factors were replicated via confirmatory factor analysis in an independent sample and demonstrated general measurement invariance across gender, e-cig use, and cigarette use. This suggests that the latent structure of the CEAC is similar across these groups and that it is viable to adequately compare CEAC scales across groups. Importantly, whereas full measurement invariance was suggested across gender, only partial measurement invariance was found across e-cig use and cigarette use, suggesting that although users and non-users have similar latent structures of their CEAC beliefs, they have different means and intercepts of CEAC beliefs. Relatedly, our path analysis suggested that e-cig use was significantly associated with scores

on all three CEAC subscales after controlling for age and gender, whereas cigarette use was associated only with scores on the *General Effects* subscale after controlling for demographics.

Interestingly, although cigarette and e-cig users reported higher scores for beliefs about e-cigs as compared to cigarettes, participants across product use statuses reported more positive beliefs about e-cigs as compared to cigarettes (i.e., each group's mean item score was above the scale midpoint). This means that, overall, people view e-cigs as safer and more beneficial than cigarettes, accurately reflecting empirical data that suggests that e-cigs are likely less harmful than traditional cigarettes. Although e-cig use could result in decreased cigarette use and harm, there is emerging evidence that, although likely less harmful than cigarettes, e-cigs are associated with a host of other negative health outcomes (FDA, 2014; Schweitzer, et al., 2015; Sussan, et al., 2015; Lerner, et al., 2015) and thus, are not without risk.

The more favorable views of e-cigs as compared to cigarettes could increase the prevalence of e-cig use in the future. Future research should address the veracity of these beliefs, contrast these comparative beliefs with emerging data suggesting significant risks associated with e-cig use, and evaluate whether these beliefs lead to willingness to use, intent to use, and future use prospectively. Although our data is cross-sectional and, therefore, we cannot determine whether cigarette and e-cig use lead to more favorable views or more favorable views drive increased rates of use, it is likely that both these directions occur in nature to some extent. These positive perceptions of e-cig use could be driving increased e-cig use or could be a result of positive personal experiences with e-cig use, such as monetary and health benefits. Data suggests that e-cig beliefs are related to increased likelihood to use e-cigs in the future (Peters, et al., 2015; Pokhrel, et al., 2014); if these beliefs are also related with increased likelihood to use e-cigs in the future, they could serve as a viable point of intervention. For example, prevention strategies could seek to modify overly positive views of e-cigs through more education about risks associated with e-cig use. Interestingly, whereas e-cig users reported higher scores on all CEAC subscales, cigarette users only reported more positive *General Effects* scores. Cigarette and e-cig users differ in that e-cig users score higher on the *General Benefits* and *Health Benefits* subscales, which might be a factor determining who transitions from cigarette to e-cig use, although this should be examined in future work.

In addition to assessing health and general benefit beliefs, the CEAC also examines under-investigated aspects of e-cig use—such as social enhancement, cost effectiveness, and enjoyment of use. As the health effects of e-cigs are more readily apparent and of public health importance, these external beliefs may be neglected in research; however the present study demonstrates that addressing these external beliefs could lead to better understanding of e-cig use.

There are some limitations to the current study. First, although the prevalence rates for e-cig use in sample 1 are similar to previous rates (6.2%), prevalence rates for cigarette use in this sample were slightly lower than previous estimates (King, et al., 2013), likely due to education level (CDC, 2013). Second, both samples completed the study online, which could

bias reports; however, laboratory and in person surveys face similar challenges (Kraut, et al., 2004). Additionally, both studies are subject to self-selection biases. Further, we did not assess if e-cig users were in the process of transitioning from cigarettes, former smokers, or if some were former e-cig users. Additionally, we did not assess relative use of cigarettes and e-cigs, which precludes validly assessing our models in a dual using group. It is also possible that there are dimensions related to e-cig use behavior and intent not included in the scale, such as sensory experience; however, research suggests this construct is not related to willingness to try e-cigs (Pokhrel, et al., 2014). The present scale was not statistically compared to other scales assessing e-cig use beliefs, which limits conclusions related to discriminant and construct validity. Importantly, as the present study is cross-sectional in design, no causal inferences should be made. It should also be noted that the phrasing of the items, which forces the direct comparison between e-cigs and cigarettes, does not allow for differentiating if scores are due to beliefs driven by cigarettes or e-cigs. Also, two items loaded onto the Health Benefits factor, which is a potential limitation of this scale.

Overall, the present study demonstrated that individuals view e-cigs as safer as and more beneficial than cigarettes, and that such beliefs are higher in those who are current e-cig or cigarette users. As demonstrated across two independent samples, the CEAC appears to be a valid and reliable way to assess these comparative beliefs across product use status and gender. Future work should establish how these comparative beliefs are influenced by e-cig use and/or influence subsequent transition to and increases in e-cig use over time. Although e-cigs are likely less harmful than cigarettes, and thus these comparative beliefs represent that state of nature, e-cigs are not completely without risk. Comparative beliefs should be contrasted with emerging data concerning negative health effects associated with e-cigs.

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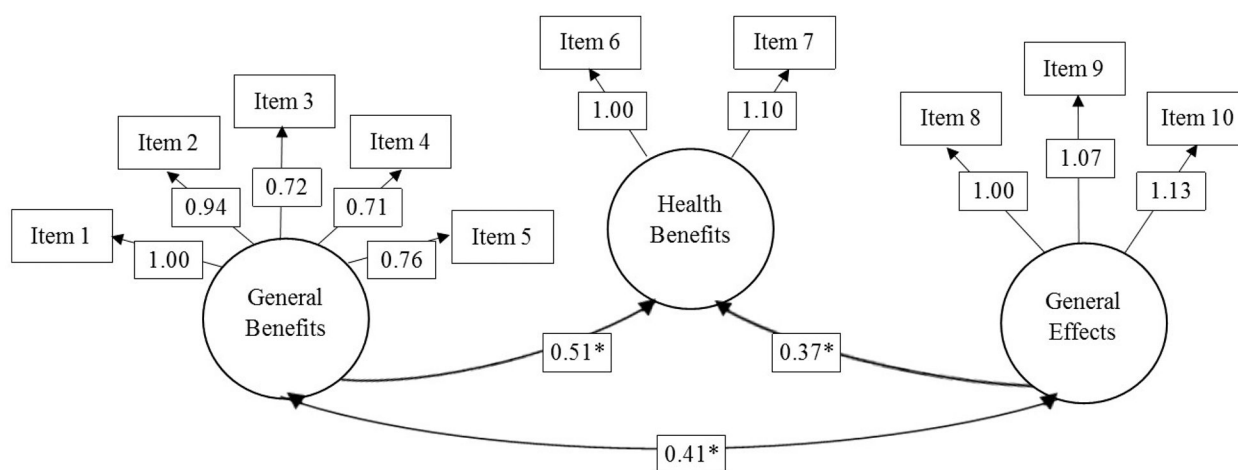


Figure 1.
Confirmatory Factor Analysis Standardized loadings for the CEAC in the Sample 2. * $p < .001$

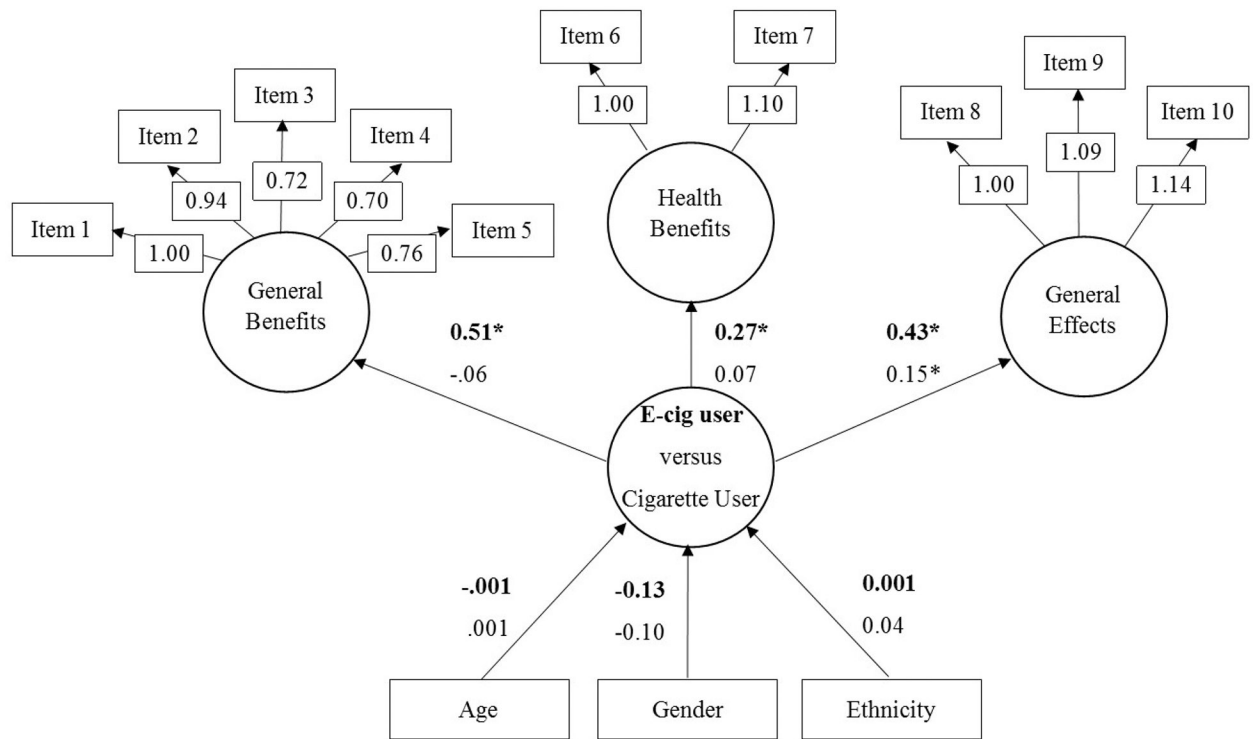


Figure 2.

Structural Equation Path Model examining how e-cig and cigarette use is related to the three CEAC subscales, controlling for age, gender, and ethnicity. Bolded path values indicate standardized coefficients for e-cig users and non-bolded indicate standardized valued for cigarette users. CFI = 0.99, TLI = 0.99, RMSEA = 0.08 (0.07 – 0.09, 90% confidence interval), * $p < .001$

Table 1.

Factor Loadings of the Comparing E-cigarettes and Cigarettes Questionnaire (CEAC) items using Exploratory Factor Analysis in Sample 1

| | General Benefits | General Effects | Health Benefits |
|--|------------------|-----------------|-----------------|
| Proportion of Variance Explained | 22.6% | 21.8% | 16.3% |
| 1. Electronic cigarettes can be used to quit or cut down on smoking traditional cigarettes | 0.55 | 0.24 | 0.24 |
| 2. Electronic cigarettes are less expensive than traditional cigarettes | 0.59 | 0.16 | 0.14 |
| 3. Electronic cigarettes are more convenient or easier to use than traditional cigarettes | 0.81 | | |
| 4. Electronic cigarettes are more enjoyable to use than traditional cigarettes | 0.52 | 0.14 | 0.25 |
| 5. Electronic cigarettes are more socially acceptable to use than smoking traditional cigarettes | 0.67 | 0.17 | 0.19 |
| 6. Electronic cigarettes are less harmful to the user's health than traditional cigarettes | 0.23 | 0.23 | 0.77 |
| 7. Electronic cigarettes are less harmful to the health of those in close proximity to the user than traditional cigarettes | 0.26 | 0.19 | 0.88 |
| 8. Compared to traditional cigarettes, electronic cigarettes can improve health (13) | 0.12 | 0.58 | 0.23 |
| 9. Using electronic cigarettes, compared to traditional cigarettes, can improve my general sense of smell (16) | 0.24 | 0.83 | 0.14 |
| 10. Using electronic cigarettes, compared to traditional cigarettes, can improve my sense of taste (17) | 0.22 | 0.96 | 0.13 |
| Items not retained: | | | |
| 1. Electronic cigarettes can reduce withdrawal symptoms from traditional cigarettes, such as anger, anxiety, depression, sleep disturbance and increased appetite. | 0.63 | 0.22 | 0.34 |
| 2. Using electronic cigarettes, compared to traditional cigarettes can improve smoker's cough and ability to breathe | 0.32 | 0.16 | 0.81 |
| 3. Using electronic cigarettes, compared to traditional cigarettes can improve ability to engage in physical activities and exercise | 0.31 | 0.20 | 0.81 |
| 4. Electronic cigarettes are less addictive than traditional cigarettes | 0.34 | 0.80 | 0.20 |
| 5. Electronic cigarettes will not produce as much cravings as traditional cigarettes | | | |
| 6. Electronic cigarettes will produce fewer withdrawal symptoms compared to traditional cigarettes | 0.52 | 0.48 | 0.33 |
| 7. Electronic cigarettes can reduce cravings for traditional cigarettes | 0.55 | 0.28 | 0.41 |

Note. Exploratory Factor Analysis using oblimin rotation. Bolded values indicate highest factor loading for each item. Item numbers in parentheses are the original item numbers prior to removal of items due to cross-loadings. "Items not retained" factor loadings represent loadings when all 17 items entered into the model.

Table 2.

CEAC scale scores across demographic and product use status variables.

| | Cig User | Non-User | E-cig User | Non-User | Male | Female |
|------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------|-------------|
| | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| Sample 1 | | | | | | |
| General Benefits | 3.89 (0.68) ^a | 3.32 (0.83) ^a | 3.56 (0.87) | 3.36 (0.83) | 3.43 (0.81) | 3.3 (0.85) |
| General Effects | 3.15 (0.97) | 2.80 (0.97) | 3.10 (0.93) | 2.81 (0.98) | 2.99 (0.98) | 2.78 (0.97) |
| Health Benefits | 2.92 (1.21) | 2.93 (1.07) | 3.06 (1.22) | 2.91 (1.07) | 2.94 (1.08) | 2.93 (1.09) |
| Sample 2 | | | | | | |
| General Benefits | 3.43 (0.84) | 3.52 (0.83) | 3.97 (0.75) ^c | 3.27 (0.78) ^c | 3.50 (0.82) | 3.45 (0.86) |
| General Effects | 3.42 (1.01) ^b | 3.13 (1.06) ^b | 3.84 (0.98) ^d | 2.99 (0.98) ^d | 3.33 (1.02) | 3.17 (1.08) |
| Health Benefits | 2.94 (1.14) | 2.82 (1.06) | 3.21 (1.16) ^e | 2.73 (1.04) ^e | 2.95 (1.12) | 2.80 (1.07) |

Note. Possible range for each scale score item mean is 0 to 4. Independent samples t-tests were conducted for CEAC scales between groups within each demographic and smoking status category. Relationships marked with a superscript were significant at $p < .01$ and are described below. All other relationships were not significant at $p < .01$. Age was not significantly related to any demographic variables or subscale for Sample 1 or Sample 2 (p 's ranged from 0.15 to 0.65)..

^a $t(449) = -4.58, p < .001$;

^b $t(696) = -3.56, p < .001$;

^c $t(697) = -11.14, p < .001$;

^g $t(697) = -10.55, p < .001$;

^h $t(697) = -5.46, p < .001$

Table 3.

Measurement Invariance by Product use and Gender in Sample 2

| | χ^2 | df | p | CFI | RMSEA | χ^2 | p | χ^2 |
|---|----------|----|-------|------|-------|----------|---|----------|
| Cigarette User | | | | | | | | |
| Configural | 88.71 | 56 | 0.004 | 0.99 | 0.04 | | | |
| Metric | 100.06 | 63 | 0.002 | 0.99 | 0.04 | 11.35 | | .12 |
| Scalar | 164.09 | 70 | <.001 | 0.97 | 0.06 | 75.38 | | <.001 |
| χ^2 for cigarettes users ($n = 296$) | 0.59 | | | | | | | |
| χ^2 for non-cigarettes users ($n = 403$) | 1.00 | | | | | | | |
| E-cig User | | | | | | | | |
| Configural | 96.11 | 56 | 0.001 | 0.99 | 0.04 | | | |
| Metric | 120.98 | 63 | <.001 | 0.98 | 0.05 | 24.87 | | .001 |
| Scalar | 132.45 | 70 | <.001 | 0.98 | 0.05 | 36.34 | | .001 |
| χ^2 for E-cig users ($n = 212$) | 0.65 | | | | | | | |
| χ^2 for non-e-cig users ($n = 487$) | 1.07 | | | | | | | |
| Gender | | | | | | | | |
| Configural | 85.72 | 56 | 0.01 | 0.99 | 0.04 | | | |
| Metric | 91.38 | 63 | 0.01 | 0.99 | 0.04 | 5.66 | | .58 |
| Scalar | 97.32 | 70 | 0.02 | 0.99 | 0.03 | 11.61 | | .64 |
| χ^2/df for men ($n = 366$) | 0.79 | | | | | | | |
| χ^2/df for women ($n = 333$) | 0.75 | | | | | | | |

Note. Invariance was assessed using the following criteria: CFI > 0.95, RMSEA < 0.05. χ^2 is comparison of current model with configural invariance model.

Table 4.

CFA Factor Loadings by group in Sample 2

| | Cig User | Non-User | E-cig User | Non-User | Male | Female |
|---|----------|----------|------------|----------|------|--------|
| General Benefits | | | | | | |
| 1. Electronic cigarettes can be used to quit or cut down on smoking traditional cigarettes | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2. Electronic cigarettes are less expensive than traditional cigarettes | 0.98 | 1.01 | 1.38 | 0.80 | 1.01 | 0.98 |
| 3. Electronic cigarettes are more convenient or easier to use than traditional cigarettes | 0.73 | 0.69 | 0.88 | 0.63 | 0.69 | 0.73 |
| 4. Electronic cigarettes are more enjoyable to use than traditional cigarettes | 0.83 | 0.70 | 1.37 | 0.61 | 0.70 | 0.83 |
| 5. Electronic cigarettes are more socially acceptable to use than smoking traditional cigarettes | 0.81 | 0.68 | 0.87 | 0.72 | 0.68 | 0.80 |
| General Effects | | | | | | |
| 6. Electronic cigarettes are less harmful to the user's health than traditional cigarettes | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 7. Electronic cigarettes are less harmful to the health of those in close proximity to the user than traditional cigarettes | 1.12 | 0.99 | 1.15 | 1.00 | 0.99 | 1.12 |
| Health Benefits | | | | | | |
| 8. Compared to traditional cigarettes, electronic cigarettes can improve health (13) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 9. Using electronic cigarettes, compared to traditional cigarettes, can improve my general sense of smell (16) | 1.04 | 0.91 | 1.00 | 0.95 | 0.91 | 1.04 |
| 10. Using electronic cigarettes, compared to traditional cigarettes, can improve my sense of taste (17) | 1.09 | 0.97 | 1.01 | 1.01 | 0.97 | 1.09 |